FACTORS ASSOCIATED WITH DIARRHEA AMONG CHILDREN LESS THAN 5 YEARS OLD IN SUDAN: A SECONDARY ANALYSIS OF SUDAN MULTIPLE INDICATOR CLUSTER SURVEY 2014

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ปัจจัยที่มีความสัมพันธ์กับโรคท้องร่วงในกลุ่มเด็กอายุต่ำกว่า 5 ปี ประเทศซูดาน: ข้อมูลทติยภูมิจากการสำรวจพหุดัชนีแบบจัดกลุ่ม ปี 2557

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรมหาบัณฑิต
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ปีการศึกษา 2559

Thesis Title	FACTORS ASSOCIATED WITH DIARRHEA AMONG CHILDREN LESS THAN 5 YEARS OLD IN SUDAN: A SECONDARY ANALYSIS OF SUDAN MULTIPLE INDICATOR CLUSTER SURVEY 2014
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เทสฟิต บราฮัน เนทซีเลี้ยบ : ปัจจัยที่มีความสัมพันธ์กับโรคท้องร่วงในกลุ่มเด็กอายุต่ำกว่า 5 ปี ประเทศซูดาน: ข้อมูลทติยภูมิจากการสำรวจพหุดัชนีแบบจัดกลุ่ม ปี 2557 (FACTORS ASSOCIATED WITH DIARRHEA AMONG CHILDREN LESS THAN 5 YEARS OLD IN SUDAN: A SECONDARY ANALYSIS OF SUDAN MULTIPLE INDICATOR CLUSTER SURVEY 2014) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ปีเตอร์ ซีนอส, 69 หน้า.

โรคอุจจาระร่วงเป็นโรคที่มีการขับถ่ายของเหลวทางทางเดินของอุจจาระมากกว่าสามครั้งในหนึ่งวัน (หรือขับถ่ายบ่อยกว่าคนปกติ) ซึ่งเป็นสาเหตุสำคัญของตายและภาวะป่วยเป็นโรคในเด็กอายุต่ำกว่า 5 ขวบในประเทศกำลังพัฒนาโดยเฉพาะอย่างยิ่งในประเทศแถบแอฟริกาใต้-สะฮาราวมทั้งประเทศซูดาน การศึกษาครั้งนี้มีจุดมุ่งหมายเพื่อศึกษาปัจจัยที่เกี่ยวข้องกับโรคอุจจาระร่วงในเด็กอายุต่ำกว่า 5 ปีในประเทศซูดานโดยใช้ข้อมูลจากการสำรวจพหุดัชนีแบบกลุ่ม ปี พ.ศ. 2557 (MICS)

จากการทำการสำรวจเด็กโดยแบบสอบถามจำนวน 14,081 คนที่มีอายุต่ำกว่า 5 ปี ที่ได้ทำได้รับการพิจารณาสำหรับการศึกษาครั้งนี้ ข้อมูลถูกป้อนและทำความสะอาดโดยโปรแกรม SPSS รุ่น 17 โดยใช้การวิเคราะห์สองตัวแปรโดยใช้การทดสอบไคสแควร์และการวิเคราะห์พหุตัวแปรใช้การวิเคราะห์การถดถอยโลจิสติกที่ช่วงเชื่อมั่น 95% เพื่อทดสอบความสัมพันธ์ระหว่างตัวแปรต้นและตัวแปรตาม ตัวแปรทั้งหมดที่มีค่า p - value < 0.2 จะใช้การวิเคราะห์สองตัวแปรและการวิเคราะห์พหุตัวแปร

ความชุกของโรคอุจจาระร่วงเป็น 26.9% (3,785 คนจาก 14,081 คนที่เป็นโรคท้องร่วง) ในการวิเคราะห์พหุตัวแปรหลังจากการควบคุมปัจจัยอื่น ๆ เด็กจากครอบครัวที่มีฐานะค่อนข้างดีมีโอกาส 1.21 เท่าในการเกิดอาการท้องร่วง, (OR: 1.21, 95% CI: 1.037-1.423, P=0.016) เมื่อเทียบกับเด็กจากครอบครัวที่มีฐานะดีมาก เด็กที่มีน้ำหนักตัวน้อยมากมีโอกาสเกิดอาการท้องเสียได้ 1.59 เท่า (OR:1.59, 95% CI: 1.301-1.948, P <0.001) ซึ่งมากกว่าเด็กที่มีน้ำหนักปกติตามอายุที่มาจากคะแนนมาตรฐาน ความเสี่ยงต่อการเป็นโรคอุจจาระร่วงในเด็กที่ป่วยหนักน้อยกว่าเด็กที่เป็นโรคอ้วน 32%(OR: 0.68, 95% CI: 0.468-0.995, P = 0.047) เด็กอายุ 6-11 ปีและอายุ 12-23 เดือนมีความเสี่ยงต่อการเกิดอาการท้องร่วงประมาณ 2.5 เท่า (OR: 2.49, 95% CI: 2.105-2.944, P <0.001 หรือ: 2.45, 95% CI: 2.114-2.838, P <0.001 ตามลำดับ) เมื่อเทียบกับเด็กอายุ 48-59 เดือน

พบว่าปัจจัยทางโภชนาการเกี่ยวข้องกับอาการท้องร่วง รัฐบาลควรมีความพยายามอย่างต่อเนื่องในการขจัดภาวะทุพโภชนาการและความหิวโหย การสำรวจสถานการณ์เด็กในประเทศซูดาน ปี พ.ศ. 2557 ได้ก่อประโยชน์ที่มีอย่างมาก แต่ยังคงมีคำถามบางอย่างเกี่ยวกับข้อมูลบางประเภทเกี่ยวกับแหล่งที่มาหลักและการบำบัดน้ำดื่มและห้องสุขา ควรมีการศึกษาเพิ่มเติมในรูปแบบของการศึกษาระยะยาว เนื่องจากข้อมูลดังกล่าวยังไม่เพียงพอสำหรับการหาสาเหตุของโรคอุจจาระร่วงโดยใช้การศึกษาการสำรวจสถานการณ์เด็กในประเทศซูดาน ปี พ.ศ. 2557 ได้

สาขาวิชา สาธารณสุขศาสตร์ ลายมือชื่อนิสิต .....

ปีการศึกษา 2559 ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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Diarrhea is the passage of three or more loose or liquid stools per day (or feces are discharged frequently from the bowl than the normal for the person). It is a leading cause of mortality and morbidity in children under the age of five in developing countries especially in the Sub-Sahara Africa including Sudan. The aim of the study was to explore the factors associated with diarrhea among children aged under 5 years in Sudan using the 2014 Sudan Multiple Indicator Cluster Survey (MICS).

A total of 14081 children under 5 years old who had completed the survey questionnaire were considered for this study. Data was entered and cleaned using SPSS version 17. Bivariate analysis was done using Pearson's Chi square test while multivariate analysis was done using binary logistic regression with 95% CI to examine the association between the dependent and independent variables. All variables with p-value <0.2 using the bivariate analysis was included in multivariate analysis.

The prevalence of diarrhea was 26.9% (3785 children with diarrhea out of 14081). In multivariate analysis after controlling for other factors; children from the fourth wealth index quintile were 1.21 times more likely to develop diarrhea, (OR: 1.21, 95% CI: 1.037-1.423, P=0.016) than those children from the richest wealth index quintile. Children who were severely underweighted were 1.59 times more likely to develop diarrhea, (OR: 1.59, 95% CI: 1.301-1.948, P<0.001) than children who had a normal weight for age Z-score. The risk of diarrhea was 32% lower in severely wasted children, (OR: 0.68, 95% CI: 0.468-0.995, P=0.047) than those children who were obese. Children aged 6-11 and 12-23 months were about 2.5 times more at risk of getting diarrhea, (OR: 2.49, 95% CI: 2.105-2.944, P<0.001; OR: 2.45, 95% CI: 2.114-2.838, P<0.001 respectively) in comparison to children aged 48-59 months.

Nutritional factors were found to be associated with diarrhea. Continuous governmental efforts to eradicate malnutrition and hunger are recommended. The MICS 2014 of Sudan has produced much of great value. But there are some questions about certain kinds of information. Unexpected results were found regarding main source and treatment of drinking water and toilet facilities. Further studies in the form of longitudinal studies are needed as one cannot infer causality using this kind of study.

Field of Study: Public Health Student's Signature .....

Academic Year: 2016 Advisor's Signature .....

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LIST OF ABBREVATIONS

AIDS	Acquired Immune Deficiency Syndrome
CBS	Central Bureau of Statistics
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CPHS	College of Public Health Sciences
EA	Enumeration Areas
DHS	Demographic and Health Survey
HIV	Human Immunodeficiency Virus
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
SD	Standard Deviation
TOT	Training Of Trainers
UNICEF	United Nations Children's Fund
WHO	World Health Organization
UN	United Nation
NGO	Non-Governmental Organization
IQR	Inter Quartile Range
OR	Odds Ratio
SE	Standard Error
B	Beta
LSMS	Living Standards Measurement Surveys
SAM	Severe Acute Malnutrition
OCHA	Coordination of Humanitarian Affairs
GAM	Global Acute Malnutrition

CHAPTER I

INTRODUCTION

1.1 BACKGROUND

Mortality rates of Children in general and mortality of infants in particular, are usually regarded as the broad indicators in society development or as main indicators of a community health status. Reducing mortality in children by two-third is one target of Millennium Development Goal (MDG) (Gebru, Taha, & Kassahun, 2014).

Annually, nearly 1.7 billion cases of diarrheal disease occur worldwide. Killing about 760,000 children yearly, contributing equal percentile with pneumonia, diarrhea is regarded as the main contributor of mortality in these population (World Health Organization, 2013). This 1.7 billion episodes of diarrhea costs the health system about 7 billion US dollars yearly. Diarrhea remains a high burden disease despite the availability of simple, affordable, and effective treatments. The Sub-Saharan Africa and Southeast Asia are the regions with the highest rates child mortality from diarrhea (Hutton & Haller, 2004).

Globally in 2015 alone, there were a total death of 5.9 million children under the age of 5 years old. Majority of the causes of death in children are caused due to conditions that can be prevented or treated by getting access to a simple and easily affordable intervention. More than 45% of deaths in children are associated to malnutrition as underlying cause of diarrhea which makes the disease among the main causes of death in children less than five years old. The sub-Sahara African children are 14 times more at risk of dying before they reach five years in comparison to children in the developed world (World Health Organization, 2016).

Being one of the sub-Saharan Africa countries, Sudan has high prevalence rates of diarrhea and Malnutrition. In the 2000 Multiple Indicator Cluster Survey (MICS) report of Sudan, it was reported that the occurrence of diarrhea among children aged below five years was 28% just two weeks before the survey,

which differs from one state to another with 40% in Blue Nile to 19% in South Kordofan (Siziya, Muula, & Rudatsikira, 2013).

Globally, both the mortality and morbidity rates from diarrhea has dropped since the 1990s, but the overall disease burden yet remains unacceptably high, specifically in sub-Saharan African countries. In order to achieve a sustainable progress in overcoming such unmet health needs, program planning and implementation needs to be adjusted to the specific requirements and needs of a local setting (Diouf, Tabatabai, Rudolph, & Marx, 2014).

Diarrhea is the passage of three or more loose or liquid stools per day (or feces are discharged frequently from the bowl than the normal for the person). Diarrhea can be prevented and treated. Usually it is a symptom of an infection in the intestinal tract that can be caused by a variety of bacteria, virus and parasitic organisms. Infection is spread through contaminated foods or drinking-water, or from one person-to-another as a result of poor hygiene. As a result, diarrhea is a major cause of malnutrition, and malnourished children are more likely to fall ill from diarrhea (World Health Organization, 2013).

As per the WHO criteria diarrhea has three clinical forms: acute watery diarrhea – lasts several hours or days which also includes cholera; acute bloody diarrhea – also called dysentery; and persistent diarrhea – lasts 14 days or longer. (World Health Organization, 2013).

Under nutrition in children is classified in to stunting, wasting and underweight as per the anthropometric criteria which determines childhood under nutrition by assessing the anthropometric status of a child relative to a standard reference. Stunting is low height for age which indicates chronic malnutrition; wasting refers to low weight for height that indicating acute under nutrition; and underweight that refers to low weight for age which can reflects a combination of both acute and chronic under nutrition. These three forms of childhood under nutrition are determined using the Z-score. It is computed by dividing the difference between the observed value and the median reference value with the standard deviation of a reference population. The Z-score of -2 is generally considered as the

cut-off point for screening the individuals who are likely to be malnourished (World Health Organization, 1995).

Mothers' demographic factors have shown to be related with diarrhea in children. Children with young mothers have increased incidence or prevalence of diarrhea (Melo et al., 2008). Children which are born; in rural areas, households with low income, or from mothers denied of basic education are at greater risk of dying before age five (World Health Organization, 2016). Child demographic factors including the child age and sex status plays a great role in determining child risk to diarrhea (Bani, Saeed, & Al Othman, 2002).

