UPPSALA UNIVERSITET

Prevalence of Diarrhea and Associated Risk Factors in Children Under Five Years of Age in Northern Nigeria: A Secondary Data Analysis of Nigeria Demographic and Health Survey 2013.

Degree Project in International Health

Department of International Maternal and Child Health, IMCH

Hanaa Hussein

May 2017

Supervisors: Andreas Mårtensson, Carina Källestål

Word count: 10,757

Abstract

Background

Diarrhea is the second leading cause of under five child mortality worldwide after pneumonia. Daily, Nigeria loses about 2,300 under-fives ranking the country as the second largest contributor to the under five mortality rate from diarrhea. The absence of clean water, essential sanitation and hygiene is responsible for almost 88% of the disease burden in the country.

Aim

This study aimed to identify the risk factors for the occurrence of childhood diarrhea among children aged between 0-5 years in northern Nigeria regions.

Method

Demographic and health survey (DHS) data of Nigeria 2013 was used for this study. Data was analyzed from the three northern Nigeria regions: Western, Eastern, and Central. The study population was under five children who were residents in the households during the survey. Bivariate and multivariate logistic regression was computed to assess independent factors of childhood diarrhea.

Results

The prevalence of diarrhea in a two weeks period among under five children in the northern regions was 12.7 %. The results of this study showed that maternal education, religion, age, working status, unprotected water source, main floor material, DPT3 and polio3 vaccination were found to be positively associated risk factors for childhood diarrhea after adjusting for other variables.

Conclusion

The results of this study have critical policy implications for health intervention programs and emphasize that promoting women education levels and the delivery of improved sanitation and hygiene through efficient educational programs may have a significant importance on the child health and survival in Nigeria.

Acknowledgments

I would like to thank my professors Carina Källestål and Andreas Mårtensson for all the help and supervision they have provided during the course to finish the thesis.

Also, I would like to thank my parents and my family for their support and encouragement throughout the last two years of my masters program.

Finally, special thanks to my husband Mohammed for his support through the hard times to make this achievable.

Table of Contents

Abbreviations

WHO	World Health Organization
U5MR	Under Five Mortality Rate
MDG4	Millennium Development Goal 4
SDG	Sustainable Development Goal
WASH	Water, Sanitation and Hygiene
LGA	Local Government Tiers
GAPPD	Global Action Plan for the Prevention and Control of Pneumonia and Diarrhea
NDHS	Nigeria Demographic and Health Survey
EAs	Enumeration Areas
PSU	Primary Sampling Unit
DPT	Diphtheria, Pertussis, Tetanus
COR	Crude Odds Ratios
AOR	Adjusted Odds Ratios
CI	Confidence Intervals
VIF	Variance Inflation Factor
NA	Not Applicable
CFR	Code of Federal Regulations
LIC	Low Income Countries

List of Tables

Figures

1. Introduction

1.1 Background Information

The world health organization (WHO) defines diarrhea as the passage of three or more loose or liquid stools per day in a period not exceeding 14 days (1). Diarrhea is commonly a sign of an infection in the intestinal tract that is caused by different bacteria, virus and parasitic entities (1). In low resource areas, Rotavirus and Escherichia coli bacteria cause the highest incidents of diarrhea (2). These microorganisms spread throughout unclean water and contaminated food or from one person to another, and are most widespread in settings with poor hygiene and absence of access to clean drinking water and sanitation (2). Diarrhea continues to be one of the leading causes of child mortality, mostly in children less than 5 years of age living in low and middle-income countries (3).

Globally, there has been an increased progress in reducing the under-5 mortality rate (U5MR). Sub-Saharan Africa, the region with the highest under 5 mortality rate in the world has shown an essential improvement (4). Reduction of U5M rate increased from 1.6 % in 1990s to 4.1 % in 2000–2015, this significant decline has prevented the death of 48 million children under age of 5 (4). Regardless of these improvements, progress was not enough to reach the millennium development goal 4 (MDG 4) to reduce by two-thirds the under 5 mortality rate in many regions (5). By January 2016, sustainable development goals (SDG) took effect succeeding MDGs that ended by 2015 and only 47 countries of which 34 are in Sub-Saharan Africa will not meet the intended Sustainable development goal target of 25 deaths per 1000 live births by 2030 if they maintain their present trends in decreasing under-5 mortality (5). More than half of under-5 child deaths are due to diseases that are avoidable and curable through simple, reasonable interventions (5).

In 2015, 5.9 million children globally died before reaching their fifth birthday where diarrhea was responsible for 9 % of these deaths (6). An estimated 1.7 million cases of diarrheal diseases arise each year killing around 760,000 children under the age of 5 (1,6). The majority of deaths take place in children less than 2 years of age living in

South Asia and sub- Saharan Africa (7). In 2013, 6.3 million children under 5 died in which 2.9 million of them in the WHO African Region, about 473000 from diarrhea (8).

1.2 Sanitation, Hygiene and Diarrhea

Diarrhea is more prevalent in low and middle-income settings as a result of the absence of safe drinking water, sanitation and hygiene, and mostly a worse health and nutritional status (9). An estimated 2.5 billion individuals need enhanced sanitation facilities, and almost one billion people lack access to safe drinking water (9). These unhygienic settings allow diarrhea-causing pathogens to multiply and spread more quickly (9).

Rural access to safe drinking water sources is decreasing, and individuals using an improved source still need to travel for long distances to get water (10). A high number of children in urban regions are being raised in overloaded unsanitary houses and districts, although urban areas are home to the majority of modern-day health services, several urban children are deprived of even basic facilities (10). These areas are regularly at high risk for disasters and in the absence of adequate access to safe drinking water or sufficient water sources for basic hygiene, children's health will suffer (10).

Thus, improved water, sanitation and hygiene play an essential role in preventing deaths in children under 5. Looking deeper within the subject of water, sanitation and hygiene will show why despite all the socioeconomic progress and implementation of child survival interventions, diarrhea remains a main killer though it is preventable (11).

Since 1990, 2.1 billion people obtained access to an "Improved" type of sanitation, such as flush toilets or latrines (12). This indicates that in 2015, 68 percent of the universal population had access to such toilets marking it as a notable success but still distant from the 2015 Millennium Development Goal target which has been missed by almost 700 million people (12). In the SDG era, 2.4 billion people still do not have an improved sanitation facility, of which 950 million still practice public defecation (12).

It has been anticipated that in 2012 a total of 842,000 diarrheal deaths resulted from poor water, sanitation and hygiene (WASH) (46% from contaminated water, 26% from

sanitation and 28% from hand hygiene) (13). This is around half of diarrheal diseases, or an estimated 1.5% of the total disease burden (14). Based on what is known about disease transmission routes and probable barriers, the latest assessment implies that adequate WASH can avoid the deaths of 361,000 children under the age of five, or 5.5% of mortalities in that age group (14). A different estimate, which involves WASH in addition to other interventions, for example oral rehydration management and exclusive breastfeeding, indicates that 95% of diarrheal mortalities in children under the age of five can be avoided by 2025 by directed scale-up of such confirmed interventions (15).

Just four low/middle income countries in eastern and southern Asia reached the MDG target 7.C to halve the proportion of the population without sustainable access to safe drinking water and basic sanitation by 2015 (12). In the African region, which displays the lowest declines in mortality rates and the most noticeable reduction in improvement trends have been less significant where coverage remains under 40 percent (16).

There are several indirect risk factors that are associated with child diarrhea and can be classified into socioeconomic, environmental and behavioral risk factors at household level and have been acknowledged by different researchers. They include: mother age, residence, education level, number of children less than five years in the household, access to toilet facilities and drinking water, wealth, work status and many others (11,17,18,19,20,21). These risk factors intertwine between each other and can vary due to different reasons.

A study by Mihrete et al. found that the work status of the mother and the number of under five children in the household were risk factors for child diarrhea (11). Children of working mothers had higher odds to get diarrhea as compared to children of non-working mothers also odds of diarrhea decreased when the number of under five children in the household was two or less. Gebru et al. stated that children of non-educated mothers had higher odds of getting diarrhea as compared to children whose mothers were literate (17). Moreover, children whose families practiced improper refuse disposal were more likely to get diarrhea compared to children whose families practiced proper refuse disposal.

In his study "Household Wealth, Residential Status and the Incidence of Diarrhea among Children under five in Ghana", Kyereme indicated that household wealth is an important indicator of child mortality from diarrhea since children living in poor conditions have more risk of exposure to infectious agents due to the poor sanitation and hygiene if compared to children living in middle and rich households (18). He also stated that children living in rural communities had higher odds of getting diarrhea as compared to children living in urban communities.

Mengistie et al. found a positive association between the type of drinking water source and diarrhea where children in families that had an unprotected water source had increased odds of having diarrhea as compared to children in families that had a protected water source (19). Amgusi et al. reported increased diarrhea episodes among children who received polio 3 vaccinations compared to children who were not vaccinated (20). However, children who did not get DPT 3 vaccines had increased odds to experience diarrhea compared to children who got a full vaccine (20). Moreover, Gascon et al. argues that increasing the time taken to reach the water source is associated with a lower risk of diarrhea; the risk of diarrhea being much less if the water source is more than 10 minutes away from house compared to being less than 1 minute away (21). Furthermore, having a covered latrine in the household was associated with a lower risk of children getting diarrhea as compared to children living in households with a simple latrine.

1.3 Health Systems in Nigeria

The Nigerian health care system is poorly established and has experienced numerous backdrops, particularly at the local government levels (22). Due to the absence of sufficient and practical surveillance systems there is no tracking system to supervise the outbreak of communicable diseases (22). The delivery of health care in Nigeria is the responsibility of the three tiers of government: federal, state, and local government (23). The primary health care system is ran by the 774 local government tiers (LGA) with help from their own state ministries of health as well as private medical specialists (23). The ministry of health at the state level directs the secondary health care system, patients at

this level are sent from the primary health care (23). The tertiary health care is delivered by teaching clinics and specialist hospitals.

Health facilities are insufficient in Nigeria; this involves health centers, staff and medical tools. This insufficiency is much more severe in rural areas, there is an average of one doctor to 30,000 individuals and 2 hospital beds to 1,000 individuals (24). 70% of health services are delivered by private funds and 30% by public funds (24). Poverty continues to be very prominent in Nigeria especially in the rural regions because of the absence of employment and poor growth of human capital (24). This makes it hard for the public to pay for their health necessities which led to reduced utilization and availability of healthcare services in several areas of the country (24).

