University of the Witwatersrand
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RISK FACTORS ASSOCIATED WITH ANAEMIA AMONG CHILDREN UNDER FIVE YEARS OF AGE IN UGANDA

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DECLARATION

I, Muhammad Mustanser Ali, am submitting my research report for the requirement of completion of the Master of Science Degree in the discipline of Infectious Disease Epidemiology, School of Public Health, Faculty of Health Sciences,University of the Witwatersrand. The report has not been submitted for any other examination purpose to this or any other university. I declare that this is my personal work. Where I used someone else's thoughts or ideas, I cited these appropriately.

Signed
Mustansar Ali

Date 15 June 2018

DEDICATION

I dedicate my research report to my mother.

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ABSTRACT

Background

Anaemia remains a public health challenge, especially in developing countries because of its relationship to neurocognitive delays, especially among children under five. According to the World Health Organization (WHO) report for 1993-2005, 293.1 million children were affected by anaemia globally. Risk factors for anaemia that need to be examined in children include socio-demographic characteristics, infection with the Human Immunodeficiency virus (HIV), malnutrition and malaria.

Objectives

The objectives of the study were to estimate the prevalence of anaemia and identify the potential risk factors (including socio-demographic factors) among children under five years of age who participated in a cross-sectional survey in Uganda in 2011.

Methods

Data that were collected in a cross-sectional survey during 2011 in Uganda (N = 1 808) were analysed. Children were defined as being anaemic if their haemoglobin levels were below 11.0 g/dl, as per the WHO definition. Cross tabulations, and ordinary and ordinal logistic regression analysis were the primary methods used.

Results

The main finding was that the prevalence of anaemia in children under five years of age was high, at 50.3% (95% CI: 46% - 54%). Of those with anaemia 1.6% had severe anaemia, 26.2% had moderate anaemia, and 22.6% had mild anaemia. From the multiple ordinary and ordinal logistic regression analyses, age group of the child, region, breastfeeding status of the mother,

use of antenatal health care facilities, household wealth index, household age group, marital status of household head, and literacy level of the household head were associated with childhood anaemia. Children with anaemia were more likely to be younger than 24 months old, have had malaria, have poor nutritional status, and live in rural areas. The children were also more likely to be anaemic if their mothers had a high education, and were young , and if they lived with a household head aged 79-95 years. They were less likely to be anaemic if they had a household head in one of the relatively higher wealth indices, a household head with a literacy level of 'medium', and a household head who was divorced.

Conclusion

Anaemia was highly prevalent among children under five years of age in Uganda in 2011. Several child- maternal- and household head-related risk factors were identified. Modifiable risk factors should be targeted in Uganda to reduce anaemia in children. Malaria and nutrition programmes (including iron supplementation) should be stepped up, and pregnant women and mothers of new born children should be encouraged to attend health care centres, including antenatal care facilities. Children with un-modifiable risk factors, such as living in rural or low GDP areas should be closely monitored for risk factors that predispose them to anaemia.

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
CD4	Cluster of differentiation 4 cells
HAART	Highly Active Antiretroviral Therapy
HIV	Human Immunodeficiency Virus
IPT	Intermittent Preventive Treatment
IRS	Inter-Residual spraying
ITN	Insecticide –Treated Net
MIS	Malaria Indicator Survey
PEAP	Poverty Eradication Action Plan
UDHS	Uganda Demographic Health Survey
UNAP	Uganda Nutrition Action Plan
UNICEF	United Nations Children’s Fund
UMCSP	Uganda Malaria Control Strategic plan
WHO	World Health Organization

DEFINITIONS OF TERMS

Anaemia - A state in which the number of red blood cells is low; as a result, their carrying capacity of oxygen is low to meet the physiological needs of the body.

Cluster of differentiation 4 - A glycoprotein that is found on the surface of immune cells such as T-helper cells, monocytes, macrophages and dendritic cells.

HIV - A virus that attacks the immune system of the human body, and which destroys the white cells of the human body, T helper cells, monocytes, and macrophages.

Incidence - The proportion of new cases of a disease in a particular population during a given period.

Micronutrient Deficiency A lack of nutrients in the human body such as Vitamin A, B, C, Riboflavin, Iron, and Folate.

Malaria - An infectious disease, transmitted through mosquitos, that is caused by parasites which destroy red blood cells in the human body.

Prevalence - The proportion of existing disease in a given population at a particular time.

CHAPTER 1 – INTRODUCTION

This chapter begins with a definition of anaemia, specifically in children under five years of age. The factors associated with anaemia are discussed in the background. The literature review describes programmes in Uganda regarding reduction of anaemia, and the prevention strategies for factors that are associated with anaemia. The problem statement, justification, research question, aim and objectives are provided.

1.1 Background

1.1.1 Definition of anaemia

Anaemia is defined as a state in which the number of red blood cells is low; as a result, their oxygen carrying capacity is too low to meet the physiological needs of the body.[1] All human body cells depend on oxygen for life. According to the World Health Organization (WHO), children aged 0-59 months are considered to be anaemic when their haemoglobin levels are below 11.0 g/dl and, adults are anaemic when their haemoglobin levels are less than 13.5 g/dl (for men) or less than 12.0 g/dl (for females).[2] In children, anaemia can cause severe conditions that include cognitive impairment, motor development and stunting. Some of the primary areas affected during neurocognitive impairment include attention, speech, memory, difficulty in speaking, visual problems and various executive functions.[2] Other conditions that also develop due to prolonged neurocognitive impairment include seizures, prolonged coma, hypoglycaemia, and cerebrospinal fluid tumour necrosis at the time of cerebral malarial anaemia.[3, 4] Morbidity from infectious diseases is also increased in anaemic children.[3] One of the reasons is that anaemia destroys the immune mechanism and therefore it is associated with increased morbidity rates.[5] However, because of its insidious nature, mild to moderate anaemia remains untreated and undiagnosed for a certain period of time by health care workers, which can also result in increased infectious disease rates among anaemic children.[6] There are several adverse outcomes associated with for anaemia in children under five years of age, but cognitive impairment is the most common one.[7]

1.1.2 Causes of anaemia

There are several causes of anaemia but, in children, the most common cause is iron deficiency. Children who suffer from iron deficiency anaemia during the first two years of life have poor cognitive development and, consequently, poor school performance and poor work performance later in life.[8, 9] Iron is a major component for haemoglobin. It functions mainly to transport oxygen and it is also essential for cell growth and differentiation.[10] According to worldwide figures, 50% of notified anaemia cases are due to iron deficiency, but the percentage may vary according to the population and geographical location.[6, 11] Anaemia is also caused by deficiencies in other micronutrients, such as folate, riboflavin, and vitamins A and B12.[12, 13] Acute and chronic diseases, such as malaria, tuberculosis, cancer, and HIV are important causes of anaemia.[12, 13] In developing countries, many infectious diseases lead to anaemia, such as malaria, HIV, tuberculosis, diarrhoea, and Helminthic infections.[14] Anaemia can also be due to inherited genetic disorders which result in the destruction of red blood cells, such as sickle cell disease and haemoglobinopathies.[12, 13]

1.1.3 Global prevalence of anaemia in children

Anaemia in children remains a public health challenge, particularly in developing countries. According to the WHO report for 1993-2005, 293.1 million children were affected by childhood anaemia, globally.[7] In a 2011 WHO report, it was estimated that 800 million children and women had anaemia.[15] Approximately 50% of pre-school children and pregnant women suffer from anaemia in developing countries, compared to 30-40% in developed countries.[16] Anaemia is a significant predictor of morbidity and mortality in sub-Saharan Africa where prevalence ranges from 21.1% to 64.4%.[14, 17-19] According to the WHO report for 1993-2005, it was estimated that 28.5% children living in sub-Saharan Africa had anaemia.[7] The highest prevalence of anaemia in sub-Saharan Africa is found among pre-school children (67.6% ~ 83.5 million children), and pregnant women (57.1%).[3] Approximately 75% of children under the age of five years have anaemia in East Africa,[20] where the prevalence among all individuals has been estimated to be between 44% and 76%.[20]

1.1.4 Prevalence of anaemia in children in Uganda

Anaemia alone affects over 50% of individuals of the Ugandan population.[15] The 2001 Uganda Demographic and Health Survey (UDHS) found that 64% of children under five years of age were affected by anaemia.[21] An increase was seen in the 2006 UDHS , where the prevalence was 73%.[22] The figure dropped again in the 2011 UDHS when 49% of the children were considered to be anaemic.[23] According to the recent 2016 UDHS, the prevalence of anaemia was 53%.[24]

Anaemia was one of the most common causes of case morbidity in Uganda 2002 for children, when 2.3% of the burden of the disease was recorded as due to anaemia.[25] Diarrhoea and malnutrition were the second most common causes of case morbidity and mortality among children under five as reported by the WHO report in 2002.[26]

1.1.5 Anaemia due to malaria

In malaria endemic regions, malaria is one of the most common causes of anaemia.[7, 27] Among children, malaria-associated anaemia is one of the major contributors to morbidity and mortality.[28, 29]

There is a chance of developing anaemia due to asymptomatic low-density parasitaemia if there is ineffective treatment for malaria parasitaemia, or if it persists too long in the human body.[30, 31] Malaria causes destruction of erythrocytes due to parasites, resulting in malarial anaemia.[32] In the malarial endemic regions of sub-Saharan Africa, all four parasites of malaria exist in the country, but 90% of the disease develops due to Plasmodium falciparum strains that play a pivotal role in the development of severe anaemia.[33] In 2001, Plasmodium falciparum malaria parasitaemia was notified as the most common cause of malarial anaemia.[34-37] In 2008, it was reported that most children were repeatedly infected with Plasmodium falciparum parasite in sub-Saharan Africa, and subsequently developed anaemia.[38] It is estimated that, every year, half a million children die due to severe malarial anaemia in Africa.[38, 39]

During the first year of life, the prevalence of anaemia increases with age in developing countries. The malarial anaemia burden increases during the second half of the first year of life when there is a complete loss of maternal antibodies and fetal haemoglobin.[40, 41]

Malaria is considered as endemic in Uganda and in more than 90% of countries in sub-Saharan Africa. [42-44]Severe anaemia, defined as a haemoglobin level below 8 g/dl, is one of the primary manifestations of complicated malaria disease.[45, 46] Both malaria and anaemia cause morbidity and mortality that contribute to the burden of illness in Uganda.[15, 47] A report from the National Malaria Control Programme (NMCP) has shown that malaria cases alone contribute 30 to 50% to the burden of anaemia among outpatients.[42] In comparison, those who are admitted to hospitals contribute 15 to 20% to the malarial anaemia disease burden in Uganda.[42] A report in 2014 by the NMCP showed that 20% of deaths occur among children under five and pregnant women due to malarial anaemia disease.[42]

Cumulative prevalence of malaria was reported to be 19% in the 2014 Malaria Indicator Survey (MIS) among children under five years of age; a significant decrease of 23% from the 2009 MIS in which the prevalence was estimated at 42%.[48] In the 2009 MIS, severe malarial anaemia prevalence was reported to be around 10% in children under five years of age; dropping to 5% in the 2014 survey.[48]

According to the 2006 UDHS data, the incidence of mortality due to all causes was 137 deaths per 100 000 for children under five years of age. Malaria-related anaemia mortality contributed 5.6% in the same year. In the same survey, the mortality rates for children aged four to six years, and pregnant women during their first pregnancy, were 16% and 6%, respectively.[49] In 2009, 44.5% children were found with malaria parasitaemia, but this figure dropped to 20% in 2014.[48]

1.1.6 Anaemia due to HIV

In Human Immune Deficiency Virus (HIV) infection, anaemia remains one of the most common haematological complications, and has a substantial effect on quality of life, mainly associated with clinical outcomes.[50] A study published in 2001 showed that 90% of adults and children infected with HIV develop anaemia.[51]

The causes of anaemia in HIV-infected patients are multifactorial in nature and include chronic diseases, opportunistic infections, drugs, and nutritional deficiencies.[51] The mechanism of anaemia in HIV infection mainly involves the destruction of red blood cells, reduction in the production of red blood cells and, eventually, blood loss.[51-54] Any of these abnormalities has a direct or indirect effect on HIV infection, opportunistic infections and toxicity of therapeutic agents.[55]

Acquired immune deficiency syndrome (AIDS) is a significant predictor of anaemia. Many studies have shown that, as the level of haemoglobin decreases, the progression of HIV disease increases.[52] Low levels of haemoglobin are associated with poor outcomes, especially in AIDS patients.[50, 56-58]

The prevalence of anaemia in HIV-infected children depends on multilevel factors, such as stage of HIV disease, age, ethnicity, concurrent illness, and the definition of anaemia used.

Research has shown that, as HIV disease progresses, the prevalence and severity of anaemia increases.[59] One of the main reasons for high prevalence of anaemia in HIV-infected children in developing countries is due to iron deficiency anaemia which is related to low socioeconomic status.[60, 61]

Mortality is mainly associated with moderate and severe anaemia and is seen in both adult and paediatric HIV patients.[52] HIV-associated anaemia decreases quality of life, increases mortality, and has a significant effect on important markers such as cluster of differentiation 4 (CD4) cells and viral load.[52, 57, 62]

Moderate to severe anaemic cases were seen in 2002 among HIV-infected children who were hospitalized in Uganda. These children also had comorbidities, such as tuberculosis and malaria infection, and height for age Z score <2. However, these conditions were only seen among children younger than three years who were not on highly active antiretroviral therapy (HAART).[63]

Since the beginning of HAART, the epidemiology of anaemia has changed among HIV-infected patients.[52] HAART is very effective in the treatment of anaemia in HIV infection. Studies have shown that recovery from anaemia is significantly improved over time among HIV-infected patients on HAART.[64] In Uganda, many HIV-infected children are now receiving HAART from 6 months to 12 years of age, but we do not know the prevalence of, and factors associated with, anaemia among HIV-infected children.

