1-9-2015

An Analysis of Risk Factors for Incomplete Immunization for Children in Côte d'Ivoire: Examination of 1998-1999 and 2011-2012 Demographic and Health Survey Data

Alfred Douba

An Analysis of Risk Factors for Incomplete Immunization for Children in Côte d'Ivoire: Examination of 1998-1999 and 2011-2012 Demographic and Health Survey Data

by

Alfred Douba

GEORGIA STATE UNIVERSITY

A Thesis Submitted to the Graduate Faculty

Of Georgia State University in Partial Fulfillment

Of the

Requirements for the Degree

MASTER OF PUBLIC HEALTH

ATLANTA, GEORGIA

30303

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I would like to thank Dr. Ike Solomon Okosun, the committee Chairperson, and Dr. Christine Elizabeth Stauber, the committee member for their steady and invaluable support all along the process of writing this paper. I also extend my acknowledgments to all the School of Public Heath faculty.

I dedicate this thesis to my family, all the workers of the Unites States Embassy in Côte d'Ivoire, the International Institute of Education, all the contributors to the Fulbright scholarship, and to my friends for their continuous support.

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

aP	: acellular pertussis
BCG	: bacille Calmette-Guérin vaccine
CDC	: center for disease control and prevention
DHS	: demography and health survey
DNA	: deoxyribonucleic acid
DPT	: diphtheria pertussis tetanus vaccine
DPT-HepB-Hib	: diphtheria pertussis tetanus-hepatitis B-haemophilus influenzae type b vaccine
DTaP	: diphtheria tetanus acellular pertussis vaccine
EPI	: expanded program on immunization
GAVI	: global alliance for vaccine and immunization
GDP	: gross domestic product
HBsAg	: hepatitis B surface antigen
HepB	: hepatitis B
Hib	: haemophilus influenzae type b
HIV	: human immunodeficiency virus
IgA	: immunoglobulin A
IgG	: immunoglobulin G
IPV	: inactivated poliomyelitis vaccine
MCV	: measles-containing vaccine
MMR	: measles mumps rubella vaccine
MR	: measles rubella
OPV	: oral poliomyelitis vaccine
PAB	: protection at birth against tetanus
Polio 3	: poliomyelitis vaccine third dose
TT	: tetanus toxoid
UNFPA	: United Nations Fund for Population Activities
UNICEF	: United Nations Children's Fund
WHO	: World Health Organization
wP	: Whole pertussis
Yfv	: yellow fever vaccine

An Analysis of Risk Factors for Incomplete Immunization for Children in Côte d'Ivoire: Examination of 1998-1999 and 2011-2012 Demographic and Health

by

Alfred Douba

Approved:

_____
Committee Chair

_____
Committee Member

_____
Date

ABSTRACT

Background: Immunization is said to be the most effective public health intervention to prevent morbidity, complications, and mortality due to infectious disease among children. Due to the importance of vaccination in terms of infectious disease prevention, in terms of high cost-effectiveness ratio, international organizations, governments, and donors have intensified efforts to increase immunization coverage globally. Despite the efforts, thousands of children remain unimmunized or not fully vaccinated worldwide.

Objective: To identify factors associated with incomplete immunization among children in Côte d'Ivoire.

Method: The 1998-1999 and 2011-2012 Côte d'Ivoire Demography and Health Survey (DHS) data were used in this study. The included 3878 children aged 12 to 59 months with 1326 children from 1998-1999 DHS, and 2552 children from 2011-2012 DHS. Descriptive analysis was performed. Spearman's correlation coefficient was computed to examine the relationship between variables. Univariate analysis was performed to examine the association between the dependent variable (incomplete immunization) and each independent variable using logistic regression. Variables with a p-value less than .05 in the univariate analysis were included in the multivariate analysis. Multivariate analysis was performed to determine predictors of immunization status using logistic regression (stepwise method).

Results: About 42.7% and 50.1% of Côte d'Ivoire were not fully immunized in 1998-1999 and 2011-2012, respectively. Child birth place, mothers' access to media, mothers' literacy, place of residence, and religion were the best predictors of incomplete immunization.

Conclusion: Health authorities in Côte d'Ivoire should take into account these immunization status predictors in order to address the issue of incomplete immunization.

Author's Statement Page

In presenting this thesis as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote from, to copy from, or to publish this thesis may be granted by the author or, in his/her absence, by the professor under whose direction it was written, or in his/her absence, by the Associate Dean, School of Public Health. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation which involves potential financial gain will not be allowed without written permission of the author.

_____

Signature of Author

Notice to Borrowers Page

All theses deposited in the Georgia State University Library must be used in accordance with the stipulations prescribed by the author in the preceding statement.

The author of this thesis is: Alfred Douba

Student's Name: Alfred Douba

Street Address: 1709 Defoor Avenue Unit A

City, State, and Zip Code: Atlanta, Georgia 30318-7533

The Chair of the committee for this thesis is: Doctor Ike S. Okosun, PhD.

Professor's Name: Dr. Ike S. Okosun

Department: School of Public Health

College:

Georgia State University
School of Public Health
P.O. Box 3995
Atlanta, Georgia 30302-3995

Users of this thesis who not regularly enrolled as students at Georgia State University are required to attest acceptance of the preceding stipulation by signing below. Libraries borrowing this thesis for the use of their patrons are required to see that each user records here the information requested.

NAME OF USER	**ADDRESS**	**DATE**	**TYPE OF USE (EXAMINATION ONLY OR COPYING)**

CHAPTER I

INTRODUCTION

Background

Immunization or vaccination is defined as "the artificial induction of active immunity by introducing into a vulnerable host the specific antigen (living modified agent, killed organism, or inactivated toxin) of a pathogenic organism" (Porta, 2008). Immunization has a huge impact on populations' health worldwide. Due to immunization, small pox which accounted for 300 to 500 million deaths (Smallpox-related virus, 2010) was eradicated in 1980 as reported by Henderson (1999), and Etana and Deressa (2012). To build on small pox eradication, the World Health Organization (WHO) established the Expended Program on Immunization (EPI) in 1974 as reported by WHO (2013a), and Bugvi et al. (2014). Vaccination plays a major role in infectious disease prevention. It is said to be the most effective public health intervention to prevent morbidity, complications, and mortality due to infectious disease among children as reported by the National Institute of Public Health of Quebec (2007), Antai (2009), and Odusanya, Alufohai, Meurice, and Ahonkhai (2008). According to the WHO, each year, immunization prevents an estimated 2.5 thousand child deaths (2009a, 2013a). Due to the large number of deaths averted by immunization and the financial benefit it provides, immunization is listed among the most cost-effective public health intervention as mentioned by Edwards (2010), the WHO, UNICEF, and the World Bank (2009), and the Global Alliance for Vaccines and Immunization (2001). Small pox eradiation costs, for example, estimated in US$ 100 million resulted in an estimated savings of US$ 1.3

billion as reported by the WHO, UNICEF, and the World Bank (2009), and Bloom, Canning, and Weston (2005). In addition, studies showed that every dollar spent in Measles-Mumps-Rubella (MMR) vaccine, and Diphtheria- Tetanus -Pertussis (DTP) vaccine produces US$ 21 and US$ 24 savings respectively in direct medical costs (Armstrong, 2007). Moreover, a study conducted in United States (US) found that for every dollar spent, the routine immunization program saves in direct cost and in additional cost to society more than $5 and about $11 respectively (Zhou et al., 2005).

Knowing the importance of vaccination in terms of infectious disease prevention, and its good cost-effective ratio, international organizations, governments, and donors have intensified their efforts to increase immunization coverage globally (Machingaidze, Wiysonge, and Hussey, 2013) in general, and particularly in countries with less than 80% coverage at district level, and less than 90% at national level. Despite these joint efforts, thousands of children remain unimmunized or not fully vaccinated worldwide. For instance, according to the WHO, in 2012, the global number of children who did not receive the first dose of DPT, and those who did not receive the third dose were estimated to 12.6 and 22.6 million respectively (2013b).