1.2 RATIONALE

Like all the sub-Sahara Africa countries, Sudan has high burden of both morbidity and mortality rates of diarrhea in children under 5 years of age compared to other age groups as reported by the MICS surveys. In a national level there is limited information regarding the causes/risk factors of diarrhea in children aged less than 5 years old. The reports of Sudan Multiple Indicator Cluster Survey (MICS) are usually based on limited analysis of collected data, usually done by a cross sectional studies at hospital based or a smaller community based, which leaves out a lot of important information existing in the data (Siziya et al., 2013).

To improve the diarrhoea situation in Sudan, factors that are associated with diarrhoea must be identified and addressed at all levels of the community, hence this study. In this study further analysis of the MICS data will be done to further explore the factors associated with diarrhea in children aged less than 5 years. This study will provide a broader framework that includes individual, household and community factors to enhance our understanding of a range of factors influencing diarrhoea at various levels. This study will have paramount importance to address the issue of diarrhoea among children less than 5 years old in order to generate the relevant scientific approaches towards the reduction of diarrhoea morbidity and mortality and the achievement of Millennium Development Goal in Sudan.The results of this study will also be helpful in making recommendations to public health

policy makers of the sub-Saharan Africa in achieving the target of Millennium Development Goal to address diarrhea. The outcome of this study will also serve as a baseline for further studies.

1.3 RESEARCH QUESTION

What are the factors that are significantly associated with diarrhea in children less than 5 years old in the 2014 Multiple Indicator Cluster survey of Sudan?

1.4 STUDY OBJECTIVES

1.4.1 GENERAL OBJECTIVE

To find out the factors that are significantly associated with diarrhea among children aged under five years in Sudan using the 2014 Multiple Indicator Cluster survey of Sudan.

1.4.2 SPECIFIC OBJECTIVES

1. To find the association between household socio-demographic factors and diarrhea in children under five years old in Sudan using the 2014 Multiple Indicator Cluster survey.
2. To explore the association between maternal socio-demographic factors and diarrhea in children under five years old in Sudan using the 2014 Multiple Indicator Cluster survey.
3. To explore the association between demographic factors of the children and diarrhea in children under five years old in Sudan using the 2014 Multiple Indicator Cluster survey.
4. To explore the association between nutritional status and diarrhea in children aged under five years old in Sudan using the 2014 Multiple Indicator Cluster survey.

1.5 STATISTICAL HYPOTHESES (NULL HYPOTHESES)

1. There is no association between household socio-demographic factors and diarrhea in children under 5 years old in the 2014 Multiple Indicator Cluster Survey of Sudan.

2. There is no association between maternal socio-demographic factors and diarrhea in children under 5 years old in the 2014 Multiple Indicator Cluster Survey of Sudan.
3. There is no association between child's demographic factors and diarrhea in children under 5 years old in the 2014 Multiple Indicator Cluster Survey of Sudan.
4. There is no association between nutritional status and diarrhea in children less than 5 years old in the 2014 Multiple Indicator Cluster Survey of Sudan.

1.6 CONCEPTUAL FRAMEWORK

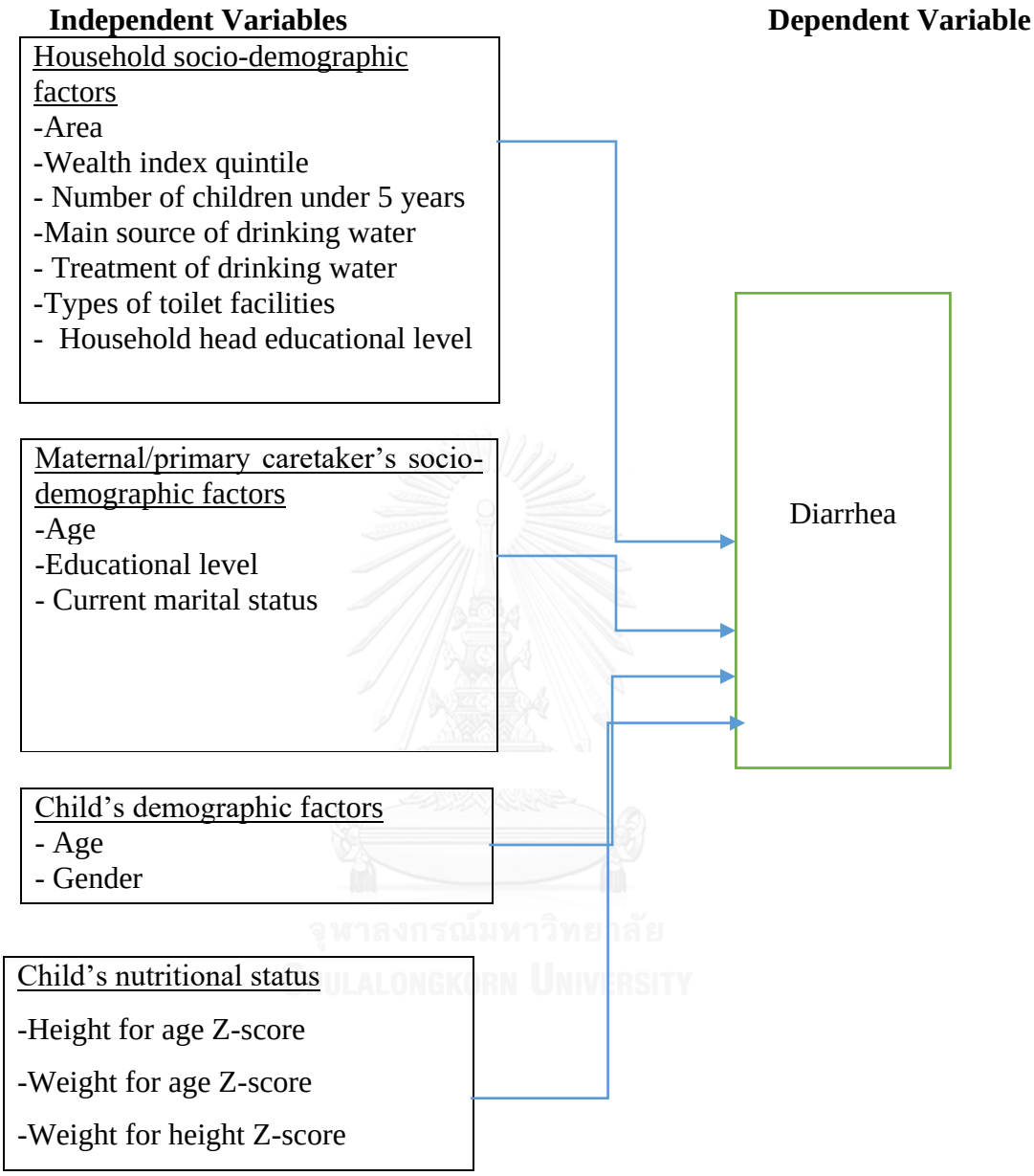

Figure 1: Conceptual framework

1.7 OPERATIONAL DEFINITIONS

The operational definition of the variables in this study are mainly defined based on the UNICEF Multiple Indicator Cluster Survey (MICS) definitions and Central Bureau of Statistics (CBS) Sudan in collaboration with the Ministry of Health, 2014.

a. Area refers to the location of a household. It is classified as either urban or rural.
b. Household wealth index refers to the economic level of the household. The households were classified as poorest, second, middle, forth and richest. It is a compound indicator of wealth based on UNICEF. It is widely used in all MICS surveys. It is calculated based on information of the ownership of certain assets, materials used for household construction, having electricity, access to drinking water and nature of sanitation facilities in a household.
c. Number of children under 5 years refers to all children in the household who were less than five years old during the survey.
d. Main source of drinking water. Classified as improved and unimproved drinking water supply. The population using improved sources of drinking water are those using any of the following types of supply: piped water (into dwelling, compound, yard or plot, to neighbor, public tap/standpipe), tube well/borehole, protected well, and protected spring. Bottled water was considered as an improved water source only if the household is using an improved water source for hand washing and cooking. Unimproved drinking water supply included unprotected well, unprotected spring, unfiltered rainwater collection and tanker truck from unprotected source and bottled water.
e. Treatment of drinking water refers to whether the household treats water to make it safe to drink. It is classified as yes or no. Water for drinking was considered treated when the following procedures of treatment were followed: boiling, adding bleach or chlorine, solar

disinfection, Use water filter. Water Strained through a cloth, Let it stand and settle and using other methods were considered untreated.

f. Type of toilet facility was classified as improved or unimproved sanitation facility. Improved facilities included flush// pour flush connected to a sewage system, septic tanks or pit latrines; and pit latrines with slabs. Unimproved facilities included use of flush / pour flush to rivers or canals, pit latrines without slabs or no facilities (use bush or field).
g. Educational level of the head of household refers to the highest level of school joined by the head of household. It could be none, primary, secondary+.
h. Age: Age of the mother/caretaker refers to completed years at last birthday before the interview.
i. Level of education: refers to the highest level of education completed; classified as none, primary, secondary+.
j. Current marital status is classified as never married/in union, currently married/ in union or formerly married/in union of the mother/caretaker.
k. Child's age refers to age in completed months.
l. Gender refers to either male or female.
m. Weight for age z-score is a nutritional status indicator of weight and age of a child expressed in standard deviations from the median of CDC reference population. It is classified as less than -2 standard deviations (underweight) and -2 or more standard deviations.
n. Height for age z-score is a nutritional status indicator of height and age of a child expressed in standard deviations from the median of CDC reference population. It is classified as less than -2 standard deviations (stunted) and
   -2 or more standard deviations.
o. Weight for height z-score is a nutritional status indicator of weight and height of a child expressed in standard deviations from the median of CDC reference population. It is classified as less than -2

standard deviations (wasted), -2 to 2 standard deviations (normal) and more than 2 standard deviations (overweight).

p. Diarrhea is defined as the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual) or blood in stool in last two weeks as reported by the caretaker.

The Centers for Disease Control and prevention (CDC) in 2000 developed a standard growth chart after a series of national health examination surveys using anthropometric measurements. The reference population used to construct the CDC Growth Charts for children is a nationally representative samples of children aged 2-20 years for physical measurement of their weight and height. CDC promotes one set of growth charts for all racial and ethnic groups. Racial- and ethnic-specific charts are not recommended because studies support the premise that differences in growth among various racial and ethnic groups are the result of environmental rather than genetic influences. Z-score is the deviation of an individual's value from the median value of a reference population, divided by the standard deviation of the reference population (or transformed to normal distribution).

CHAPTER II

LITERATURE REVIEW

2.1 DIARRHEA

Diarrhea is the passage of three or more loose or liquid stools per day (or feces are discharged frequently from the bowl than the normal for the person). Diarrhea can be prevented and treated. Usually it is of an infection in the intestine tract that can be caused by a variety of bacteria, virus and parasitic organisms. Infection is spread through contaminated foods or drinking-water, or from one person-to-another as a result of poor hygiene. As a result, diarrhea is a major cause of malnutrition, and malnourished children are more likely to fall ill from diarrhea (World Health Organization, 2013).

2.1.1 GLOBAL MAGNITUDE AND BURDEN OF DIARRHEA

Annually, nearly 1.7 billion cases of diarrheal disease occur worldwide. Killing about 760,000 children yearly, diarrhea is regarded as the main contributor of mortality in children under 5 years. Acute watery diarrhea is the most common form of diarrhea worldwide and is among the leading causes of morbidity and mortality in children below 5 years (World Health Organization, 2013). The burden of diarrhea costs the health system about 7 billion US dollars annually (Hutton & Haller, 2004).

The fourth Millennium Development Goal (MDG 4) aims to reduce the 1990 mortality rate among under-five children by two thirds (Gebru et al., 2014). Child mortality is also closely linked to MDG 5- to improve maternal health.

2.1.2 DIARRHEA SITUATION IN SUDAN

Diarrhea continues to be a leading cause of morbidity and mortality in Sudan. Sudan's rate of child mortality, measured as the number of deaths per 1,000 live births, decreased from 106 in 2000 to 73 in 2012. However, child mortality in Sudan far exceeds the global rate of child mortality, which was 48 in 2012. Contributing to this disparity was diarrheal disease, which is a leading cause of preventable death in

Sudan. The World Health Organization estimated that diarrhea accounted for 13.1% of deaths among children under five in Sudan in a 2009 report (Li, 2014).

According to the Multiple Indicator Cluster Survey Report of 2000, 28% of children under the age of five in Sudan had experienced a diarrhea episode within the two weeks preceding the survey, which differs from one state to another with 40% in Blue Nile to 19% in South Kordofan (Siziya et al., 2013). Repeated out breaks of diarrhea is very common in Sudan according to the reports of Sudan Ministry of Health. Sudan tend to have a relatively more mortality of under-five from diarrhea in comparison to neighboring countries. According to the 2015 reports on diarrhea mortality among children under five years of age in 5 East African countries; Sudan diarrhea morality rate among under five years old was reported to be the highest which stands at 18% (Carvajal-Vélez et al., 2016).