1.4 Rationale of the Study

Since the year 2000, four countries Democratic Republic of Congo, India, Nigeria and Pakistan have consistently encountered the highest number of diarrhea deaths globally (14). However, Nigeria's efforts toward decreasing preventable child deaths have been met with steady and constant progress toward MDG4 (25). The under-five mortality rate (U5MR) has decreased from 191 deaths per 1000 live births in 2000 to 89 deaths per 1000 live births in 2014 as the end-point status of U5MR. Nigeria was close to achieve the 2015 target of 64 deaths per 1000 live births by 28%, yet deaths from diarrheal diseases are still the highest despite all the progress made (25).

Each day, Nigeria loses about 2,300 under-fives which reflects the country's rank as the second largest contributor to the U5MR from diarrhea in the global ranking and its low Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhea (GAPPD) intervention score of 31% (26). A country's "GAPPD score" measures the usage of interventions that protect against, prevent and treat pneumonia and diarrhea. The higher the score, the more interventions are being used (26). Absence of clean water, essential sanitation and hygiene is responsible for almost 88% of the disease burden due to diarrhea (26). Although diarrheal mortality continues to be improperly high, it is steadily decreasing by 4% per year, while disease rate is decreasing more modestly (14). Interventions that focus on the major causes and on the most vulnerable children must further increase these declines (7). To direct these attempts, strong data describing the

burden, risk factors and case mortality of extremely life-threatening and disabling episodes are crucial, however such data have been inadequate in regions with the highest child mortality; Nigeria in specific. Therefore, this study sought to address these knowledge gaps through assessing the prevalence of child diarrhea in northern Nigeria regions and the associated behavioral, environmental and socioeconomic risk factors among children under the age of five.

1.4.1 Research question

What are the diarrheal diseases risk factors leading to children under five years of age mortality in northern Nigeria regions?

1.4.2 Aim

To identify the risk factors for the occurrence of childhood diarrhea among children aged 0-5 year in northern Nigeria.

1.4.3 Specific Objectives

1. To assess the prevalence of childhood diarrhea in northern Nigeria regions
2. To determine the behavioral, environmental and socioeconomic risk factors for the occurrence of diarrhea among children aged under 5 years in northern Nigeria.

1.4.4 Inclusion Criteria

Children under five years of age who were residents in the household during the time of the survey.

1.5 Conceptual framework

In Figure 1, some of the socioeconomic, behavioral and environmental risk factors that might lead to the occurrence of diarrhea episodes among children under 5 years are represented. The figure shows interaction of diverse factors that include level of education, mother working status, residence, wealth and other risk factors with each other leading to the occurrence of diarrhea which in severe cases leads to under 5 child mortality. This shows that several factors are interlinked to cause illness and that one factor alone might not lead to a diarrheal episode but a combination of factors can.

Conceptual framework

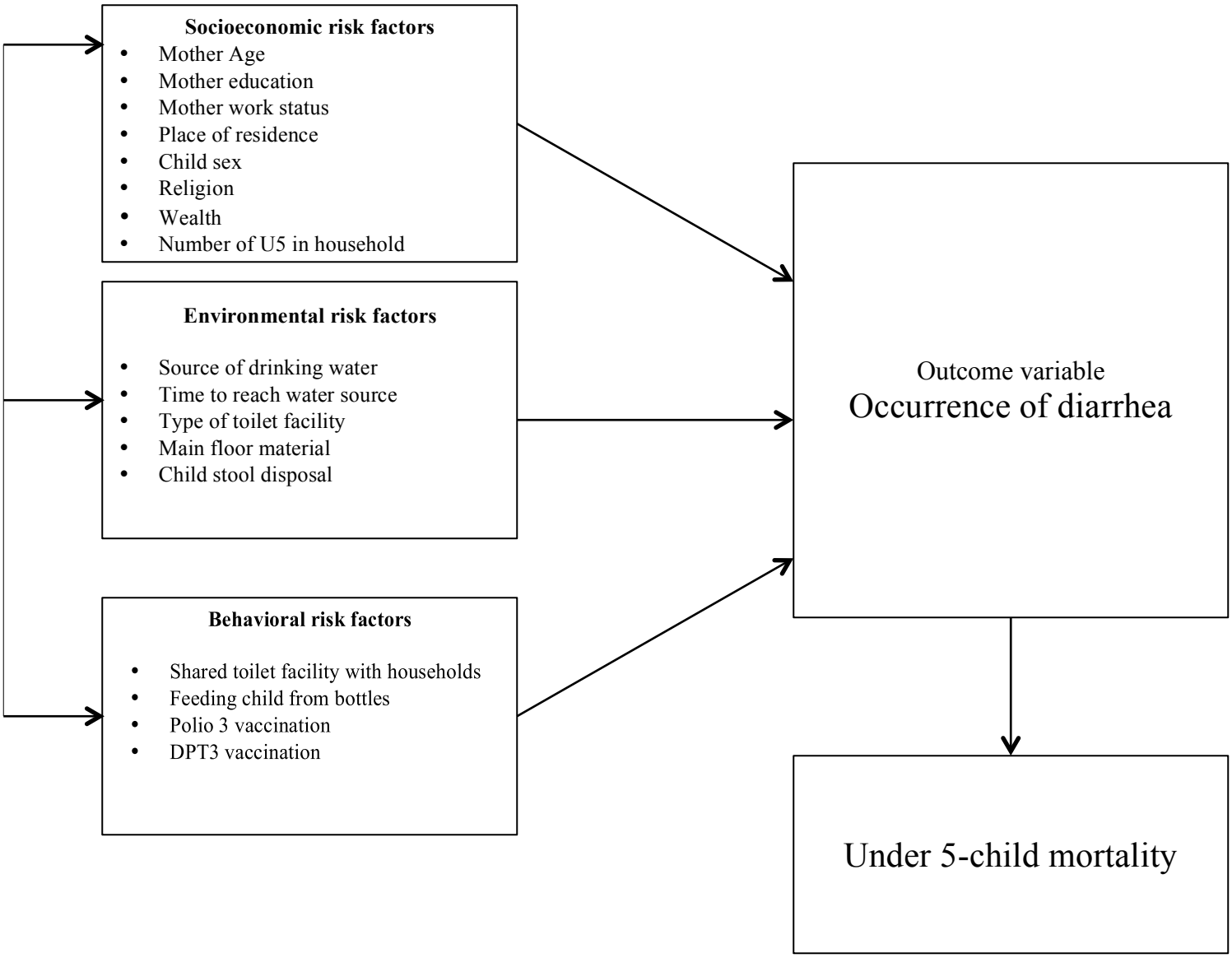

Figure 1. Conceptual framework: Interacting Interlinked Risk Factors Leading to the Occurrence of Diarrhea among Children Under 5

2. Methods

2.1 Study Design

The design used in this study is a secondary analysis of data from Nigeria Demographic and Health Survey (NDHS) 2013, which is a nationally representative, cross sectional descriptive survey that covered the entire population residing in non-institutional dwelling units in the country.

2.2 Study Setting

This Demographic and Health Survey was implemented in Nigeria which is located on the west coast of Africa. It occupies around 923,768 square kilometers of land extending from the Gulf of Guinea on the Atlantic coast in the south to the borders of the Sahara Desert in the north. The republics of Niger and Chad in the north, the Republic of Cameroon on the east, and the Republic of Benin on the west define the land borders (27). Nigeria landscape is characterized by two principal landforms: lowlands and highlands. The highlands stretch from 600 to 1,300 meters in the North Central and the east highlands, with lowlands of less than 20 meters in the coastal areas (27). Nigeria is the most populated country in Africa and the 14th largest in land area. The country's 2006 Population and Housing Census placed the country's population at 140,431,790. Currently, Nigeria is made up of 36 states and a Federal Capital Territory, grouped into six geopolitical zones: North Central, North East, North West, South East, South South, and South West (27). Most of the heavily inhabited states are located in the southern part of the country. Kano, with an average density of 442 people per square kilometer, is the most densely populated state in the north.

Three zones were specifically selected for the purpose of this study: North Central, North East and North West since extensive regional differences exist in child health indicators with the North-East and North-West geopolitical zones of the country having the worst child survival records. The northern regions are areas of conflicts, emerging epidemics and suffer from devastated health services (28).

2.3 Study Population

The study is focused on children under five years of age whom had diarrhea in the last two weeks prior to the Nigeria Demographic and Health Survey (NDHS), which was conducted from the 15th of February to the end of May 2013. The sample size includes a total of 20,493 children under five years of age who are residents in the households during the time of the survey and were involved in the analysis.

2.4 Sampling

The NDHS did not mention exactly how the sample size was reached but indicated, "The sample for the 2013 NDHS was nationally representative and covered the entire population residing in non-institutional dwelling units in the country".

2.4.1 Sampling Design and Implementation

The survey used as a sampling frame the list of enumeration areas (EAs) prepared for the 2006 Population Census of the Federal Republic of Nigeria, provided by the National Population Commission. Administratively, Nigeria is divided into states and each state is subdivided into local government areas (LGAs), and each LGA is divided into localities. In addition to these administrative units, during the 2006 population census, each locality was subdivided into census enumeration areas (27).

The primary sampling unit (PSU), referred to as a cluster in the 2013 NDHS, is defined on the basis of EAs from the 2006 EA census frame. The 2013 NDHS sample was selected using a stratified three-stage cluster design consisting of 904 clusters, 372 in urban areas and 532 in rural areas. A representative sample of 40,680 households was selected for the survey, with a minimum target of 943 completed interviews per state (27). A complete listing of households and a mapping exercise were carried out for each cluster from December 2012 to January 2013, with the resulting lists of households serving as the sampling frame for the selection of households. All regular households were listed (27). A fixed sample of 45 households was selected per cluster. All women age 15-49 who were either permanent residents of the households in the 2013 NDHS

sample or visitors present in the households on the night before the survey were eligible to be interviewed (27).