Studies have been conducted in different countries to identify determinants of childhood immunization (Stronegger, and Freidl, 2009; Han, 2014; Nath et al., 2007). Research found that parental education (Bosch-Capblanch, Banerjee, and Burton, 2012; Wiysonge, Uthman, Ndumbe, and Hussey, 2012), maternal knowledge (Owais, Hanif , Siddiqui, Agha, and Zaidi, 2011; Etana, and Deressa, 2012), antenatal care (Hu, Li, Chen, Chen, and Qi, 2013; Sia, Kobiané, Sondo, and Fournier, 2007), child birth place (Maina, Karanja, and Kombich, 2013; Komlan et al., 2005), place of residence (Payne, Townend,

Jasseh, Jallow, and Kampmann, 2013; Fernancez., Awofeso, and Rammohan, 2011; Acosta-Ramirez, Duran-Arenas, Eslava-Rincon, and Campuzano-Rincon, 2005), household wealth (Edwards, 2010; Roy, 2010), mother's age (Waldhoer, Haidinger, Vutuc, Haschke, and Plank, 1997), and family size (Maina, et al., 2013; Acosta-Ramirez et al., 2005) were associated with childhood vaccination. These studies examined socio-demographic factors associated with immunization in a given year but not over the time. Therefore, it appears useful to identify factors associated with immunization status among children in Côte d'Ivoire, and determine the trends of these factors, in order to inform health policy makers in general, and particularly Expanded Program on Immunization (EPI) managers, in order to achieve immunization coverage objectives.

Research question

Do factors that are associated with children incomplete immunization change over the time in Côte d'Ivoire?

Hypotheses

Null hypothesis (H_0): Factors that are associated with childhood routine immunization status do not change over the time in Côte d'Ivoire.

Alternative hypothesis (H_1): Factors associated with childhood routine immunization vary over the time in Côte d'Ivoire.

CHAPTER II

LITERATURE REVIEW

Country profile

Côte d'Ivoire is a West African country which covers an area of 124, 500 square mile (322 462 km^2). Its neighboring countries are Ghana on the East, Guinea on the West, Mali and Burkina-Faso on the North; on the South the country is limited by the Atlantic Ocean (Direction de Coordination du Programme Elargi de vaccination, 2011a). The climate in the southern part of the country is an equatorial climate with dense forest, and in the northern part it is a tropical climate with savanna and woodland. There are many watercourses across the country, and four main rivers that are Comoe (720 miles), Bandama (652.4 miles), Cavally (435 miles), and Sassandra (403.9 miles) (Direction de Coordination du Programme Elargi de vaccination, 2011b).

The landscape is composed of plateaus which rise on the Northwest and fall on the coastal plain on the South bordered by lagoons (Direction de Coordination du Programme Elargi de vaccination, 2011a). There are 60 ethnic groups in the country, which are classified in 4 groups (Akan, Gour, Mande, and Krou). The most common religions are Animism, Christianity, and Islam (Direction de Coordination du Programme Elargi de vaccination, 2011b). According to UNICEF, in 2012, the population was estimated to be 19,839,800 with 9,557,000 people under 18 years, and 3,088,200 children under 5 years of age. In the same year, urban population was estimated at 52%, and the adult literacy rate was estimated to 56.9% (2013).

Côte d'Ivoire has experienced a sociopolitical crisis since 2002. This crisis worsened by the end of 2010 after the presidential elections followed by an armed conflict. The post-electoral crisis had a negative impact on the health system in general and particularly on vaccination program. Loss of cars, motorbikes, and cold chain equipment were common in most of health districts. In addition, the adverse impact of the crisis on the economy resulted in a government decreased funding of health sector (Direction de Coordination du Programme Elargi de vaccination, 2011a). Moreover, financial institutions and private companies closed for security reasons. As a result, the Gross Domestic Product (GDP) expectedly dropped by 7.3%. However, an economic growth of 5.5% was forecasted in 2012 (5.9%) if the social and security situation normalized in the second half of 2011 (Direction de Coordination du Programme Elargi de vaccination, 2011b).

In Côte d'Ivoire, there are three tiers of health care system. The first level is composed of First Contact Health Facilities with 1680 immunization centers. The second level includes general hospitals, specialized hospitals, and regional hospitals. The third level is composed of four university hospital, and seven specialized institutes. It is important to mention that the first level reference is the second level which reference level is the third level. There is an unbalanced distribution of health facilities. For example, Abidjan 1 and Lagunes 2 regions, where 20% of EPI target population live, includes about 40% of urban health facilities, and 65% of centers for maternal and child health.

There are 20 health regions and 82 health districts in the country. Activities of health regions and districts are coordinated by the Ministry of health. Health regions and

districts receive financial and technical support from partners such as the WHO, UNICEF, GAVI Alliance, International ROTARY, Red Cross International Comity, Japan cooperation (Ministère de la Sante et de la Lutte contre le Sida, 2012).

Expanded Program on Immunization in Cote d'Ivoire

The EPI started in Côte d'Ivoire in 1978 under a pilot project in the city of Abengourou. Since then, EPI was implemented across the entire country. In 1990, with the support of partners, strategies such as social mobilization and advanced strategy were implemented to improve routine immunization coverage the country. However, a survey that was conducted in 1991 found that immunization coverage was still low. From 1991 until 1995, the National Institute of Public Hygiene was in charge of the EPI. Between 1994 and 1995, a change in the health system resulted in the creation of health districts, and the EPI Executive Department, a new department charged with the implementation of the EPI. In 2000, the EPI Executive Department became the EPI Management Head Office. EPI Management Head Office works in close collaboration with the National Institute of Public Hygiene for vaccines management, the Pharmacy of Public Health and the Drug Head Office for vaccines and syringes supply and quality control, and the Equipment Head Office for equipment maintenance. Immunization centers are located in health facilities of the three level of the health care system. EPI in Côte d'Ivoire has strengths such as the political will, a budget for vaccines and syringes supply, availability of immunization services in all health districts, sufficient capacity of cold chain, and diseases surveillance system. Despite these strengths, the EPI has weaknesses, such as low performances of surveillance system, recurrent vaccines shortages, absence of cold chain and vehicle renewal plan, insufficient supervision, and complex and slow process

for accessing GAVI financial support (Direction de Coordination du Programme Elargi de Vaccination, 2010).

Routine immunization schedule

At the beginning of the EPI in Côte d'Ivoire, the immunization schedule included vaccines against six basic diseases which are tuberculosis, diphtheria, pertussis, tetanus, poliomyelitis, and measles, as reported by Lim, Stein, Charrow, and Murray (2008). Over the time, some diseases were targeted and other vaccines were added. In 2013, the routine immunization schedules included 9 vaccines with 6 vaccines against the 6 basic diseases and 3 against hepatitis B, *Heamophilus influenza b* infections, and yellow fever (WHO, 2014).

EPI immunization schedule takes into account WHO recommendations with 5 contacts for children under 1 year of age (Table 1) and 5 contacts for women (Table 2). Children and women are vaccinated free of charge in routine immunization centers.

Table 1. EPI routine immunization schedule for children under 1 year of age, Côte d'Ivoive

Age	Vaccine
At birth	BCG, OPV0
6 weeks	OPV1, DPT-HepB-Hib1
10 weeks	OPV2, DPT-HepB-Hib2
14 weeks	OPV3, DPT-HepB-Hib3
9 months	Measles, Yellow fever

Source: Plan d'introduction du vaccin contre le pneumocoque dans le PEV de routine en Côte d'Ivoire
Pneumococcal vaccine introduction plan in EPI in Côte d'Ivoire

Table 2. EPI tetanus toxoid routine immunization schedule for childbearing age women, Côte d'Ivoive

Period	Vaccine
First contact	TT1
1 month after the first dose	TT2
1 month after the second dose	TT3
1 month after the third dose	TT4
1 year after the fourth dose	TT5

Source: EPI internet site (http://pev.site90.net/index.htm#)

Characteristics of vaccines of the EPI in Côte d'Ivoire

Vaccines that are included in EPI routine immunization schedule are monovalent (contain only one antigen) including BCG, measles, and yellow fever vaccines, or polyvalent (contain more than one antigen) such as diphtheria-tetanus-pertussis-hepatitis B-*Haemophilus influenza b*, and polio vaccines. Both monovalent and polyvalent vaccines require a temperature between 2°C and 8 °C. Vaccine are stable for 3 to 4 years from the manufacturing date within this temperature range (WHO, 2011a).