Table 1: 2015 Estimates on diarrhea specific mortality among children under five

Country	Under five death due to diarrhea	% deaths among children 1–59 months caused by diarrhea
Sudan	9,536	**18 %**
Eritrea	694	14 %
Kenya	5,442	13 %
Uganda	7,001	12 %

Source: (Carvajal-Vélez et al., 2016).

2.2 HOUSEHOLD FACTORSASSOCIATEDWITH DIARRHEA IN CHILDREN

A study done in Latin America using a pooled data from 12 Demographic and Health Surveys (DHS) and 9 Living Standards Measurement Surveys (LSMS) showed that economic status of a household as an important determinant of diarrhea in children (Hatt & Waters, 2006).

In Dhaka, Bangladesh, a case-control study have shown that income in the uppermost quartile of the population was independently associated with 41% of risk reduction of severe diarrhea compared to the household with the lowest quartile (Mahalanabis, Faruque, Islam, & Hoque, 1996).

A study carried out in developing countries have shown that lack of access to safe drinking water is significantly associated with an increased risk of diarrhea in children (Hatt & Waters, 2006). Another similar study done in the developing world also have shown the increase in diarrheal cases in children denied of safe drinking water which greatly contributes to their mortality rate (Marino, 2007).

A cohort study of 1,314 children in Guinea-Bissau showed that the use of water from unprotected public water supply for drinking purpose was independently associated with an increased risk of diarrhea among those children (Mølbak, Jensen, & Aaby, 1997).

A survey done in east Africa revealed that there is an increased risk of diarrhea in children whenever there is poor hygienic practices and childcare. The study also pointed out that there exists an association between educational level of the household head and diarrhea in children (Tumwine et al., 2002).

A cross sectional study carried out in Egypt showed that children residing in rural area are at higher risk of diarrhea in comparison to those who live in urban (El Gilany & Hammad, 2005).

The use of quality water for drink purpose, the quality of the environment in which the children lived, the child caregiver knowledge about safe source of water and type of container use for the storage of water were found to be significant According to a cross sectional study on determinants of diarrhea in children in Sub-Saharan Africa (Tambe, Nzefa, & Nicoline, 2015).

A study on determinants of diarrhea among 900 children younger than 5 years done in Ethiopia using the 2011 DHS study revealed that having more than two under five children, absence of toilet facility, low level of maternal education and age of a child to be significantly associated with an increased risk of diarrhea. Children

from those households who had no toilet facility were found to be about six times more likelihood to have diarrhea than children from households who had toilet facility. Being the second or third child was also found to have about three times more likelihood to have diarrhea compared to being the first child (Mihrete, Alemie, & Teferra, 2014).

In this research study household socio-demographic factors namely; area, wealth index quintile, number of children under five years in the household, main source of drinking water, treatment of drinking water, types of toilet facilities and household head educational level were taken into consideration to see their association with diarrhea in children less than five years in Sudan.

2.3 MATERNAL/CARETAKER'S FACTORS ASSOCIATED WITH DIARRHEA IN CHILDREN

In previous studies maternal and caretaker's socio-demographic factors have shown to be associated with increased risk of diarrhea in children. A cross sectional study carried out among 250 children in Saudi Arabia showed an increased diarrhea prevalence in those children with young mothers, in children who were not under the care of their mothers (Bani et al., 2002). High incidence of diarrhea in children with young mothers was reported in a cohort study done in Brazil (Melo et al., 2008).

A study done in Latin America demonstrated that children whose mothers have advanced educations are at significantly diminished risk of diarrhea, compared with children whose mothers have no education (Hatt & Waters, 2006). Lack of education of the mother was associated with increased risk of diarrhea in children was shown in a study done in Guinea-Bissau (Mølbak et al., 1997).

Age, educational level and current marital status of the mother/ female primary caretaker were the variables of interest of this study.

2.4 CHILD DEMOGRAPHIC FACTORS ASSOCIATED WITH DIARRHEA IN CHILDREN

Many factors are believed to be associated with diarrhea in children under 5 years old. Age, and gender of a child are among factors that can determine child's susceptibility to diarrhea (Bani et al., 2002).

Gender of a child was shown to have association with diarrhea; where male children were shown to have more diarrheal episodes than their female counterparts (Melo et al., 2008).

A MICS study done in Thailand found out that child's gender was significantly associated with diarrhea in children less than 5 years old after adjusting for confounders; were male children were more likely to suffer from diarrhea in comparison to their female counterparts (Wilunda & Panza, 2009).

Among the child demographic factors associated with diarrhea; age and gender of a child were the variables considered for this study purpose.

2.5 MALNUTRITION SITUATION IN SUDAN

One million children in Sudan under the age of five suffer from acute malnutrition. Some 550,000 among them are severely malnourished and at risk of dying. Another two million are stunted owing to chronic malnutrition. Of Sudan's 184 localities, 53 have severe acute malnutrition (SAM) rates that are classified as 'very critical' (above three percent), the UN Office for the Coordination of Humanitarian Affairs (OCHA) in Sudan reports in its latest weekly bulletin. The highest SAM rates measured are above 20 percent, and are found in three localities in South Darfur and Red Sea states. Most of the children with SAM are found in North Darfur, El Gezira, South Darfur, Khartoum and El Gedaref. These five states carry 51 percent of the national SAM burden. A S3M (Simple Spatial Survey Methodology used to collect data on child malnutrition) survey conducted by Unicef in 2013 revealed that 128 of the 184 localities in Sudan have a stunting rate classified as 'high' (above 30 percent). Moreover, there are pockets of very high stunting rates, found mostly in the eastern states of Red Sea, Kassala and El Gedaref, with the highest being El Gedaref at 73

percent. This results in an average global acute malnutrition (GAM) rate of 16.3 percent, which is above the 15 percent threshold that constitutes a critical emergency. In several localities across the country, however, the GAM rate is alarmingly higher. In Red Sea state, Toker locality has a GAM rate as high as 46.7 percent, and in Agig locality it constitutes 37.4 percent. Among the Darfur states, the poorest nutrition levels were observed in North Darfur, where El Sereif, Alliet, Dar El Salam, and Kalamindo localities have GAM rates above 25 percent. Ongoing conflict, displacement and food insecurity continue to fuel and exacerbate the diarrhea situation(UN, 2015).

2.6 MEASURING UNDER NUTRITION IN CHILDREN USING THE THREE PARAMETERS

Under nutrition in children is classified in to stunting, wasting and underweight as per the anthropometric criteria which determines childhood under nutrition by assessing the anthropometric status of a child relative to a standard reference. Stunting is low height for age which indicates chronic malnutrition; wasting refers to low weight for height that indicates acute under nutrition; and underweight that refers to low weight for age which can reflects a combination of both acute and chronic under nutrition. These three forms of childhood under nutrition are determined using the Z-score. It is computed by dividing the difference between the observed value and the median reference value with the standard deviation of a reference population. The Z-score of -2 is generally considered as the cut-off point for screening the individuals who are likely to be malnourished. The Z-score system is suitable for population use because it is possible to compute summary statistics like the mean and standard deviation. Besides the Z-score system of anthropometry, there is a percentile system which refers to the position of an individual on a given reference distribution. Percentiles are commonly used in clinical setting because their interpretation is straight forward. It is however inappropriate to compute summary statistics with percentiles (World Health Organization, 1995).

2.7 CHILD NUTRITIONAL STATUS ASSOCIATED WITH DIARRHEA IN CHILDREN

Malnutrition especially in children under 5 is both a risk factor and consequence of diarrhea. Most mortality related to diarrhea occurs in low income countries, and the highest rates of diarrhea occur among malnourished children (Black, Morris, & Bryce, 2003). Malnutrition in under 5 years of age children is a global health problem especially in many low income countries, and is associated with high morbidity and mortality in these age group. In Unmatched case-control study done in Bangladesh, among 6881 severely malnourished under 5 children hospitalized for diarrhea, severely underweight children were found to be older than 11 months, mother without any education, with poor toilet sanitation at home and had history of diarrhea (Chisti et al., 2007).

In a cross sectional study carried out in South Africa among 868 children aged between 3 months and 59 months showed that level of education of the mother and presence of a toilet were significantly associated with underweight for age (Chopra, 2003).

A cross-sectional study of 131 children aged 30 to 80 months to determine socio-demographic and environmental factors associated with stunting in Guatemalan showed that child stunning to be related with the educational level of primary caretakers and size of a household (Sereebutra, Solomons, Aliyu, & Jolly, 2006).

Under nutrition continues to be the primary cause of ill-health and premature mortality among children in the African region. Under nutrition has been identified as an underlying cause of an estimated 53% of all deaths in children younger than age 5 years. The rough estimation of Under nutrition as an underlying cause of diarrhea is about 61%(Bryce, Boschi-Pinto, Shibuya, Black, & Group, 2005).

Severe stunting was significantly associated with increased mortality hazards compared with the reference category (O'Neill, Fitzgerald, Briend, & Van den Broeck, 2012). Overall, 52.5% of all deaths in young children are attributable to under

nutrition, which stands at 60.7% because of diarrhea (Caulfield, de Onis, Blössner, & Black, 2004).

The height for age z-score, weight for age z-score and weight for height z-score which are measures of stunting, underweight and wasted respectively that assess under nutrition in children were the variables considered to be associated with diarrhea in children under five years of age.

CHAPTER III

METHODOLOGY

This study used secondary data from the Sudan MICS that was conducted in 2014 by the CBS Sudan in collaboration with the Ministry of Health as part of the global MICS programme. UNICEF coordinated the technical and financial support of the survey. The datasets for this secondary study were obtained by requesting the official website of UNICEF that deals with global MICS through an email online at, http://mics.unicef.org/surveys .

3.1 STUDY DESIGN

The primary data was collected at a nationwide survey through a cross-sectional study design. This research study was done using the analysis of a secondary data of Sudan MICS 2014.

3.2 STUDY AREA

Through survey a nationwide data has been collected from rural and urban areas of the eighteen states of Sudan.

3.3 STUDY POPULATION

The study population of this research was children who were under five years of age during Sudan MICS 2014. Of the total 14,751 children under five years who were eligible for the survey, 14,081 children who completed the survey questionnaire were the study population of this research study.

3.4 SCOPE OF STUDY

This study covered all the 18 states. It include both urban and rural parts of these states. Datasets collected at a national level was utilized to explore the association of several factors with diarrhea in children.

3.5 SAMPLING TECHNIQUE

For the primary data collection purpose, from the 18 States of Sudan for the purpose of producing States level estimation with a moderate precision, a minimum of 40 enumeration areas (EAs) were selected in each State, resulting in a sample that was not self-weighting. The urban and rural areas within each state were identified as the main sampling strata and the sample was selected in two stages. In the first stage, within each stratum, a specified number of EAs were selected systematically with probability proportional to size. In the second stage, after a household listing was carried out within the selected enumeration areas, a systematic sample of 25 households was drawn in each selected EA. All of the selected EAs were visited during the fieldwork period. The sample was thus stratified by state and then by urban / rural areas.

3.6 SAMPLE SIZE

In the 2014 Sudan Multiple Indicator Cluster Survey, of the total 18,000 households selected in the sample, 17,142 were found to be occupied. Of these, 16,801 households were successfully interviewed. In the interviewed households, 14,751 children under the age of five years were listed in the household questionnaires. Questionnaires were completed for 14,081 of these children. In the MICS study Children under 5 years of age were 15.2% of the total study population of the survey (97,049).

3.7 MEASUREMENT TOOLS

Three types of questionnaires were used in the survey (part of all of the 3 questionnaires were used for this study) :

1) A household questionnaire was used to collect information on all de jure household members, the household, and the dwelling;

2) A women’s questionnaire administered in each household to all women aged 15-49 years; and

3) An under-5 questionnaire, administered to mothers or caretakers of all children under 5 years living in the household. Questionnaire was adapted from the generic English MICS Model questionnaire. The questionnaire was translated into Arabic.

The questionnaires included the following:

Household Questionnaire, including the following modules:

1. Household Information Panel 2. List of Household Members 3. Education
4. Water and Sanitation

Individual Women questionnaire, including the following modules:

1. Woman's Information Panel 2. Woman's Background

Children under Five questionnaire, including the following modules:

1. Under Five Child Information Panel 2.Age 3. Care of Illness 4. Anthropometry

3.8 DATA COLLECTION

For the purpose of the primary data collection, these activities were carried out. Training of Trainers (TOT) was conducted in Khartoum, the capital city of Sudan, during the period 24th May 2014 – 5th June 2014. 18 State directors, 18 National Supervisor, 54 team supervisor and 18 measurers from Ministry of Health attended the TOT. Training of interviewers and measurers was conducted in the States the period 8th -17th July 2014. Pre-test conducted in Khartoum states covering two clusters urban/ rural with one day workshop convened for questionnaire finalization. The exercise was to test the language, the clarity of questions, coding, skipping, the translation, test areas of senility and the overall do-ability within the country context and specifics.