1.1.7 Anaemia due to nutritional factors

Malnutrition remains a challenge in developing countries, especially among young children and women of reproductive age.[65] Malnourished women often give birth prematurely and tend to delivered underweight babies.[66] Their babies are more likely to die or are at high risk of suboptimal growth and development.[66] Ill health and undernutrition are passed from generation to generation, and morbidity and mortality occur among those who are severely malnourished. Underweight babies and individuals who are mild or moderately malnourished contribute to the burden of the disease in developing countries.[67]

Globally, one of the most common nutritional disorders is micronutrient deficiency. Iron and iodine deficiency are a world-wide problem among children under five and women of reproductive age,[68, 69] resulting in anaemia-related nutritional disorder. A lack of iron stores in the human body due to iron deficiency causes anaemia.[61] There are multilevel causes of iron deficiency anaemia, but the main one is poor diet and breastfeeding discontinued within the first two years of life. [70] Iron is three times more effectively absorbed in breast milk than in cow's milk. Breast milk is therefore a sufficient source of iron for infants in the first 4-6 months of life.[71, 72] Mothers who give cow's milk to their infants during the first year of life may put them at risk of developing iron deficiency anaemia in early infancy.

The causes of nutritional anaemia are mainly deficiencies in folate, protein, copper, cobalt, zinc, Vitamins A, E, B2, B6 and B12, and ascorbic acid[73, 74] which play pivotal roles in the metabolism of haemoglobin.[75] An inadequate intake of animal foods can cause vitamin B12 deficiency which can result in the development of megaloblastic anaemia which can further affect the haemoglobin level in the human body.[76]

Globally, approximately 3.5 billion people suffer from iron deficiency anaemia.[77] In developing countries, 33% of men, 44% of women, 42% of pre-school children, and 53% of school-aged children suffer from iron deficiency anaemia. Asia and Africa have the highest prevalences of iron deficiency anaemia in the world.[68] In developing countries, the main cause of anaemia is low bioavailability of iron from plant-based diets. As a result, inadequate iron intake and limited intake of iron fortified foods lead to serious complications in children, such as neurological impairment, and growth and developmental retardation, which might not be reversible.[78]
Iron deficiency anaemia decreases the immune level of the human body. However, some studies have shown that taking excessive amounts of iron supplements leads to infectious diseases.[79] Iron deficiency anaemia is one of the factors responsible for 841 000 maternal and perinatal deaths per year. It was the direct cause of death of 134 000 young children, annually, in a study by Stoltzfus et al. published in 2004.[80]

Malnutrition is one of the main causative factors for mortality in young children under five years of age in Uganda.[81] According to the 2011 UDHS, 30% of households were considered to be food insecure; thus, chronic undernutrition in children remains a serious issue.[81] In 2011 and 2012 it was reported that 60% of deaths in children were due to nutritional problems.[81] In Uganda, anaemia in women and children is highly prevalent because of micronutrient deficiency, including vitamin A, and iron deficiency.[82]

1.2 Literature review

Several studies have shown a high prevalence of anaemia in Uganda but reported prevalences differ. In 1989, Karaire et al. reported that 62% of healthy children attending the young childrens clinic at Mulago hospital had severe anaemia.[83] Some years later, in 2003, a lower prevalence was reported (21.4%) by Nakiboneka et al. (2003).[84] In 2006, the prevalence of anaemia in children under five years old in Uganda was reported to have increased again, to 72%.[85] In late 2009, the MIS documented that the prevalence of anaemia was 60% in children younger than five years.[86]

1.2.1 Anaemia and malaria

Global burden of malaria

According to the WHO, 214 million cases of malaria are reported globally. Around 438 000 malaria deaths were recorded globally in 2015, of which 90% occurred in Africa.[87] Approximately 306 000 deaths due to malaria in children under five were documented by the WHO in 2015; 292 000 children died due to malaria disease before reaching their fifth birthday in Africa.[87]

Malaria in Uganda

A high malaria transmission was reported in Uganda during 2011 and the country ranked at number three in malaria mortality in sub-Saharan Africa.[23] Malaria is one of the leading causes of death among children under five years of age and the number one illness among adults in Uganda.[88] It causes enduring and debilitating suffering that affects daily life. Among children, it affects school performance and attendance. In adults, it results in decreased work performance and increased household poverty.[89]

Malaria is thought to be the primary causes of severe anaemia in 50% of individuals living in high transmission areas.[90] Malaria disease is stable in approximately 95% of Ugandans; more than 90% of malaria infections are reported to be due to plasmodium falciparum.[91] Plasmodium falciparum contributes to the development of severe malarial anaemia through several mechanisms, including direct destruction of both parasitized and un-parasitized red blood cells and dyserythropoiesis. Malaria also contributes to iron deficiency anaemia during acute episodes of the disease.[92]

The role of malaria in the development of anaemia in malaria endemic areas, and the incidence and age patterns of anaemia disease are strongly dependent on the transmission of the falciparum parasites.[93] Transmission of the parasite is extensively seen during the rainy season. Severe anaemia is one of the most common complications among mothers and children with malaria.

Generally, the average age of children who present with severe malaria anaemia is around 1.8 years.[94] The degree of the anaemia depends on the transmission of the parasites among mother and children. [95]

The WHO reported that 90% of the Ugandan population is living in the high transmission areas of malaria.[96] The epidemiology of malaria varies according to the setting, but high transmission has been recorded in Uganda among people who live in high endemic areas.[97] The WHO 2012 data revealed that Uganda was ranked fourth in the world for the number of malaria-associated morbidity cases, and sixth for malaria-associated deaths.[96]

Uganda has enhanced its disease control prevention facilities during the past few decades. There was a substantial increase in ownership of insecticide-treated nets (ITNs) per household, from 16% in 2006 to 60% in 2011.[22, 23] In contrast to this, indoor residual spraying (IRS) coverage remains low at 6-7%.[22, 23] Despite these malaria control efforts, malaria remains a problem in Uganda.[98]

There are a number of malaria control activities in Uganda which are monitored by cross-sectional surveys. These include the Demographic Health Survey which has been conducted every five years since 2001, and the MIS conducted in 2009 and 2014-15. The main aim of these surveys was to estimate the coverage of malaria control interventions. For the measurement of malaria endemicity and the intensity of transmission, annual entomological inoculation rates are considered as a gold standard measure, but this is physically demanding work and the rates are therefore rarely measured.[99]

The Ugandan government explicitly supports malaria control programmes, and international funding is also available. Nevertheless, very few health indicators are available to control malarial anaemia in the country. Despite this, due to the recent scale-up of control strategies for malarial disease, there is a high chance of reducing anaemia prevalence if all other factors associated with anaemia are controlled.[100]

Programmes in Uganda to control malaria

The Roll Back Malaria (RBM) programme was first initiated by the WHO in 1998 to monitor malaria disease internationally. Its main aim was to halve the 2000 malaria morbidity and mortality rates by 2010, and to further reduce the burden of disease by 50% by 2015. The initiative of the RBM in Uganda is a framework addressing the control activities for malaria in the country. The primary objective of this initiation is for every pregnant women and child under five years of age to have access to ITNs, for protection against malaria. The second objective is to have prompt and effective treatment for malaria available within 24 hours of onset of illness. The third objective is that every pregnant woman should have access to intermittent preventive treatment (IPT).

A further plan to control malaria in a sustainable manner is the Uganda Malaria Control Strategic Plan (UMCSP) 2005-2010. The project supports the five-year health sector strategic plan which is part of the Poverty Eradication Action Plan (PEAP). Malaria remains a high level public health problem and poverty issue in the PEAP. The UMCSP plan was built entirely on the basis of the last five-year performance review. The PEAP highlighted several interventions to control malaria, and to remove the taxes on mosquito nets and insecticides. Last but not least, the UMCSP plan also launched a home-based treatment programme to eliminate malaria.

1.2.2 Anaemia and HIV

Global burden of HIV in children

According to the recent 2015 estimate that 36.7 million people were living with HIV globally, including 1.8 million children, the global HIV prevalence is 0.8%.[101] Approximately 2.1 million new HIV infections were reported in 2015, of which 150 000 were in children. Most of the children were living in sub-Saharan Africa and became infected from their HIV-positive mothers during pregnancy or breastfeeding.[102]

HIV/AIDS in Uganda

HIV prevalence in Uganda increased from 6.4% in 2004 to 7.3% in 2011 in those mother aged 15-49 years.[103] From 2013 to 2015, the number of people living with HIV/AIDS increased from 1.4 million to 1.5 million.[103] A seroprevalence of 6.5% was reported among children under five years who attended an outpatient clinic at Mulago Hospital in Uganda in 2003.[104] According to a 2003 estimate, approximately 84 000 children aged 14 years and younger were living with HIV in Uganda.[105]

Anaemia rates in HIV-infected children have been reported to be very high. For example, Clark et al.(2002) reported a prevalence of anaemia of 91.7% among of HIV-infected children aged 9-36 months; the prevalence of moderate to severe anaemia was 35.1%.[63]

Totin et al.(2002), in a study on the prevalence of anaemia in Uganda among HIV-infected and non-HIV-infected children, found that 44.3% of HIV-infected children had iron deficiency anaemia. They found no difference in the prevalence of anaemia among HIV positive and HIV negative children (both were 44.3%). He concluded that it is not clear that HIV infection causes anaemia, and that further research is needed to identify factors that are associated with anaemia in HIV-infected children in Uganda.

One of the most conclusive reasons for the high prevalence of anaemia among HIV positive children and their mothers is iron deficiency that is compounded by low socioeconomic status.[106, 107] HIV infection has been strongly associated with anaemia. The use of HAART among mothers during pregnancy will significantly prevent the transmission of HIV to the fetus. This could reduce the burden of anaemia disease among children in populations in which seroprevalence of HIV is high.[108]

A more specific and detailed clinical history ,family history about HIV ,drug history and a physical exam should be recorded for both mother and child to evaluate treatable causes of risk factors for anaemia.[52] Clinical and immunological staging also need to be indicated because severe anaemia is associated with advancing HIV disease.[62]

National strategies to prevent HIV in Uganda

The first strategy is to initiate awareness to ensure that no baby is born with HIV. Therefore, all pregnant women should visit antenatal care facilities as soon as they have missed two menstrual periods. It is the duty of the antenatal carer to test every pregnant woman for HIV; if any woman is HIV positive, immediate treatment should be provided, according to the guidelines suggested by the Ugandan Ministry of Health. The objective of the treatment is to take care of the mother's health and to protect the child against HIV.

A second strategy is for the youth (both in and out of school) to take responsibility for prevention of HIV. They need avoid risky behaviour to remain free of HIV infection and to ensure that they protect others from infection, as well as to provide care and support to those who are infected. It is also the duty of parents, teachers, local councillors, and religious leaders to guide and instruct the youth to avoid risky behaviours that expose to them to HIV.

A third strategy is for adults to be frequently tested for HIV so that they know their status. All adults should practice, safe sex by using condom and accessing free male circumcision. Those who test HIV positive should immediately access treatment such as HAART. Recent research in Uganda showed that 89% of new infections occur among adults due to risky behaviours and in those who engage with multiple sexual partners. In contrast to this, 10% of HIV infections are transmitted from parents to newborns.[109] [110]

A fourth strategy should involve all political and religious leaders. It is their duty to send a clear messages to the public regarding HIV testing, including testing as a part of pre-marriage counseling.

1.2.3 Anaemia and malnutrition

The global situation of malnutrition

According to the recent UNICEF report on malnutrition (May 2017), half of the global deaths in children under five years of age were attributable to malnutrition. Approximately 3 million young children unnecessarily lost their lives because they were malnourished.[111]

One of the consequences of malnutrition is stunted growth. According to statistics from the 2015 UNICEF report,[112] 23.2% of children under five years had stunted growth worldwide. This figure is lower than that reported in 1990 when the rate of stunting was 39.6%. The number of children with stunting fell from 255 million to 156 million. According to the 2015 report, two out of four children in South Asia, and one out of three children in sub-Saharan Africa are stunted.[112] Although the number of stunted children decreased globally from 1990 to 2015, in West and Central Africa the number increased, from 19.9 million to 28.3 million.[111]

Other consequences of malnutrition are overweight and obesity. Globally, approximately 42 million children under five years of age were overweight in 2015; a significant increase from 31 million in 2000.[113]

The increasing figures for stunting and overweight are of serious concern for West and Central Africa where health resources are not well equipped to manage these conditions, or to control the consequences of the growing burden of malnutrition. [113]

Micronutrient deficiency is another consequence of malnutrition. The highest rates of Vitamin A deficiency were noted in 2010 in sub-Saharan Africa and South Asia, viz. 48% and 44%, respectively.[114]

Malnutrition in Uganda

In 2012, the population of children under five years in Uganda was 6.5 million. According to the Uganda Demographic Health Survey of 2011,[23] the prevalence of stunted children under five years was 33%. This was 5% less than the 38% prevalence reported in the 2005-06 survey.[81] In 2005-2006, the prevalence of underweight children was 16%; in 2011, this figure dropped by 2%, to 14%.[82]

In 2000-01, 64% of children under five years of age and 30% of women of reproductive age (15-49 years) had iron deficiency anaemia in Uganda.[115] Iron deficiency anaemia affects about three-quarters of children age 6-59 months and half of women of reproductive age in Uganda.[116] In 2003, a prevalence of anaemia of 65% was estimated among postpartum women in a study conducted in Tororo district in Eastern Uganda.[19] According to the 2002 Ugandan Ministry of Health anaemia policy, an estimated 30% of maternal deaths were due to anaemia.[117]

The indicators of malnutrition in children under five years of age and women of reproductive age in Uganda have shown worsening trends over the past 15 years. In 1995, the prevalence of stunting was 45% in children under five years.[118] There was only a small decline (to 39%) in the prevalence after 10 years (UDHS, 2006). An estimated 2.3 million children are still malnourished today in Uganda.