2.4.2 Data collection

All aspects of the NDHS data collection procedures were pretested in November 2012. Twenty members of the technical team, who also served as trainers/quality assurance personnel, participated in the training of trainers and reviewed the questionnaires thoroughly before finally conducting the pretest fieldwork as interviewers. The training of trainers consisted of an overview of the project and the objectives of the survey; detailed descriptions of interviewing techniques, field procedures, all sections of the household and individual questionnaires; and two days of field practice (27). The Household Woman's Questionnaire was pretested in four locations in Makurdi (Benue), where the residents are predominantly Hausa, Yoruba, English, and Igbo speaking. The teams were divided according to languages. The supervisors and editors were drawn from among the trainees (27).

The questionnaires were pretested in 120 households. A debriefing session was held in November 2012 at the end of the pretest fieldwork. Based on observations from the field and suggestions made by the 9-pretest teams, revisions were made in the wording and translations of the questionnaires. The 2013 NDHS was carried out by 37 interviewing teams, one for each of the 36 states of the country and Federal Capital Territory. Each team consisted of a supervisor, a field editor, four female interviewers, two male interviewers, and two drivers. Fieldwork was conducted from February 15, 2013 to the end of May (27).

2.5 Methods and Variables

2.5.1 Outcome Variable

The primary outcome variable was the reported occurrence of diarrhea. If the child had diarrhea in the last two weeks including the last 24 hours prior to data collection time.

2.5.2 Predictor Variables

The 17 independent variables included in the study were identified from a literature review conducted earlier (29) and associated with occurrence of diarrheal episodes among children under five years of age. They included: respondents age group, respondents work status, respondents education level, respondents religion, type of residence, household wealth, sex of the child, number of children under five in the household, major source of drinking water, time to reach water source, type of toilet facility, main material of the floor, if toilet facility is shared with other households, usage of bottle with a nipple for drinking, child stool disposal, polio 3 vaccination and DPT3 vaccination. The respondents were mothers of children aged 5 and less in the reproductive age between 15-49 years whom were surveyed using the woman's questionnaire.

Age group: The current age of the respondent in completed years was calculated using the century month code of the date of birth of the respondent and the century month code of the date of interview.

Work status: The respondent was asked whether she is currently working or not.

Education level: This was the highest level of education that was attained by the household member. It was reported in four categories namely: no education, primary, secondary and higher.

Religion: The respondent was asked about her religion.

Type of residence: This was reported in terms of urban or rural.

Household wealth: The wealth index was a merged measure of household's cumulative living standard and was calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities. This process placed the interviewed households in five wealth quintiles that included poorest, poorer middle, richer and richest.

Sex of the child: The respondent was asked about the sex of the under 5 child in the household.

Number of children under 5 in the household: The respondent was asked about the

number of children resident in the household and aged under five. Visiting children were not included.

Major source of drinking water: It was categorized to either improved source which included piped, public tap, tube well or bore hole, protected well, protected spring, rain water and bottled water or unimproved source which included unprotected well, unprotected spring, tanker truck, surface water, sachet water and others.

Time to reach water source: The respondent was asked how long does it take to go get water and come back. It was reported in minutes.

Type of toilet facility: It was categorized as either improved and included flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to ventilated latrine, pit latrine with slab and compositing toilet or unimproved and included flush to somewhere, flush to don't know where, flush to latrine without slab, bush/field, bucket toilet and hanging toilet.

Main material of the floor: It was categorized into natural floor that included earth/sand and dung, rudimentary floor that included wood planks and palm/bamboo, finished floor that included parquet or polished wood, vinyl or asphalt strips, ceramic tiles, cement, carpet/rug and others.

Toilet facility shared with other households: The respondent was asked if she shared the toilet facility with other households. It was reported with either yes or no.

Child drank from a bottle with nipple: The respondent was asked if her child used a bottle with nipple to drink anything. This was reported as yes or no.

Child stool disposal: The respondent was asked what was done to dispose of stools the last time her child passed stools. This was reported as either proper and included child used toilet, rinsed into toilet, and rinsed into drain or improper and included thrown into garbage, left in the open, buried and rinsed into river/river banks.

Polio 3 vaccination: The respondent was asked how many times was the polio vaccine given to her child.

DPT3 vaccination*:* The respondent was asked how many times was the DPT vaccine given to her child.

2.6 Statistical analysis

2.6.1 Data Cleaning and Variable Management

The Child Recode dataset was imported to R Commander and was saved in STATA file format. The dataset was cleaned by removing all the inapplicable variables, and 18 applicable variables were selected and included in the study. R commander was used to recode all the relevant variables.

2.6.2 Statistical methods

Data was analyzed using R commander statistical software Version 3.3.2 with R Commander (Rcmdr) statistical package Version 3.3.2. Descriptive statistics were used to summarize the study variables and logistic regression was used to study the effect of the different 17 predictor variables on the outcome variable. Significant variables at p-value <0.05 in the bivariate analysis were only used in the multivariate analysis.

Descriptive statistics were used to describe and summarize the participant's and household characteristics and this was presented in tables 1, 2 and 3. Pearson's Chi Squared test and two-way contingency tables were used to assess for statistical significance and the distribution frequencies of the outcome variable in relation to the predictor variables respectively.

Logistic regression analysis was performed to determine the association between the outcome variable and the predictor variables. In the beginning, bivariate analysis was done in order to assess the association of each predictor variable with the outcome variable. Crude Odds Ratios (CORs) were obtained from this analysis and the significance level was set at 95% confidence Interval.

Multivariable analysis was done using all the significant variables obtained from the bivariate analysis. This produced the Adjusted Odds Ratios (AORs) at 95% confidence interval and presented in table 8. The significant variables were used in three different models where each model represented a region of the three northern regions: north east,

north west and north central. Multicollinearity of variables was investigated by calculating variance inflation factor (VIF) but none observed.

2.6.3 Missing values

The outcome variable had 1810 Not Applicable (NA's). For the predictor variables, respondent's religion had 120 NA's, respondent's work status had 90 NA's, household drinking water source had 42 NA's, household time needed to reach water source had 91 NA's, child stool disposal had 1306 NA's, usage of bottle had 1092 NA's, floor material had 100 NA's, type of toilet facility had 27 NA's, shared toilet facility had 5911 NA's, polio vaccination had 2328 NA's and DPT vaccination had 1850 NA's. These NAs were not removed manually since R Commander does not include them during data analysis. The "don't know" response and missing response were recoded to NA for both the outcome and predictor variables.

2.6.4 Bias

The DHS uses accurate sample selection protocols to reduce selection bias. The team responsible of implementing the household listings and selection was different from the team in charge of conducting the interviews with the respondents in the selected households.

3. Ethical considerations

The Institutional Review Board of ICF International complied with the United States Department of Health and Human Services requirements for the "Protection of Human Subjects" (45 CFR 46) reviewed and approved the Nigeria 2013 Demographic and Health Survey. Before conducting the interviews, an informed consent statement, which provided details about the purpose, duration and interview procedures as well as the potential benefits and risks to the respondents, was read to the participants. Verbal consent was obtained from the participants and those who did not give a verbal consent were excluded from the study.

4.Results

4.1 Flow of participants

The flow of the participants is summarized in the flow chart below (Figure 2). The NDHS, 2013 child recode file with a total of 30,472 under five children included in the survey was used. This total represented the six regions of in the country: north west, north central, north east, south west, south east and south south. In this study only the northern regions were included thus a total of 9,936 observations were excluded that represented the southern regions.

A total of 43 children under five in the northern region who are not residents of the households were excluded. The final sample included in the study was a total of 20,493 under five children who were residents in the surveyed households during the NDHS, 2013. They were from north west, north east and north central regions. In this study, diarrhea was defined as the passage of three or more loose stools over 24 hours period or more frequently than normal for a child.

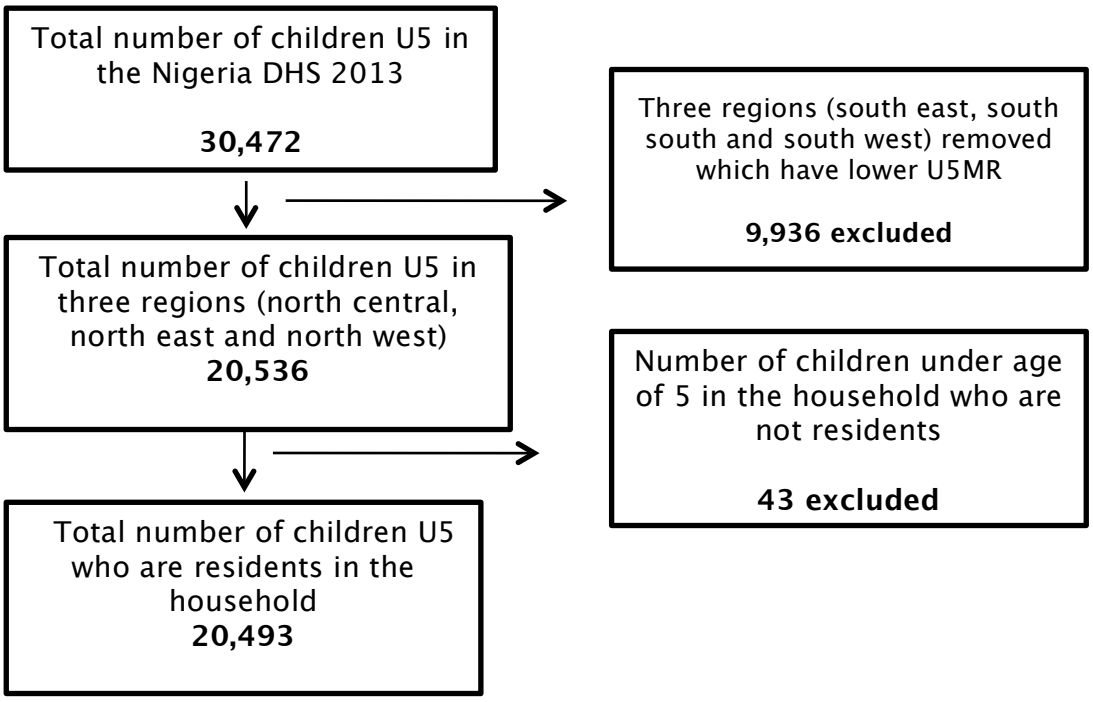

Figure 2. Flow of the Participants included in the Study from Nigeria DHS 2013

4.2 Characteristics of the study participants

In the Northeast region, the majority of the mothers had no education (67.7%) followed by primary (16.3%) and the smallest group was those with higher education level (2.5%). Working mothers (46%) were less than the non-working ones (53.9%). Almost half (46.9%) of the respondents were in the age group of 25-34 years and the least were in the age group of 35-49 (24.3%). Islam was the most common (82.2%) among the religions and the least common was the traditionalists (0.7%). The others were Christians (14.4%) and Catholics (2.5%). Similarly, in the Northwest region, the majority of the mothers had no education (79.4%) followed by primary (11.6%) and the smallest group was those with higher education level (0.9%). Working mothers (63.6%) were more than the non-working ones (36.3%). Almost half (46.8%) of the respondents were in the age group of 25-34 years and the least were in the age group of 35-49 (25.7%). Islam was the most common (95.5%) among the religions and the least common was the traditionalists (0.8%). The others were Christians (2.3%) and Catholics (1.2%). However, in the north central regions, only 36% of the mothers had no education followed by secondary (28.2%) and the smallest group was those with higher education (9.2%). 75.8% of the mothers were working and 24.2% not working. More than half of the mothers (53.1%) were in the age group of 25-34. Islam was the major religion (49.9%) followed by other Christians (34.5%) and the least were the traditionalists (1.6%) (Table 1).