BCG

Bacillus Calmette-Guérin or BCG is tuberculosis vaccine. It originates from *mycobacterium bovis.* There are many strain of *mycobacterium bovis* but the most broadly used in routine immunization program worldwide are "Danish 1331" strain, "Tokyo 172" strain, and "Moscow" strain. BCG is administered through intradermal route in the insertion region of the deltoid on the right arm. The dose used to vaccinate a child is 0.05 ml. It is important to emphasize that HIV-positive children should not be

vaccinated with BCG. Usually BCG injection resulted in a scar at the injection site about three month later. The presence of the scar is an evidence for previous BCG vaccination. Protection acquired after neonatal BCG vaccination can last 10 to 20 years or more. This protection is useful in prevention of military tuberculosis and tuberculous meningitis which are severe childhood disease. In addition, research showed that BCG provides also protection against leprosy, Buruli ulcer, and glandular disease due to other environment mycobacteria. BCG injection can be followed by adverse events. These events are mainly an ulcer at the injection site, a local injection-site abscess, suppurating lymphadenitis or local lymphadenopathy, osteitis or osteomyelitis, and dissemination of BCG (WHO, 2011b).

DTP-HepB-Hib

DPT-HepB-Hib or pentavalent consists of a combination of five vaccines and provides protection against diphtheria, pertussis, tetanus, hepatitis B, and *Haemophilus influenza* type b infections.

Diphtheria vaccine is made of diphtheria toxoid obtained by action of formaldehyde on diphtheria toxin. This toxin is produced by a bacterium - *Corynebacterium diphtheriae.* Diphtheria vaccine dosage unit is the limit of flocculation (Lf). Each dose of children vaccines contain 7.5 to 25 Lf while adult and adolescents' vaccines contain 2 to 3 Lf per dose. Adolescents and adults' vaccine contain less unit because they are more sensitive to local and systemic reactions associated with diphtheria vaccine. It is said that 0.01 IU/mL of circulating diphtheria antitoxin provides immunity against the disease. The duration of immunity after diphtheria vaccination varies between early and more recent studies, and between countries. Studies conducted in US in the

1960s found that 10% of children lost immunity 7 to 13 years after primary immunization series whereas in the late 1980s research showed that 10% of children lost immunity after one year, 67% after 3 to 13 years, and 83% after 14 to 23 years as reported by the WHO (2009a). However, in Italy and United Kingdom, research found that, four to eight years after the primary series of three doses, 96% to 100% of immunized children had protective antibodies. These different findings may attributed to diverse immunization schedules, different vaccines, or diverse level of exposure to *Clostridium diphtheriae* natural consolidation of diphtheria immunity as reported by the WHO (2009a). Side effects associated with diphtheria vaccine are erythema, and swelling at the injection-site, and transient febrile (WHO, 2009a).

Tetanus vaccine is made of tetanus toxoid which is obtained by inactivation of tetanus toxin by formaldehyde. Tetanus toxin is produced by *Clostridium tetani* which is an anaerobic bacterium. Tetanus toxoid induces the production of tetanus antitoxins. Antitoxins produced by mother by active immunization passes the fetus through the placenta and prevent neonatal tetanus. The minimum antitoxin protective level is 0.01 IU/ml. The degree as well as the duration of protection increases with the number of doses of vaccine received. One dose alone induces only little or no immunity. The second doses produces a level of antitoxin greater than the minimum protective level of 0.01 IU/ml. The third dose induces a protection, which last at least five years. The fourth and the fifth dose ensure immunity for at least 10 and 20 years, respectively. It is important to underline that immunity decline over the time. The most common adverse effects associated with tetanus vaccine are local swelling and pain. In addition, malaise, fever, and headache have been reported. Finally, brachial neuropathy (an estimated 0.5 to 1 case

per 100 000 vaccine recipients) and anaphylactic reaction (four cases in about 2 million doses administered) occur after tetanus vaccination (WHO, 2007a).

There are different types of pertussis or whooping cough vaccines – the whole-cell pertussis vaccines (wP vaccines), and the acellular pertussis vaccines (aP vaccines). These vaccines protect against effects of pertussis toxin produced by *Bordetella pertussis*, which is the pathogenic agent of pertussis or whooping cough. Since the wP vaccines are composed of killed whole bacteria, they induce a large immune response against many antigens. Both aP and wP antigens are mainly associated with diphtheria and tetanus toxoids to produce DTaP and DTwP vaccines. A combination with additional antigens (hepatitis B antigen and *haemophilus inflenzae* type b polisaccharide) is possible by given DTaP-HepB-Hib and DTwP-HepB-Hib vaccines. The degree of protection induced by the pertussis vaccines increases with the number of doses received, and decrease over the time. Research found that protection acquired by vaccination lasts 7 to 14 years. Pertussis vaccines are associated with local reactions including warmth, tenderness, redness, and swelling, and systemic reactions such as fever, fretfulness, vomiting, and anorexia. Monovalent vaccines (vaccine containing one pertussis antigen) have less local side-effects compare to combination vaccines. Overall, combination vaccines are safe, efficacious, and are used in EPI routine immunization worldwide (WHO, 2010).

Hepatitis B vaccine is made of hepatitis B virus surface antigen (HBsAg). There are two type of hepatitis B vaccine – plasma derived vaccine, and recombinant DNA vaccine. Hepatitis B vaccine is administered by intramuscular route. The preferred injection site is the anterolateral thigh for infants and children less than 2 years, and the deltoid muscle for older children and adults.

Anti-HBs antibody level of more than 10 IU/L, measured 1 to 3 months after a complete immunization schedule defines the seroprotection against hepatitis B virus infection. Antibodies anti-HBs decrease quite rapidly after the primary immunization series and more slowly afterward. Protection acquired by a complete immunization series can last 15 years after vaccination. HBsAg is combined with other antigens or toxoids to give DTP-HepB-Hib. Hepatitis B vaccine can be administered simultaneously with other vaccines such as BCG, DTP, polio, measles, and yellow fever vaccines. Hepatitis B vaccine is not contraindicated during pregnancy or lactation but individuals with a history of allergic reaction to the vaccine's components are often advised not to receive the vaccine. Adverse effects associated with hepatitis vaccine frequently include local pain, myalgia and transient fever, and rarely severe anaphylactic reactions with an estimated risk of 1.1 cases per million doses administered (WHO, 2011a).

Haemophilus influenzae type b (Hib) vaccine is made of purified Hib capsular polysaccharide (PRP) linked (conjugated) to a protein carrier. PRP can be conjugated to three type of protein carrier - tetanus toxoid, a mutated non-toxic diphtheria toxin, and a Neisseria meningitides type b outer membrane protein complex. Hib vaccination induces the production of antibodies anti-PRP. The level of anti-PRP determines the term of protection. Hence, short-term and long-term protections are characterized by anti-PRP concentration of 0.15 μg/ml and 1.0 μg/ml, respectively. Hib vaccine can be combined with diphtheria-tetanus-pertussis (DTP) and hepatitis B (HepB) vaccines to give DTP-HepB-Hib. Also, Hib vaccine can be administered at the same time with BCG, DTP, measles, polio, HepB, yellow fever vaccines, and vitamin A supplementation. Hib vaccine had a huge impact on the decrease of Hib infections in both developed and

developing countries. For example, Hib disease has mostly disappeared in the United States, Canada, Australia, New Zealand and Western Europe due to the introduction of Hib vaccine into routine childhood immunization programs. In addition, in Malawi, the introduction of Hib vaccine into the EPI decreased Hib disease by 87% in children under 2 years and by 88% in children under 5 years. Moreover, in the Gambia, the incidence of Hib meningitis in infants decreased from 200 per 100 000 to 21 per 100 000 due to the introduction of Hib vaccine into the EPI in 1997 as reported by the WHO (2007b). Despite the efficacy of Hib vaccine, failure can occur in a vaccinated population due to factors such as prematurity, immunoglobulin deficiency, malignancy, neutropenia, and modification in Hib structure (WHO, 2007b).