Overall, there were 54 teams for the 18 States. Each team consist of 6 members: 3 female interviewers, one supervisor, one editor and one measures. Therefore, the total field staff were 54 teams 6 members for each team. Each State was supported with the State CBS director and the National state supervisor (Central Bureau of Statistics (CBS), 2016).

In the 2014 Sudan MICS six SPSS data files were produced, (households, household members, women in reproductive age (15-49 years of age), Birth history, Female genital mutilation/cutting and mothers or primary caretakers of children under the age of five).

The fieldwork began in August 2014 and concluded in November 2014.

3.9 INCLUSION AND EXCLUSION CRITERIA

All children below 5 years old who completed the survey questionnaire were included in the study. Children whose data on important variables was missed were excluded from analysis.

3.10 DATA ANALYSIS

In the 2014 Sudan MICS six SPSS data files were produced, (households, household members, women in reproductive age (15-49 years of age), Birth history, Female genital mutilation/cutting and mothers or primary caretakers of children under the age of five). For the purpose of this research study, only the three datasets namely households, women in reproductive age (15-49 years of age), and mothers or female primary caretakers of children under the age of five were used. Most of the independent variables and the dependent variable i.e. diarrhea were available in the dataset of children recorded or computed after the survey. Other variables of interest which were not included in the dataset of children under 5 years old were added to the dataset of the children by merging the two datasets. The cluster number, the household number and individual line number (child/women) was used to merge the variables of interest from other datasets. This was done by creating a unique identification number common to both datasets.

Frequencies and percentages (mean and SD where applicable) were calculated for data on each variable and bivariate data analysis was done by using Pearson's Chi-square to identify the relationship between dependent and independent variables. Multivariate analysis was computed using binary logistic regression to find the adjusted odds ratio and was reported by p-values and 95% CI. All variables which

were found to be statistically significant (p=0.05) using the bivariate analysis were included in multivariate analysis. Variables with p-values less than 0.2 by bivariate analysis was also included in multivariate analysis. Logistic regression analysis was employed to formulate a model that predicts the probability of a child less than 5 years will suffer from diarrhea. P-value less than 0.05 was considered as statistical significant. Statistical Package for the Social Sciences SPSS version 16 licensed for CPHS Chulalongkorn University.

3.11 ETHICAL CONSIDERATION

The study protocol was submitted to and got ethical approval from the Ethics Review Committee for Research Involving Human Research Subjects, Health Science Group, Chulalongkorn University.

3.12 BENEFICIARIES

Since Diarrhea is the leading cause of morbidity and mortality in Sub-Saharan Africa region, identifying the factors associated with Diarrhea can contribute in preventing/controlling the problem in children aged less than 5. The results of this study could contribute in the efforts of achieving the target of the Millennium Development Goals of this particular disease. The findings of this study will be reported to UNICEF for their knowledge and further actions.

3.13 STUDY PERIOD

The primary study was carried out from August 2014 to November 2014. This secondary data study was conducted between January 2017 and July 2017.

CHAPTER IV

RESULTS

This chapter presents the findings of the study under the following parts:

The general descriptive characteristics of the:

4.1.1 Household socio-demographic factors of children less than five years old in Sudan.

4.1.2 Maternal/caregivers socio-demographic factors of respondents for children under five years.

4.1.3 Socio-demographic factors of children under age five

4.1.4 Nutritional status of children under 5 years old.

4.1.5 Prevalence of diarrhea among under 5 years old.

4.2 Bivariate analysis of factors associated with diarrhea in children aged less than 5 years using Pearson's chi square test

4.3 Multivariate analysis of factors associated with diarrhea in children aged less than 5 years using binary logistic regression.

4.1 DESCRIPTIVE STATISTICS

In the 2014 MICS of Sudan from the total 14751 eligible children, a total of 14081 mothers/ caretakers (a response rate of 95.5%) of children under five years of age who completed the survey questionnaire were part of this study. The analysis data file of this study was created by merging variables from three different datasets. The datasets for women in reproductive age (15-49 years) containing age and marital status of the mother/female primary caretaker and that of household files which contained important variables of this study such as main source of drinking water, treatment of drinking water, types of toilet facilities, number of children under age five in the household and household head educational level were made to be merged into child dataset which was the main dataset of this study. In order to do so, a unique

identification variable was created and applied in the successful merging of these datasets.

4.1.1 HOUSEHOLD SOCIO-DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF CHILDREN

About 73 % of the children included in this study were from households located in the rural part of Sudan. Majority of this study population were from South Kordofan state followed by Blue Nile state with 7.8 % and 7.1% of children respectively. The Red sea state with 2.9 % and the Northern state with 3.8 % were found to have the least number of children among the Sudan states. A huge number of children (69.1 %) were from households with greater than one child. The median number of children under five years old in the households was 2 with an inter-quartile range of 1. Majority of the children in this study were from households that belong to Second 26.5 % and Poorest 23.1 % wealth index quintiles whereas only 12.8 % of the children under 5 in the study belonged to the household with richest wealth index quintile. Most of the children (61.3%) were from households that used improved water as their main source for drinking purpose. Only 25.8 % of the children belonged to the households that treat water to make it safe for drinking. Only 32.3% of the children under 5 years old were found to be from households which used improved kind of toilet facility. Majority of the children (44.4 %) were from households where the heads of the households were with no education, with significantly fewer children (23.4 %) belonged to households where the heads had completed Secondary and above education. Table 2 summarizes all the household characteristics of children who were under five years during the survey in Sudan.

Table 2: household socio-demographic and economic characteristics of children aged less than 5 years in Sudan in 2014

Characteristic	Frequency (N=14081)	%
Area		
Urban	3811	27.1
Rural	10270	72.9
State		
Northern	532	3.8
River Nile	565	4.0
Red Sea	404	2.9
Kassala	655	4.7
Gadarif	858	6.1
Khartoum	699	5.0
Gezira	800	5.7
White Nile	754	5.4
Sinnar	814	5.8
Blue Nile	1006	7.1
North Kordofan	750	5.3
South Kordofan	1092	7.8
West Kordofan	741	5.3
North Darfor	885	6.3
West Darfor	843	6.0
South Darfor	975	6.9
Central Darfor	837	5.9
East Darfor	871	6.2
Number of children under 5 in the household		
1	4352	30.9
>1	9729	69.1
Median (IQR)		2(1)

Table 2 continued: household socio-demographic and economic characteristics of children aged less than 5 years in Sudan in 2014

Characteristic	Frequency (N=14081)	%
Household wealth index quintile		
Poorest	3248	23.1
Second	3734	26.5
Middle	3088	21.9
Fourth	2212	15.7
Richest	1799	12.8
Main source of drinking water		
Improved	8625	61.3
Unimproved	5435	38.6
Missing	21	0.1
Treat water to make safe for drinking		
No	10302	73.2
Yes	3634	25.8
Missing	145	1.0
Kind of toilet facility		
Improved	4554	32.3
Unimproved	9506	67.6
Missing	21	0.1
Household head's education level		
None	6256	44.4
Primary	4409	31.3
Secondary+	3286	23.4
Missing	130	0.9

4.1.2 MATERNAL/CARETAKER'S CHARACTERISTICS OF CHILDREN

Data on age was collected for mothers/female caregivers of the child bearing age 15-49 years. The mean age of mothers/female caregivers was 29.8 years, with a standard deviation of 6.7. Mothers/ caregivers who were aged 15-19 years were 4.1% among the interviewed women in the child bearing age of 15-49 years. Majority of women (28.1 %) belonged to the age group of 25-29 years. The least proportion of mothers/caregivers belonged to the age group 45-49 with 2.5 %.

A great majority of mothers /caregivers (46.8%) had not completed any educational level while only twenty percent of mothers/caregivers had achieved their secondary and above education. Information on data regarding marital status was only collected for mothers/female caregivers of the child bearing age 15-49 years. The vast majority (94.1%) mothers/ female caretakers among this child bearing age group were found to be currently married, with the smallest proportion (0.3%) of the group

belonging to the never married category. Table 3 presents the necessary information on mothers/ caregivers socio-demographic characteristics.

Table 3: Characteristics of 15-49 years mothers/caretakers of children aged less than 5 years in Sudan in 2014

Characteristics	Frequency (N=14081)	%
Age in years		
15-19	573	4.1
20-24	2347	16.7
25-29	3954	28.1
30-34	3023	21.5
35-39	2491	17.7
40-44	959	6.7
45-49	359	2.5
Missing	375	2.7
Mean (SD)	29.76 (6.745)	
Mother/caretaker's education level		
None	6587	46.8
Primary	4666	33.1
Secondary +	2812	20.0
Missing	16	0.1
Current marital status		
Currently married	13249	94.1
Formerly married	415	2.9
Never married	41	0.3
Missing	376	2.7

4.1.3 DEMOGRAPHIC CHARACTERISTICS OF CHILDREN UNDER 5 YEARS

Using the 2014 Sudan MICS study the male total number of children under five years were slightly higher (51.1%) in comparison with their female counterparts. The mean of the children who have completed the survey questionnaire was 28.90 months resulting in a standard deviation of 17.19. Children in the age range of 0-5 months comprises eleven percent of the study population. The big majority (22.8%) of the children falls in the age group of 36-47 months with children in the age range of 6-11 months being the least proportion of children with only about 10%.

Table 4 presents the demographic characteristics of all study children who were under five years old during the Sudan survey.

Table 4: Demographic characteristics of children aged less than 5 years in Sudan in 2014

Characteristic	Frequency (N=14081)	%
Gender		
Male	7190	51.1
Female	6891	48.9
Age in months		
0-5	1543	11.0
6-11	1423	10.1
12-23	2641	18.8
24-35	2647	18.8
36-47	3217	22.8
48-59	2610	18.5
Mean (SD)	28.90 (17.118)	

4.1.4 CHARACTERISTICS OF NUTRITIONAL STATUS OF CHILDREN

Children nutritional assessment was done using the three known WHO parameters: height for age Z score, weight for age Z score and weight for height Z score. Anthropometric measurements was not taken for the whole study population. There are a relatively huge number of missing children in the three nutritional status parameters. In the Height for age Z-score there were 21.8% missing children, Weight for age Z-score 19.3% missing and in the Weight for height Z-score 11.9 % of children missed. These large missing from the primary data of these study population was due to incomplete birth rate (month and/or year) and failure to take proper measurement of height and/or weight for these children during the survey.

Given the result of the parameter height for age z score, 15.2 % of the study children had a score of z less than -3 indicating severely stunted; 15.8 % of the children registered a z score of between -3 and -2.01 which classified them as having a moderate stunting. The corresponding computed mean and standard deviation of the Z score for the parameter height for age were -1.59 and 1.71 respectively.

Considering finding of the parameter weight for age z score, 10.2 % of the study children were found to have a score of z less than -3 signaling severely underweight; whereas 17.2 % of the children had a z score of -3 to -2.01 in which satisfies the criteria

of classifying them under the moderate underweight. The mean of this Z score parameter was -1.48 and a standard deviation of 1.37.

As per the result of the measured weight for height Z score, 3.9 % of the measured children had a z score of z less than -3 (severely wasted) and 10.1 % had a z score of -3 to -2.01 which falls under the moderate waste group. 2.5 % of the children scored more than 2 which enabled them to be grouped as overweight. The mean of this Z score parameter was -0.81 and a standard deviation of 1.32. Table 5 summarizes the nutritional assessment of children based on the anthropometric measurements in Sudan.

Table 5: Nutritional status of children aged under 5 years in Sudan in 2014

Characteristic	Frequency (N=14081)	%
Height for age Z-score		
<-3	2136	15.2
-3 to -2.01	2221	15.8
≥ -2	6654	47.2
Missing	3070	21.8
Mean (SD)	-1.59(1.71)	
Weight for age Z-score		
<-3	1435	10.2
-3 to -2.01	2431	17.2
≥ -2	7501	53.3
Missing	2714	19.3
Mean (SD)	-1.48 (1.37)	
Weight for height Z-score		
<-3	544	3.9
-3 to -2.01	1421	10.1
-2 to 2	10086	71.6
> 2	351	2.5
Missing	1679	11.9
Mean (SD)	-0.81(1.32)	

4.1.5 DIARRHEA AMONG CHILDREN AGED LESS THAN 5 YEARS OLD

In the 2014 Sudan MICS, respondents for the children under five years questionnaire were asked whether their child less than 5 years had episodes of diarrhea two weeks prior to the survey. The proportion of children under 5 years of age who had an episode of diarrhea in the 2 weeks preceding the MICS survey of Sudan were about 27% as shown in table 6.