Approximately 60% of the underlying causes of death are due to malnutrition; 25% of infant and maternal deaths in Uganda are caused by malnutrition (USAID, 2014). [116] One out of five young children and women of reproductive age in Uganda suffer from vitamin A deficiency which can lead to serious illness and mortality.[116]

There are very few studies on nutritional deficiencies in Uganda. In 1994, Bakaki reported that 18% of children aged three months to 13 years had iron deficiency anaemia in rural areas of eastern Uganda.[119] In 2003, 16% of children were found to have iron deficiency anaemia in the urban slums of Kampala.[120]

One of the most common micronutrient deficiencies in the world is iron. Due to low stores of iron among children, iron deficiency anaemia is common around the growth period, especially between the ages of 6 and 24 months, and particularly when birth weight is low. [121]

Approximately 75% of iron stores in the haemoglobin and the tissues of newborn infants. A few studies have shown that children with iron deficiency anaemia are more like to develop severe malarial anaemia;[121] therefore iron supplementation can improve the haematological status among mothers and their children.[121-123] However, iron supplementation also provides the parasites with the iron they require to develop, thus it may increase the chances of mothers and children getting malaria.[124, 125]

National strategies to prevent malnutrition in Uganda

One of the objectives of the Uganda Nutrition Action Plan (UNAP) is to ensure that all Ugandans are well nourished and live healthy and productive lives. Nutritional problems can be achieved, for example, by women of reproductive ages receiving good nutrition while they are pregnant. Women should be enabled to nourish their children from the time of conception to the time of weaning. These women should, in addition, receive adequate treatment from well-resourced health care facilities to properly feed and take care of their children to ensure that they grow into healthy adults. It is particularly important to provide all nutritional needs of young children until to their second birthdays.

1.3 Problem statement

Anaemia remains a serious public health issue for developing countries such as Uganda. Children often do not get diagnosed and treated properly because of poor health services. Uganda is a low income country, with problems of nutritional deficiencies, HIV and malaria, all of which are associated with anaemia in children.

The consequences of anaemia include poor school performance, increased susceptibility to infections, lowered resistance to the disease, cognitive impairment, poor physical growth, low work capacity, and poor social and economic development. All of these are worsened by chronic diseases associated with child anaemia.

The prevalence of anaemia is substantially higher among HIV-infected children. [126] A study in 2002 found 90.9% of HIV-infected infants in Uganda to be anaemic compared to 76.9% of HIV negative infants.[126] Blood transfusion, a treatment for severe anaemia, is not feasible when HIV prevalence rates are high, regardless of the high costs to patient's family as well and the health system.[127]

In Uganda, the prevalence of anaemia is high among children and women because of micronutrient deficiency. There is a lack of knowledge regarding the risk factors that are associated with anaemia in children infected with comorbidities, such as HIV. Ahmad et al.

identified risk factors associated with iron deficiency anaemia, and their associations with weight and height;[128] other studies addressed anaemia and factors that were associated with children under five in developing countries. For this reason, there is a need for good clinical management and prevention strategies to control comorbidities, and thus reduce the incidence of anaemia.

1.4 Justification

Anaemia contributes significantly to the burden of disease among young children in Uganda. In malaria endemic areas, risk factors associated with anaemia in children have not been well documented. Data were collected in a survey that was designed to investigate the prevalence of anaemia in women and children in Uganda in 2011. The opportunity arose to analyse the data to estimate the prevalence of anaemia in children younger than five years of age in Uganda, and to identify risk factors associated with anaemia in this group.

1.5 Aim

To estimate the prevalence of anaemia in children under five years old in Uganda 2011 and to identify the associated risk factors.

1.6 Objectives

1. To estimate the prevalence of anaemia among children under five years old in Uganda in 2011, using existing survey data.
2. To compare the socio-demographic and other characteristics of anaemic and non-anaemic children under five years of age.
3. To determine risk factors for anaemia, including malaria.

CHAPTER 2 - METHODS

This section describes the methods used in the study, including the statistical analyses. The description of the procedures includes checking the validity of the results.

2.1 Study design

This was a cross-sectional quantitative secondary analysis of data collected from mothers and household heads about children under the age of five.

2.2 Study area/site

Uganda is located in East Africa. It is a landlocked country bordering Kenya to the east, Tanzania to the south, Rwanda to the south west, the Democratic Republic of Congo to the west, and South Sudan to the north (Figure 2.1). The country has an area of 241 039 square kilometers and is divided into 112 districts. It has a favourable climate because of its high altitude. The Central, Eastern and Western parts of the country have two rainy seasons per year, high rainfall from March through May and light rainfall from September to December. The survey from which the data for this study were obtained was conducted in 10 urban and rural regions: Kampala, Central 1, Central 2, East Central, Eastern, North, West Nile, Karamoja, and Western and Southwest.

2.3 Study population

The UDHS was a household cross-sectional survey conducted to capture information about children from their mothers and from household heads. The study population comprised all children under five years of age who participated in the 2011 UDHS, and whose haemoglobin levels were tested (N = 2 214).

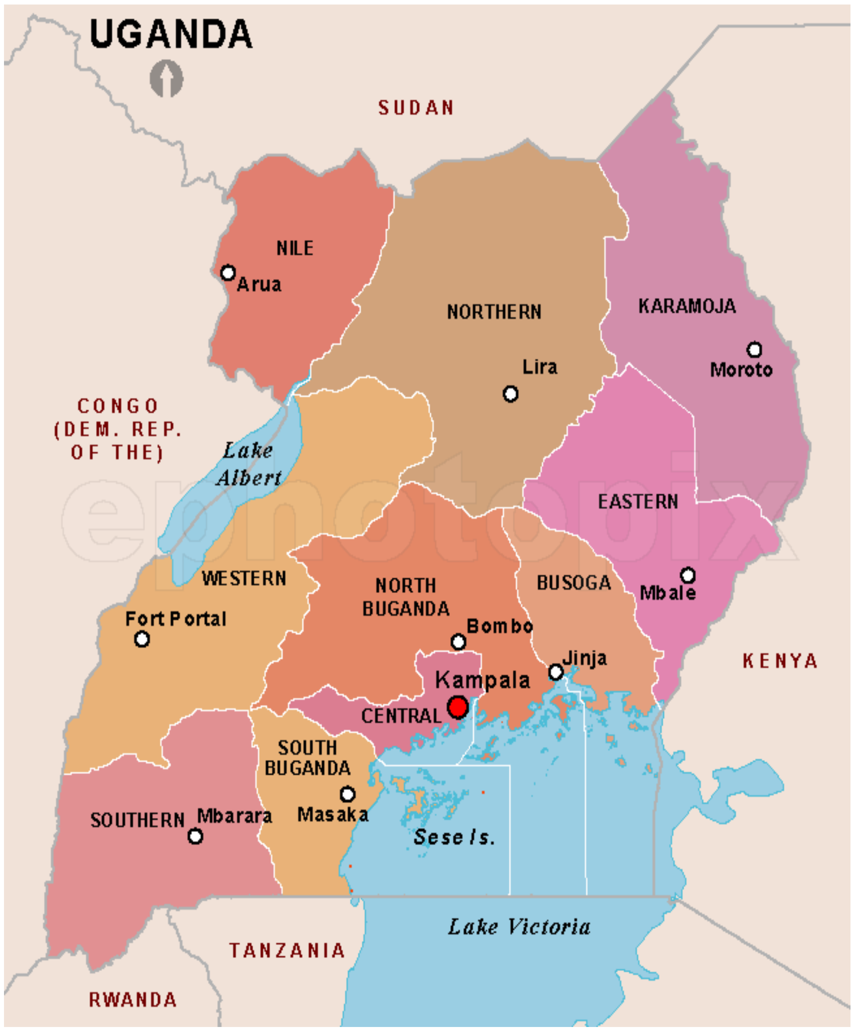

Figure 2.1 Map showing Uganda regions[129]

2.4 Data collection and data collection tools

The data for this study were extracted from the Demographic Health Survey (DHS) website. Cluster sampling was done in two stages: 404 enumeration areas were selected in the first stage for the 2009/10 Uganda Household national survey. In second stage, households in each cluster were selected from a complete listing of households, which was updated before the survey. Information regarding the 2 214 children, for whom anaemia status was tested, was collected from a total of 7 878 mothers and household heads during the door-to-door UDHS cross-sectional survey in 2011, using questionnaires which stayed a night before the survey in the house.

Questionnaires were based on the 2009 MIS and questions used in the 2006 UDHS. Data collected included demographic information about all household members, possession and use of mosquito bed nets, nutrition and HIV status. Each mother was asked about her age and level of education, preventive treatment for malaria, history of pregnancy, and details about children less than five years old, including recent history of fever, and current use and cost of anti-malarial treatment.

Clinical tests were conducted on all children younger than five years, using rapid diagnostic tests for malaria, finger prick blood samples to check haemoglobin levels, and thick and thin blood smears for malarial parasites.

2.5 Study variables

The outcome variable for this analysis was anaemia. The explanatory variables, listed in Table 2.1, were grouped into child factors, maternal factors, antenatal care factors, and household factors. These were evaluated as risk factors associated with anaemia.

The independent variables included demographic, socio-economic and malaria-related characteristics, such as sex, age, type of residence, socioeconomic status, wealth index, nutritional status, malaria status and severity, use of insecticidal sprays to treat mosquito nets, and concurrent illnesses. HIV was excluded as the information was not provided in the dataset provided by the DHS gatekeeper.

Table 2.1 Variables included in the analysis, by objective

Objective	**Relevant variables**
To estimate the prevalence of anaemia among children under five years old in Uganda in 2011, using existing survey data	No. of children with anaemia Total no. in study population
To compare the sociodemographic and other characteristics of anaemic and non-anaemic children under five years of age	Child's age, sex, type of residence, region, mosquito bed net use and type, malaria, anaemia status and severity, nutritional status Maternal age, type of residence, region, education, religion, currently breastfeeding status, current illnesses, smoking status, and use of iron supplements. Antenatal care variables: type of health care facility Household use of mosquito bed nets, wealth index, education, age, literacy, sex, education, and marital status
To determine risk factors for anaemia including malaria	As for objective 2

2.6 Data quality control/management

The total number of observations in the dataset obtained from the DHS website was 7 878. The total number of children under the age of five years who were included in the UDHS 2011, and for whom anaemia was tested was 2 214. All children for whom the anaemia result was not valid, i.e. "unknown anaemia status" (N=406), were excluded, leaving 1 808 observations for secondary data analysis. During data quality control, duplicates were checked by using the command 'duplicate report' in STATA version 13 (no duplicates were found). Data were also checked for vailidity and, if not valid, they were set to missing, using the 'generate missing values' command in STATA.

Two new variables were generated:

1. Malaria: coded as 1 for those with a positive malaria diagonosis, and 2 for those with a negative malaria diagnosis.
2. Nutritional status: coded as 1 (good nutritional status) for those who were fed bananas or yoghurt, and 2 (poor nutrional status) for those who were not fed any of these foods.

Literacy levels were categorized as 1 for "zero" (head of the household cannot read at all); 2 for "low" (head of the household can read a part of sentence); 3 for "medium" (head of the household can read an entire sentence); and 4 for "high" (head of the household did not require any card with the required language).

2.7 Statistical analysis

All statistical analyses were conducted using STATA version 13.

Descriptive statistics

Frequencies (n) and percentages (%) were used to describe categorical variables. Pearson's chi-square test was used to investigate statistical associations of factors with anaemia.

Inferential statistics

The Pearson's chi-square test was used for dichotomous outcomes (e.g. anaemia: yes or no). Univariate and multiple logistic regression analyses were carried out to identify which factors were associated with anaemia. Ordinal logistic regression analysis was conducted for the ordered categorical outcome variables, such as the severity of anaemia (mild, moderate or severe). Unadjusted and adjusted odds ratios were calculated to identify risk factors associated with anaemia in children under five years of age.

Univariate analysis was conducted, after which multiple logistic regression models were fitted. For the univariate analysis, the level of the significance was set at 0.20. If any explanatory variable was not associated with anaemia (p-value > 0.20), it was excluded from the further regression analysis. In the final multiple logistic regression model, the p-value was set at 0.05. Confounding was restricted by fitting the multivariable logistic regression model at the 5% significance level.

2.8 Data limitations

In the original UDHS from which the data were obtained, data that could be used to diagnose iron deficiency, such as serum iron ferritin and total iron binding capacity, were not collected due to budget constraints. Similarly, information about other factors associated with anaemia, such as Vitamin B12 and folic acids, and auto-immune diseases, were was not collected. HIV status of the children could not be included in the analysis as this was not provided in the data obtained from the UDHS.