OPV

There are two type of polio vaccine – live attenuated vaccine or oral polio vaccine (OPV) and inactivated polio vaccine (IPV) or injectable vaccine. Both OPV and IPV are made of polio virus. There are three types of polio virus - type 1, type 2, and type 3. The vaccine can be monovalent (contains one type of polio virus), bivalent (contains 2 types of virus), or trivalent (contains the three types of virus). Polio vaccine included in EPI vaccine is trivalent IPV or OPV. IPV is mostly used in developing countries, whereas OPV is utilized in developing countries. Polio vaccine induces the production of serum antibody and secretory antibody. Individuals are protected against a specific type of poliovirus if they produce a type-specific serum-neutralizing antibody, although serum neutralizing antibody level needed for protection against clinical illness has not been determined. Secretory immunoglobulin A (IgA) antibody provides a local barrier to poliovirus infection. One to three weeks after administration, OPV induces the production of

secretory IgA antibody (in the intestine and the nasopharynx), which inhibits wild virus replication in the intestine. In addition, OPV multiplies in the intestine and disseminated from vaccinated individuals to unimmunized persons who can consequently produce secretory IgA antibody. Secretory IgA antibody is said to be useful in protecting people and in decreasing the rate of transmission of wild poliovirus by immune individuals. These secretory IgA can persist for 5 to 6 years. Trivalent OPV is recommended for EPI in developing countries due to its low cost, superiority in bestowing intestinal immunity, ease of administration, and the possibility to infect household and community contacts secondarily. OPV can cause paralysis as an adverse effect. In the OPV series, the relative frequency of paralysis associated with the initial dose is estimated to 1 case per 700 000 doses, and one case per 6.9 million ulterior doses. Usually, live vaccines are not administered to immune-compromised individuals. However, in countries where HIV infection is a problem, asymptomatic HIV positive persons are vaccinated in accordance with EPI schedule. An alternative to OPV for vaccination in HIV positive children is IPV. In 1988, the World Health Assembly decided the global eradication of poliomyelitis. To achieve polio eradication, it is necessary to reach a high level of OPV coverage. Supplementary immunization activities may be implemented in countries where routine immunization may not be sufficient to stop wild polio virus transmission. Additional doses of OPV should be administer to children under 1.5 years in routine immunization in order to maintain immunity against the three type of polio virus in countries where the circulation of wild poliovirus has been stopped or largely reduced (WHO, 1993a).

Measles vaccine

Measles vaccine is made of measles wild attenuated virus. Different wild-type strain such as Edmonston, Schwartz, Moraten, Leningrad, and Shanghai are used to produce measles vaccine. Attenuated measles virus can be associated with rubella and mumps antigens to give measles-rubella vaccine (MR) or measles-rubella-mumps vaccine (MMR). The usual route of injection of measles vaccine is the subcutaneous route; however, it can be administer intramuscularly. As the natural measles virus infection, measles vaccine induces cellular and humoral response but these responses are lower in terms of magnitude and duration compared to those generated by natural infection. The immunity conferred by measles vaccination last for decades, and the level of neutralizing antibodies needed to insure a clinical protection against the disease is $\geq$ 120 mIU/mL.

Many factors (age, sex, passively-acquired maternal IgG antibodies, HIV infection and other immunosuppressive conditions, concurrent acute infections, nutrition status, host genetics) influence immune response to vaccination. For example, older infants produce better responses compare to younger infants; girls produce higher antibodies than boys; passively-acquired maternal IgG antibodies, HIV infection, concurrent acute infections, and malnutrition reduce immune responses; genetic differences can lead to difference level of immune response after vaccination. Adverse event are associated with measles vaccine. The frequent adverse effects are fever, and injection-site pain and tenderness. Rarely, thrombocytopenia and Anaphylactic reactions can occur (WHO, 2009b).

Yellow fever vaccine

Yellow fever (17 D vaccine) is made of live attenuated human yellow fever virus. Different strains are used to produce yellow fever vaccine; however, these strains came

from the same primary strain. The vaccine is administered through subcutaneous route to a dose of 0.5 ml from 6 months of age because cases of encephalitis were reported in children of 4 months and younger. Yellow fever vaccine induce the production of antibodies (neutralizing, hemagglutination inhibition, and complement fixation antibodies) which protect immunized individuals against the disease. The protection conferred by vaccination last many decades. In many countries' EPI routine immunization programs, yellow fever vaccine is administer simultaneously with measles vaccine at 9 months of age. Yellow fever vaccine is a lyophilized vaccine which loses all its potency within one hour when it is reconstituted with diluent at 37°C. Therefore, it must be reconstituted with refrigerator-temperature diluent and kept in an ice-bath in order to maintain its potency for up to 3 hours. Yellow fever vaccine is well tolerated. Therefore, adverse events association with the vaccine are mild and limited to low grade fever and headache (WHO, 1993b).

CHAPTER III

METHODS AND PROCEDURES

Data source and sample size

- **Data Source**

The 1998-1999 and 2011-2012 Côte d'Ivoire Demography and Health Surveys (DHS) data were used for this study. These data were obtained from DHS data at http://www.dhsprogram.com/data/dataset_admin/download-datasets.cfm, after a written request explaining the purpose of the study. This request was followed by a written agreement, from the Demographic and Health Survey Program and ICF International, which authorized the data use.

Côte d'Ivoire DHS was based on a random sampling with two stratification levels and two-stage cluster sampling survey. The first level of stratification was regions stratification. The second level was the stratification of rural and urban areas within each region. This stratification resulted in a list of all rural and urban strata of the country. From this list, strata were selected by random sampling. Subsequently, household to be surveyed were randomly selected from the selected strata. The number of households included in the survey was proportional to the stratum size and the number of strata selected was proportional to the region size (Republique de Côte d'Ivoire, 2001; Republique de Côte d'Ivoire, 2013).

- **Study sample**

The study sample was based on children data set from 1998-1999 DHS which contained 1992 cases, and children data set from 2011-2012 DHS which contained 7776 cases. Only children aged 12 to 59 months were eligible for the study. In addition, cases with missing data were excluded from the data sets. The sample was 3878 children representing 1326 children from 1998-1999, and 2552 children from the 2011-2012 DHS.

Definition of the variables

- **Dependent variable**

The outcome variable was vaccination defined as "not fully unimmunized". A child defined as not fully unimmunized if he/she did not received at least one of the following vaccines: BCG, the third dose of pentavalent (DTP-HepB-Hib 3), the third dose of polio (polio 3), and measles vaccine.

- **Independent variables**

Independent variables in the study included child's sex, age, birth place, birth order, number of under-five children in the household, mother's age, mother's highest education, mother's access to media (radio, television, and/or newspaper), mother's literacy, head of the household, type of place of residence, and religion.

Statistical analysis

Descriptive analysis was performed to examine the rate of non-immunization by year. The Chi-square test was computed to compare differences among variables subgroups across years. Differences in rates of BCG, DPT3, polio3, and measles vaccinations were

computed to determine the trend of children who remains unimmunized for these vaccines. Spearman correlation analysis was performed to examine the relation between studied variables. Univariate logistic regression analysis was performed to examine the association between the dependent variable and each independent variable. The measure of association was the odds ratio (OR) from the logistic regression analyses with the 95% confidence interval (CI) used to determine statistical significance. Variables with a p-value less than .05 in the univariate analysis were included in the multivariate logistic regression analysis. Multivariate analysis was performed to determine predictors of immunization status using stepwise method logistic regression analysis.

CHAPTER IV

RESULTS

A. Descriptive

Table 3. Proportional distribution of selected variables, Côte d'Ivoire, 1998-1999 and 2011-2012

Variables	**Total**	**1998-1999 N (%)**	**2011-2012 N (%)**	**P***
Number of children aged 12-59 months	3878	1326 (100)	2552 (100)	
Not fully immunized children	1805	556 (41.9)	1249 (48.9)	.0001
Child sex				
male		652 (49.2)	1264 (49.5)	.832
female	3878	674 (50.8)	1288 (50.5)	
Child age (months)				
12-23		351 (26.5)	718 (28.1)	
24-35	3878	371 (28.0)	693 (27.2)	.451
36-47		306 (23.0)	612 (24.0)	
48-59		298 (22.5)	529 (20.7)	
Child birth place				
Home		542 (40.9)	1149 (45.4)	.007
Health facility	3855	784 (59.1)	1380 (54.6)	
Child birth order				
1rst		324 (24.4)	518 (20.3)	
2nd		247 (18.6)	498 (19.5)	
3rd	3878	195 (14.7)	405 (15.9)	.025
4th		145 (11.0)	333 (13.0)	
≥5th		415 (31.3)	798 (31.3)	
		Mean (SD)	**Mean (SD)**	
Number of under-five children in the household		2.30 (1.69)	2.37 (1.44)	.20

*P value is from the Chi-square test comparing 1998-1999 to 2011-2012 data
*t value is from the independent samples t test

Distribution of selected variables for year 1998-1999 and year 2011-2012 are presented in Table 6. As shown, distribution of selected variables varied across years.