Table 6: Diarrhea in the past two weeks among children aged less than 5 years in Sudan in 2014

Characteristic	Frequency (N=14081)	%
Diarrhea		
Yes	3785	26.9
No	10296	73.1

4.2 BIVARIATE ANALYSIS OF FACTORS ASSOCIATED WITH DIARRHEA IN CHILDREN UNDER 5 YEARS IN SUDAN

In the bivariate analysis: the following factors were analyzed using Pearson chi-square to see their associations with diarrhea in children less than five years of age.

4.1.1 Association between household socio-demographic factors and diarrhea

4.1.2 Association between maternal/ primary caretaker's demographic factors and diarrhea

4.1.3 Association between child's demographic factors and diarrhea

4.1.4 Association between child's nutritional status and diarrhea

4.2.1 ASSOCIATION BETWEEN HOUSEHOLD SOCIO-DEMOGRAPHIC FACTORS AND DIARRHEA

The following household factors were found to have no statistical significant association between diarrhea in children less than 5 years old in Sudan in the period two weeks preceding the survey and:

- Area
- treating water for drinking to make it safe
- and main source of drinking water

The chi square and p values of these above listed household factors are listed below in table 7.

Table 7: Household socio-demographic factors with no statistically significant associations with diarrhea in children under 5 years in 2014

	Diarrhea in the Past two weeks			
	Yes	No		
Factor	**N (%)**	**N (%)**	**$\chi 2$**	**P value**
Area (N=14081)			1.497	0.221
Urban	1053 (27.6)	2758 (72.4)		
Rural	2732 (26.6)	7538 (73.4)		
Treat water to make safe for drinking(N=13936)			0.619	0.431
No	2757 (26.8)	7545 (73.2)		
Yes	997 (27.4)	2637 (72.6)		
Main source of drinking water (N=14060)			1.129	0.288
Improved	2291 (26.6)	6334 (73.4)		
Unimproved	1488 (27.4)	3947 (72.6)		

Table 7 shows the Household socio-demographic factors which had a significant statistical association with diarrhea in children under 5 years two weeks before the MICS survey time in Sudan.

A statistically significant association between the number of children under 5 years in the household and diarrhea among children was demonstrated (p=0.048). The rate of diarrhea in the households with one under five years old child was slightly higher (28 %) in comparison with the rate of diarrhea in households with more than one children less than 5 years (26.4%).

A significant association between the household head educational level and occurrence of diarrhea in children aged less than 5 years was shown (p= 0.014). Households in which the heads had a primary level of education showed a high proportion of diarrhea episodes (p=28.4%) while households where the heads had no education level registered a diarrhea episode of 25.9% in the period 14 days prior to the survey. Another factor that was considered to be associated with diarrhea in children under five years was household wealth index quintile. It was classified into five major categories; poorest, second, middle, fourth and richest. The information regarding the wealth index quintile in the primary data was collected by asking the participants about their housing characteristics and personal or household material assets their households own. This variable demonstrated a highly significant association (p=<0.001) with

diarrhea episodes in children aged less than five years in Sudan. Households with the fourth wealth index quintile were shown to have the highest proportion of diarrhea (30.7%) while households in the poorest wealth index quintile category showed 26.6 % prevalence of diarrhea in children less than five years in Sudan. Kind of toilet facility utilized by the households was another variable of interest of this study. Based on the information gathered by asking the mothers or primary caretakers of the children, all the mentioned toilet facilities was made to be classified into two groups; improved and unimproved toilet facilities. The kind of toilet facilities used by the households was significantly associated (p=0.033) with diarrhea in children under the age of five years in Sudan. Diarrhea rate (28 %) was reported among children from households that used improved kind of toilet facility while the rate of the diarrhea episode among children from households that had unimproved kind of toilet facility was 26.3 %.

Full information of the findings about the chi square test and p values of the above factors is presented in table 8.

Table 8: Household socio-demographic factors with statistically significant associations with diarrhea in children under 5 years in 2014

	Diarrhea in the Past two weeks			
	Yes	**No**		
Factor	**N (%)**	**N (%)**	**χ2**	**P value**
Children < 5 years in the household (N=14081)			3.927	0.048
1	1218 (28)	3134 (72)		
>1	2567 (26.4)	7162 (73.6)		
Household head's education level (N=13951)			8.568	0.014
None	1619 (25.9)	4637 (74.1)		
Primary	1252 (28.4)	3157 (71.6)		
Secondary +	871 (26.5)	2415 (73.5)		
Household wealth index quintile (N=14081)			21.52	<0.001
Poorest	865(26.6)	2383(73.4)		
Second	996 (26.7)	2738 (73.3)		
Middle	776 (25.1)	2312 (74.9)		
Fourth	678 (30.7)	1534 (69.3)		
Richest	470 (26.1)	1329 (73.9)		
Kind of toilet facility (14060)			4.526	0.033
Improved	1277 (28.0)	3277 (72.0)		
Unimproved	2504 (26.3)	7002 (73.7)		

4.2.2 Association between maternal/ primary caretaker's demographic factors and diarrhea

Age of maternal/ primary caretaker's was one of the study variables that was assumed to have association with diarrhea in children under five years in Sudan. In this study, the age of mothers or female child caretakers in the age group of 15-49 years or the child bearing age group was considered as a study variable.

Age of mother/caretaker was significantly associated (p=0.003) with diarrhea in children under 5 years in Sudan. The highest episodes of diarrhea (32.1%) were among those children whose mothers or caretakers fall in the age group of 15-19 years. The lowest rate of diarrhea (20.6%) was in children whose mothers or caretakers were in the age group of 45-49 years.

In the 2014 MICS of Sudan mother's education refers to educational attainment of mothers as well as caretakers of children under 5, who are the respondents to the under-5 questionnaire if the mother is deceased or is living elsewhere. This factor was not statistically significant (p=0.100) with diarrhea among children aged below five years in Sudan.

There was also no statistical significant association between mother current marital status (p=0.396) and diarrhea in children less than 5 years in Sudan. Table 9 provides all the details of maternal/caretaker factors and information on chi square and p values.

Table 9: Association between maternal/primary caretaker's socio-demographic factors and diarrhea in children in 2014

Factor	Diarrhea in the past two weeks		$\chi 2$	P-value
	Yes	No		
	N (%)	N (%)		
Age in years (N=13706)			20.068	0.003
15-19	184 (32.1)	389 (67.9)		
20-24	651 (27.7)	1696 (72.3)		
25-29	1109 (28.0)	2845 (72.0)		
30-34	791 (26.2)	2232(73.8)		
35-39	665 (26.7)	1826 (73.3)		
40-44	244 (25.4)	715 (74.6)		
45-49	74 (20.6)	285 (79.4)		
Mother's/caretaker's education level (N=14065)			4.614	0.100
None	1728 (26.2)	4859 (73.8)		
Primary	1307 (28.0)	3359 (72)		
Secondary +	746 (26.5)	2066 (73.5)		
Current marital status (N=13705)			1.853	0.396
Currently married	3607 (27.2)	9642 (72.8)		
Formerly married	101 (24.3)	314 (75.7)		
Never married	10 (24.4)	31 (75.6)		

4.2.3 Association between child's demographic factors and diarrhea

There existed no significant association between the children gender and episode of diarrhea among these population (p=0.145). Male children showed a higher period prevalence of diarrhea (27.4%) than their female counterparts (26.3%) over the two weeks period.

There was a strong significant association between the children age in months and the existence of diarrhea among the study population (p<0.001). Children in the age group of 6-11 months and 12-23 months reported the highest diarrhea period-prevalence over a two-week time window with almost 36% while children in the age group of 48-59 months reported the lowest rate of diarrhea; 18.3%.

Table 10 provides all the information of child demographic factors and their association with diarrhea in children less than five years in Sudan.

Table 10: Association between child's demographic factors and diarrhea in children in 2014

Factor	Diarrhea in the Past two weeks		$\chi 2$	P value
	Yes	No		
	N (%)	N (%)		
Sex (N=14081)			2.123	0.145
Male	1971 (27.4)	5219 (72.6)		
Female	1814 (26.3)	5077 (73.7)		
Age in months (N=14081)			341.32	<0.001
0-5	347 (22.5)	1196 (77.5)		
6-11	508 (35.7)	915 (64.3)		
12-23	954 (36.1)	1687 (63.9)		
24-35	798 (30.1)	1849 (69.9)		
36-47	701 (21.8)	2516 (78.2)		
48-59	477 (18.3)	2133 (81.7)		

4.2.4Association between child's nutritional status and diarrhea

There existed a significant association between the height for age child nutrition assessment parameter and episodes of diarrhea in those children (p=0.002). The rate of diarrhea was higher (31.2%) in the severely stunted (z-score <-3) children followed by the moderately stunted (z-score -3 to -2.01) children with an episode of the illness (29.4%).

Both parameters of Weight for age Z-score and Weight for height Z-score had a strong statistical significant association with diarrhea in children below five years in Sudan (p<0.001).

In the weight for age Z-score nutritional assessment tool, the rate of the illness was higher in children who were severely underweight (z-score <-3) and moderately underweight (z-score -3 to -2.01) with 34% and 30.8% respectively. In the weight for height Z-score nutritional assessment tool, the rate of the illness was higher in children who were moderately wasted (z-score -3 to -2.01) and severely wasted (z-score <-3) with about 33% and 30% respectively.

Table 11: Association between nutritional status and diarrhea in children in 2014

	Diarrhea in the Past two weeks			
	Yes	No		
Factor	**N (%)**	**N (%)**	**χ2**	**P value**
Height for age Z-score (N=11011)			12.434	0.002
<-3	667(31.2)	1469(68.8)		
-3 to -2.01	652(29.4)	1569(70.6)		
≥ -2	1824(27.4)	4830(72.6)		
Weight for age Z-score (N=11367)			41.81	< 0.001
<-3	488(34.0)	947(66.0)		
-3 to -2.01	748(30.8)	1683(69.2)		
≥ -2	1990(26.5)	5511(73.5)		
Weight for height Z-score (N=12402)			22.051	< 0.001
<-3	162(29.8)	382(70.2)		
-3 to -2.01	466(32.8)	955(67.2)		
-2 to 2	2739(27.2)	7347(72.8)		
> 2	88(25.1)	263(74.9)		

4.3. Multivariate analysis

In the multivariate analysis: the following characteristics or factors were analyzed using binary logistic regression as predictors of diarrhea in children less than five years old in Sudan to formulate a set of models.

4.3.1 Modelling household socio-demographic factors associated with diarrhea

4.3.2 Modelling maternal/caretaker Socio-demographic factors associated with diarrhea

4.3.3 Modelling Child socio-demographic factors associated with diarrhea in children

4.3.4 Modeling the anthropometric measurements of nutritional status of children with diarrhea

4.3.5 Modeling both the socio-demographic factors and the anthropometric measurements of nutritional assessment of children with diarrhea

4.3.6 Multivariate analysis of factors associated with diarrhea in children under 5 years in Sudan.

4.3.1 Modelling household socio-demographic factors associated with diarrhea

All the household socio-demographic factors associated with diarrhea in children under five years old in Sudan were tested using binary logistic regression.

Among the household socio-demographic factors: area, water source, toilet facility and water treatment were not significantly associated with diarrhea.

Number of children in the household, household wealth index quintile and head of household educational level were all significantly associated with diarrhea in children under 5 years in Sudan. Number of children in the household which was classified as households with one child and with more than one child. It was significantly associated with diarrhea where children from households with only one child being about 1.1 times more likely to develop diarrhea than children from households with more than one child (p=0.023).

Wealth index quintile was significantly associated with diarrhea (p=0.002). Children whose households were from the fourth wealth index quintiles were 1.2 times more likely to develop diarrhea than those children whose households were from the richest wealth index quintile whereas children whose households were from the poorest and second wealth index quintiles were about 1.1times more likely to develop diarrhea than those children whose households were from the richest wealth index quintile.

Household head educational level was significantly associated with diarrhea (p=0.022). Children from households were the head of the house had only completed primary level of education were about 1.1 times more likely to develop diarrhea than those children from households were the head of the household had accomplished a secondary and higher level of education.

Table 12 deals with details of the socio-demographic factors associated with diarrhea in children less than 5 years old. Where all the coefficient regression (B), odd's ratio (OR) with 95% CI and p-values are listed.