Table 1. Frequency and Percentage Distribution of the Mother's Characteristics in Northern Nigeria Regions, 2013

Characteristics	North East N= 6359 (%)	North West N= 9685 (%)	North Central N= 4449 (%)
Education			
No education	4311 (67.79)	7695 (79.45)	1604 (36.05)
Primary	1037 (16.31)	1127 (11.64)	1178 (26.48)
Secondary	847 (13.32)	772 (7.97)	1256 (28.23)
Higher	164 (2.58)	91 (0.94)	411 (9.24)
Work status			
Working	2916 (46.07)	6140 (63.69)	3360 (75.8)
Not Working	3414 (53.93)	3500 (36.31)	1073 (24.2)
Age			

15-24	1826 (28.72)	2648 (27.34)	1046 (23.51)
25-34	2987 (46.97)	4541 (46.89)	2366 (53.18)
35-49	1546 (24.31)	2496 (25.77)	1037 (23.31)
Religion			
Islam	5210 (82.29)	9208 (95.53)	2193 (49.94)
Catholic	160 (2.53)	122 (1.27)	606 (13.80)
Traditionalist	46 (0.73)	80 (0.83)	73 (1.66)
Other Christian	915 (14.45)	229 (2.38)	1519 (34.59)

4.3 Characteristics of the households

In the northeast region, 79.1% of the households were living in rural areas. There was uneven distribution of wealth among households, 69.2 % of the households were in the poorest and poorer quintiles, 15.7 % in the middle quintile and 14.9% in the richer and richest quintiles. 58.2% of the households had two under five children or less while 41.7% of the households had three under five children and above. Males (51.9%) and females (48%) children under five in the households were almost equal. Likewise, in the northwest region, 80.1% of the households were living in rural areas. The majority of households (71.5%) were in the poorest and poorer quintiles, 14.2% in the middle quintile and the smallest group were in the richer and richest quintile (14.2%). 58.4% of the households had two under five children or less while 41.5% of the households had three under five children and above. Males (50%) and females (49.9%) children under five in the households were almost equal. However, in the north central region 29.7% of the households were living in urban areas. The majority of households were in the richer and richest quintiles (37.6%), 31.4% in the middle quintile and smallest group were in the poorest and poorer quintiles (30.9%). 74.5% of households had 2 children under or less while only 25.4% had three under five children and above. Males (50.1%) and females (49.8%) children under five in the households were almost equal (Table 2).

Table 2. Frequency and Percentage Distribution of the Household Characteristics in Northern Nigeria Regions, 2013

Characteristics	North East N= 6359 (%)	North West N= 9685 (%)	North Central N= 4449 (%)
Residence			
Urban	1329 (20.9)	1926 (19.89)	1324 (29.76)
Rural	5030 (79.1)	7759 (80.11)	3125 (70.24)
Wealth Status			
Poorest	2412 (37.93)	3805 (39.29)	420 (9.44)
Poorer	1993 (31.34)	3121 (32.23)	955 (21.47)
Middle	1004 (15.79)	1380 (14.25)	1398 (31.42)
Richer	609 (9.58)	925 (9.55)	923 (20.75)
Richest	341 (5.36)	454 (4.69)	753 (16.93)
Number of U5 in household			
2 or less	3704 (58.25)	5659 (58.43)	3315 (74.51)
3 or more	2655 (41.75)	4026 (41.57)	1134 (25.49)
Child sex			
Male	3306 (51.99)	4848 (50.06)	2231 (50.15)
Female	3053 (48.01)	4837 (49.94)	2218 (49.85)

4.3.1 Environmental conditions

In the Northeast, 43.6% of the households drank water from a protected water source and more than half (56.3%) drank from an unprotected source. Only 13.9% of the households had access to drinking water on premises. However, 54.5% needed less than 30 minutes to reach the water source while 31.5% needed more than 30 minutes to reach there.

The majority of households used an unimproved toilet facility (54.5%) while 45.4% used an improved one. Yet, 69.9% of child stool disposal was properly disposed and 30% was improperly disposed. Natural floor (57.4%) was the main material of the floor used in households followed by finished floor (42.4%) and wood/palm and bamboo planks (0.1%) were the least used. However, in the Northwest, more than half of the households (54.7%) drank water from a protected water source and 45.2% drank from an unprotected source. 28.1% of the households had access to drinking water on premises. Yet, 47.2% needed less than 30 minutes to reach the water source while 24.5% needed more than 30 minutes to reach there. 47.1% of the households used an unimproved toilet facility while more than half (52.8%) used an improved one. Only 19.2% of child stool disposal was improperly disposed and 80.7% was properly disposed. Natural floor (63%) was the main material of the floor used in households followed by finished floor (36.7%) and wood/palm and bamboo planks (0.2%) were the least used. In the north central region, more than half of the households (57.9%) drank water from a protected water source and 42% drank from an unprotected source. 17.4% of the households had access to drinking water on premises. Yet, more than half (55.6%) needed less than 30 minutes to reach the water source while 26.9% needed more than 30 minutes to reach there. The majority of households (60.3%) used an unimproved toilet facility while 39.6% used an improved one. 62% of child stool disposal was improperly disposed and 38% was properly disposed. Finished floor (64.7%) was the main material of the floor used in households followed by natural floor (35.6%) (Table 3).

4.3.2 Behavioral conditions

In the northeast and northwest region, the majority of households did not share toilets with other households (86.8% and 83% respectively) while less than 17% shared their toilets. Feeding children from a bottle was uncommon among the households (94.3% and 93.3%) and less than 7% used bottles to feed the child. The majority of U5 children in the households did not get a full DPT vaccination. Also, 64.3% did not get full polio vaccination in the northeast and 42.2% in the northwest. However, in the north central region 45.7% of the households shared toilets with other households and 54.2% did not share their toilets. 88.8% of households did not feed use bottles to feed their children and

11.1% used bottles. More than half of U5 children in the households did not get a full DPT vaccination (54%). Also, 56.2% did not get full polio vaccination.

Table 3. Frequency Distribution of Environmental and Behavioral Conditions of Households, Northern Nigeria Regions, 2013.

Characteristics	North East N= 6359 (%)	North West N= 9685 (%)	North Central N= 4449 (%)
Source of drinking water			
Protected	2769 (43.63)	5288 (54.75)	2572 (57.95)
Unprotected	3577 (56.37)	4371 (45.25)	1866 (42.05)
Time to reach water source			
On premises	870 (13.96)	2702 (28.17)	772 (17.45)
Less than 30 min	3397 (54.51)	4534 (47.26)	2461 (55.63)
More than 30 min	1965 (31.53)	2357 (24.57)	1191 (26.92)
Type of toilet facility			
Unimproved	3467 (54.56)	4557 (47.15)	2681 (60.31)
Improved	2887 (45.44)	5107 (52.85)	1764 (39.69)
Child stool disposal			
Improper	1792 (30.07)	1728 (19.27)	2625 (62)
Proper	4167 (69.93)	7238 (80.73)	1609 (38)
Main Floor material			
Natural floor	3636 (57.48)	6070 (63.04)	1564 (35.62)
Finished floor	2683 (42.41)	3535 (36.71)	2871 (64.72)
Wood/ Palm/bamboo planks	7 (0.11)	24 (0.25)	1 (0.02)
If toilet shared with other Households			
No	4031 (86.84)	6603 (83.05)	1079 (54.25)
Yes	611 (13.16)	1348 (16.95)	910 (45.75)
Bottle feeding			
No	5663 (94.38)	8430 (93.32)	3756 (88.86)
Yes	337 (5.62)	603 (6.68)	471 (11.14)
DPT3 vaccination			
No	4472 (77.63)	7607 (87.77)	2244 (54.06)
Yes	1289 (22.37)	1060 (12.23)	1907 (45.94)
Polio3 vaccination			
No	3677 (64.36)	3495 (42.24)	2336 (56.26)
Yes	2036 (35.64)	4780 (57.76)	1816 (43.74)

4.4 Prevalence of diarrhea

The overall prevalence of diarrhea was 12.7% in the three northern regions in a two weeks period. The northeastern region being the most prevalent (6.8%) followed by the northwestern region (4.3%) and the least prevalent was the north central (1.6%). Diarrhea was prevalent in the rural areas (9.9%) and among the poorest households in particular (4.4%). Diarrhea was prevalent among non-educated mothers (8.5%) and working mothers (7.7%). The prevalence of diarrhea was the highest among mothers aged between 25-34 years (5.9%) and children to Muslim mothers (10.7%). Concerning diarrhea prevalence among households, diarrhea was higher among households using unprotected source of drinking water (6.6%) and households that needed less than 30 minutes to reach the water source (6.5%). The prevalence of diarrhea was 4.6% among households practicing improper child stool disposal and 6.6% in households using an unimproved toilet facility. Diarrhea was the highest in households having a natural floor as a main floor material (7.4%).