Table 4. Proportional distribution of selected variables, Côte d'Ivoire, 1998-1999 and 2011-2012 (continue)

Variables	Total	1998-1999 N (%)	2011-2012 N (%)	P
Mothers' age (years)				
15-24		392 (29.5)	690 (27.0)	
25-34		636 (48.0)	1253 (49.1)	
35-44	3878	268 (20.2)	543 (21.3)	.381
45-49		30 (2.3)	66 (2.6)	
Mothers' education				
No education		786 (59.3)	1751 (68.6)	
Primary	3878	371 (28.0)	587 (23.0)	.0001
Secondary and higher		169 (12.7)	214 (8.4)	
Mothers' literacy				
Can read	3877	467 (35.2)	556 (21.8)	.0001
Cannot read		858 (64.8)	1996 (78.2)	
Head of the household				
Man	3878	1146 (86.4)	2181 (85.5)	.415
Woman		180 (13.6)	371 (14.5)	
Media access				
No	3878	426 (32.1)	1008 (39.5)	.0001
Yes		900 (67.9)	1544 (60.5)	
Place of residence				
Urban	3878	777(58.6)	849 (33.3)	.0001
Rural		549 (41.4)	1703 (66.7)	
Religion				
Catholic		284 (21.4)	412 (16.1)	
Protestant	3878	184(13.9)	527 (20.7)	.0001
Muslim		584 (44.0)	1170 (45.8)	
Traditional, no religion		274 (20.7)	443 (17.4)	

There were statistically significant difference between subjects' maternal education, maternal literacy, media access, place of residence, and religion in 1998-1999 and year 2011-2012 ($p < .001$). As shown, proportion of eligible subjects' mothers representing no education, living in urban setting, and of Catholic religion were greater in 1998-1999. Fewer subjects had access to media in 2011-2012 compared to 1998-1999.

Table 5. Proportional distribution of not immunized children per vaccine, Côte d'Ivoire, 1998-1999 and 2011-2012

	1998-1999		**2011-2012**			
Vaccine	**Sample size**	**Not immunized N (%)**	**Sample size**	**Not immunized N (%)**	**P**	***Absolute difference**
BCG	1326	194 (14.6)	2552	461 (18.1)	.007	3.5
DPT 3	1326	432 (32.6)	2552	893 (35.0)	.133	2.4
Polio 3	1326	458 (34.5)	2552	743 (29.1)	.001	-5.4
Measles	1326	314 (23.7)	2552	783 (30.7)	.0001	7.0

*Absolut difference is the difference of not fully immunized percentage between 2011-2012 and 1998-1999

Table 5 provides distribution of subjects who were not immunized in Cote d'Ivoire, in 1998-1999 and 2011-2012. As shown, the rate of non-immunization for BCG, measles were higher in 2011-2012 compared to 1998-1999 ($p < .001$). The rate of non-immunization for polio 3 was higher in 1998-1999 than 2011-2012 with rates of 34% and 29.1% respectively. However, there was no difference in the rate of non-immunization for DPT 3 for the study period ($p = .133$).

Table 6. Spearman's correlation coefficient for selected variables, Côte d'Ivoire, 1998-1999 and 2011-2012

		Year 2011-2012												
	Variable	Not fully vaccinated	Child's age in months	Birth order number	Number of children 5 and under	Place of delivery	Sex of child	Type of place of residence	Age 5-year groups	Access to media	Highest educational level	Literacy	Religion	Sex of household head
Year 1998-1999	Not fully vaccinated	1	.007	.023	.142**	-.200**	.010	.157**	-.038*	-.158**	-.150**	.181**	.151**	-.068**
	Child's age in months	-.009	1	.017	.054**	-.036	.006	.006	.148**	.004	-.017	.018	-.001	-.011
	Birth order number	.100**	.027	1	.116**	-.139**	-.017	.135**	.698**	-.098**	-.207**	.158**	.045*	-.088**
	Number of children 5 and under	.036	.010	.159**	1	-.138**	.012	.181**	-.017	-.085**	-.102**	.128**	.113**	-.069**
	Place of delivery	-.326**	.015	-.115**	-.104**	1	-.032	-.344**	-.034	.258**	.238**	-.218**	-.092**	.055**
	Sex of child	.001	.049	-.027	-.008	-.008	1	.031	-.013	-.024	-.009	.009	-.002	-.021
	Type of place of residence	.251**	.005	.087**	.176**	-.481**	.009	1	.021	-.332**	-.215**	.252**	.080**	-.072**
	Age 5-year groups	.050	.130**	.708**	.084**	-.027	.017	.021	1	-.048*	-.108**	.059**	-.013	-.050*
	Access to media	-.247**	-.055*	-.175**	-.047	.269**	-.024	-.294**	-.178**	1	.316**	-.308**	-.183**	.058**
	Highest educational level	-.212**	-.006	-.225**	-.133**	.285**	-.041	-.215**	-.137**	.369**	1	-.776**	-.261**	.129**
	Literacy	.230**	.002	.218**	.131**	-.273**	.051	.220**	.136**	-.356**	-.863**	1	.242**	-.130**
	Religion	.186**	.010	.081**	.149**	-.221**	.055*	.145**	.014	-.146**	-.292**	.303**	1	-.132**
	Sex of household head	.011	-.022	-.069*	-.078**	.020	.033	-.043	.020	.060*	.038	-.072**	-.087**	1

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Table 6 provides Spearman's correlation coefficient for 1998-1999 and 2011-2012 variables. As shown, there was a significant positive relationship between incomplete immunization and children birth order, place of residence, maternal literacy, and religion in 1998-1999. There was a significant negative relationship between incomplete immunization and child birth place, access to media, and maternal education in 1998-1999. In 2011-2012, there was a significant positive relationship between incomplete immunization and number of children in the household, place of residence, maternal literacy, and religion. However, there was a significant negative relationship between incomplete immunization and child birth place, maternal age group, access to media, education, and sex of household head.

B. Univariate analysis

Table 7. Univariate analysis of selected variables and Odds of not being fully immunized, Côte d'Ivoire, 1998-1999 and 2011-2012

Variables	Not fully immunized			
	1998-1999		2011-2012	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Child sex				
male	1 (Reference)		1 (Reference)	
female	1.00 (.80, 1.25)	.966	1.04 (.89, 1.21)	.600
Child age (months)	1.05 (.77, 1.44)	.737	1.02 (.81, 1.28)	.83
12-23	.93 (.68, 1.27)	.680	.79 (.63, 1.00)	.05
24-35	.95 (.69, 1.32)	.783	1.03 (.82, 1.30)	.76
36-47	1 (Reference)		1 (Reference)	
48-59				
Child birth place				
Home	3.95 (3.13, 4.98)	.0001	2.26 (1.92, 2.65)	.0001
Health facility	1 (Reference)		1 (Reference)	
Child birth order				
1rst	1 (Reference)		1 (Reference)	
2nd	.93 (.66, 1.32)	.709	1.02 (.80, 1.31)	.819
3rd	1.04 (.725, 1.50)	.818	.98 (.75, 1.27)	.887
4th	1.15 (.77, 1.72)	.483	.98 (.74, 1.29)	.903
≥5th	1.62 (1.21, 2.18)	.001	1.14 (.91, 1.42)	.231
Number of under-five children in the household	1.10 (1.02, 1.16)	.006	1.21 (1.14, 1.28)	.0001

The result of the univariate analysis of the association between selected child variables and Odds of not being fully immunized in 1998-1999, and 2011-2012 is presented in Table 7. As shown, and with the exception of child birth place and number of children under 5 per household, child sex, and age were found not to be significantly associated with child immunization.

In 1998-1999, and 2011-2012 child birth place and increased number of children less than 5 years per household were associated with increased Odds of not fully vaccinated. In 1998-1999, and 2011-2012, birth at home, was associated with increased Odds of not being fully immunized, with Odds ratio of 3.95 (95% CI=3.13-4.98) and 2.26 (95% CI=1.92-2.65), respectively. Increased number of children per household was associated with increased Odds of not being fully immunized, with Odds ratio of 1.10 (95% CI=1.02-1.16) and 1.21(95% CI=1.14-1.28) in 1998-1999, and 2011-2012 respectively.