Table 12: Modelling household socio-demographic factors associated with diarrhea in children less than 5 years in 2014

Variable	B	OR	95% CI Lower	Upper	P-value
Area*	0.20	1.020	0.925	1.126	0.690
Number of children β	0.094	1.099	1.013	1.192	0.023
Wealth index quintile					0.002
Poorest	0.082	1.086	.904	1.305	0.380
Second	0.067	1.069	.899	1.271	0.450
Middle	-0.031	0.969	.827	1.136	0.702
Fourth	0.218	1.244	1.076	1.439	0.003
Richest®		1			
Household head's education level					0.022
None	-0.002	.998	.894	1.113	0.969
Primary	0.112	1.119	1.004	1.247	0.042
Secondary+ ®		1			
Water source δ	-0.076	0.125	.993	1.173	0.072
Toilet facility δ	0.083	1.086	.977	1.207	0.125
Water treatment ϰ	0.013	1.013	.927	1.107	0.770
Constant	-1.121	0.326			<0.001

® Reference group *Urban compared to rural β 1 compared to more than 1, δ Improved compared to unimproved, ϰYes compared to No

4.3.2 Modelling maternal/caretaker Socio-demographic factors associated with diarrhea in children less than 5years

Maternal/caretaker Socio-demographic factors associated with diarrhea modelling in children less than 5years diarrhea was also done using binary logistic regression.

Marital status and educational level of mother/caretaker were not significantly associated with diarrhea. Mother/caretaker age was significantly associated with diarrhea. Children from households were their mothers or caretakers were at the younger age group 15-19 years had about 1.8 times more likely to develop diarrhea than those children from households were the mother/caretaker was from the oldest age group 45-49 years (p=0.005). Children in all the other age groups were also almost 1.4 times more likely to develop diarrhea than those children from households were the mother/caretaker was from the oldest age group 45-49 years.

Table 13: Modelling maternal/caretaker Socio-demographic factors associated with diarrhea in children less than 5years in 2014

			95% CI		
Variable	**B**	**OR**	**Lower**	**Upper**	**P-value**
Caretaker age					0.005
15-19	0.586	1.797	1.315	2.455	<0.001
20-24	0.378	1.460	1.111	1.918	0.007
25-29	0.393	1.481	1.135	1.933	0.004
30-34	0.298	1.347	1.029	1.763	0.030
35-39	0.329	1.389	1.059	1.823	0.018
40-44	0.268	1.308	0.974	1.756	0.074
45-49®		1			
Marital status					0.324
Currently married	0.223	1.249	0.611	2.557	0.542
Formerly married	0.062	1.064	0.503	2.251	0.870
Never married®		1			
Caretaker educational level					0.491
None	0.000	1.000	0.904	1.106	0.999
Primary	0.049	1.050	0.944	1.168	0.368
Secondary+ ®		1			
Constant	-1.570	0.208			<0.001

® Reference group

4.3.3 Modelling Child socio-demographic factors associated with diarrhea in children

Gender and age of the child as socio-demographic characteristics modelling were used with diarrhea. Gender of the child which was classified as either male or female was not significantly associated with diarrhea (p=0.15).

Age of the child had a strong significant association with diarrhea in children (p<0.001). Children aged 6-11 and 12-23 months were about 2.5 times more likely to develop diarrhea than children aged 48-59 months while those children aged less than 6 months were only about 1.3 times more likely to develop diarrhea than children aged 48-59 months.

Table 14 provides full information of the child socio-demographic factors associated with diarrhea.

Table 14: Modelling Child socio-demographic factors and diarrhea in children in 2014

			95% C.I. for EXP (B)		
Variable	**B**	**OR**	**Lower**	**Upper**	**P value**
Age of child					<0.001
<6	0.261	1.299	1.112	1.517	0.001
6-11	0.909	2.482	2.143	2.876	<0.001
11-23	0 .929	2.531	2.229	2.874	<0 .001
24-35	0.658	1.931	1.696	2.198	<0 .001
36-47	0.221	1.248	1.096	1.421	0 .001
48-59®		1			
Child gender*	0.054	1.056	0.979	1.138	0.159
Constant	-1.526	0.217			<0.001

® Reference group *Male compared to female

4.3.4 Modeling the anthropometric measurements of nutritional status of children with diarrhea

The commonly used means of children nutritional assessment for growth retardation anthropometric measurements i.e. height for age, weight for age and weight for height were used as predictors of diarrhea in multivariate analysis using the binary logistic regression.

The height for age z-score was not significantly associated with diarrhea in children under five years old in Sudan using the multivariate analysis while controlling for other factors.

Both weight for height Z-score and weight for age Z-score were significantly associated with diarrhea in children less than five years of age using the multivariate analysis as predictors for diarrhea. Weight for height Z-score was significantly associated with diarrhea (p=0.026). Children who were moderately wasted (Z-score between -3 and -2.01) were 1.2 times more likely to develop diarrhea than those children who were obese that had a weight for height Z-score > 2. Weight for age Z-score had a strong significant association (p<0.001) with diarrhea in children under 5 years. Children who were severely underweight (Z-score <-3) were about 1.5 times more likely to develop diarrhea than children who had a normal weight for age Z-score (Z-score ≥-2).

Table 15: Modeling the anthropometric measurements of nutritional status of children with diarrhea in 2014

Variable	B	OR	95% CI (EXP B) Lower	Upper	P value
Height for age Z-score					0.858
< -3	-0.040	0.960	0.825	1.118	0.601
-3 to -2.01	-0.004	0.996	0.885	1.121	0.951
≥ -2®		1			
Weight for age Z-score					<0.001
< -3	0.413	1.512	1.241	1.841	<0.001
-3 to -2.01	0.183	1.200	1.058	1.361	0.004
≥ -2®		1			
Weight for height Z-score					0.026
< -3	-0.170	0.844	0.585	1.217	0.363
-3 to -2.01	0.166	1.180	0.866	1.608	0.293
-2 to 2	0.002	1.002	0.766	1.312	0.986
> 2®		1			
Constant	-1.013	0.363			<0.001

® Reference group

4.3.5 Modeling both the socio-demographic factors and the anthropometric measurements of nutritional assessment of children with diarrhea

The socio-demographic factors(social variables) and anthropometric measurements (physical variables) for the nutritional assessment of children were included together to compare a nested models and to see how they can interact and affect each other in predicting diarrhea in children less than five years old in Sudan.

Child gender and height for age Z-score had no significant association with diarrhea. Both of these variables were also non-significant in their own set of child social variable and physical variable respectively. Weight for height Z-score although it showed a significant association with diarrhea in children under five years old (p=0.017) as a whole; when it comes to the individual dummy variables none of them were significant.

Age of a child, weight for age Z-score and weight for height Z-score were significantly associated with diarrhea in children in using the combined nested model. Age of a child and weight for age Z-score had a strong significant association (p<0.001)

with diarrhea in children less than five years old. Children in the age group of 6-23 months were having the highest risk of diarrhea with the odds of about 2.5 times more in comparison to the eldest age group of 48-59 months. Children who were severely underweighted and moderately underweighted were about 1.6 and 1.3 times more likely to get diarrhea respectively when compared with children who were normal for their weight for age.

Table 16 shows all the nested modelling for both the physical variables (nutritional status factors) and child social status (socio-demographic factors). The coefficient regression (B), OR with its CI upper and lower values and p-values are all indicated there.

Table 16: Modeling both the socio-demographic factors and the anthropometric measurements of nutritional assessment of children with diarrhea in 2014

		95% CI EXP (B)		
Variable	**B**	**OR**	**Lower**	**Upper**	**P-value**
Child gender	-0.030	0.970	0.891	1.057	0.490
Age of child					<0.001
<6	0.337	1.400	1.167	1.681	<0.001
6-11	0.938	2.554	2.168	3.009	<0.001
12-23	0.921	2.511	2.176	2.898	<0.001
24-35	0.590	1.804	1.557	2.090	<0.001
36-47	0.145	1.156	0.995	1.342	0.058
48-59®		1			
Height for age Z-score	0.009	1.009	0.935	1.089	0.823
Weight for age Z-score					<0.001
< -3	0.456	1.578	1.294	1.925	<0.001
-3 to -2.01	0.245	1.278	1.125	1.451	<0.001
≥ -2®		1			
Weight for height Z-score					0.017
< -3	-0.332	0.717	0.494	1.041	0.080
-3 to -2.01	0.068	1.071	0.782	1.467	0.670
-2 to 2	-0.017	0.983	0.748	1.292	0.902
> 2®		1			
Constant	-1.501	0.223			<0.001

® Reference group

4.3.6 Multivariate analysis of factors associated with diarrhea in children under 5 years in Sudan

Logistic regression analysis was employed to predict the probability of a child less than 5 years would suffer from the illness. All the variables that were

significantly associated with diarrhea in the bivariate analysis were included in the multivariate analysis. In addition to that, variables with $p \leq 0.2$ in the bivariate analysis were included as predictors. The variables that satisfied these criteria were: number of children < 5 years in the household, household head educational level, mother's/caretaker's education level, household wealth index quintile, kind of toilet facility, age of mother/caretaker, sex of the child, Age of child in months, height for age z-score, weight for age z-score and weight for height z-score.

Education level of household head, maternal/caretakers educational level, mother's/female caretaker's age, toilet facility, number of children in the household, gender of the child and height for age z-score were not significantly associated with diarrhea in children under five years old in Sudan using the multivariate analysis while controlling for other factors.

Weight for height Z-score, weight for age Z-score, household wealth index quintile and child's age in months were all significantly associated with diarrhea in children less than five years of age using the multivariate analysis as predictors for diarrhea after controlling for other factors.

Weight for height Z-score was significantly associated with diarrhea ($p=0.012$). Children who were severely wasted (Z-score <-3) were about 0.7 times more likely to develop diarrhea than those children who were obese (Z-score > 2). This could be due survival bias were children who were severely wasted might already be dead considering the severity of their illness. Most mortality related to diarrhea occurs in low income countries, and the highest rates of diarrhea death occur among malnourished children (Black et al., 2003).

Weight for age Z-score had a strong significant association ($p<0.001$) with diarrhea in children under 5 years. In multivariate analysis children who were severely underweight (Z-score <-3) were about 1.6 times more likely to develop diarrhea than children who had a normal weight for age Z-score (Z-score ≥-2).

Wealth index quintile was highly significantly associated with diarrhea ($p=0.001$). Children whose households were from the fourth and poorest wealth index

quintiles were 1.2 and 1.1 times more likely to develop diarrhea than those children whose households were from the richest wealth index quintile respectively.

Child's age had a highly significant association with diarrhea ($p<0.001$). Children aged 6-11 and 12-23 months were about 2.6 times more likely to develop diarrhea than children aged 48-59 months while those aged less than 6 months were only 1.4 times more likely to develop diarrhea than children aged 48-59 months.

In table 17 using those variables included in the multivariate analysis as predictors for diarrhea in children under five years old in Sudan, the researcher was able to construct a model. A model to predict that a child whose age was less than 5 years old during the survey would have diarrhea was constructed as follows:

Logit (having diarrhea) = -1.342-0.382(<-3 weight for height Z-score) + 0.040 (-3 to -2.01 weight for height Z-score) – 0.049 (-2 to 2 weight for height Z-score) + 0.465 (<-3 weight for age Z-score) + 0.247 (-3 to -2.01 weight for age Z-score) -0.006 (height for age Z-score) + 0.126 (poorest wealth index quintile) + 0.077 (Second wealth index quintile) -0.074 (Middle wealth index quintile) + 0.194 (Fourth) -0.069 (Number of children <5 in the household) +0.021 (Household head's educaton level) -0.004 (Caretaker's education level) -0.025 (Child gender) + 0.324 (< 6 Child's age in months) + 0.912 (6-11 Child's age in months) + 0.896 (12-23 Child's age in months) + 0.579 (24-35 Child's age in months) + 0.126 (36-47 Child's age in months) + 0.085 (Kind of toilet facility) -0.027 (Caretaker's age).

Table 17: Multivariate analysis of factors associated with diarrhea in children below 5 years in 2014

		Adjusted	95% CI		
Variable	**B**	**OR**	**Lower**	**Upper**	**P-Value**
Weight for height Z-score					0.012
<-3	0.382	0.683	0.468	0.995	0.047
-3 to -2.01	0.040	1.041	0.758	1.431	0.803
-2 to 2	0.049	0.952	0.723	1.254	0.728
>2®		1			
Weight for age Z-score					<0.001
< -3	0.465	1.592	1.301	1.948	<0.001
-3 to -2.01	0.247	1.28	1.125	1.458	<0.001
≥2®		1			
Height for age Z-score	-0.006	0.994	0.919	1.075	0.877
Wealth index quintile					0.001
Poorest	0.126	1.134	0.927	1.387	0.221
Second	0.077	1.081	0.892	1.307	0.431
Middle	-0.074	0.929	0.78	1.107	0.412
Fourth	0.194	1.215	1.037	1.423	0.016
Richest®		1			
Number of children <5	-0.069	0.934	0.851	1.025	0.150
Household head's education	0.021	1.021	0.956	1.091	0.529
Caretaker's education level	-0.004	0.996	0.924	1.074	0.914
Child gender	-0.025	0.975	0.895	1.063	0.572
Child age in months					<0.001
< 6	0.324	1.382	1.148	1.665	0.001
6-11	0.912	2.489	2.105	2.944	<0.001
12-23	0.896	2.449	2.114	2.838	<0.001
24-35	0.579	1.784	1.535	2.074	<0.001
36-47	0.126	1.135	0.974	1.322	0.105
48-59®		1			
Kind of toilet facility	0.085	1.089	0.969	1.224	0.153
Caretaker's age	0.027	0.974	0.943	1.005	0.101
Constant	1.342	0.261			<0.001

®Reference group

CHAPTER V

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 DISCUSSION

This research study examined various factors associated with diarrhea among children who were less than 5 years old in Sudan using the multiple indicator cluster survey (MICS) in 2014 during the period between August 2014 and November 2014.