2.9 Ethical considerations

Informed consent to participate in the UDHS was obtained from the children's caregivers. Ethics approval for the overall survey was obtained from the local Ugandan Ethics Committee. The data obtained from the DHS gatekeeper contained no identifying information to ensure confidentiality. For the secondary data analysis of the UDHS, ethics clearance was obtained from the Human Research Ethics Committee, University of the Witwatersrand (Appendix 2).

CHAPTER 3 - RESULTS

This chapter presents the results of the statistical analyses of the data obtained from the Demographic Health Survey (DHS) gatekeeper for UDHS 2011. The study population is described, followed by the prevalence of anaemia in children. The socio-demographic characteristics of anaemic and non-anaemic children under the age of five years are compared, and the risk factors associated with anaemia are presented.

3.1 Description of the study participants

The study participants included in this analysis comprised 1 808 children under five years of age. Table 3.1 shows the socio-demographic characteristics by severity of anaemia among the children. About half of the children had anaemia (50.3%); in a few cases (1.6%) it was severe, but much higher (and similar) proportions of children had moderate or mild anaemia (26.2% and 22.6%, respectively). Of those with anaemia, most were in the 13-24 months age group (30.5%). Overall, the proportions of male and female children with anaemia were similar, but there was a higher proportion of female than male children with severe anaemia (64.9% and 35.1%, respectively). Most of the affected children lived in rural areas (83.2%). Of those with anaemia, 52.3% had malaria. Although more children with anaemia had slept under a net (ITN treated or not) the preceding night, the proportion who had not was still relatively high (43.8%). Of all the children in the study, most lived in the Eastern region of the country (20.2%); the fewest lived in Karamoja (3.8%). More children with anaemia were classified as having poor than good nutritional status (59.7% and 40.3%, respectively).

Table 3. 1 Socio-demographic characteristics of children under five years of age in Uganda, by severity of anaemia, 2011

characteristic	Severity of anaemia								Total	
	Severe		Moderate		Mild		None			
	n	%	n	%	n	%	n	%	N	%
Anaemia	29	1.6	474	26.2	408	22.6	897	49.6	1 808	50.3
Age group (months)										
0-12	8	23.6	95	21.8	72	17.1	76	8.7	251	14.3
13-24	9	42.8	151	31.0	120	27.9	180	21.4	460	25.7
25-36	6	17.9	98	21.1	79	19.9	200	21.5	383	21.0
37-48	3	8.5	80	16.2	83	20.6	233	25.7	399	21.8
49-59	3	7.2	50	9.9	54	14.5	208	22.7	315	17.2
Sex										
Male	10	35.1	247	52.1	204	49.4	439	48.8	900	49.6
Female	19	64.9	227	47.9	204	50.6	458	51.2	908	50.4
Residence area										
Rural	27	97.2	406	91.2	325	88.1	690	84.1	1 448	87.1
Urban	1	2.0	55	7.0	62	9.6	171	13.6	289	10.8
Semi-urban	1	0.7	13	1.7	21	2.3	36	2.3	71	2.1
Malaria										
No	14	42.3	250	51.9	213	52.7	468	54.8	945	53.4
Yes	15	57.7	224	48.1	195	47.3	429	45.2	863	46.6
Mosquito net usage										
None	12	34.7	209	43.3	178	43.9	399	46.6	798	44.9
Treated	14	48.9	215	45.4	188	45.7	401	43.0	818	44.4
Untreated	3	16.4	50	11.3	42	10.4	97	10.4	192	10.7
Region										
Eastern	8	48.0	73	22.6	65	21.7	119	17.2	265	20.2
Western	5	13.7	27	7.3	43	12.6	124	18.0	199	13.9
East central	5	16.9	99	21.5	49	11.4	68	7.9	221	12.4
Southwest	0	0.0	18	4.4	28	8.7	127	17.6	173	11.8
North	1	2.1	22	4.7	37	9.0	117	11.5	177	9.0
Central 2	3	7.6	48	11.8	27	7.3	67	7.2	145	8.5
Central 1	1	5.0	30	8.3	34	10.2	59	7.0	124	8.0
West Nile	4	3.9	80	10.0	55	7.9	64	4.0	203	6.5
Kampala	1	2.0	30	4.7	29	4.9	79	7.3	139	6.0
Karamoja	1	0.6	47	4.8	41	6.4	73	2.3	162	3.8
Nutritional status										
Poor	15	68.5	291	60.6	238	59.2	391	43.9	935	52.1
Good	14	31.5	183	39.4	170	40.8	506	56.1	873	47.9

3.2 Prevalence of anaemia, and associated risk factors

Prevalence of anaemia

The prevalence of anaemia among children under five years of age was 50.3% (95% CI: 46%-54%). Fig. 3.1 shows that 1.6% (95% CI: 1%-2%) had severe anaemia, 26.2% (95% CI: 23%-30%) had moderate anaemia, and 22.6% (95% CI: 19%- 24%) had mild anaemia. Only 49% (95% CI: 46%-54%) did not have anaemia.

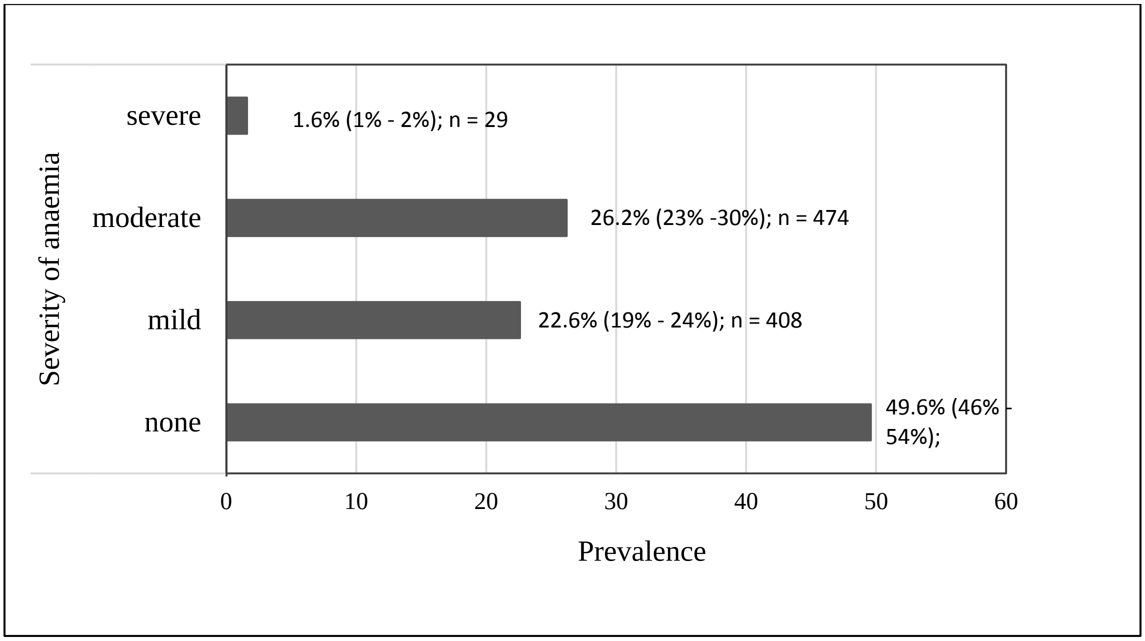

Figure 3.1 Prevalence of anaemia by severity among children under five years

Child, maternal and household head factors associated with anaemia

Table 3.2 shows the comparison of child level characteristics in children under the age of five years with and without anaemia. Age group, residence area, region and nutritional status were significantly associated with anaemia. The highest prevalence of anaemia was among children in the youngest age group (0-12 months). The prevalence decreased with increase in age group. The prevalence of anaemia was higher in children living in rural and semi-urban areas than in those living in urban areas. Children with poor nutritional status had a higher prevalance of anaemia than those with good nutritional status.

Table 3.2 Child-related socio-demographic factors associated with anaemia in children under five years of age in Uganda, 2011 (N= 1 808)

Child characteristic	Anaemia n	%	p-value
Age group (months)			
0-12	175	69.6	
13-24	280	58.7	
25-36	183	49.0	
37-48	166	41.3	
49-59	107	34.5	<0.001
Sex			
Male	461	51.1	
Female	450	49.5	0.596
Residence			
Rural	118	52.0	
Semi-urban	35	46.4	
Urban	758	37.3	<0.001
Malaria			
No	477	48.9	
Yes	434	51.8	0.308
Mosquito net usage			
None	399	48.4	
Treated	417	51.8	
Untreated	95	51.9	0.545
Region			
Karamoja	89	70.6	
West Nile	139	69.0	
East Central	153	68.4	
Central 2	78	57.5	
Eastern	146	57.5	
Central 1	65	56.5	
Kampala	60	39.1	
North	60	36.5	
Western	75	35.6	
South West	46	26.1	<0.001
Nutritional status			
Poor	544	58.1	
Good	367	41.8	<0.001

Table 3.3 Maternal-related socio-demographic factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Maternal characteristic	Anaemia		p-value
	n	%	
Age group (years)			
15-19	56	56.2	
20-24	210	53.0	
25-29	265	51.1	
30-34	181	46.0	
35-39	135	50.0	
40-44	48	51.8	
45-49	16	37.4	0.473
Education			
None	160	50.0	
Primary	571	51.9	
Secondary	147	46.2	
Higher	33	42.2	0.315
Religion			
Muslim	135	61.5	
Catholic	420	52.2	
Pentecostal	94	50.6	
Protestant	236	45.5	
Seventh-day adventist			
	18	43.2	
Other			0.022
	8	30.3	
Breast feeding status			
No	312	42.6	
Yes	599	55.2	<0.001
Health check up after delivery			
No	378	55.7	
Yes	219	51.2	0.225
Smoking (cigarettes)			
No	903	50.2	
Yes	8	62.6	0.499
Use of snuff			
No	879	50.1	
Yes	31	69.1	0.109

Table 3.3 shows the comparison of maternal level characteristics for children under the age of five years with and without anaemia. Religion was significantly associated with child anaemia.

Muslim children had the highest prevalence of anaemia, followed by Catholic children.There was also an association between child anaemia and mother's current breastfeeding status. Children who were currently breastfed had a higher prevalence of anaemia than those who were not.

Table 3.4 shows the comparison of maternal antenatal health care behaviour characteristics for children under the age of five years with and without anaemia. The proportion of children with anaemia was lower in those who mothers attended antenatal care at any health care facility, i.e. home services (p=0.004), antenatal government health care services (p=0.007), or private antenatal health care facilities (p<0.001). There was no association between mothers' use of iron supplements during pregnancy and child anaemia.

Table 3.4 Antenatal health care factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Antenatal characteristic	**Anaemia n**	**%**	**p-value**
Antenatal care at home			
No	573	53.3	
Yes	338	46.3	0.004
Antenatal care at government hospital			
No	428	54.8	
Yes	483	47.1	0.007
Antenatal care at private hospital			
No	514	54.5	
Yes	397	46.0	<0.001
Iron supplements*			
No	828	50.6	
Yes	83	47.1	0.447

*iron pills, sprinkles or syrup

Table 3.5 Household head characteristics associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Household head characteristic	Anaemia n	%	p-value
Age group (years)			
16-36	531	52.3	
37-57	319	47.1	
58-78	54	53.2	
79-95	7	40.8	0.280
Education			
None	160	50.0	
Primary incomplete	475	52.6	
Primary complete	96	48.4	
Secondary	138	45.7	
incomplete	9	56.0	
secondary complete	33	42.2	0.459
Higher			
Sex			
Male	682	50.8	
Female	229	48.5	0.521
Literacy			
Zero	460	56.5	
Low	99	46.1	
Medium	330	44.4	
High	22	75.3	<0.001
Wealth index			
Poorest	281	61.5	
Poorer	190	52.9	
Middle	173	52.2	
Richer	130	42.1	
Richest	137	37.8	<0.001
Mosquito bed net for child			
No	170	51.5	
Yes	741	50.0	0.707
Child slept under mosquito bed net			
No	327	47.4	
Yes	584	52.0	0.163
Marital status			
Never in union	26	46.0	
Married	455	50.0	
Living with partner	350	52.1	
Widowed	20	41.6	
Divorced	2	13.1	
Separated	58	51.2	0.324

Table 3.5 shows the comparison of household level characteristics for children under the age of five years with and without anaemia. The literacy level and the wealth index of the household head were significantly associated with child anaemia. The highest prevalence of anaemia was found where the household heads had high literacy levels (although the numbers were small), followed by situations where the household head had a literacy level of zero. The poorest households had the highest prevalence of children with anaemia; the prevalence of anaemia decreased as the wealth index improved.

The statistical associations of all child level determinants with anaemia, including age group, sex, having slept under a mosquito bed net the previous night, the type of mosquito net, residence area, region, and nutritional status, were investigated in the univariate analysis. The multivariate model included age group, region, residence area, and nutritional status.