Table 8. Univariate analysis of selected variables and Odds of not being fully immunized, Côte d'Ivoire, 1998-1999, and 2011-2012 (continue)

Variables	Not fully immunized			
	1998-1999		2011-2012	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Mother's age (years)				
15-24	.52 (.24, 1.11)	.094	1.72 (1.03, 2.89)	.038
25-34	.50 (.24, 1.05)	.076	1.37 (.82, 2.27)	.219
35-44	.68 (.32, 1.47)	.337	1.48 (.88, 2.50)	.135
45-49	1 (Reference)		1 (Reference)	
Mother's education				
No education	5.38 (3.46, 8.37)	.0001	2.45 (1.81, 3.31)	.0001
Primary	3.37 (2.11, 5.38)	.0001	1.42 (1.02, 1.98)	.037
Secondary and Higher	1 (Reference)		1 (Reference)	
Media access				
No	2.92 (2.30, 3.71)	.0001	1.92 (1.63, 2.25)	.0001
Yes	1 (Reference)		1 (Reference)	
Literacy				
Can read	1 (Reference)		1 (Reference)	
Cannot read	2.80 (2.19, 3.58)	.0001	2.48 (2.03, 3.03)	.0001
Head of the household				
Man	1 (Reference)		1 (Reference)	
Woman	1.06 (.77, 1.46)	.682	.67 (.54, .84)	.001
Place of residence				
Urban	1 (Reference)		1 (Reference)	
Rural	2.83 (2.26, 3.55)	.0001	1.97 (1.66, 2.33)	.0001
Religion				
Catholic	1 (Reference)		1 (Reference)	
Protestant	1.63 (1.09, 2.41)	.015	1.48 (1.14, 1.93)	.003
Muslim	1.97 (1.44, 2.67)	.0001	2.01 (1.59, 2.54)	.0001
Traditional/no religion	3.33 (2.34, 4.73)	.0001	2.71 (2.06, 3.58)	.0001

In 1998-1999 as well as in 2011-2012, the number of children not fully immunized was associated with mother's education, media access, literacy, place of residence, and

religion. The dependent variable was associated with the variable "Head of the household" in 2011-2012 only. However, the number of children not fully immunized was not associated with mother's age in 1998-1999 and in 2011-2012 also.

C. Multivariate analysis

Table 9. Multivariate analysis of selected variables and Odds of not being fully immunized, Côte d'Ivoire, 1998-1999, and 2011-2012

	Not fully immunized			
	1998-1999		**2011-2012**	
Variables	**Adj. OR(95% CI)**	**P-value**	**Adj. OR(95% CI)**	**P-value**
Child birth place				
Home	2.57 (1.96, 3.37)	.0001	1.72 (1.44, 2.05)	.0001
Health facility	1 (Reference)		1 (Reference)	
Media access				
No	1.82 (1.38, 2.38)	.0001	1.27 (1.06, 1.53)	.009
Yes	1 (Reference)		1 (Reference)	
Literacy				
Can read	1 (Reference)		1 (Reference)	.0001
Cannot read	1.95 (1.19, 3.20)	.008	1.59 (1.27, 1.99)	
Place of residence				
Urban	1 (Reference)		1 (Reference)	
Rural	1.38 (1.04, 1.83)	.023	1.29 (1.06, 1.58)	.002
Religion				
Catholic	1 (Reference)		1 (Reference)	
Protestant	1.72 (1.12, 2.64)	.013	1.32 (1.00, 1.74)	.049
Muslim	1.71 (1.21, 2.43)	.002	1.74 (1.36, 2.23)	.0001
Traditional and no religion	1.89 (1.28, 2.79)	.001	1.82 (1.36, 2.44)	.0001
Number of under-five children in the household	NA		1.13 (1.06, 1.20)	.0001
Mother's education				
No education	1.17 (.59, 2.30)	.650		
Primary	1.85 (1.12, 3.07)	.016	NA	
Secondary and higher	1 (Reference)			

NA = Not applicable

The result of the multivariate logistic regression analyses of the association between selected variables and odds of not being fully immunized in 1998-1999, and 2011-2012 are presented in Table 9. Child birth place, media access, literacy, place of residence, and religion were associated with odds of not being fully immunized in 1998-1999 as well as in 2011-2012. Increased number of children less than five years in the household was associated with increased odds of not being fully immunized only in 2011-2012.

CHAPTER V

DISCUSSION AND CONCLUSION

- **Possible reasons for the increase of not fully unimmunized children**

In this study we examined the trend of socio-demographic factors that are associated with immunization status among children aged 12 to 59 months using DHS data from 1998-1999 and 2011-2012. The number of not fully unimmunized children in 2011-2012 sample (1249, 48.9%) compared to those of 1998-1999 (556, 41.9%) was statistically significant (P = .0001). This difference could be explained by many reasons.

The first reason may be due to the insufficiency of supply of immunization service. The strategy Reach Each District has been implemented in all the health districts through the country using first contact health facilities which offer immunization services. A study conducted in 2010, in order to write the External Review of Expanded Program on Immunization, found that the strategy Reach Each District was insufficiently implemented in some health districts. Immunization supply service was insufficient for all types of immunization strategy: fixe, advanced, and out of reach strategy. Some vaccines were not administered during immunization session mainly because health personnel wanted to reduce vaccine wastage, and because of vaccines shortage (Direction de Coordination du Programme Elargi de Vaccination, 2010).

The second reason may be attributed to insufficiency in immunization service use. The study conducted in 2010, mentioned above, found that the access to immunization program which is assessed by DPT1 and TT1 coverage was high (more than 90% for each of them). However, continuity of immunization service which is assessed by dropout rates of DPT1-DTC3, DPT1-MCV, TT1-TT2, and TT1-TT3 was low (dropout

rates was far beyond the threshold of 10%). For example, in 2011, only 33 (21%) health districts out of 82 had a dropout rate less than 10% (Direction de Coordination du Programme Elargi de vaccination, 2011b; Direction de Coordination du Programme Elargi de vaccination, 2013), and the dropout rate at of DPT1-MCV was 26% at national level (WHO, and UNICEF, 2011).

The third reason may be due to vaccines shortage. The country experienced vaccines shortages for months and in different years. For instance, in 2010, BCG, TT, yellow fever, and measles vaccine were out of stock for 2, 2, 5, and 1 months respectively. The following year, 2011, pentavalent vaccine (DPT-HepB-Hib) was out of stack for 3 months, and auto-disable syringes were out of stock for 5 months (Direction de Coordination du Programme Elargi de vaccination, 2011a).

The fourth reason may be due to financial problems. Almost all financial institutions and private companies had to close for security reasons, and for the cessation of financial operations of the Central Bank of West African Countries with Côte d'Ivoire during the post-electoral period. This situation severely affected the economy of the country. Consequently, vaccines suppliers did not get paid. Therefore, vaccines supply was suspended. This suspension led to vaccines shortage over the time (Direction de Coordination du Programme Elargi de vaccination, 2011a).

The fifth reason may be due to the social and military crisis. The Côte d'Ivoire experienced a sociopolitical crisis since 2002. This crisis worsened after the presidential election, in November 2010, which led to a war between March 2011 and Mai 2011. The crisis had a negative impact on heath system in general, and especially on immunization system. For example, the government decreased his contribution on health expenses. In

addition, losses of cold chain equipment, vehicles, and motorbikes were reported in the vast majority of health districts. Moreover, vaccines and syringes shortage was reported (Direction de Coordination du Programme Elargi de vaccination, 2011a).

- **Factors associated with immunization status**

Birth place

Birth place was associated with immunization status in 1998-1999 as well as in 2011-2012. In 1998-1999, children born at home were 2.5 times more likely not to be fully immunized compared to those born at health facilities (95%CI = 1.91, 3.28). In 2011-2012, although the odd of not being fully immunized when born at home decreased compared to 1998-1999, children born at home were 1.72 more likely to be not fully immunized compared to those born at health facilities (95%CI = 1.44, 2.05). Our findings are similar to those of previous studies (Nankabirwa, Tylleskär, Tumwine, Sommerfelt, and Promise-ebf Study Group, 2010; Nath et al., 2007; Maina, et al., 2013, Komlan et al., 2005). In Sub-Saharan African region, many women often give birth at home for reasons such as lack of transport and/or funds, long distance to reach health facilities, and lack of motivation (not necessary to deliver in a health facility) (Montagu, Yamey, Visconti, Harding, and Yoong, 2011; Kitui J., Lewis S., and Davey G., 2013; Partnership for maternal, newborn and child health, n.d.). The lack of motivation to deliver in a health facility could be explained by social and cultural beliefs as reported by Montagu et al. (2011).