The findings of this secondary research study will be discussed under the following major parts:

5.1.1 Prevalence of diarrhea in children under 5 years in Sudan

5.1.2 Association between household socio-demographic factors and diarrhea among the study population

5.1.3 Association between child caretakers' socio-demographic factors and diarrhea in children in Sudan

5.1.4 Association between children's demographic factors and diarrhea in children in Sudan

5.1.5 Association between children nutritional status and diarrhea in children in Sudan

5.1.1 PREVALENCE OF DIARRHEA IN CHILDREN UNDER 5 YEARS IN SUDAN

The overall prevalence of diarrhea among children less than five years old in Sudan using the 2014 SMICS was 26.9 % (3785 children with diarrhea out of 14081). The prevalence of diarrhea in Sudan had shown only a slight decrease from the Sudan reports of the Multiple Indicator Cluster Survey 2000, were 28% of children under the age of five in Sudan had experienced a diarrhea episode within the two weeks preceding

the survey (Siziya et al., 2013). This periodic prevalence of diarrhea from this study is higher than the prevalence of diarrhea among children reported from the study done in Latin America using a pooled data from 12 Demographic and Health Surveys (DHS), which reported that 16.9% of the children under five years old had developed diarrhea during the two weeks preceding the surveys (Hatt & Waters, 2006) .

The definition of a case of diarrhea in this survey, was the mother's (or caretaker's) report that the child had such symptoms over the specified period; no other evidence were sought beside the opinion
of the mother. While this approach is reasonable in the context of a MICS survey, these basically simple case definitions must be kept in mind when interpreting the results, as well as the potential for reporting and recall biases. Further, diarrhea, is not only seasonal but are also characterized by the often rapid spread of localized outbreaks from one area to another at different points in time. The timing of the survey and the location of the teams might thus considerably affect the results, which must consequently be interpreted with caution. For these reasons, although the period-prevalence over a two-week time window is reported, these data should not be used to assess the epidemiological characteristics of these diseases but rather to obtain denominators for the indicators related to use of health services and treatment (Central Bureau of Statistics (CBS), 2016).

5.1.2 ASSOCIATION BETWEEN HOUSEHOLD SOCIO-DEMOGRAPHIC FACTORS AND DIARRHEA AMONG CHILDREN LESS THAN FIVE YEARS IN SUDAN

Household socio-demographic factors can have a significant impacts on diarrhea among children less than five years old.

Wealth index quintile had a significant association with diarrhea after adjusting for other factors. This finding is consistent with several other studies which have found a significant association between household economic status and diarrhea among children (Hatt & Waters, 2006). Children from the fourth, poorest and second wealth quintile index were found to be at a greater risk of diarrhea in comparison to children whose households were from the richest wealth index quintile. Though the relation was not linear, children living in poor households can have higher diarrhea rates than their wealthier counterparts, probably due to inadequate access to sanitary

facilities, unclean/unsanitary environment in their home, poor child hygiene practices and prone to diarrhea infection due to lack of food for their normal growth patterns. Children from the middle wealth index quintile

Although a study done in Egypt found that children from rural areas were at a higher risk of developing diarrhea than their urban counterparts (El Gilany & Hammad, 2005), this study did not show a significant association between diarrhea and area (urban or rural). This could be important finding in that it might be as a result of the government lasting endeavor to close the gap between urban and rural for a better and universal outcomes in health.

It is obvious that someone would anticipate the household head educational level to have an association with diarrhea in children. However, the findings of this study failed to show such an expected association after controlling for confounding factors in the multivariate analysis. Educational level of head of household was significantly associated with diarrhea in the bivariate analysis before it completely lost its significant margin in the multivariate. This contradicts with the findings from three East African countries were they have reported an association between household head's education and diarrhea in children(Tumwine et al., 2002). Educational level of a household head can influence the socio-demographic variables and other health practices which can have an impact on morbidity in children. However this was not the case in this study.

Number of children less than five years in the household was found to have a significant association with diarrhea by bivariate analysis in this study. But after adjusting for other factors, the significance was lost in multivariate analysis. This contradicts with the finding in Thailand were they reported that number of children in the household was significantly associated with diarrhea (Wilunda & Panza, 2009).

This study did not show a significant association in both main source and treatment of drinking water with diarrhea in children aged less than five years. With 61.3 % of households get access to safe drinking water, only 25.8% of the households treat water to make it safe for drinking. Previous study done in Tanzania which was a case control study showed no association between different water sources and diarrhea

in children (Gascon et al., 2000). Water is believed to be the main media in the transmission of diarrhea. A study carried out in developing countries have shown that lack of access to safe drinking water is significantly associated with an increased risk of diarrhea in children (Hatt & Waters, 2006). Another similar study done in the developing world also have shown the increase in diarrheal cases in children denied of safe drinking water which greatly contributes to their mortality rate (Marino, 2007). Since the households that get access to safe drinking water and treat water to make it safe for drinking are unacceptably low, it was expected that these variables to be significantly associated with diarrhea. Hence this unexpected non-significant relationship needs further investigation.

Kind of toilet facility was having a significant association with diarrhea in bivariate analysis, before it lost its significance in multivariate analysis once the other variables were under control. Despite the low access to improved toilet, only 32.3% of the households in this study use improved kind of toilet facility, the variable failed to show a significant association. A study done in Ethiopia showed that children from those households who had no toilet facility were found to be about six times more likelihood to have diarrhea than children from households who had toilet facility (Mihrete et al., 2014). The use of unimproved toilet facility is related to poor hygienic practices that can lead into food and water being contaminated leading to infections in children. This might need further assessment.

5.1.3 ASSOCIATION BETWEEN CHILD CARETAKERS' SOCIO-DEMOGRAPHIC FACTORS AND DIARRHEA IN CHILDREN IN SUDAN

Child caretaker age was significantly associated with diarrhea in bivariate analysis. But it failed to maintain its significance in multivariate analysis after controlling for other variables. Caretakers include in this analysis were women who were in the child bearing age 15-49 years. Children with caretakers aged 15-19 years had the highest episodes of diarrhea (32.1%). A possible explanation for this observation is that younger mothers are less experienced in baby care. The lowest rate of diarrhea (20.6%) was in children whose mothers or caretakers were in the age group of 45-49 years that might be attributed to the gained child care experience among those aged mothers. The finding in this study is similar to a previous study which reported

High incidence of diarrhea in children with young mothers in a cohort study done in Brazil (Mølbak et al., 1997).

Maternal/caretaker educational level did not show an association with diarrhea in children, as it did not maintained its significance in the multivariate analysis similar to the household head education level. The findings from this study are in contrary to studies done in other countries which have shown that mother education is associated with diarrhea in children (Mølbak et al., 1997). Uneducated mothers or caretakers are less exposed to the importance of hygiene, better childcare and are less awareness of disease causation factors and prevention measures. With about 80% of the caretakers being without any education or have completed only primary level, it was wise thinking to expect an association but it was not in this case which might need further investigation.

Mother's marital status did not show significant association with diarrhea in children under five years in bivariate analysis. This finding was similar to a study done in Philippines (Costello, Lleno, & Jensen, 1996).

5.1.4 ASSOCIATION BETWEEN CHILDREN'S DEMOGRAPHIC FACTORS AND DIARRHEA IN CHILDREN IN SUDAN

Gender and age of a child were the children demographic factors to be associated with diarrhea in children less than five years old.

Male children were 51.1% of the survey children. Child's gender was not significantly associated with diarrhea, it had lost its significance after adjusting for confounders. The non-significant association of child's gender with diarrhea in children of this study contradicts with other studies. A MICS study done in Thailand found out that child's gender was significantly associated with diarrhea in children less than 5 years old after adjusting for confounders were male children were more likely to suffer from diarrhea in comparison to their female counterparts. They stated that it could be due to the tendency of males for greater environmental exposure than girls (Wilunda & Panza, 2009). Gender of a child was also shown to have association with diarrhea; where male children were shown to have more diarrheal episodes than their female counterparts (Melo et al., 2008).

The finding of this study showed a strong association between child's age and diarrhea in children below five years. The finding of this study showed a higher risk of the illness among children aged 6-23 months. Children in these age group were about 2.5 times more at risk of getting diarrhea in comparison to the eldest age group of 48-59 months. The explanation for this could be that Those children aged 6-23 months are subjected to an increased risk of diarrhea contamination and infection as the result of their exposure to the environment as they start to crawl and are exposed to a variety of foods where they start their complementary feeding and with the fact that their immune system is not yet well developed. Children in the age group of 24-35 and <6 months were also at a greater risk of getting diarrhea about 1.8 and 1.4 times respectively in comparison to the children in the age group of 48-59 months. Children in the age group of 36-47 months were with the lowest risk with an adjusted OR=1.1. This may be due to the fact that as children gets older, their immune system becomes well developed which results in fewer infection rates in comparison to children in the young age. This is a similar finding to that of Thailand 2008 MICS study were they reported that children aged 6-23 months were found to have a higher risk of diarrhea (Wilunda & Panza, 2009).

5.1.5 ASSOCIATION BETWEEN CHILDREN NUTRITIONAL STATUS AND DIARRHEA IN CHILDREN IN SUDAN

Under nutrition as a risk factor for diarrhea has been shown in many cohort studies (Coles et al., 2005). Since 2006, the nutritional status of children in Sudan remains as very challenging issues for child survival. The prevalence of malnutrition is still over the WHO emergency threshold of 15% (Central Bureau of Statistics (CBS), 2016).This study have shown association between the two anthropometric measurements of nutrition in children (Weight for height Z-score and Weight for age Z-score) and diarrhea in both the bivariate analysis and also after controlling for other factors in multivariate analysis. Only one indicator of nutrition (height for age Z score) did not show significant association with diarrhea in children less than five years old. The finding of this study for the significant association of the two nutritional indicators with diarrhea was as expected given that 27.4 % of children were underweight and 14% wasted. The explanation for this finding could be that children which have a retarded growth (underweight and wasted) are more prone to any

environmental exposures and diarrhea infection as they are immune compromised. The continuous influx of displaced populations and refugees represent key determinant factors for increased child malnutrition in Sudan (Central Bureau of Statistics (CBS), 2016). It is believed that diet plays a great role in building our body immune system and defense mechanism for any foreign substance. The rough estimation of Under nutrition as an underlying cause of diarrhea is about 61% (Bryce et al., 2005).

The finding of the height for age as non-significant with diarrhea was unexpected, given that 31% of children were stunted. This finding was similar to the MICS study done in Thailand were all the three indicators of nutrition were found to be not significantly associated with diarrhea in children (Wilunda & Panza, 2009). More detailed study should be done regarding this nutritional indicator.

5.2 CONCLUSION

This study found household wealth index quintile to be significantly associated with diarrhea were children in the poor, second and fourth wealth index quintiles being at a greater risk of diarrhea compared to children from the richest households. Regarding to age of a child, the highest risk of diarrhea was in children in the age group of 6-23 months. Considering the nutritional status of children, the two nutritional anthropometric measurements for underweight and wasting were significantly associated with diarrhea.

5.3 LIMITATIONS OF THE STUDY

A commonly faced problem in using secondary data for researches is the problem of data incompleteness and missing. By using this type of study one cannot infer causality. Since this study was done using data collected through a survey of cross sectional study design, only associations can be made. As diarrhea morbidity information was collected for the period two weeks preceding the survey as reported by respondents of the children under 5 questionnaires, there is a potential for recall bias.

5.4 RECOMMENDATIONS

The MICS 2014 survey of Sudan has produced much of great value. But there are some questions about certain kinds of information. Unexpected results were

found regarding main source of drinking water, treatment of drinking water and kind of toilet facilities. Special attention in prevention and care should be given to children 6-23 months as they are having the highest risk of diarrhea. The government of Sudan should be involved in a continuous efforts in eradicating malnutrition and hunger as it has been the main challenging issue in child survival and diarrhea crisis. The government of Sudan should work on keeping peace throughout the country; as the continuous ongoing conflicts are the main cause of people displacement and food insecurity which exacerbate the diarrhea situation and lead to catastrophic disease out breaks. Governments and Non-governmental organizations (NGOs) should boost the aid they provide to displaced children as they are prone to diarrhea infections and disease out breaks. Further studies, like longitudinal studies design, are needed to understand the complete dynamics of diarrhea morbidity and associated factors in children.