As shown in Table 3.6, the odds of having anaemia decreased as the age group increased (p=<0.001). The odds of children aged 13 months or older having anaemia were significantly lower than the odds in children aged 12 months or younger. Anaemia was also associated with living in some regions, i.e. Karamoja, East Central, North and South West (compared to living in Kampala); and residential area (children living in rural areas had an odds of having anaemia that was almost twice that for children living in urban areas; p=0.006). The odds of having anaemia were 2.51 (95% CI: 0.85-7.40) times higher in children living in the Karamoja region, compared to those living in Kampala; 2.34 (95% CI: 1.15-4.74) times higher in those living in the East Central region; and 2.15 (95% CI: 1.08-4.26) higher in those living in the West Nile

Table 3.6 Child level factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

	Unadjusted analysis			Adjusted analysis		
Variable	**Odds ratio**	**95% CI**	**p-value**	**Odds ratio**	**95% CI**	**p-value**
Age group						
(months)	1(baseline)	-	-	1(baseline)	-	-
0-12	0.62	0.41-0.92	0.018	0.58	0.38-0.89	0.014
13-24	0.41	0.29-0.60	<0.001	0.42	0.27-0.63	<0.001
25-36	0.30	0.02-0.41	<0.001	0.27	0.18-0.39	<0.001
37-48	0.22	0.15-0.34	<0.001	0.20	0.13-0.30	<0.001
49-59						
Region						
Kampala	1(baseline)	-	-	1(baseline)	-	-
Karamoja	3.73	1.45-9.58	0.006	2.51	0.85-7.40	0.095
East Central	3.37	2.00-5.65	<0.001	2.34	1.15-4.74	0.018
West Nile	3.46	2.08-5.76	<0.001	2.15	1.08-4.26	0.028
Central 1	2.02	1.03-3.94	0.039	1.39	0.63-3.06	0.410
Central 2	2.10	1.26-3.51	0.005	1.34	0.69-2.60	0.380
Eastern	2.09	1.18-3.71	0.011	1.26	0.62-2.55	0.519
Western	0.85	0.49-1.48	0.585	0.53	0.27-1.04	0.068
North	0.89	0.50-1.59	0.707	0.47	0.22-0.99	0.049
South West	0.54	0.32-0.91	0.022	0.32	0.16-0.64	0.001
Residence						
Urban	1(baseline)		-	1(baseline)	-	-
Rural	1.82	1.32-2.50	<0.001	1.85	1.18-2.87	0.006
Semi-urban	1.45	0.91-2.32	0.110	0.83	0.41-1.65	0.596
Sex						
Male	1(baseline)			1(baseline)		
Female	0.93	0.74-1.18	0.597	0.91	0.71-1.15	0.439
Malaria						
No	1(baseline)			1(baseline)		
Yes	1.12	0.89-1.40	0.308	1.16	0.74-1.82	0.499
Nets						
No nets	1(baseline)			1(baseline)		
Only treated	1.14	0.90-1.44	0.266	1.04	0.67-1.61	0.849
nets	1.14	0.75-1.73	0.515	0.80	0.45-1.45	0.477
Only untreated net						
Nutritional status						
Poor	1(baseline)			1(baseline)		
Good	0.51	0.40-0.65	<0.001	0.75	0.58-0.95	0.021

region. Those in the South West region were less likely to be anaemic compared to those who lived in Kampala [OR=0.32 (95% CI: 0.16-0.64)]. The odds of having anaemia were 1.85 (95% CI: 1.18-2.87) times higher among children living in rural areas, compared to those living in urban areas. Children with good nutritional status had a 25% lower odds of having anaemia than those with poor nutritional status (p=0.021).

The statistical associations of all maternal level determinants with anaemia, including age group, region, religion, attending health check ups for other illnesses, breast-feeding status, education, smoking status, and residence area, were investigated in the univariate analysis. The final model contained region, breastfeeding status, and residence area (Table 3.7). Those who lived in rural areas were more likely to be anaemic (p-value=0.006) compared to those who lived in urban areas. Those who lived in the Southwest region were less likely to be anaemic (p-value=0.001) than those who lived in Kampala. The odds of children being anaemic were more than twice as high in those who lived in Karamoja, East Central and West Nile regions, compared to those who lived in Kampala. The odds of being anaemic were higher among children who were being breastfed, compared to those who were not 2.42 (95% CI: 1.82-3.21); and higher in those who lived in rural compared to urban areas 1.85 (95% CI: 1.18-2.27).

Table 3.7 Maternal level factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Variable	Unadjusted analysis			Adjusted analysis		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Age group (years)						
15-19	1(baseline)	-	-	1(baseline)	-	-
20-24	0.88	0.50-1.53	0.656	0.91	0.43-1.92	0.822
25-29	0.81	0.48-1.38	0.455	1.00	0.49-2.02	0.991
30-34	0.66	0.38-1.14	0.144	0.91	0.45-1.83	0.801
35-39	0.77	0.44-1.38	0.393	1.29	0.63-2.64	0.481
40-44	0.83	0.40-1.71	0.630	0.73	0.29-1.85	0.519
45-49	0.46	0.20-1.07	0.073	0.67	0.24-1.90	0.458
Region						
Kampala	1(baseline)	-	-	1(baseline)	-	-
Karamoja	3.73	1.45-9.58	0.006	2.51	0.85-7.40	0.095
East Central	3.37	2.00-5.65	<0.001	2.34	1.15-4.74	0.018
West Nile	3.46	2.08-5.76	<0.001	2.15	1.08-4.26	0.028
Central 1	2.02	1.03-3.94	0.039	1.39	0.63-3.06	0.410
Central 2	2.10	1.26-3.51	0.005	1.34	0.69-2.60	0.380
Eastern	2.09	1.18-3.71	0.011	1.26	0.62-2.55	0.519
Western	0.85	0.49-1.48	0.585	0.53	0.27-1.04	0.068
North	0.89	0.50-1.59	0.707	0.47	0.22-0.99	0.049
South West	0.54	0.32-0.91	0.022	0.32	0.16-0.64	0.001
Current breast feeding status						
No	1 (baseline)	-	-	1 (baseline)	-	-
Yes	1.66	1.32-2.07	<0.001	2.42	1.82-3.21	<0.001
Health checkup after delivery						
No	1 (baseline)	-	-	1 (baseline)	-	-
Yes	0.83	0.62-1.11	0.225	0.78	0.56-1.08	0.140

Table 3.7 Maternal level factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808) cont.

Variable	Unadjusted analysis			Adjusted analysis		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Religion						
Catholic	1(baseline)	-	-	1(baseline)		
Muslim	1.46	1.10-2.22	0.011	1.19	0.74-1.92	0.461
Seventh-day Adventist	0.69	0.31-1.03	0.065	1.13	0.38-3.36	0.820
Pentecostal	0.93	0.82-1.57	0.420	0.95	0.54-1.68	0.878
Protestant	0.76	0.64-1.05	0.124	0.76	0.52-1.12	0.167
Other	0.39	0.23-1.16	0.112	0.41	0.74-2.30	0.314
Highest education						
None	1(baseline)	-	-	1(baseline)	-	-
Primary	1.07	0.74-1.56	0.697	1.10	0.66-1.81	0.706
Secondary	0.85	0.54-1.35	0.514	0.91	0.47-1.75	0.785
higher	0.72	0.40-1.31	0.292	1.43	0.60-3.42	0.413
Smoke cigarettes						
No	1(baseline)	-	-	1(baseline)	-	-
yes	1.66	0.37-7.40	0.504	0.62	0.93-4.16	0.625
Use snuff						
No	1(baseline)	-	-	1(baseline)	-	-
yes	2.23	0.811-6.15	0.119	0.56	0.15-2.03	0.384
Residence						
Urban	1(baseline)		-	1(baseline)	-	-
Rural	1.82	1.32-2.50	<0.001	1.85	1.18-2.87	0.006
Semi-urban	1.45	0.91-2.32	0.110	0.83	0.41-1.65	0.596

Table 3.8 Antenatal health care factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Variable	Unadjusted analysis			Adjusted analysis		
	Odds ratio	**95% CI**	**p-value**	**Odds ratio**	**95% CI**	**p-value**
Home-based antenatal care						
No	1(baseline)	-	-	1(baseline)	-	-
Yes	0.75	0.62-0.91	0.005	1.35	0.80-2.28	0.252
Government hospital antenatal care						
No	1(baseline)			1(baseline)		
Yes	0.73	0.58-0.91	0.007	0.76	0.54-1.07	0.122
Private hospital antenatal care						
No	1(baseline)			1(baseline)		
Yes	0.71	0.59-0.86	<0.001	0.63	0.41-0.97	0.040
Iron supplements						
No	1(baseline)	-	-	1(baseline)	-	-
Yes	0.87	0.60-1.24	0.448	0.84	0.58-1.21	0.356

*iron pills, sprinkles or syrup

The results presented in Table 3.8 show that anaemia was significantly associated with mothers' utilisation of private antenatal health care facilities. The odds of being anaemic were 37% lower [OR=0.63 (95% CI: 0.41-0.97)] in children born to mothers who utilized private hospital antenatal care facilities compared to those who did not use any facilities.

The statistical associations of all household head factors with anaemia were investigated. The final model contained household education, wealth index and literacy (Table 3.9). Children living with a household head who had a primary education (complete or incomplete) were more likely to be anaemic compared to those living with a household head with no education. The odds of being anaemic were more than 2 times higher [OR=2.26 (95% CI: 1.19-4.30)] in children whose household head had an incomplete secondary education compared to those who had no education. Children living with a household head in the richer or richest wealth index were less

Table 3.9 Household factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

Variable	Unadjusted analysis			Adjusted analysis		
	Odds ratio	95% CI	p-value	Odds ratio	95% CI	p-value
Household head age group (years)						
16-36	1(baseline)			1(baseline)		
37-57	0.81	0.62-1.05	0.125	0.87	0.66-1.61	0.364
58-78	1.03	0.64-1.66	0.884	1.07	0.64-1.78	0.772
79-95	0.62	0.22-1.72	0.367	0.51	0.21-1.25	0.146
Sex of household head						
Male	1(baseline)			1(baseline)		
Female	0.90	0.68-1.21	0.522	1.00	0.71-1.39	0.993
Household education						
None	1(baseline)			1(baseline)		
Primary incomplete	1.10	0.76-1.61	0.591	1.58	1.05-2.38	0.026
Primary complete	0.93	0.56-1.54	0.798	1.99	1.08-3.65	0.027
Secondary incomplete	0.84	0.52-1.33	0.465	2.26	1.19-4.30	0.013
Secondary complete	1.27	0.34-4.73	0.719	3.58	0.91-14.01	0.067
Higher	0.72	0.40-1.31	0.292	2.44	1.12-5.31	0.024
Mosquito bed net for child						
No	1(baseline)			1(baseline)		
Yes	0.94	0.69-1.28	0.708	0.90	0.63-1.31	0.608
Child slept under mosquito bed net						
No	1(baseline)			1(baseline)		
Yes	1.20	0.92-1.55	0.163	1.32	0.96-1.82	0.080
Wealth index						
Poorest	1(baseline)	-	-	1(baseline)	-	-
Poorer	0.70	0.50-0.98	0.040	0.72	0.51-1.02	0.068
Middle	0.68	0.48-0.96	0.029	0.73	0.49-1.07	0.115
Richer	0.45	0.31-0.66	<0.001	0.47	0.31-0.72	0.001
Richest	0.37	0.26-0.54	<0.001	0.36	0.22-0.59	<0.001
Literacy						
Zero	1(baseline)	-	-	1(baseline)	-	-
Low	0.65	0.46-0.92	0.387	0.68	0.47-0.97	0.038
Medium	0.61	0.47-0.78	0.004	0.55	0.37-0.80	0.002
High	2.35	0.97-5.70	0.046	2.32	1.00-5.37	0.048
Current Marital status						
Never in union	1(baseline)			1(baseline)		
Married	1.17	0.61-2.23	0.630	0.95	0.48-1.87	0.883
Living with partner	1.27	0.64-2.49	0.482	1.09	0.54-2.20	0.799
Widowed	0.83	0.29-2.40	0.739	0.65	0.22-1.87	0.425
Divorced	0.17	0.03-0.97	0.046	0.18	0.02-1.24	0.082
Separated	1.23	0.58-2.57	0.580	1.09	0.52-2.31	0.802

likely to be anaemic compared to those living with a household head in the poorest group. The odds of being anaemic decreased by 64% [OR=0.36 (95% CI: 0.22-0.59)] in children whose household heads belonged to the richer group compared to those whose household heads belonged to the poorest subgroup. Children from households where the literacy levels were low or medium were less likely to be anaemic than those from households where the literacy levels were zero; those from households with high literacy were more likely to be anaemic. The odds of being anaemic were more than twice 2.32 (95% CI: 1.00-5.37) in children whose household head literacy levels were high compared to those whose household head literacy levels were zero.

Table 3.10 shows the combined multiple logistic regression model that was fitted, including child, maternal and household factors that were significantly associated with anaemia in children in the univariate model. The combined model showed that child age, religion, region, mother’s education, household age group, household head wealth index, and household head literacy level were all associated with child anaemia.

Younger children had higher odds of being anaemic. As the age increased the odds of having anaemia decreased. Those children who lived in the Western, North, or Southwest regions were less likely to be anaemic compared to those living in Kampala, while those in East central region were more than twice a likely to be anaemic [OR = 2.51 (95% CI: 0.90-6.94), although this was not statistically significant (p-value=0.076).

The odds of having anaemia decreased by 33% 0.67, 95% CI: 0.77-2.16) among children whose mothers were Protestant as compared to those whose mothers were Catholic (p-value = 0.051).