4.5 Risk factors associated to childhood diarrhea in the northern regions

4.5.1 Socioeconomic risk factors

In the bivariate analysis, only sex of the child did not show a significant association with child diarrhea. However, region, place of residence, wealth status, number of under 5 in the household, mother education, work status, age and religion all showed a significant association with childhood diarrhea. Children living in the northwestern region were 64% less likely to have diarrhea when compared to children living in the northeastern region [COR: 0.36, 95% CI (0.32 - 0.39)]. Similarly, children residents of the north central region showed 74% less odds to have diarrhea compared to children in the northeastern one [COR: 0.26, 95% CI (0.23 - 0.30)]. Children in urban areas showed 10% reduction in childhood diarrhea compared to children in rural areas [COR: 0.90, 95% CI (0.81-0.99)]. Children in richest households had 36% less odds to have diarrhea when compared to children in poorest households [COR: 0.64, 95% CI (0.52-0.77)]. In households where the number of children was three and more the odds of diarrhea was 9% higher compared to households were number of children was 2 or less [COR: 1.09, 95% CI (1.01 - 1.19)].

Maternal education was found to have a strong association with childhood diarrhea. Children to mothers with secondary education [COR:0.81, 95% CI (0.71 – 0.93)] and higher education [COR: 0.52, 95% CI (0.38 – 0.70)] were respectively 19% and 48 % less likely to have diarrhea compared to children to mothers with no education. Likewise, the mother work status had a significant association with diarrhea. Children to mothers whom had work were 11% less likely to have diarrhea compared to children to mothers whom were not working [COR: 0.89, 95% CI (0.81-0.97)]. Mother age and religion were also found to be significantly associated with child diarrhea. Children to mothers in the 25-34 age group and were 15% less likely to have diarrhea compared to children to mothers aged 15-24 years old [COR: 0.85, 95% CI (0.77 – 0.94)]. Children to Christian mothers were 22% [(COR: 0.78, 95% CI (0.68- 0.90)] and children to catholic mothers were 33% [COR: 0.67, 95% CI: (0.52-0.84)] less likely to have diarrhea compared to children to Muslim mothers (Table 4).

Table 4. Crude odds Ratio of Under 5 diarrhea in Relation to Socioeconomic Risk Factors of Households, Northern Nigeria, 2013

Variables	Diarrhea N=18510 (%)		Crude Odd ratio (95% CI)
	Yes	No	
Region			
North East	1252 (6.8)	4462 (24.1)	1
North West	799 (4.3)	7843 (42.3)	**0.36 (0.32 – 0.39)****
North Central	289 (1.6)	3865 (20.9)	**0.26 (0.23 – 0.30)****
Place of residence			
Rural	1834 (9.9)	12379 (66.8)	1
Urban	506 (2.8)	3791 (20.5)	**0.90 (0.81 – 0.99)****
Wealth status			
Poorest	815 (4.4)	5070 (27.4)	1
Poorer	719 (3.9)	4644 (25.1)	0.96 (0.86 – 1.07)
Middle	419 (2.3)	3068 (16.6)	**0.84 (0.74 – 0.96)****
Richer	249 (1.3)	2049 (11.1)	**0.75 (0.64 – 0.87)****
Richest	138 (0.7)	1339 (7.2)	**0.64 (0.52 - 0.77)****
Number of U5 in the household			
2 or less	1380 (7.5)	9899 (53.5)	1
3 and above	960 (5.2)	6271 (33.8)	**1.09 (1.01–1.19)****

Sex of the child			
Female	1164 (6.3)	8022 (43.3)	1
Male	1176 (6.4)	8148 (44)	0.99 (0.91 – 1.08)
Mother education			
No education	1581 (8.5)	10515 (56.8)	1
Primary	416 (2.2)	2655 (14.3)	1.04 (0.92 – 1.16)
Secondary	296 (1.6)	2404 (13)	**0.81 (0.71 – 0.93) ****
Higher	47 (0.4)	596 (3.2)	**0.52 (0.38 – 0.70)****
Mother work status			
Not working	911 (5)	5944 (32.1)	1
Working	1429 (7.7)	10226 (55.2)	**0.89 (0.81 - 0.97)****
Age of Mother			
15-24	699 (3.9)	4278 (23.1)	1
25-34	1098 (5.9)	7849 (42.4)	**0.85 (0.77 – 0.94)****
35-49	543 (2.9)	4043 (21.8)	**0.82 (0.72 – 0.92)****
Religion of the mother			
Islam	1966 (10.7)	12950 (69.9)	1
Other Christian	264 (1.4)	2317 (12.5)	**0.78 (0.68 – 0.90)****
Traditionalist	34 (0.2)	157 (0.8)	1.04 (0.67 – 1.57)
Catholic	76 (0.5)	746 (4)	**0.67 (0.52 – 0.84)****

** Statistically significant at p-value <0.05

4.5.2 Environmental risk factors

In the bivariate analysis, only the source of drinking water and the main floor material showed a statistically significant association with childhood diarrhea. Children in households where the main source of drinking water was not protected had 22% higher odds to have diarrhea compared to children in households that used a protected source [COR: 1.22, 95% CI (1.12-1.34)].

The analysis showed an 18% reduction in diarrhea in households with finished floor as the main floor material compared to households with natural floor [COR: 0.82, 95% CI (0.75-0.90)]. However, households with wood and palm/bamboo floor were three times more likely to have diarrhea compared to households with natural floor [COR: 3.74, 95% CI (1.64-8.05)]. Time needed to reach water source, child stool disposal and type of toilet facility did not show any statistically significant relation to child diarrhea (table 5).

Table 5. Crude Odds Ratio of Under 5 Diarrhea in Relation to Environmental and Behavioral Risk Factors of Households, Northern Nigeria, 2013

Variables	Diarrhea N=18510 (%)		Crude Odd ratio (95% CI)
	Yes	No	
Source of drinking water			
Protected	1122 (6.1)	8556 (46.3)	1
Unprotected	1218 (6.6)	7614 (41)	**1.22 (1.12 – 1.34)****
Time to water source			
On premises	493 (2.7)	3457 (18.6)	1
Less than 30 min	1197 (6.5)	8167 (44.2)	1.09 (0.97 - 1.22)
More than 30 min	650 (3.5)	4546 (24.5)	1.11 (0.98 – 1.26)
Child stool disposal			
Improper	909 (4.9)	5578 (30.1)	1
Proper	1431 (7.8)	10592(57.2)	0.99 (0.90 – 1.0)
Type of toilet facility			
Unimproved	1212 (6.6)	8350 (45.1)	1
Improved	1128 (6.1)	7820 (42.2)	0.99 (0.90- 1.07)
Main Floor material			
Natural floor	1357 (7.4)	8635 (46.6)	1
Finished floor	965 (5.2)	7518 (40.6)	**0.82 (0.75 – 0.90)****
Wood/Palm/bamboo planks	18 (0.1)	17 (0.1)	**3.74 (1.64 – 8.05)****
If toilet shared with other Households (n= 13180)			
No	1333 (10.1)	9187 (69.7)	1
Yes	325 (2.5)	2335 (17.7)	1.04 (0.84 – 1.09)
Bottle feeding			
No	2129 (11.6)	15013 (81.1)	1
Yes	211 (1.1)	1157 (6.2)	0.96 (0.81 – 1.13)
DPT 3 vaccination			
No	1919 (10.4)	12366 (66.8)	1
Yes	421 (2.3)	3804 (20.5)	**0.71 (0.63 – 0.79)****
Polio 3 vaccination			
No	1247 (6.8)	8645 (46.7)	1
Yes	1093 (5.9)	7525 (40.6)	**0.91 (0.83 – 0.99)****

** Statistically significant at p-value <0.05

4.5.3 Behavioral risk factors

In the bivariate analysis, only DPT3 and polio3 vaccination showed a statistically significant association with childhood diarrhea. Children who got DPT3 vaccination were 29% less likely to have diarrhea compared to children who did not get vaccinated [COR: 0.71, 95% CI (0.63 – 0.79)]. Concerning polio3 vaccination, children who got a polio3 vaccination were 9% less likely to have diarrheal episodes compared to children who did not get vaccinated [COR: 0.99, 95% CI (0.83 – 0.99)]. Sharing toilet with other households and feeding the child from a bottle did not show any statistically significant association with diarrhea (Table 5).

4.6 Multivariable analysis

Three different selective models were constructed based on bivariate analysis to avoid extreme number of variables assessed as independent factors. Variables in the bivariate analysis of socioeconomic, environmental and behavioral risk factors which were found to be statistically significant at p-value <0.05 were further considered in the multiple logistic regression models of the adjusted odds ratios. Moreover, place of residence, wealth status, mother's education, mother's work status, mother's religion, mother's age, number of under 5 in the household, source of drinking water, main floor material, DPT3 vaccination and polio3 vaccination were found to be significant independent risk factors for the reported occurrence diarrhea in bivariate analysis. In order to be able to identify the risk factors of each region separately, the northern region was represented by three different models, model I represented the north east region, model II represented the north west region and model III represented the north central (Table 6).

4.6.1 Model I

In the North East region, mother's education, work status, religion, source of drinking water, main floor material, DPT3 vaccination and polio3 vaccination were the only statistically significant risk factors of diarrhea after adjusting to other variables. Children whose mothers had primary education were 32% more likely to have diarrhea compared to those whose mothers had no education when adjusting to other variables [AOR: 1.32,

95% CI (1.09 – 1.58)]. Children of working mothers were 36% more likely to have diarrhea compared to children of non-working mothers [AOR: 1.36, 95% CI (1.19 - 1.56)]. The odds of diarrhea were 47% less in children to other Christian mothers [AOR: 0.53, 95% CI (0.42 – 0.67)] and 47% less in children to catholic mothers [AOR: 0.53, 95% CI (0.32 – 0.85)] when compared to children to Muslim mothers. More specifically, odds of diarrhea were 1.2 times higher in children living in households using an unprotected source for drinking water compared to whose living in households using a protected source [AOR: 1.20, 95% CI (1.04 – 1.38)].