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APPENDIX

APPENDIX A

Ethical approval

AF 02-12

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University
Jamjuree 1 Building, 2nd Floor, Phyathai Rd., Patumwan district, Bangkok 10330, Thailand,
Tel/Fax: 0-2218-3202 E-mail: eccu@chula.ac.th

COA No. 096/2017

Certificate of Approval

Study Title No. 069/60 : FACTORS ASSOCIATED WITH DIARRHEA AMONG CHILDREN LESS THAN 5 YEARS OLD IN SUDAN: A SECONDARY ANALYSIS OF SUDAN MULTIPLE INDICATOR CLUSTER SURVERY 2014

Principal Investigator : MR. TESFIT BRHANE NETSEREAB

Place of Proposed Study/Institution : College of Public Health Sciences, Chulalongkorn University

The Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University, Thailand, has approved constituted in accordance with the International Conference on Harmonization – Good Clinical Practice (ICH-GCP).

Signature: ..... Signature: .....

(Associate Professor Prida Tasanapradit, M.D.) (Assistant Professor Nuntaree Chaichanawongsaroj, Ph.D.)

Chairman Secretary

Date of Approval : 11 May 2017 Approval Expire date : 10 May 2018

The approval documents including:

1) Research proposal
2) Researcher

Protocol No. 069/60
Date of Approval 11 MAY 2017
Approval Expire Date 10 MAY 2018

The approved investigator must comply with the following conditions:

1. *The research/project activities must end on the approval expired date of the Research Ethics Review Committee for Research Involving Human Research Participants, Health Sciences Group, Chulalongkorn University (RECCU). In case the research/project is unable to complete within that date, the project extension can be applied one month prior to the RECCU approval expired date.*
2. *Strictly conduct the research/project activities as written in the proposal.*
3. *Using only the documents that bearing the RECCU's seal of approval with the subjects/volunteers (including subject information sheet, consent form, invitation letter for project/research participation (if available).*
4. *Report to the RECCU for any serious adverse events within 5 working days*
5. *Report to the RECCU for any change of the research/project activities prior to conduct the activities.*
6. *Final report (AF 03-12) and abstract is required for a one year (or less) research/project and report within 30 days after the completion of the research/project. For thesis, abstract is required and report within 30 days after the completion of the research/project.*
7. *Annual progress report is needed for a two- year (or more) research/project and submit the progress report before the expire date of certificate. After the completion of the research/project processes as No. 6.*

APPENDIX B

QUESTIONNAIRES USED IN THIS RESEARCH STUDY FROM THE SURVEY

Sudan questionnaire for children under five, 2014

Sudan Multiple Indicator Survey 2014

under-five child information panel	**uf**
This questionnaire is to be administered to all mothers or caretakers (see Household Listing Form, column HL9) who care for a child that lives with them and is under the age of 5 years (see Household Listing Form, column HL6).	
UF1. Cluster number: ___ ___ ___	UF2. Household number: ___ ___
UF3. Child's name: Name _____	UF4. Child's line number: ___ ___
UF5. Mother's / Caretaker's name: Name _____	UF6. Mother's / Caretaker's line number: ___ ___
UF7. Interviewer name and number:	UF8. Day / Month / Year of interview:

Name _____ ___ ___	___ ___ / ___ ___ / ___ ___ ___ ___

AGE		AG
AG1. NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT THE DEVELOPMENT AND HEALTH OF (*name*). ON WHAT DAY, MONTH AND YEAR WAS (*name*) BORN? *Probe:* WHAT IS HIS / HER BIRTHDAY? *If the mother/caretaker knows the exact birth date, also enter the day; otherwise, circle 98 for day.* *Month and year must be recorded.*	Date of birth Day ..... __ DK day ..... 98 Month ..... __ Year ..... 2 0 __	
AG2. HOW OLD IS (*name*)? *Probe:* HOW OLD WAS (*name*) AT HIS / HER LAST BIRTHDAY? *Record age in completed years.* *Record '0' if less than 1 year.* *Compare and correct AG1 and/or AG2 if inconsistent.*	Age (in completed years) ..... _	

CARE OF ILLNESS MODULE		CA
CA1. IN THE LAST TWO WEEKS, HAS (*name*) HAD DIARRHOEA?	Yes ..... 1 No 2	2⇨CA7

ANTHROPOMETRY MODULE		AN
After questionnaires for all children are complete, the measurer weighs and measures each child. Record weight and length/height below, taking care to record the measurements on the correct questionnaire for each child. Check the child's name and line number in the List of Household Members before recording measurements.		
AN1. *Measurer's name and number:*	Name_____ __ __	
AN2. *Result of height / length and weight measurement:*	Either or both measured.....1	
	Child not present.....2	2⇨AN6
	Child or mother/caretaker refused.....3	3⇨AN6
	Other (*specify*) _____ 6	6⇨AN6
AN3. *Child's weight:*	Kilograms (kg).....__.__	
	Weight not measured.....99.9	⇨AN3B
AN4. *Child's length or height:*	Length / Height (cm).....___._	
	Length / Height not measured.....999.9	⇨AN4B

MICS

HOUSEHOLD QUESTIONNAIRE

Sudan Multiple Indicator Survey 2014

HOUSEHOLD INFORMATION PANEL	HH
HH0.state code **HH1**. Cluster number: __ __	**HH2**. Household number: __ __
HH3. Interviewer's name and number: Name _____ __ __	**HH4**. Supervisor's name and number: Name _____ __ __
HH5. Day / Month / Year of interview: __ __/__ __/ 2014 **HH6**. AREA: Urban..... 1 Rural..... 2	

WE ARE FROM THE ***Central Bureau of Statistics***. WE ARE CONDUCTING A SURVEY ABOUT THE SITUATION OF CHILDREN, FAMILIES AND HOUSEHOLDS. I WOULD LIKE TO TALK TO YOU ABOUT THESE SUBJECTS. THE INTERVIEW WILL TAKE ABOUT *35* MINUTES. ALL THE INFORMATION WE OBTAIN WILL REMAIN STRICTLY CONFIDENTIAL AND ANONYMOUS. MAY I START NOW?

☐ *Yes, permission is given ⇨ Go to HH18 to record the time and then begin the interview.*

☐ *No, permission is not given ⇨ Circle 04 in HH9. Discuss this result with your supervisor.*

WS8. WHAT KIND OF TOILET FACILITY DO MEMBERS OF YOUR HOUSEHOLD USUALLY USE? *If "flush" or "pour flush", probe:* WHERE DOES IT FLUSH TO? *If not possible to determine, ask permission to observe the facility.*	Flush / Pour flush Flush to piped sewer system 11 Flush to septic tank 12 Flush to pit (latrine) 13 Flush to somewhere else 14 Flush to unknown place / Not sure / DK where 15 Pit latrine Ventilated Improved Pit latrine (VIP) 21 Pit latrine with slab 22 Pit latrine without slab / Open pit 23	
	Composting toilet 31 Bucket 41 No facility, Bush, Field 95 Other (*specify*) _____ 96	

WATER AND SANITATION			WS
WS1. WHAT IS THE MAIN SOURCE OF DRINKING WATER FOR MEMBERS OF YOUR HOUSEHOLD?	Piped water		
	Piped into dwelling	11	11⇨WS6
	Piped into compound, yard or plot	12	12⇨WS6
	Piped to neighbour	13	13⇨WS6
	Public tap / standpipe	14	14⇨WS3
	Elevated tank, handpump (Kharjaka)	15	15⇨WS3
	Dug well		31⇨WS3
	Protected well	31	32⇨WS3
	Unprotected well	32	
	Water from spring		
	Protected spring	41	41⇨WS3
	Unprotected spring	42	42⇨WS3
	Surface water (river, stream, dam, hafeer, lake, pond, canal, irrigation channel) filtered	52	52⇨WS3
	Surface water (river, stream, dam, hafeer, lake, pond, canal, irrigation channel) unfiltered	53	53⇨WS3
	Tanker-truck/ Cart with tank		
	Transported from sources (11, 12,13, 14, 15,31, 41,52)	61	61⇨WS3
	Transported from sources (32, 42, 53)	62	62⇨WS3
	Unknown source	63	63⇨WS3
	Bottled water	91	96⇨WS3
	Other (*specify*)	96	

HOUSEHOLD CHARACTERISTICS	
HC2. HOW MANY ROOMS IN THIS HOUSEHOLD ARE USED FOR SLEEPING?	Number of rooms __ __
HC3. *Main material of the dwelling floor.* *Record observation.*	Natural floor Earth / Sand 11 Dung 12 Rudimentary floor Wood planks 21 Ganaa (Palm / Bamboo) 22 Finished floor Parquet or polished wood 31 Vinyl or asphalt strips 32 Ceramic tiles 33 Cement/ Dafra (bricks+cement) 34 Carpet 35 Concrete 36 Marble.....37 Other (*specify*) _____ 96
HC4. *Main material of the roof.* *Record observation.*	Natural roofing No Roof 11 Thatch / Palm leaf 12 Sod 13 Rudimentary roofing Rustic mat 21 Ganaa (Palm / Bamboo) 22 Wood planks 23 Cardboard 24 Traditional roof (mat+wood planks) 25 Finished roofing Metal / Tin (Zinc) 31

QUESTIONNAIRE FOR INDIVIDUAL WOMEN

MICS

Sudan Multiple Indicator Survey 2014

WOMAN'S INFORMATION PANEL WM	
This questionnaire is to be administered to all women age 15 through 49 (see List of Household Members, column HL7). A separate questionnaire should be used for each eligible woman.	
WM0 State code	
WM1. Cluster number:	**WM2**. Household number:
WM3. Woman's name: Name	**WM4**. Woman's line number:
WM5. Interviewer's name and number:	**WM6**. Day / Month / Year of interview: __/__/__

MARRIAGE		**MA**
MA1. ARE YOU CURRENTLY MARRIED?	Yes, currently married.. 1 Not currently married ... 2	2¢MA5
MA2. HOW OLD IS YOUR HUSBAND? *Probe*: HOW OLD WAS YOUR HUSBAND LAST BIRTHDAY?	Age in years ..... . DK 98	
MA3. BESIDES YOURSELF, DOES YOUR HAVE ANY OTHER WIVES?	Yes ..... 1 No..... 2	2¢MA7
MA4. HOW MANY OTHER WIVES DOES HE CURRENTLY?	Number .... DK 98	¢MA7 98¢MA7

MA5. HAVE YOU EVER BEEN MARRIED?	Yes, formerly married... 1 No..... 2	2¢FGM module
MA6. WHAT IS YOUR MARITAL STATUS YOU WIDOWED, DIVORCED OR SEPARATED?	Widowed..... 1 Divorced ..... 2 Separated..... 3	
MA7. HAVE YOU BEEN MARRIED ONLY ONCE OR MORE THAN ONCE?	Only once ..... 1 More than once 2	1¢MA8A 2¢MA8B
	DK year 9998	

WOMAN'S BACKGROUND		W
WB1. IN WHAT MONTH AND YEAR WERE YOU BORN?	Date of birth Month ..... DK month ..... 98 Year ..... DK year 9998	
WB2. HOW OLD ARE YOU? *Probe:* HOW OLD WERE YOU AT YOUR LAST BIRTHDAY? *Compare and correct WB1 and/or WB2 if*	Age (in completed years).....	
WB3. HAVE YOU EVER ATTENDED SCHOOL OR KHALWA OR PRESCHOOL?	Yes.....1 No 2	2¢WB7
WB4. WHAT IS THE HIGHEST YOU ATTAINED?	KHALWA……..00 PRESCHOOL……..0 1 PRIMARY…… 03 BASIC……0 VOCATIONAL TRAINING……05 INTERMEDIATE……..06 SECONDARY……..0 HIGH SCHOOL (3 YEARS) HIGH SCHOOL…(4 YEARS)……...09 INTERMEDIATE DIPLOMA ……10 UNIVERSITY……...1 1 POST GRADUATE……12	00¢WB 01¢WB 7 12¢N EXT MODU LE
WB5. WHAT IS THE HIGHEST GRADE YOU COMPLETED AT THAT LEVEL? *If the first grade at this level is*	Grade	

WB6. *Check WB4:*

D *Vocational training or higher (WB4=05, 06, 07, 08,09,10,11) ¢ Go to Next Module.*

D *Primary (WB4=02, 03 or 04) ¢ Continue with WB7.*

VITA

Mr. Tesfit Brhane Netsereab was born on 1st January, 1980 in Adi Hallo, Eritrea. He graduated in Bachelor of Science in Public Health from Asmara College of Health Sciences (ACHS), Eritrea in 2010. He was working as assistant lecturer in ACHS from the day he graduated until July, 2015.