Place of residence

Place of residence was associated with immunization status in 1998-1999 and in 2011-2012 also. Children living in rural area were 1.38 more likely not to be fully immunized compared to those of urban area in 1998-1999. In 2011-2012, children of rural area were 1.29 more likely to have incomplete immunization than their urban counterparts. Our findings confirmed those of previous studies conducted in Malawi (Munthali, 2007), Benin (Komlan et al., 2005), and Ethiopia (Roy, 2010). However, other studies conducted in Gambia (Payne et al., 2013), Malawi (Donsa, 2013), and in other Sub-Saharan African countries (Wiysonge et al., 2012) found that children living in rural areas were more likely to be not fully immunized compared to those of urban areas. In rural areas, children incomplete immunization status could be explained by the long distance between the place of residence and health facilities (Munthali, 2007) which poses a problem of transport and cost of transport (Rainey et al., 2011). In urban areas, mothers' concern about being absent from work (Payne et al., 2013; Rainey et al., 2011), and parents' concern about vaccine adverse effects could explained children incomplete immunization status.

Media access

Access to media was associated to the immunization status in 1988-1999 as well as in 2011-2012. In 1998-1999, children of women who had no access to media were 1.82 times more likely to be incompletely immunized compared to those whose mothers had access to media. In 2011-2012, the odd of being not fully vaccinated decreased slightly. Children of women who had no access to media were 1.06 times more likely to have incomplete immunization than their counterparts whose mothers had access to radio,

television, and/or newspaper. Our findings confirmed those of previous studies which reported that lack of mothers' access to media increased the likelihood of their children to be incompletely vaccinated (Bugvi et al. 2014; Donsa, 2013; Bosch-Capblanch et al. 2012, Wiysonge et al., 2012). Media played an important role in health in general, and especially in children immunization. In Philippines, a communication campaign for Expended Program on Immunization focused on measles, in Metro Manila region, increased not only measles coverage (from 21 to 45 percent) but also all other vaccines coverage (from 20 to 24 percent) within five months (Rasmuson M., 1990). Access to media influenced immunization completion through behavior change (Noar, 2006; Waisbord, and Larson, 2005). Information sprayed through media increases parents awareness about immunization. Therefore, parents care-seeking behavior change; eventually, they get their children vaccinated.

Literacy

Literacy was associated with immunization status in 1998-1999 and in 2011-2012 as well. In 1998-1999, children of women who could not read were 1.95 times more likely to be incompletely immunized compared to those of women who could read. In 2011-2012, children of women who could not read were 1.59 times more likely to have incomplete immunization compared to those of women who could read. Like our study, previous research found that women literacy was associated with a higher likelihood of having a child vaccinated (Edwards, 2010; Maina, et al., 2013). Literacy can be seen as a proxy indicator for education level and consequently carry the identical profit of education in the mother (Edwards, 2010). Education increases women's understanding of

health and consequently augment their use of maternal and children health services (Greenaway, Leon, and Baker, 2012).

Implications/recommendations

Our study showed that birth place, place of residence, access to media, and literacy are the strongest predictors of immunization status in Côte d'Ivoire. Therefore, to address the issue of children incomplete immunization, health officials and particularly the coordinator director of the Expended Program on Immunization, and health districts directors should promote delivery at health facilities, access to media, literacy through education, and focus immunization effort in rural area. To reach these objectives, health minister should work in cooperation with education minister, and communication minister. Moreover, future studies are needed to reexamine immunization predictors in order to redirect efforts to get children vaccinated.

Limitations

The findings of our study should be interpreted in the light of some limitations. First, recall bias cannot be ruled out as possible explanation for the findings of this study. During data collection in this study, mothers provided account about the immunization status of their children when the health card of the child was not available. Thus, we cannot vouch for the rightness of what they say. In addition, wealth index of household was not included the analysis because 1998-1999 data set did not contain this information. The exclusion of wealth index, which has been found associated with immunization status in other studies, could have an impact on immunization predictors

found in our study. In this study, we did not use weighting scheme to correct for the complex sampling methods that were used in DHS.

Conclusion

This study which examined the trend of socio-demographic factors associated with children aged 12 to 59 months using 1998-1999 and 2011-2012 DHS data of Côte d'Ivoire found that incompletely immunized children increased over the time. Looking at the factors associated with immunization status, birth place, place of residence, access to media, and literacy were the strongest predictors of immunization status. Health minister and other health officials should take into account these immunization status predictors, and work in cooperation with education minister, and communication minister in order to address the issue of children incomplete immunization in Côte d'Ivoire. Finally, future studies are needed to reexamine the trend of socio-demographic factors associated with children immunization status in order to redirect efforts to get children vaccinated.

REFERENCES

Acosta-Ramirez, N., Duran-Arenas, L. G., Eslava-Rincon, J. I., & Campuzano-Rincon, J. C. (2005). Determinants of vaccination after the Colombian health system reform. *Rev Saude Publica, 39*(3), 421-9

Antai, D. (2009). Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants. *BMC Infectious Diseases, 9*(181), 1-10. doi:10.1186/1471-2334-9-181

Armstrong, E. P. (2007). Economic benefits and costs associated with target vaccinations. *Supplement to Journal of Managed Care Pharmacy*, *13*(7), 12-15

Bloom, D. E., Canning, D. & Weston, M. (2005). The value of vaccination. *World economics*, *6*(3)
Retrieved from
http://www.who.int/immunization_supply/financing/value_vaccination_bloom_canning_weston.pdf

Bosch-Capblanch, X., Banerjee, K., & Burton, A. (2012). Unvaccinated children in years of increasing coverage: how many and who are they? Evidence from 96 low- and middle-income countries. *Tropical Medicine and International Health, 17*(6), 697-710. doi:10.1111/j.1365-3156.2012.02989.x

Bugvi, A. S., Rahat, R., Zakar, R., Zakar, M. Z., 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), 1-7

Direction de Coordination du Programme Elargi de Vaccination de Côte d'Ivoire (2010). *Revue externe 2010 du Programme Elargi de Vaccination*. Abidjan, 12-14

Direction de Coordination du Programme Elargi de vaccination de Côte d'Ivoire (2011a). *Plan d'action 2011 du Programme Elargi de Vaccination: plan d'urgence*. Abidjan, 82p

Direction de Coordination du Programme Elargi de Vaccination de Côte d'Ivoire (2011b). *Plan Pluriannuel Complet 2011-2015 du Programme Elargi de Vaccination*. Abidjan, 108p

Direction de Coordination du Programme Elargi de vaccination de Côte d'Ivoire (2013). *Plan d'action 2013 du Programme Elargi de Vaccination*. Abidjan, 31p

Donsa, L.D. (2013). *An examination of mothers' socio-demographic factors associated with incomplete vaccination status among under-five populations in Malawi* (master's thesis). Retrieved from http://scholarworks.gsu.edu/iph_theses/

Edwards, A. E. (2010). *Maternal barriers to childhood vaccinations in Tanzania: an examination of the 2004-2005 demographic and health survey* (master's thesis). Retrieved from http://scholarworks.gsu.edu/iph_theses/

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), 1-9

Fernancez, R. C., Awofeso, N., & Rammohan, A. (2011). Determinants of apparent rural-urban differentials in measles vaccination uptake in Indonesia. *Rural and Remote Health, 11*(1702), 1-14

Greenaway, E. S., Leon, J., & Baker, D. P. (2012). Understanding the association between maternal education and use of health services in Ghana: Exploring the role of health knowledge. *J Biosoc Sci., 44(6),* 733–747. doi:10.1017/S0021932012000041

Han, K., Zheng, H., Huang, Z., Qiu, Q., Zeng, H., Chen, B., & Xu, J. (2014). Vaccination coverage and its determinants among migrant children in Guangdong, China. *BMC Public Health, 14*(203), 1-8

Henderson, D. A. (1999). Eradication: Lessons from the Past. *MMWR Supplements, 48*(SU01), 16-22

Hu, Y., Li, Q., Chen, E., Chen, Y., & Qi, X. (2013). Determinants of Childhood Immunization Uptake among Socio-Economically Disadvantaged Migrants in East China. *Int. J. Environ. Res. Public Health*, *10*, 2845-2856. doi:10.3390/ijerph10072845

Institut National de santé publique du Quebec (2007). *Enquête sur la couverture vaccinale des enfants québécois en 2006*. Québéc, 103p

Kitui, J., Lewis, S., & Davey, G. (2013). Factors influencing place of delivery for women in Kenya: an analysis of the Kenya demographic and health survey, 2008/2009. *BMC Pregnancy and Childbirth 13*(40), 1-10

Komlan, Q., Roméo, G., Gaudence, D. J., Léonard, F., Flore, O., and Hugue, T. (2005). Equite d'accès et immunisation au benin: Rapport sur le profil des inégalités d'accès des enfants à la vaccination. 56p