Table 3.10 Child, maternal and household factors associated with anaemia in children under five years of age in Uganda, 2011 (N = 1 808)

	Multivariate (adjusted analysis)		
Variables	**Odds ratio**	**95%CI**	**p-value**
Child age group (months)			
0-12	1(baseline)	-	-
13-24	0.50	0.31-0.82	0.006
25-36	0.40	0.19-0.80	0.011
37-48	0.23	0.10-0.50	<0.001
49-59	0.09	0.03-0.22	<0.001
Region			
Kampala	1(baseline)		
East central	2.51	0.90-6.94	0.076
Karamoja	1.50	0.39-5.82	0.549
Central 1	1.18	0.45-3.11	0.725
Central 2	1.14	0.43-2.98	0.781
West-Nile	1.01	0.36-2.80	0.971
Eastern	0.74	0.28-1.94	0.553
Western	0.36	0.14-0.90	0.029
North	0.30	0.10-0.84	0.023
Southwest	0.20	0.07-0.52	0.001
Religion			
Catholic	1(baseline)		
Muslim	1.29	0.77-2.16	0.326
Seventh day-adventist	1.28	0.44-3.72	0.648
Pentecostal	0.80	0.45-1.43	0.469
Protestant	0.67	0.77-2.16	0.051
Other	0.24	0.05-1.19	0.082
Mother's education			
None	1(baseline)		
Primary	1.12	0.50-2.52	0.778
Secondary	2.46	0.57-10.59	0.225
Higher	3.13	1.13-8.68	0.028
Household age group			
16-36	1(baseline)		
37-57	0.90	0.59-1.37	0.635
58-78	1.12	0.58-2.17	0.729
79-95	0.22	0.07-0.66	0.007
Household head wealth index			
Poorest	1(baseline)	-	-
Poorer	0.82	0.51-1.31	0.415
Middle	0.87	0.50-1.50	0.616
Richer	0.53	0.30-0.92	0.025
Richest	0.30	0.15-0.59	0.001

Household head literacy level			
Zero	1(baseline)	-	-
Low	1.13	0.65-1.96	0.643
Medium	0.56	0.34-0.91	0.021
High	1.84	0.58-5.75	0.292
Household head marital status			
Never in union	1(baseline)		
Married	0.94	0.36-2.45	0.902
Living with partner	1.01	0.37-2.74	0.977
Widowed	0.53	0.16-1.70	0.289
Divorced	0.14	0.02-1.02	0.053
Separated	1.12	0.40-3.14	0.827

Children with mothers with education beyond secondary school were more likely to be anaemic as compared to those with mothers who had no education (p-value=0.028). The odds of having anaemia increased more than 3-fold [OR=3.13 (95% CI: 1.13-8.68)] among children whose mothers had completed higher education compared to those whose mothers had no education.

Children with a household head in the age group 79-95 years (p-value=0.007) were less likely to be anaemic compared to household head age group 16-36. The odds of having anaemia increased by 12% [OR=1.12 (95% CI: 0.58-2.17)] among children who lived with a household head aged 58-78 years as compared to those who lived with a household aged 16-36 years, but this was not significantly significant (p-value=0.729).

Children with a household head in the richest wealth index were less likely to be anaemic compared to poorest subgroup (p-value=0.001). The odds of being anaemic decreased by 70% [OR=0.30 (95% CI: 0.15-0.59)] among children whose household head belonged to the richest subgroup as compared to those whose household head belonged to the poorest subgroup.

Children with household heads whose literacy levels were categorised as medium were more likely to be anaemic compared to those whose household head literacy levels were zero (p-value=0.021). The odds of having anaemia were almost twice as high [OR=1.89 (95% CI: 0.58-5.75) among children who lived with household heads with high literacy levels as compared to those who lived with household heads with literacy levels of zero, although this was also not statistically significant (p-value=0.292).

Children living in a household where the head was divorced had a lower odds of having anaemia [OR=0.14 (95%CI: 0.02-1.02); p-value=0.053] compared to those living in a household where the head had never been in a relationship. The odds of having anaemia increased by 12% [OR=1.12 (95% CI: 0.40-3.14)] among children where the household head was separated but this was not statistically significant (p-value=0.827).

Factors associated with severity of anaemia

Instead of having a binary outcome, i.e. whether a child had anaemia or not, an ordinal logistic regression was carried out to determine the likelihood of severe anaemia among children, considering childhood factors, maternal factors (including antenatal health care factors), and household factors. Child anaemia was categorised as severe, moderate, mild and no anaemia.

Table 3.11 Factors associated with anaemia severity in children under five years of age in Uganda, 2011 (N =1 808)

	Multivariate (adjusted analysis)		
Variable	**Odds ratio**	**95%CI**	**p-value**
Child-age group (months)			
0-12	1(baseline)	-	-
13-24	1.71	1.12-2.62	0.013
25-36	2.25	1.18-4.30	0.014
37-48	3.73	1.81-7.71	<0.001
49-59	9.27	3.92-21.92	<0.001
Region			
Kampala	1(baseline)	-	-
South West	5.76	2.41-13.77	<0.001
North	3.67	1.45-9.26	0.006
Western	3.01	1.31-6.93	0.009
Eastern	1.33	0.56-3.16	0.504
West-Nile	1.12	0.47-2.67	0.783
Karamoja	1.06	0.39-2.88	0.899
Central2	1.05	0.43-2.57	0.905
Central 1	0.99	0.42-2.33	0.999
East central	0.51	0.19-1.34	0.173
Household head age group (years)			
16-36	1(baseline)	-	-
37-57	1.19	0.84-1.69	0.317
58-78	1.18	0.67-2.07	0.550
79-95	4.01	1.26-12.72	0.018
Household head wealth index			
Poorest	1(baseline)		
Poorer	1.27	0.84-1.91	0.246
Middle	1.26	0.77-2.07	0.351
Richer	1.64	0.95-2.83	0.073
Richest	2.72	1.42-5.21	0.003
Cut values			
Constant 1	1(baseline)		
Constant 2	-3.46	-5.01-1.91	<0.001
Constant 3	-0.00	-1.53-1.52	0.996
Constant 4	1.16	0-.37-2.69	0.137

Constant 1=severe anaemia; constant 2=moderate anaemia; constant 3=mild anaemia; constant 4=no anaemia

A combined multiple ordinal logistic model regression was fitted to identify which of the risk factors was associated with severity of anaemia. The cut-off level for significance was set at 0.05. Table 3.11 shows that child's age group and region, and the household head's age group and wealth index were associated with anaemia.

The odds of having high levels of anaemia for the 49-59 month aged children was higher [OR=9.27 (95% CI: 3.92-21.92)] than for children aged 12 months or younger. Children living in the South West region had a higher odds of having high levels of anaemia [OR=5.76 (95% CI: 2.41-13.77)] compared to those living in Kampala region. The odds of having high levels of anaemia [OR= 4.01 (95% CI: 1.26-12.72)] were higher in children whose household heads were aged 79-95 years as compared to those whose household heads were aged 16-36 years. The odds of having high levels of anaemia [OR=2.72 (95% CI: 1.42-5.21)] were higher in children living with a household head in the richest wealth index, as compared to those children living with a household head who was in the poorest wealth index.

CHAPTER 4 - DISCUSSION

This chapter commences with a summary and interpretation of the results of the analysis of the data obtained from the UHDS 2011. The findings from the analyses are then compared with those published in the literature. The strengths and limitations of the study are also discussed.

4.1 Prevalence of anaemia among children under five years of age in Uganda in 2011

There was a high prevalence rate of anaemia (50.3%) among children under five years of age in Uganda 2011. In comparison to our findings, a study published by Green et al. in 2011, among children under five years of age in Uganda, reported a higher prevalence of anaemia among those who lived alongside Lake Albert (68.9%), and a lower prevalence among those who lived alongside Lake Victoria (27.3%).[130]

Rates of anaemia among children are high in Africa, generally, although they differ vastly between countries. For example, the prevalence rate of anaemia in children under 5 years of age was calculated as 82% in Benin and Mali , using DHS data of 2001, whereas it was reported to be 69.3% in Equatorial Guinea in 2011,[131] 39% in Cote d'Ivoire in 2001,[132] and 57% in Ghana in 2011 (using DHS data). All five countries are in West Africa.[133] In the same period (2012), the prevalence of anaemia was higher (71%) in a Tanzanian hospital-based study, amongst children under five years.[134]

Prevalence rates of anaemia among children under the age of five years also differ by the economic category of the country, with rates being lower in developed that developing countries.

For example, the prevalence of anaemia was reported to be high in other developing countries such as India[135] in 2004 (72%), and Jordan in 2000 (69%)[136] It was reported to be much lower in developed countries such as Norway and America (5%).[137, 138] Anaemia was found to be a major problem in industrialised countries;[15] socio economic inequalities could be one of the factors that affects the prevalence of anaemia, by influencing dietary choices.[139]

A possible reason for the high rate of anaemia in children is that mild and moderate anaemia is usually asymptomatic, and remains undiagnosed and therefore untreated.[140] Recurrent episodes of malaria infection, especially in children living in rural areas, may also make these young children more vulnerable to developing anaemia. Alternative strategies are therefore required to reduce the burden of anaemia in young children in Uganda.

4.2 The association between child-related characteristics and anaemia

The prevalence of anaemia differed by age, residence, region and nutritional status. . Children aged 6-24 months are at a high risk of being iron deficient.[141] Prevalence of anaemia was highest among children younger than 12 months (69.6%), and decreased with an increase in the age group. Children aged 49-59 months had a 91% lower odds of being anaemic than those aged 0-48 months Children aged 49-59 months were, however, more likely to be severely anaemic compared to those aged 12 months or younger. This might be related to iron deficiency. Iron stores present at birth, and in breast milk, protect infants from iron deficiency for up to 6 months,[142] but additional sources of iron are required beyond six months of age for rapid growth of red blood cells.[142] The prevalence among children younger than 12 months was also suggestive of unmet nutritional requirements. Increased activity and high growth demands could be reasons for the high prevalence of anaemia in this age group. Generally, our findings suggest that the prevalence of anaemia was highest among younger age groups, and decreased with age.

The prevalence of anaemia was slightly higher in male than female children (51.1% and 49.5%, respectively) but the difference was smaller than that reported in Tanzania (57.3% and 42.7% in males and females, respectively).[134] This result is comparable to a study by Ngesa and Mwabi [143] where the prevalence of anaemia among male children was high. The prevalence of anaemia among males is related to growth rates, which results in more iron required by the body, which is not supplied by the diet.[144]

More than 50% of the children tested positive for malaria, using the rapid diagnostic test; the proportion was the same in those who had used an untreated mosquito net the night before the survey. This is a lower proportion than reported in the 2009 MIS in Uganda, where 52.0% of children tested positive for malaria, using the rapid diagnostic test; 58.7% of those who tested positive for malaria had used an untreated mosquito net. One of the most effective approaches to control malaria in malaria endemic settings is to expand mosquito net use (both treated and untreated). Although our findings did not identify malaria as a statistically significant risk factor for anaemia, the odds of anaemia were almost 20% higher in those with malaria than in those without malaria. A number of previous studies have demonstrated the effect of malaria control and prevention efforts in decreasing anaemia.[145, 146] Over the last few decades, malaria prevention and control efforts have expanded dramatically in Africa. In Uganda, the UMIS (Uganda Malaria Indicator Survey) was the first national survey to estimate the prevalence of malaria in the country. Due to the rapid scale up of malaria control activities during this period, a reduction of almost 30% was seen in the prevalence of malaria, as reported in the 2015 Malaria Indicator Survey Report.[48]

The prevalence of anaemia was highest in children who lived in the Karamoja region (70.6%). A possible reason for this is that the Karamoja region is located in the north eastern part of Uganda and has a very low GDP growth (less than 1%), compared to other regions, such as Kampala where the prevalence of anaemia was less than a third (22.5%), and the Karamoja and South West regions (where prevalence was 22.5% and 11.4%, respectively). It is likely that the low GDP is related to high rates of poverty and under nutrition which have resulted in higher rates of anaemia among children under five, compared to other regions. Food security and nutritional assessments are conducted twice in a year in the Karamoja region.[147]

Although children from the East Central region were more than twice as likely to be anaemic than those who lived in Kampala, the association with anaemia was not statistically significant. Findings also suggested those children living in the South West region were almost six times more likely to be severely anaemic than those who lived in Kampala. This might be due to children from Kampala - a more developed region - being more likely to be fully immunized for malaria, and consequently having a lower chance of developing anaemia. The GDP in Kampala is relatively high (22.5%), as is the nutritional status of households, compared to other regions.[23] From our findings and from the literature, it would appear that choice of complementary foods markedly influences the iron status of the child.[148] The first complementary food given to an infant or child poses a high risk for iron deficiency if the iron content is already low in the body.

Children who lived in rural areas were almost twice as likely (OR 1.85) to be anaemic than those who lived in urban areas; this association was statistically significant. One of the explanations for the higher rate of anaemia in children in rural area is the poor access to health care facilities or the health care facilities being poorly resourced. These factors could play a pivotal role in the development of anaemia, preventing early diagnosis and treatment of iron deficiency anaemia.