Children in households where wood and palm/bamboo planks were the major floor material had 3.6 times higher odds to have diarrhea compared to children living in households where natural floor was the main material [AOR: 3.63, 95% CI (1.73 - 9.95)]. However, children living in households where finished floor was the main floor material had 19% less odds to have diarrhea compared to those living in households where natural floor was the main floor material [AOR: 0.81, 95% CI (0.69 - 0.94)]. Children who got DPT3 vaccination had 32% less odds to have diarrhea compared to children who did not get vaccinated [AOR: 0.68, 95% CI (0.56 – 0.82). Whereas, children who got polio 3 vaccination had 30% more odds to have diarrhea compared to those who did not get vaccinated [AOR: 1.30, 95% CI (1.11 - 1.52)] (Table 6).

4.6.2 Model II

In the Northwest region, mother's education, mother's religion, mother's age and polio3 vaccination were the only statistically significant risk factors associated with diarrhea when adjusting to other variables. Children to mothers with high education had 67% less odds to have diarrhea compared to children whose mothers had no education [AOR: 0.33, 95% CI (0.78 - 0.94)]. Children born to catholic mothers had 83 % more odds to have diarrhea compared to children born to Muslim mothers [AOR: 1.83, 95% CI (1.04 – 3.16)]. The odds of diarrhea in children whose mothers aged between 24-34 years was 17% less compared to children whose mothers aged between 15-24 years [AOR: 0.83, 95% CI (0.69 – 0.99)]. Similarly, children to mothers aged between 35-49 years had 26% less odds to have diarrhea compared to children whose mothers aged between 15-24 years [AOR:0.75, 95% CI (0.61 – 0.93)]. Children who got polio3 vaccination had 17%

higher odds to have diarrhea compared to children who did not get vaccinated [AOR: 1.17, 95% CI (1.02 – 1.37)] (Table 6).

4.6.3 Model III

In the North central region, mother's age, main floor material, DPT3 vaccination and polio vaccination were statistically significant risk factors associated with diarrhea when adjusted to other variables.

Children to mothers aged between 35-49 years had 32% less odds to have diarrhea compared to children to mothers aged between 15-24 years [AOR:0.68, 95% CI (0.47-0.99)]. The odds of diarrhea were 2.6 times higher among children living in households where wood and palm/bamboo planks were the main floor material compared to children living in households where the main floor material is natural [AOR: 2.62, 95% CI (1.08 – 8.79)]. Children who got DPT3 vaccination had 43% less odds to have diarrhea compared to those who did not get vaccinated [AOR: 0.57, 95% CI (0.42 – 0.77)]. However, children who got polio3 vaccination had 1.6 times higher odds to have diarrhea compared to children who did not get vaccinated [AOR: 1.62, 95% CI (1.23 – 2.13)] (Table 6).

Table 6. Adjusted Odd ratios of U5 Diarrhea in Relation to Socioeconomic, Environmental and Behavioral Risk Factors in the Three Northern Regions Nigeria, 2013

Risk factors	Model I**	Model II***	Model III****
	AOR (95% CI)	AOR (95% CI)	AOR (95%CI)
Place of residence*			
Rural	1	1	1
Urban	1.18 (0.95 – 1.46)	1.10 (0.85 – 1.40)	0.89 (0.61 – 1.28)
Wealth status*			
Poorest	1	1	1
Poorer	1.05 (0.82 – 1.16)	1.13 (0.93 – 1.36)	1.29 (0.78 – 2.22)
Middle	0.90 (0.69 - 1.16)	1.30 (0.99 – 1.70)	1.20 (0.69 – 2.12)
Richer	0.81 (0.57 - 1.14)	1.15 (0.78 - 1.67)	1.11 (0.59 – 2.14)
Richest	0.94 (0.60 – 1.45)	1.12 (0.67 - 1.85)	0.98 (0.46 – 2.11)
Maternal education*			
No education	1	1	1
Primary	**1.32 (1.09 – 1.58)**	1.03 (0.80 – 1.34)	1.19 (0.86 – 1.65)
Secondary	1.03 (0.80 – 1.32)	1.04 (0.75 – 1.43)	1.02 (0.70 – 1.49)
Higher	0.81 (0.47 – 1.35)	**0.33 (0.78 – 0.94)**	0.87 (0.59 – 1.95)
Mother work status*			
Not working	1	1	1
Working	**1.36 (1.19 – 1.56)**	0.93 (0.80 – 1.10)	1.13 (0.85 – 1.53)
Religion of the mother*			
Islam	1	1	1
Other Christian	**0.53 (0.42 – 0.67)**	1.41 (0.86 – 2.21)	1.14 (0.84 – 1.54)
Traditionalist	0.97 (0.45 – 1.91)	1.09 (0.45 – 2.24)	1.87 (0.75 – 4.05)
Catholic	**0.53 (0.32 – 0.85)**	**1.83 (1.04 - 3.16)**	0.99 (0.65 – 1.48)
Age of mother*			
15-24	1	1	1
24 -34	0.96 (0.82 – 1.12)	**0.83 (0.69 – 0.99)**	0.81 (0.61 – 1.10)
35-49	0.93 (0.78 – 1.12)	**0.75 (0.61 – 0.93)**	**0.68 (0.47 – 0.99)**
Number of U5 in the household*			
2 or less	1	1	1
3 and above	1.05 (0.92 – 1.20)	0.95 (0.81 - 1.11)	0.93 (0.69 – 1.23)
Source of drinking water *			
Protected	1	1	1
Unprotected	**1.20 (1.04 – 1.38)**	0.94 (0.80 – 1.11)	0.98 (0.73 – 1.30)
Main floor material *			

Natural floor	1	1	1
Wood/Palm/Bamboo planks	**3.63 (1.73 - 9.95)**	2.55 (0.71 – 7.17)	**2.62 (1.08 – 8.79)**
Finished floor	**0.81 (0.69 – 0.94)**	0.87 (0.72 – 1.06)	0.96 (0.91 – 1.78)
DPT3 vaccination*			
No	1	1	1
Yes	**0.68 (0.56 – 0.82)**	0.80 (0.61 – 1.04)	**0.57 (0.42 – 0.77)**
Polio3 vaccination*			
No	1	1	1
Yes	**1.30 (1.11 – 1.52)**	**1.17 (1.02 - 1.37)**	**1.62 (1.23 – 2.13)**

* Factors significant at p-value <0.05 in the Bivariate Analysis, ** Northeastern Region, *** Northwestern Region, **** North Central Region

5. Discussion

5.1 Main Findings

This study aimed to identify the socioeconomic, environmental and behavioral risk factors for the occurrence of childhood diarrhea among children aged under five in northern Nigeria using data from the NDHS 2013 which is a cross sectional survey. The study aimed also to assess the prevalence of childhood diarrhea in northern Nigeria three regions: Western, Eastern and Central.

In this study, the overall prevalence of diarrhea among children under five years of age in last two weeks including the last 24 hours prior to data collection time before the survey was 12.7%. In the eastern region the two-week period prevalence of diarrhea was 6.8% followed by 4.3% in the western region and 1.6% in the central. The results showed a high prevalence of diarrhea in a two-week period. The variance between regions could be attributable to the difference in the sociodemographic characteristics of the study households. The north central region showed higher socioeconomic standards compared to the other two regions, the highest number of mothers with higher education and the richer and richest households. Also, the majority of households had finished floors and highest DPT3 vaccination among under five children.

The age of the mother was positively associated with child diarrhea in the northwest and north central regions. The older the mother the less was the probability of the under five child to have diarrhea. Level of mother education and religion was also positively associated with the occurrence of diarrhea among children under five years of age where the higher the education of the mother the less was the odds of the child to experience diarrhea episodes. Moreover, in comparison to other religions, diarrhea was highest among children to Muslim mothers compared to Christian mothers. The source of drinking water also showed a significant association with under 5 diarrhea in the northeastern region only. Under five children residing in households using unprotected sources for drinking water had a higher likelihood to have diarrhea compared to those using protected sources.

Moreover, the floor material and DPT3 vaccination showed a significant association with the occurrence of diarrhea the northeaster and central regions. The presence of diarrhea was higher among households with natural floor as a main floor material, followed by finished floor and the least was among households with wood and palm/bamboo planks as main floor material. Diarrhea was higher among children who did not get a full DPT vaccination whereas it was lower among those who were fully vaccinated. Polio3 vaccination showed a significant association with diarrhea in all three northern regions. Diarrhea was higher among children who were fully vaccinated and lower among those who did not get the full vaccination. The mother working status was positively associated with diarrhea in the northeastern region only where diarrhea was higher among children of working mothers.

However, household residence and number of under five in household did not show any positive association with the occurrence of diarrhea among children under five years of age in multivariate analysis yet in the bivariate analysis they showed a statistically significant association. Furthermore, child sex, type of toilet facility, time to reach water source, child stool disposal, bottle feeding and sharing toilet with other household did not show any positive association with diarrhea.

5.2 Study findings in relation to other studies

This study provided thorough information about the significant risk factors that were associated with the occurrence of diarrhea among children under five years of age. They included mother's age, mother's education, mother's religion, mother's work status, source of drinking water, main floor material, polio 3 and DPT3 vaccination. These were the independent factors that remained significant even after adjusting to all the significant independent variables in the crude analysis for any confounding factors. This study also found a high prevalence in the occurrence of diarrhea among the under five children in a two week period. This high rate of childhood diarrhea with the extensive enhancements in water sources and sanitation toilets indicates the demand for more responsiveness. These findings are comparable to other studies conducted previously specifically in African low-income countries (LIC) as discussed below.

5.2.1 Mother's Age

The age of the mother was a significant predictor for the occurrence of diarrhea among children under five years of age. The current study revealed that odds of diarrhea were higher among children to mothers aged less than 24 years old. This was in line with a cross sectional study conducted in Ghana to determine the risk factors associated with diarrhea morbidity among under five children (30). This result can be justified by the fact that younger mothers could be less experienced with child care and have less understanding and knowledge about diarrheal disease mode of transmission and pathogens spread in the household environment compared to older mothers.

5.2.2 Mother's education

The findings of the present study emphasize that the higher the level of education of the mother the less was the risk of the under five child to experience diarrheal episodes.