Lim, S. S., Stein, D. B., Charrow, A., & Murray, C. J. L. (2008). Tracking progress towards universal childhood immunisation and the impact of global initiatives: a

systematic analysis of three-dose diphtheria, tetanus, and pertussis immunisation coverage. *Lancet*, *372*, 2031-46

Machingaidze, S., Wiysonge, C. S., & Hussey, G. D. (2013). Strengthening the Expanded Programme on Immunization in Africa: Looking beyond 2015. *PLoS Med, 10*(3), e1001405. doi:10.1371/journal.pmed.1001405

Maina, L. C., Karanja, S., & Kombich, J. (2013). Immunization coverage and its determinants among children aged 12 - 23 months in a peri-urban area of Kenya. *Pan African Medical Journal, 14*(3), 1-7. doi:10.11604/pamj.2013.14.3.2181

Ministère de la Santé et de la Lutte contre le Sida (2012). Plan d'introduction du vaccin contre le pneumocoque dans le PEV de routine en Côte d'Ivoire. Abidjan, 45p

Montagu, D., Yamey, G., Visconti, A., Harding, A., & Yoong, J. (2011). Where do poor women in developing countries give birth? A multi-country analysis of demographic and health survey data. *PLoS ONE 6*(2): e17155. doi:10.1371/journal.pone.0017155

Munthali, A. C. (2007). Determinants of vaccination coverage in Malawi: Evidence from the demographic and health surveys. *Malawi Medical Journal, 19*(2):79 - 82

Nankabirwa, V., Tylleskär, T., Tumwine, J. K., Sommerfelt, H., & Promise-ebf Study Group (2010). Maternal education is associated with vaccination status of infants less than 6 months in Eastern Uganda: a cohort study. *BMC Pediatrics 10*(92), 1-9

Nath, B., Singh, J. V., Awasthi, S., Bhushan, V., Kumar, V., & Singh, S. K. (2007). A study on determinants of immunization coverage among 12-23 months old children in urban slums of Lucknow district, India. *Indian J Med Sci, 61*(11), 598-606

Noar, S. M. (2006). A 10-year retrospective of research in health mass media campaigns: where do we go from here? *Journal of health communication, 11*, 21-42. doi:10.1080/10810730500461059

WHO. Immunization service delivery: Expended Program on Immunization. Retrieved from http://www.who.int/immunization_delivery/en/

Odusanya, O. O., Alufohai, E. F., Meurice, F. P., & Ahonkhai, V. I. (2008). Determinants of vaccination coverage in rural Nigeria. *BMC Public Health, 8* **(**381), 1-8. doi:10.1186/1471-2458-8-381

Owais, A., Hanif, B., Siddiqui, A. R., Agha, A. & Zaidi, A. K. M. (2011). Does improving maternal knowledge of vaccines impact infant immunization rates? A community based randomized-controlled trial in Karachi, Pakistan. *BMC Public Health, 11*(239), 1-8

Partnership for Maternal, Newborn & Child Health (n.d.). *Opportunities for Africa's Newborns.* Retrieved from http://who.int/pmnch/media/publications/oanfullreport.pdf

Payne, S., Townend, 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, 29,* 193–203. doi:10.1093/heapol/czt004

Porta M. (5t ed.) (2008). *A dictionary of epidemiology*. Ney York, Oxford university press.

Rainey, J. J., Watkins, M., Rymana, T. K., Sandhua, P., Boa, A., Banerjee, K. (2011). Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: Findings from a systematic review of the published literature, 1999–2009. *Vaccine, 29*, 8215– 8221

Rasmuson, M. (1990). *Sustaining EPI: What Can Communication Do?* A publication of the HEALTHCOM Project, 17p

Republique de Côte d'Ivoire (2001). *Enquête Démographique et de Santé: Côte d'Ivoire 1998-1999*. Abidjan, 226p

Republique de Côte d'Ivoire (2013). *Enquête Démographique et de Santé et a indicateurs multiples: 2011-2012*. Abidjan, 561p

Roy, S. G. (2010). *Risk factors for childhood immunization incompletion in Ethiopia* (master's thesis). Retrieved from http://scholarworks.gsu.edu/iph_theses/

Smallpox-related virus. (2010). Retrieved from http://health.universityofcalifornia.edu/2010/08/30/smallpox-related-virus/

Stronegger, W. J., & Freidl, W. (2009). A hierarchical analysis of social determinants of measles vaccination coverage in Austrian schoolchildren. *European Journal of Public Health*, 20 (3), 354–359. doi:10.1093/eurpub/ckp188

Sia, D., Kobiané, J-F., Sondo, B. K., & Fournier, P. (2007). Les facteurs individuels et du milieu de vie associés à la vaccination complète des enfants en milieu rural au Burkina Faso: Une approche multiniveau. *Cahiers Santé, 17*(4), 201-206

The Global Alliance for Vaccines and Immunization (2001). *Advocacy for Immunization*. Retrieved from http://www.path.org/vaccineresources/files/GAVI-AdvocacyHandbook.pdf10

The World Bank (2014). *Côte d'Ivoire overview*. Retrieved from http://www.worldbank.org/en/country/cotedivoire/overview

UNICEF (2013). *Côte d'Ivoire: Statistics*. Retrieved from http://www.unicef.org/infobycountry/cotedivoire_statistics.html

UNICEF, UNFPA, & WHO (2012). *Achieving and sustaining maternal and neonatal tetanus elimination: strategic plan 2012-2015*. New York, 22p. Retrieved from http://apps.who.int/immunization_monitoring/diseases/MNTE_resources/en/index1.html

Waisbord, S. & Larson, H. (2005). *Why invest in communication for immunization: Evidence and lessons learned*. Retrieved from http://www.who.int/entity/immunization/hpv/communicate/why_invest_in_communication_for_immunization_unicef_healthcommunicationspartnership_path_usaid.pdf

Waldhoer, T., Haidinger, G., Vutuc, C., Haschke, F., & Plank, R. (1997). The impact of sociodemographic variables on immunization coverage of children. *European Journal of Epidemiology,* 13, 145–149

WHO (1993a). *The immunological basis for immunization series; module 6: Poliomyelitis*. Geneva, WHO press, 24p

WHO (1993b). *The immunological basis for immunization series; module 8: Yellow fever*. Geneva, WHO press, 14p

WHO (2007a). *The immunological basis for immunization series; module 3: Tetanus*. Geneva, WHO press, 51p

WHO (2007b). *The immunological basis for immunization series; module 9: Haemophilus influenzae type b*. Geneva, WHO press, 42p

WHO (2009a). *The immunological basis for immunization series; module 2: Diphtheria*. Geneva, WHO press, 28p

WHO (2009b). *The immunological basis for immunization series; module 7: Measles*. Geneva, WHO press, 51p

WHO (2010). *The immunological basis for immunization series; module 4: Pertussis*. Geneva, WHO press, 50p

WHO (2011a). *The immunological basis for immunization series; module 22: Hepatitis B*. Geneva, WHO press, 29p

WHO (2011b). *The immunological basis for immunization series; module 5: Tuberculosis*. Geneva, WHO press, 29p

WHO (2014). *WHO vaccine-preventable diseases: monitoring system; 2013 global summary; WHO UNICEF estimates time series for Cote d'Ivoire*. Retrieved from http://apps.who.int/immunization_monitoring/globalsummary/estimates?c=CIV

WHO, & UNICEF (2011). Côte d'Ivoire: WHO and UNICEF estimates of immunization coverage; 2011 revision. Retrieved from http://www.who.int/immunization_monitoring/data/civ.pdf

WHO, UNICEF, & World Bank (2009). *State of the world's vaccines and immunization (3rd ed.)*. WHO press, Geneva, 169p. Retrieved from http://www.who.int/immunization/sowvi/en/

Wiysonge, C. S., Uthman, O. A., Ndumbe, P. M., & Hussey, G. D. (2012). Individual and contextual factors associated with low childhood immunization coverage in Sub-Saharan Africa: A multilevel analysis. *PLoS ONE, 7*(5), e37905

Zhou, F., Santoli, J., Messonnier, M. L., Yusuf, H. R., Shefer, A., Chu, S. Y., Rodewald, L., & Harpaz, R. (2005). Economic Evaluation of the 7-Vaccine Routine Childhood Immunization Schedule in the United States, 2001. *Arch Pediatr Adolesc Med., 159,* 1136-1144

APPENDIX

Appendix A: Immunization predictors, reasons of incomplete immunization, and proposed solution