Anaemia was associated with poor nutritional status (58.1% of children with anaemia had poor nutrition). The odds of being anaemic if nutritional status was good were 25% lower than if nutritional status was poor. This association was statistically significant. Ugandan is a poor country with a much lower GDP (26.2 billion dollars) than some other Sub-Saharan African countries, such as Nigeria (406.0 billion dollars), South Africa (294.1 billion dollars), Tanzania (47.2 billion dollars) and Ghana (43.3 billion dollars), according to 2016 International Monetary Fund data. Unbalanced diets and lack of vitamins, fatty acids and proteins are possible reasons for high rates of poor nutrition in the country. These findings are in agreement with those from other studies in Uganda[81, 85] and a study in under 5 year olds in Kenya.[149] Under nutrition among under five year olds is very likely due to poor health education, limited employment opportunities and poverty

Most (75%) of the anaemia in under 5 year olds in Uganda is likely to be due to iron deficiency. According to recent research in Kenya, malaria is strongly associated with anaemia; as are inflammations, blood disorders, and stunting, in children under five years of age.[150] However, in sub-Saharan Africa, the interaction of malaria with iron deficiency anaemia makes it difficult to address the issue of anaemia with iron supplements alone.[151, 152] The WHO recommends that iron supplements are taken in settings where the prevalence of anaemia in children (especially in those younger than 12 months) is above 40%, where food is not fortified with iron. Uganda qualifies for this supplement. The recommended dosage is 2 mg/kg body weight for all children aged 6 to 23 months.[153]

4.3 The association between maternal-related characteristics and anaemia

Anaemia in children under five years of age was associated with mother's religion and breast feeding status. More children with mothers in the 15-19 year age group (56.2%) were anaemic, compared to those with older mothers. As the age of the mother increased, the odds of having anaemia decreased among children. Early motherhood age was one of the most important risk factors for developing anaemia among children. The high risk of children of teenage mothers developing anaemia indicates that they are less likely to be able to meet the nutritional needs of their children, and are perhaps also not prepared for the responsibilities of motherhood. Our findings support those from Cape Verde and rural Indian communities where children with teenager mothers were more likely to be anaemic.[154, 155]

Children with less educated mothers were more likely to suffer from anaemia compared to children with mothers who were better educated. These findings support a Korean study that also revealed that children with mother who were better educated were less likely to be anaemic.[123] Hence, the findings suggest that educated amongst mothers can influence the incidence of anaemia among children under five, perhaps by adopting better feeding practices.

Anaemia was more prevalent among Muslim children (61.5%). This finding is very similar to that in Indian Muslim children[155] A possible reason for this is that Muslims generally have large families which could result in increased poverty, and reduced nutritional status.

Anaemia was more prevalent in children whose mothers were breast feeding (55.2%). This was lower than the rate reported in an Indian study where the prevalence of anaemia among children under five whose mothers were breast feeding was 62.9%.[155] Children of breast feeding mothers were more than twice as likely to be anaemic than those of non-breastfeeding mothers. This might be due to lack of iron stores in the mother's breast milk which could result in the development of anaemia among children. These findings support other research that has been done in Uganda.[8] The literature also reveals that, when an infant is exclusively breastfeed for the first six months of life, iron stores from birth and the infants meet with their physiological requirements. Therefore, in later life they do not need many iron supplements in addition to iron-containing foods.[156, 157]

Health seeking behaviour of mothers was also associated with their children's anaemic status. Children whose mothers visited private antenatal health care facilities were less likely to be anaemic compared to those whose mothers did not visit any health care facility. Anaemia was high in children whose mothers did not go for health check-ups after delivery (55.7%), and in those who did not visit an antenatal health care facility (54.8%). This is because those who visited antenatal health care facilities had been receiving antenatal health care, including iron and folate supplementation. Although the government of Uganda has been implementing public health care since 2001, in the form of a 'package', aimed at preventing anaemia among pregnant women,[158] our findings suggest that the programme is ineffective in preventing anaemia in young children. As the health care packages are available at health centres, it is necessary for pregnant mothers to visit the health centre to access them. Pregnant women should be actively encouraged to visit health care centres to obtain the health care packages, thereby accessing the anaemia interventions and health education sessions. Good health care could prevent anaemia by enabling early identification of iron deficiency anaemia. Therefore, general health care should be provided to vulnerable groups, especially children and pregnant women.

4.4 The association between household characteristics and anaemia

Anaemia in children under five years was associated with younger household heads, high literacy level and low wealth index of the household head, and his or her marital status. Children with a household head aged 79-95 years were less likely to be anaemic than those living with a household head younger than 36 years. This finding is in agreement with other studies from Uganda.[85, 115]

The prevalence of anaemia was high (75.3%) in children with household heads with high literacy levels. Although household head literacy level is an important risk factor that impacts on child health,[159] in this study we found that it had no influence on child anaemia, probably due to introduction of iron rich foods, as the foods introduced after weaning foods may depend more on cultural practices than literacy levels. Nevertheless, having a household head with a medium level of education was significantly associated with child anaemia, perhaps suggesting that common knowledge does influence child anaemia status. These findings are in agreement with studies in Uganda[85, 115] and Kenya.[149]

The prevalence of anaemia was also high (61.5%) among children with household heads in the poorest subgroup (lowest wealth index), suggesting that poverty can result in poor nutrition, including a lack of iron and vitamins, which is closely associated with the development of anaemia in young children. Our findings are in agreement with those from Brazil[160] and rural west Malaysia .[161] However, children with household heads in the richest subgroup (highest wealth index) were almost three times more likely to be severely anaemic. This might be due to the wider choice of 'non-nutritious' complementary food that wealthier families have, which might have a significant effect on the iron status of the child.[162] Complementary food low in iron content could pose a high risk for developing anaemia among children. Our findings contradicted other study findings in Uganda which reported that children who lived with wealthiest household heads and in properly constructed houses had less chance of developing anaemia.[163] One of the reasons for this is that the studies concentrated on malaria, and not food choice by the household head. They stated that those who lived in well-constructed houses had a lower chance of developing anaemia because there is less chance of contracting malaria.

Last, our findings indicated that those children who lived with household heads who were divorced were less likely to be anaemic. It is possible that divorced household heads care better for their children due to their independence, but this might be a spurious finding. The only other study that looked at marital status as a risk factor for anaemia in children concluded that divorce was a risk factor for childhood anaemia due to reduced finances to cover rent and other expenses.[164]

4.5 Strengths of the study

The strength of this study lies in the large number of children who participated in the cross-sectional survey, and the multiple potential casual factors that were collected. The inclusion of maternal- and household head-related factors extended the study beyond the child.

4.6 Study limitations

1. The data used for this study were collected to estimate the prevalence of anaemia in the country and not to identify risk factors for anaemia. Anaemia is a complex disease with multiple etiologies, and the UDHS data set had some missing information on important covariates regarding iron deficiency anaemia, such as serum iron, ferritin and total iron binding capacity (TIBC).
2. The association between HIV infection and anaemia could not be analysed because HIV information was not available in the 2011 UDHS dataset.
3. The study was a cross-sectional survey, and could therefore establish only prevalence (not incidence) of anaemia.
4. The dietary information of mothers was not available. This is potentially associated with anaemia in children, especially in young ages.
5. We cannot infer causality from cross a sectional study.
6. In cross-sectional studies, information on risk factors and health conditions (outcomes), is often obtained at the same point. Adopting standardised and validated methods, and using objective measures can help avoid information bias. The sample size was large and, in the primary study, data were collected using by cluster sampling. These factors reduce selection bias.

4.7 Conclusion

Our study documented a high prevalence of anaemia among children under five years of age in Uganda 2011, suggesting that anaemia among children is a major health issue in Uganda. In spite of the expansion of malaria control and prevention strategies in Uganda, there was no reduction in the prevalence of anaemia in children under the age of 5 years, from 2001 to 2016. Poor nutrition, malaria and living in a rural region were major risk factors for anaemia in this group of children; while mothers visiting antenatal health care centres was protective against the development of anaemia in under five year olds. There is a need to address existing interventions for malaria, malnutrition, and anaemia.

4.8 Recommendations

1. The Ugandan government and health care practitioners should concentrate on preventing anaemia rather than treating it. It is important to be aware that anaemia is often asymptomatic in nature, therefore non-specific symptoms should be actively identified and children with these symptoms should be followed up. In addition to diagnosing anaemia timeously and providing appropriate treatment, it is important to prevent and treat malaria, to provide iron supplementation. Improved access to transfusion centres is also recommended to treat those who are severely anaemic.
2. Malaria and poor nutritional status should be flagged as indicators for the development of anaemia in children .
3. Early diagnosis of malaria and referral of malaria-infected children to health care centres for appropriate treatment and management is imperative.

4. A prospective study should be designed to more accurately identify and quantify the risk factors associated with anaemia.
5. Health services, especially for children, should be improved in remote areas.
6. Promoting maternal health and providing anaemia-related information will help to reduce the incidence of anaemia.

REFERENCES

1.Ngnie-Teta I, Receveur O, Kuate-Defo B. Risk factors for moderate to severe anemia among children in Benin and Mali: insights from a multilevel analysis. *Food and Nutrition Bulletin* 2007; **28**(1): 76-89.

2.Kihara M, Carter JA, Newton CR. The effect of Plasmodium falciparum on cognition: a systematic review. *Tropical Medicine & International Health* 2006; **11**(4): 386-97.

3.Bangirana P, Opoka RO, Boivin MJ, et al. Severe malarial anemia is associated with long-term neurocognitive impairment. *Clinical Infectious Diseases* 2014; **59**(3): 336-44.

4.Boivin MJ, Sikorskii A, Familiar-Lopez I, et al. Malaria illness mediated by anaemia lessens cognitive development in younger Ugandan children. *Malaria journal* 2016; **15**(1): 210.

5.Balarajan Y, Ramakrishnan U, Özaltin E, Shankar AH, Subramanian S. Anaemia in low-income and middle-income countries. *The Lancet* 2011; **378**(9809): 2123-35.

6.Schellenberg D, Schellenberg J, Mushi A, et al. The silent burden of anaemia in Tanzanian children: a community-based study. *Bulletin of the World Health Organization* 2003; **81**(8): 581-90.

7.Haider BA, Olofin I, Wang M, Spiegelman D, Ezzati M, Fawzi WW. Anaemia, prenatal iron use, and risk of adverse pregnancy outcomes: systematic review and meta-analysis. *Bmj* 2013; **346**: f3443.

8.Kikafunda JK, Lukwago FB, Turyashemererwa F. Anaemia and associated factors among under-fives and their mothers in Bushenyi district, Western Uganda. *Public health nutrition* 2009; **12**(12): 2302-8.

9.Woldie H, Kebede Y, Tariku A. Factors Associated with Anemia among Children Aged 6–23 Months Attending Growth Monitoring at Tsitsika Health Center, Wag-Himra Zone, Northeast Ethiopia. *Journal of Nutrition and Metabolism* 2015; **2015**: 928632.

10.Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning. *The Journal of nutrition* 2001; **131**(2): 568S-80S.

11.Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. *The Lancet Global Health* 2013; **1**(1): e16-e25.

12.Balarajan Y, Ramakrishnan U, Özaltin E, Shankar AH, Subramanian SV. Anaemia in low-income and middle-income countries. *The Lancet* 2011; **378**(9809): 2123-35.

13.Tolentino K, Friedman JF. An update on anemia in less developed countries. (Am J Trop Med Hyg. 2007 Jul;77(1):44-51.).

14.Asobayire FS, Adou P, Davidsson L, Cook JD, Hurrell RF. Prevalence of iron deficiency with and without concurrent anemia in population groups with high prevalences of malaria and other infections: a study in Côte d 'Ivoire. *The American Journal of Clinical Nutrition* 2001; **74**(6): 776-82.

15.World Health Organization.The global prevalence of anaemia in 2011. WHO.Available athttp://apps.who.int/iris/handle/10665/177094. Accessed 28 May 2016.

16. World Health Organization & UNICEF.Focusing on anaemia: towards an integrated approach for effective anaemia control: joint statement by the World Health Organization and the United Nations Children's Fund.Geneva:WHO; 2004. Available at:http://www.who.int/topics/anaemia/en/who_unicef-anaemiastatement.pdf.

17.Charlton K, Kruger M, Labadarios D, Wolmarans P, Aronson. Iron, folate and vitamin B12 status of an elderly South African population. *European journal of clinical nutrition* 1997; **51**(7): 424-30.

18.Leenstra T, Kariuki SK, Kurtis JD, Oloo AJ, Kager PA, ter Kuile FO. Prevalence and severity of anemia and iron deficiency: cross-sectional studies in adolescent schoolgirls in western Kenya. *European Journal of Clinical Nutrition* 2004; **58**(4): 681-91.

19.Sserunjogi L, Scheutz F, Whyte SR. Postnatal anaemia: neglected problems and missed opportunities in Uganda. *Health policy and planning* 2003; **18**(2): 225-31.
20.Simbauranga RH, Kamugisha E, Hokororo A, Kidenya BR, Makani J. Prevalence and factors associated with severe anaemia amongst under-five children hospitalized at Bugando Medical Centre, Mwanza, Tanzania. *BMC Hematology* 2015; **15**: 13.

21.Ministry of Health Uganda Demographic Health survey,2000-2001.Available at:http://www.ubos.org/onlinefiles/.../Uganda%20DHS%202000-01%20Final%20Report.pdf.

22.Ministry of Health Uganda Demographic Health survey,2006.Available at:http://www.ubos.org/onlinefiles/uploads/ubos/.../UDHS2006Preliminaryreport.pdf.

23.Ministry of Health Uganda Demographic Health survey,2011.Available at:https://dhsprogram.com/pubs/pdf/FR264/FR264.pdf.

24.Ministry of Health Uganda Demographic Health survey,2016.Available at:http://health.go.ug/content/uganda-demographic-and-health-survey-2016.

25.Ministry of Health National Anaemia policy,Ministry of Health Uganda,2002.Available at:http://www.health.go.ug.

26. World Health Organization .Uganda WHO strategy paper for 2006 Available at http://appswho.int/hac/crises/uga/Uganda_StrategyPaper_February06_draft.pdf

27.van Eijk AM, Ayisi JG, Ter Kuile FO, et al. Malaria and human immunodeficiency virus infection as risk factors for anemia in infants in Kisumu, western Kenya. *The American journal of tropical medicine and hygiene* 2002; **67**(1): 44-53.

28.Slutsker L, Taylor TE, Wirima JJ, Steketee RW. In-hospital morbidity and mortality due to malaria-associated severe anaemia in two areas of Malawi with different patterns of malaria infection. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1994; **88**(5): 548-51.