This agrees with a study that was conducted by Mihrete et al to identify the determinants of childhood diarrhea among under five children in northwest Ethiopia which found that education was significantly associated with child diarrhea (11). The results of the current study is similar to a study by Gibru et al (17), which found that children whose mothers can not read and write were more likely to have diarrhea. Mother's education level provides knowledge on hygienic practices, child feeding and additional sanitation practices, which in turn are critical factors of childhood diarrhea.

5.2.3 Mother's work status

The current study find a significant association between mother work status and under 5 diarrhea which was in line with a study by Mihrete et al. (11) that found a positive association between working mothers and the risk for childhood diarrhea. This can be explained by the fact that a working mother does not have enough time to take care of her child since she spends most of her time at work which might increase the risk of the child to have diarrhea. However, non-working mothers spend more time at home taking care of the child thus reducing the child risk of experiencing diarrhea.

5.2.4 Mother's Religion

The mother religion was found to be a statistically significant predictor of childhood diarrhea. Children to Muslim mothers had higher likelihood of having diarrhea in addition to traditionalist mothers, whereas children whose mothers were Catholics and other Christians were less prone to witness diarrheal episodes. This is thoroughly associated to the mother's belief system and could be explained that traditionalist mothers believe that treatment of the illness requires traditional healers rather than modern curative treatments. The majority of Muslims are concentrated in the northern region of the country which might be the reason of the high prevalence of diarrhea among the Muslims compared to the Christians whom are concentrated in the southern region of the country. Thus, religion is related to diarrhea only based on the socioeconomic background of the participants rather than a belief itself. However, this contradicted a study by Gibru et al in Ethiopia where religion and Christian orthodox in specific were found to be negatively associated with diarrhea (17).

5.2.5 Source of drinking water

The household source of drinking water was found to be positively associated with childhood diarrhea. Under five children in households using protected sources including piped public taps, tube well, protected well, protected spring, and rainwater had less risk to experience diarrheal episodes. Whereas, children in households using unimproved sources including unprotected well, unprotected spring, tanker truck, surface water and sachet water were 19% more prone to diarrheal episodes. This was in line with Mengistie et al. (19) where diarrhea was significantly associated with domestic water supply from unimproved sources among children under five in eastern Ethiopia. Water source is part of the hygiene and correct handling of drinking water is an important factor to prevent any contamination. Thus, purifying techniques prior to drinking should be a part of implementation programs for households since even if water came from a protected source it could be under high risk of contamination due to unhygienic drawing from wells or storage at home that explain the presence of diarrhea among children in households that used protected sources for drinking water. In contrast, Gebru et al. (17) did not find any significant association between water source and childhood diarrhea.

5.2.6 Main floor material

The household floor material was significantly related to diarrhea in children under five years of age. Children in households with floor material made from mud and sand were at a high risk of experiencing diarrheal episodes. This could be justified by the fact that children crawling and playing in the house on floors made from mud and sand could get in contact with infectious pathogens due to fecal residues that accumulate on the exposed floor due to dirty person footwear and the natural of the floor itself. Also, children are believed to be young to be capable to wash their own hands or take enough precautions when playing on the mud or sand floor and thus would not be able to prevent the transmission of pathogens between their hands and mouth. Moreover, children in households with floor material made of wood, palm and bamboo planks had a 3.5 times higher risk to have diarrhea. Wood, palm and bamboo planks are unimproved flooring material where households with bamboo and palm planks are more prone to humidity that leads to the growth of molds in between the flooring planks where children play and where families might be eating as well. This was in line with Adebowale et al in Nigeria which found higher under five mortalities in houses built with inadequate and unimproved flooring materials such as dung, mud, sand, rudimentary and, wood palm/bamboo planks (31). Whereas, Mohammed et al in his study conducted in southern Ethiopia (32) did not find main floor material as a significant predictor for childhood diarrhea. This might be due to differences in the type of floor material used in building between Ethiopia and Nigeria.

5.2.7 DPT3 vaccination

Full Diphtheria, Pertussis, Tetanus (DPT3) vaccination was found to be positively associated with under five diarrhea. Children who received a full DPT vaccination were less likely to experience diarrheal episodes compared to those who did not receive the full vaccination. This might be due to the fact that the immunity of the child builds over time and not finishing the complete vaccination schedule will result in weakening the immunity of the child and in this case the child will be more susceptible when exposed to any contaminated food or unclean water in unhealthy environments to experience diarrhea or any other form of illness. This was in line with Amgusi et al (20) findings in

Ghana where children who did not receive complete DPT vaccines were 1.5 more likely to experience diarrhea compared to children who did not receive full vaccination.

5.2.8 Polio3 Vaccination

Full polio vaccination was found to be positively associated with under five diarrhea. Children who received a full polio vaccination were more likely to experience diarrheal episodes compared to those who did not receive the full vaccination. This can be explained by the fact that diarrhea is a side effect of the oral polio vaccine. This finding was in line with Amgusi et al (20) findings in Ghana where children who did not receive polio 3 vaccines were 32% less likely to experience diarrhea compared to children who received full vaccination.

5.2.9 Non Significant Predictor Variables

The current study found no statistically significant association between the type of residence and childhood diarrhea. This could be due to the fact that in some urban areas the living conditions of individuals are worse than conditions in rural ones. More people are moving from rural areas to urban ones which in turn is leading to the increase of the poor people living in slums of the city that are poorly managed with almost complete absence of infrastructure. Thus, children in both types of residence are prone to experience diarrhea. This finding was in line with Amgusi et al (20) who did not find a positive association between childhood diarrhea and residence.

Gebru et al. (17), Danquah et al (30) and Mohammed et al (32) found no association between the type of toilet facility and under five diarrhea. This was in agreement with the current study that found no association between the type of toilet facility in the household and diarrhea. This finding was unexpected but it could be due to the fact that children under five are not using any toilet facility and that a household that have a latrine does not automatically imply that a child uses it but the adults in the household.

The present study found no association between the time to the reach drinking water source and diarrhea. This negative association could be explained by the fact that

although when walking for a long time to fetch water this water would be more exposed to get contaminated until it reaches the household, but if the water source was not protected in the first place the risk of contamination would not be related to the distance regardless of the time needed. Thus, a protected water source that needs more than a 30 minutes walk would be protective against diarrhea than an unprotected water source that is 2 minutes away from the household and the opposite is true. This finding agreed with a randomized control trial conducted by Cha et al (33) in Ghana to study the effect of water supply on diarrhea prevalence among children under 5 which found that the prevalence of diarrhea decreased among children under 5 in households that went to neighboring areas which were benefiting from borehole drilling to take benefit of the improved water supply. However, this finding contradicted what Gascon et al. (21) found in Tanzania where increasing the distance from the water source was associated with a reduced risk of diarrhea.

The number of children under five in the household was found to have a negative association with the occurrence of diarrhea. This was similar to the findings of Danquah et al (30) that found no statistically significant relationship between childhood diarrhea and number of children younger than 5 in the household. However, Mihrete et al (11) and Gebru et al (17) found that as the number of children under 5 increase in the household the frequency of diarrhea increased significantly because the quality of care and attention from parents decreased.

5.3 Study Findings in Relation to the Conceptual Framework

The conceptual framework hypothesized that various factors were associated with diarrhea among children under the age of 5. They included different socioeconomic, environmental and behavioral risk factors. All these factors have been discussed and described in the previous sections. However, not all factors in the conceptual framework were associated with diarrhea in children. Other risk factors that have not been mentioned might also be related to diarrhea among children under 5.

5.4 Strengths and Limitations

5.4.1 Strengths of the Study

The study used data obtained form the Nigeria demographic and health survey 2013 which is representative at the national and regional level which allows the findings to be generalized among children under age of 5 in Nigeria across other southern regions which were not part of this study. Demographic Health Surveys help assist and monitor the health indicators of a country. In Nigeria, the survey is conducted every five years and is regularly led by experienced personnel. Quality of data is ensured through the use of complex sampling strategies to reduce bias. Another strength is that even though data used in this study are not clinical or longitudinal data but cross sectional surveys contribute in assessing the underlying risk factors of child diarrhea in the two weeks period prior to the survey that could be of importance for health intervention programs in Nigeria.

5.4.2 Limitations of the study

Data used in this study were from a cross sectional survey which just represented a snap of the population at that specific time thus causal relationships of socioeconomic, environmental and behavioral factors with child diarrhea could not be established since the predictor variables and the outcome variable were measured at the same period of time and made it difficult to account for seasonal changes in the occurrence of child diarrhea.

Moreover, during the DHS survey children were not clinically assessed. The illness was measured based on mothers' report of their children condition in the 2 weeks prior to the survey. These questions relied on the mother's assessment of her child health instead of relying on a clinical examination. As people from diverse backgrounds are more likely to have various perceptions of childhood diseases, the mother's report of the child health might not be similar through different socioeconomic groups. These variances could result in both under reporting or over reporting of child sickness and therefore influence the prevalence of diarrhea reported in this study. Thus, the prevalence estimates described here should be interpreted with caution. Another limitation was recall bias. Mothers might have forgotten the sickness incident during the interview leading to misreporting

on the occurrence of diarrhea. Nevertheless, it have been commonly the case in reporting diarrhea occurrence in other studies thus two weeks should be enough for most mothers to have reported appropriately. Furthermore, this study was conducted among children aged 5 years and less so the results might not be generalizable to children older than five years. A major limitation of this study was the absence of factors that might be important risk factors for diarrhea such as breastfeeding history, child nutritional status and mothers' hygiene practices.

5.4.3 Internal Validity

Personnel whom had received prior training before the survey performed the collection of data. They were trained on how to use the questionnaire forms in order to improve reliability of the data collection tools, which enhanced the quality of the data collected.

Moreover, multivariable analysis was used to eliminate the effect of confounding factors which increased internal validity as well. Findings were generally inline with other studies which might give greater certainty that the results are valid. However, the validity of the presented results rely on the ability of the respondents to appropriately report diarrhea and remember episodes that happened two weeks prior to survey.

5.4.4 External validity

Demographic Health Surveys uses standardized questionnaires that can be adjusted to different settings. The results of the study could be generalized into southern regions of Nigeria and other African countries that have high prevalence of diarrhea among under five children but with taking into consideration the different backgrounds of respondents.

5.5 Public Health Relevance

The diarrhea mortality burden among children under five in Sub Saharan Africa shows the continual weight of this preventable and curable illness in the region.

The WHO declared humanitarian health and water crisis in the north eastern Nigerian region in august 2016 where 60% of the health facilities were partially damaged and destructed with 2 million internally displaced persons with the majority being children and women. Cholera epidemic and water shortage as well as the spread of the diseases in the camps triggered severe diarrhea episodes in children under five.

A lot of efforts have been made by the Nigerian government to increase hygiene

awareness in order to interrupt diarrheal episodes. In Nigeria, the Hand Washing Campaign is one of three goals outlined in the Action Plan established for tribute of the 2008 International Year of Sanitation to ensure coverage particularly among children under five years. The evaluation of diarrhea risk factors among under five children is a fundamental step towards decreasing the higher prevalence of diarrhea among children.

The prevalence of diarrhea in a two-week period in the northern region reported in this study (12.7%) is high compared to a diarrhea prevalence rate of 18.8 % in all the country regions. These findings will aid to come up with evidence based approaches to decrease the prevalence of diarrhea among under five children and thus reduce under five morbidity and mortality since diarrhea is a leading killer disease among children under five years of age in Nigeria especially in conflict areas and epidemic zones.

This can be attained if more basic sanitation toilets are founded and awareness on appropriate hygiene and sanitation practices are improved particularly the importance of hand washing. Also, constructing assisting environments to sustainably increase sanitation and hygiene programs.

The effectiveness of the current interventions to prevent and treat diarrheal diseases and thus lower diarrhea mortality has been evidenced. Huge declines in child mortality can be reached with their implementation. Thus, thorough planning and assessment of interventions to control cases and mortality due to diarrhea is essential.

5.6 Conclusion

This study showed a high prevalence of diarrhea among children under five years of age in Nigeria. Various important socioeconomic, environmental and behavioral risk factors that lead to the occurrence of diarrhea in children under five were identified and need to be focused on. The independent variables that were found to be risk factors were mother education level, mother age and religion, source of drinking water, main floor material and full DPT vaccination. Increased risk of diarrhea was observed among non-educated and young mothers. Access to protected sources of drinking water and the presence of finished floors in the households helped in protecting children under five from experiencing diarrheal episodes as well as the increased immunity through full vaccinations.

The results of this study have critical policy implications for health intervention programs and emphasize that promoting women education levels may have a significant importance on child health and survival in Nigeria. The long-term solution for decreasing morbidity from diarrhea may include the delivery of improved sanitation and hygiene through efficient educational programs that concentrate on personal hygiene which lead to full sanitation. This should be reinforced in combination with health workers educating households on sanitation.

As stated earlier, Nigeria's diarrhea problem is due to the increased spread of pathogens caused by poor water and sanitation. The Nigerian government must concentrate on complete diarrheal disease control approaches, involving enhancement of water quality, hygiene, and sanitation also providing of oral rehydration solution particularly in the northern regions. Finally, longitudinal studies can be the best designs to provide data on the changing prevalence of diarrhea and address seasonality by including relevant factors.

References

1. WHO. Diarrhoeal disease. 2013 Apr. Available from: http://www.who.int/mediacentre/factsheets/fs330/en/ [Accessed 7th Feb 2017.

2. UNICIF. Diarrhoea. 2016 Jul. Available from: https://www.unicef.org/health/index_92007.html [Accessed 12th Feb 2017].

3. Rosenberg M. Global Child Health: Burden of Disease, Achievements, and Future Challenges. Curr Probl Pediatr Adolesc Health Care. 2007 Oct;37(9):338–62.

4. You D, Hug L, Ejdemyr S, Beise J. Levels & Trends in Child Mortality: Report 2015. New York, USA: United Nations Children's Fund; 2015.

5. You D, Hug L, Ejdemyr S, Idele P, Hogan D, Mathers C, et al. Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. The Lancet. 2015;386(10010):2275–86.

6. WHO. Children: reducing mortality. 2016 Sep. Available from: http://www.who.int/mediacentre/factsheets/fs178/en/ [Accessed 12th Feb 2017].

7. UNICIF. Diarrhoea remains a leading killer of young children, despite the availability of a simple treatment solution. Available from: http://data.unicef.org/topic/child-health/diarrhoeal-disease. / [Accessed 13th Feb 2017].

8. WHO Regional Office for Africa. 5 children under age 5 die every minute in the African Region. Available from: http://www.afro.who.int/en/media-centre/afro-feature/item/7718-5-children-under-age-5-die-every-minute-in-the-african-region.html [Accessed 16th Feb 2017].

9. UNICEF, World Health Organization. Diarrhoea: why children are still dying and what can be done. New York: UNICEF, World Health Organization; 2009.

10. One is too many: Ending child deaths from pneumonia and diarrhoea. New York, USA: United Nations Children's Fund, UNICIF; 2016 Nov.

11. Mihrete TS, Alemie GA, Teferra AS. Determinants of childhood diarrhea among underfive children in Benishangul Gumuz Regional State, North West Ethiopia. BMC Pediatr. 2014;14(1):102.

12. UNICIF. The world has missed the MDG sanitation target by almost 700 million 2016 Jan. Available from: https://data.unicef.org/topic/water-and-sanitation/sanitation/ [Accessed 24th Feb 2017].

13. Mills JE, Cumming O. The Impact of Water, Sanitation and Hygiene on Key Health and Social Outcomes: Review of Evidence. Sanitation and Hygiene Applied Research for Equity (SHARE), UNICIF: Jun.2016

14. Clasen T, Pruss-Ustun A, Mathers CD, Cumming O, Cairncross S, Colford JM. Estimating the impact of unsafe water, sanitation and hygiene on the global burden of disease: evolving and alternative methods. Trop Med Int Health. 2014 Aug;19(8):884–93. (1)

15. Khalil I, Colombara DV, Forouzanfar MH, Troeger C, Daoud F, Moradi-Lakeh M, et al. Burden of Diarrhea in the Eastern Mediterranean Region, 1990-2013: Findings from the Global Burden of Disease Study 2013. Am J Trop Med Hyg. 2016 Dec 7;95(6):1319–29.

16. Bos ER, Jamison DT, Bainga F, Feacham RGA, Makgoba M, Hofman KJ, et al., editors. Disease and Mortality in Sub-Saharan Africa: Second Edition [Internet]. The World Bank; 2006 [cited 2017 Apr 12]. Available from: http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-6397-3

17. Gebru T, Taha M, Kassahun W. Risk factors of diarrhoeal disease in under-five children among health extension model and non-model families in Sheko district rural community, Southwest Ethiopia: comparative cross-sectional study. BMC Public Health. 2014;14(1):395.

18. Kumi-Kyereme A, Amo-Adjei J. Household wealth, residential status and the incidence of diarrhoea among children under-five years in Ghana. J Epidemiol Glob Health. 2016 Sep;6(3):131–40.

19. Mengistie B, Berhane Y, Worku A. Prevalence of diarrhea and associated risk factors among children under-five years of age in Eastern Ethiopia: A cross-sectional study. Open J Prev Med. 2013;03(07):446–53.

20. Amugsi DA, Aborigo RA, Oduro AR, Asoala V, Awine T, Amenga-Etego L. Socio-demographic and environmental determinants of infectious disease morbidity in children under 5 years in Ghana. Glob Health Action. 2015 Dec;8(1):29349.

21. Gascon J, Vargas M, Schellenberg D, Urassa H, Casals C, Kahigwa E, et al. Diarrhea in children under 5 years of age from Ifakara, Tanzania: a case-control study. J Clin Microbiol. 2000;38(12):4459–62.

22. Omoruan AI, Bamidele AP, Phillips OF, others. Social health insurance and sustainable healthcare reform in Nigeria. Ethno Med. 2009;3(2):105–10.

23. Federal Republic of Nigeria: Global Aids Response Country Progress Report. Nigeria: National Agency For The Control of AIDS (NACA); 2014.

24. Welcome MO. The Nigerian health care system: Need for integrating adequate medical intelligence and surveillance systems. J Pharm Bioallied Sci. 2013 Dec;3(4):470–8.

25. Millennium Development Goals: End-Point Report. Nigeria: UNDP; 2015.

26. International Vaccine Access Center (IVAC). Pneumonia & Diarrhea Progress Report: Sustainable Progress in the Post-2015 Era [Internet]. 2015. Available from: Available from: www.jhsph. edu/research/centers-and-institutes/ivac/ resources/IVAC-2015-Pneumonia- Diarrhea- Progress-Report.pdf

27. Macro ORC. Demographic and health surveys. Calverton MD ICF Macro [Internet]. 2013 [cited 2017 Apr 12]; Available from: http://pdf.usaid.gov/pdf_docs/Pnacx579.pdf

28. UNICIF Nigeria. Emergency response. Available from: https://www.unicef.org/nigeria/ [Accessed 1st Mar 2017].

29. Hussein H. Literature Review: Risk Factors Contributing to diarrheal diseases Leading to the High Under 5 Mortalities in African Settings. IMCH, Uppsala University, 2017 Jan.

30. Danquah L. Risk Factors Associated with Diarrhea Morbidity Among Children Younger than Five Years in the Atwima Nwabiagya District, Ghana: A Cross-Sectional Study. Sci J Public Health. 2015;3(3):344.

31. Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. BMC Pediatr [Internet]. 2017 Dec [cited 2017 Apr 12];17(1). Available from: http://bmcpediatr.biomedcentral.com/articles/10.1186/s12887-016-0742-3

32. Mohammed S, Tamiru D. The Burden of Diarrheal Diseases among Children under Five Years of Age in Arba Minch District, Southern Ethiopia, and Associated Risk Factors: A Cross-Sectional Study. Int Sch Res Not. 2014;2014:1–6.

33. Cha S, Kang D, Tuffuor B, Lee G, Cho J, Chung J, et al. The Effect of Improved Water Supply on Diarrhea Prevalence of Children under Five in the Volta Region of Ghana: A Cluster-Randomized Controlled Trial. Int J Environ Res Public Health. 2015 Sep 25;12(10):12127–43.

Annex

Figure 3. Map of Nigeria *(Demographic and Health Survey Final Report, Nigeria 2013)*