29.Aimone AM, Perumal N, Cole DC. A systematic review of the application and utility of geographical information systems for exploring disease-disease relationships in paediatric global health research: the case of anaemia and malaria. *International journal of health geographics* 2013; **12**(1): 1.

30.McElroy PD, ter Kuile FO, Lal AA, et al. Effect of Plasmodium falciparum parasitemia density on hemoglobin concentrations among full-term, normal birth weight children in western Kenya, IV. The Asembo Bay Cohort Project. *The American Journal of tropical medicine and hygiene* 2000; **62**(4): 504-12.

31.Wickramasinghe SN, Abdalla SH. Blood and bone marrow changes in malaria. *Best Practice & Research Clinical Haematology* 2000; **13**(2): 277-99.

32.Orkin SH, Nathan DG, Ginsburg D, Look AT, Fisher DE, Lux IV S. Nathan and Oski's hematology of infancy and childhood: Elsevier Health Sciences; 2008.

33.Ministry of Health Uganda Malaria control strategic plan ,Ministry of Health Uganda,2005/06-2009/10.Available at:http://www.health.go.ug/docs/HSSP_III_2010.pdf.

34.Abdalla S, Weatherall D, Wickramasinghe S, Hughes M. The anaemia of P. falciparum malaria. *British journal of haematology* 1980; **46**(2): 171-83.

35.Ehrhardt S, Burchard GD, Mantel C, et al. Malaria, anemia, and malnutrition in African children—defining intervention priorities. *Journal of Infectious Diseases* 2006; **194**(1): 108-14.

36.Price RN, Simpson JA, Nosten F, et al. Factors contributing to anemia after uncomplicated falciparum malaria. *The American journal of tropical medicine and hygiene* 2001; **65**(5): 614-22.

37.VanBuskirk KM, Ofosu A, Kennedy A, Denno DM. Pediatric Anemia in Rural Ghana: A Cross-Sectional Study of Prevalence and Risk Factors. *Journal of Tropical Pediatrics* 2014; **60**(4): 308-17.

38.Dobaño C, Rogerson SJ, Mackinnon MJ, et al. Differential antibody responses to Plasmodium falciparum merozoite proteins in Malawian children with severe malaria. *Journal of Infectious Diseases* 2008; **197**(5): 766-74.

39.Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. *The Lancet Global Health* 2013; **1**(1): e16-e25.

40.Bloland P, Ruebush T, McCormick J, et al. Longitudinal cohort study of the epidemiology of malaria infections in an area of intense malaria transmission I. Description of study site, general methodology, and study population. *The American journal of tropical medicine and hygiene* 1999; **60**(4): 635-40.

41.Cornet M, Le Hesran J-Y, Fievet N, et al. Prevalence of and risk factors for anemia in young children in southern Cameroon. *The American journal of tropical medicine and hygiene* 1998; **58**(5): 606-11.

42.Ministry of Health, Uganda Malaria reduction strategic plan 2014-2020.kampala,2014.Available at:http://health.go.ug/content/uganda-malaria-reduction-strategic-plan.

43.Talisuna AO, Okello PE, Erhart A, Coosemans M, D'Alessandro U. Intensity of malaria transmission and the spread of Plasmodium falciparum–resistant malaria: a review of epidemiologic field evidence. *The American journal of tropical medicine and hygiene* 2007; **77**(6 Suppl): 170-80.

44.Yeka A, Gasasira A, Mpimbaza A, et al. Malaria in Uganda: challenges to control on the long road to elimination. I. Epidemiology and current control effort. *Acta tropica* 2012; **121**(3): 196.

45.Sumbele IUN, Samje M, Nkuo-Akenji T. A longitudinal study on anaemia in children with Plasmodium falciparum infection in the Mount Cameroon region: prevalence, risk factors and perceptions by caregivers. *BMC infectious diseases* 2013; **13**(1): 123.

46.Balarajan Y, Ramakrishnan U, Özaltin E, Shankar AH, Subramanian S. Anaemia in low-income and middle-income countries. *The Lancet* 2012; **378**(9809): 2123-35.

47. World Health organization. Expert committee on malaria: twentieth report.Geneva:WHO.: World Health Organization; 2000.

48.Ministry of Health Uganda Malaria Indicator Survey 2014-15.MIS21, kampala,2015.Available at:https://dhsprogram.com/pubs/pdf/MIS21/MIS21.pdf.Accessed 22 May 2016.

49.Casals-Pascual C, Roberts D. Severe malarial anaemia. *Current molecular medicine* 2006; **6**(2): 155-68.

50.Moore RD. Human immunodeficiency virus infection, anemia, and survival. *Clinical infectious diseases* 1999; **29**(1): 44-9.

51.Semba RD, Gray GE. Pathogenesis of anemia during human immunodeficiency virus infection. *Journal of Investigative Medicine* 2001; **49**(3): 225-39.

52.Volberding PA, Levine AM, Dieterich D, et al. Anemia in HIV infection: clinical impact and evidence-based management strategies. *Clinical infectious diseases* 2004; **38**(10): 1454-63.

53.Claster S. Biology of anemia, differential diagnosis, and treatment options in human immunodeficiency virus infection. *Journal of Infectious Diseases* 2002; **185**(Supplement 2): S105-S9.

54.Kreuzer K-A, Rockstroh J. Pathogenesis and pathophysiology of anemia in HIV infection. *Annals of hematology* 1997; **75**(5): 179-87.

55.Bain BJ. The haematological features of HIV infection. *British journal of haematology* 1997; **99**(1): 1-8.

56.Elliott AM, Halwiindi B, Hayes RJ, et al. The impact of human immunodeficiency virus on mortality of patients treated for tuberculosis in a cohort study in Zambia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1995; **89**(1): 78-82.

57.O'brien ME, Kupka R, Msamanga GI, Saathoff E, Hunter DJ, Fawzi WW. Anemia is an independent predictor of mortality and immunologic progression of disease among women with HIV in Tanzania. *JAIDS Journal of Acquired Immune Deficiency Syndromes* 2005; **40**(2): 219-25.

58.Sullivan PS, Hanson DL, Chu SY, Jones JL, Ward JW, Group AASoD. Epidemiology of anemia in human immunodeficiency virus (HIV)-infected persons: results from the multistate adult and adolescent spectrum of HIV disease surveillance project. *Blood* 1998; **91**(1): 301-8.

59.Belperio PS, Rhew DC. Prevalence and outcomes of anemia in individuals with human immunodeficiency virus: a systematic review of the literature. *The American journal of medicine* 2004; **116**(7): 27-43.

60.Enawgaw B, Alem M, Melku M, Addis Z, Terefe B, Yitayew G. Prevalence and associated risk factors of anemia among HIV infected children attending Gondar university hospital, Northwest Ethiopia: a cross sectional study. *BMC hematology* 2015; **15**(1): 12.

61.Semba RD. Iron-Deficiency Anemia and the Cycle of Poverty among Human Immunodeficiency Virus—Infected Women in the Inner City. *Clinical infectious diseases* 2003; **37**(Supplement 2): S105-S11.

62.Mocroft A, Kirk O, Barton SE, et al. Anaemia is an independent predictive marker for clinical prognosis in HIV-infected patients from across Europe. *Aids* 1999; **13**(8): 943-50.

63.Clark T, Mmiro F, Ndugwa C, et al. Risk factors and cumulative incidence of anaemia among human immunodeficiency virus-infected children in Uganda. *Annals of tropical paediatrics* 2002; **22**(1): 11-7.

64.Quaye W, Addai-Mensah A. Prevalence of anaemia and immunological markers among Ghanaian HAART-naïve HIV-patients and those on HAART. *African health sciences* 2011; **11**(1).

65.Tinker A, Finn K, Epp J. Improving women's health: issues and interventions world bank;; 2000 Jun.

66.Allen LH, Gillespie SR. What works? A review of the efficacy and effectiveness of nutrition interventions: Asian Development Bank; 2001Dec 10.

67.Fishman SM, CAULFiELD LE, De Onis M, HyDER AA, Mullany L, Black RE. Childhood and maternal underweight. 2004.

68.Stoltzfus RJ, Chwaya HM, Tielsch JM, Schulze KJ, Albonico M, Savioli L. Epidemiology of iron deficiency anemia in Zanzibari schoolchildren: the importance of hookworms. *The American journal of clinical nutrition* 1997; **65**(1): 153-9.

69.Sommer A, WEST K. Vitamin A deficiency health, survival y vision. OxforUniversity, Press. *Inc New Andork* 1996.

70.Mamiro PS, Kolsteren P, Roberfroid D, Tatala S, Opsomer AS, Van Camp JH. Feeding practices and factors contributing to wasting, stunting, and iron-deficiency anaemia among 3-23-month old children in Kilosa district, rural Tanzania. *Journal of Health, Population and Nutrition* 2005: 222-30.

71.Song JH, Sun DS, Park JS, et al. Comparison of Clinical Features of Norovirus and Rotavirus Gastroenteritis in Hospitalized Children and Norovirus Genotype Analysis. *Infection & Chemotherapy* 2010; **42**(3): 143-8.

72.El-Sayed H, Nassar M, Habib N, Elmasry O, Gomaa S. Structural and functional affection of the heart in protein energy malnutrition patients on admission and after nutritional recovery. *European journal of clinical nutrition* 2006; **60**(4): 502-10.

73.Massawe S, Ronquist G, Nyström L, Lindmark G. Iron status and iron deficiency anaemia in adolescents in a Tanzanian suburban area. *Gynecologic and obstetric investigation* 2002; **54**(3): 137-44.

74.Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ, Group CRAC. Selected major risk factors and global and regional burden of disease. *The Lancet* 2002; **360**(9343): 1347-60.

75.Fishman SM, Christian P, West KP. The role of vitamins in the prevention and control of anaemia. *Public health nutrition* 2000; **3**(02): 125-50.

76.Barugahara EI, Kikafunda J, Gakenia W. Prevalence and risk factors of nutritional anaemia among female school children in Masindi District, Western Uganda. *African Journal of food, Agriculture, nutrition and development* 2013; **13**(3).

77.Stoltzfus RJ, Dreyfuss ML. Guidelines for the use of iron supplements to prevent and treat iron deficiency anemia: Ilsi Press Washington^ eDC DC; 1998.
78.Grantham-McGregor S, Ani C. The role of micronutrients in psychomotor and cognitive development. *British Medical Bulletin* 1999; **55**(3): 511-27.

79.Caulfield LE, de Onis M, Blössner M, Black RE. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. *The American journal of clinical nutrition* 2004; **80**(1): 193-8.

80.STOLTzFUS RJ, Mullany L, Black RE. Iron deficiency anaemia. *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors* 2004; **1**: 163-209.

81.Uganda Demographic Health Survey 2011,2012,Uganda Bureau of statistics and International Inc,Calverton,Maryland,USA.Available at:https://dhsprogram.com/pubs/pdf/FR264/FR264.pdf.

82.Uganda Demographic Health Survey 2006,2007. Uganda Bureau of Statistics &Macro International Inc;Calverton;Maryland, USA.Available at:http//:www.dhsprogram.com/pubs/pdf/FR194/FR194.pdf.

83.Karaire KV. Anaemia and Iron status in Children attending young children,s clinic at Mulago Hospital. Dissertation for M.Med Paediatrics,Makerere University,1989.

84.Nakiboneka SD. Prevalence and some causative factors of severe anaemia among children admitted to the Acute Care Unit [of] Mulago Hospital. 2003.

85.Uganda Bureau of Statistics,2007. Uganda Demographic and Health Survey 2006.Calverton,MD:UBOS and Macro International Inc.Available at:http://www.dhsprogram.com/pubs/pdf/FR194/FR194.pdf.

86.Menon MP, Yoon SS. Prevalence and Factors Associated with Anemia among Children under 5 Years of Age—Uganda, 2009. *The American journal of tropical medicine and hygiene* 2015; **93**(3): 521-6.

87.World Health Organization.World Malaria Report 2016.Geneva:WHO.Available at: http://www. who.int/malaria/media/world-malaria-day-2016/en/.

88.Ministry of Health National Malaria policy,Ministry of Health Uganda, 2008.Available at:http//:www.health.go.ug.

89.Kamaranzi BK. Factors associated with late presentation of children under five and pregnant women with malaria for treatment at health units in Bungokho Health Sub District. 2010.

90.Gillespie S, Johnston JL. Expert consultation on anemia determinants and interventions. *Ottawa: The Micronutrient Initiative* 1998.

91.Okuonzi SA, Macrae J. Whose policy is it anyway? International and national influences on health policy development in Uganda. *Health policy and planning* 1995; **10**(2): 122-32.

92.Molyneux ME, Looareesuwan S, Menzies IS, et al. Reduced hepatic blood flow and intestinal malabsorption in severe falciparum malaria. *The American journal of tropical medicine and hygiene* 1989; **40**(5): 470-6.

93.Steketee RW, Nahlen BL, Parise ME, Menendez C. The burden of malaria in pregnancy in malaria-endemic areas. *The American journal of tropical medicine and hygiene* 2001; **64**(1_suppl): 28-35.

94.Menendez C, Kahigwa E, Hirt R, et al. Randomised placebo-controlled trial of iron supplementation and malaria chemoprophylaxis for prevention of severe anaemia and malaria in Tanzanian infants. *The Lancet* 1997; **350**(9081): 844-50.

95.Kuziga F, Adoke Y, Wanyenze RK. Prevalence and factors associated with anaemia among children aged 6 to 59 months in Namutumba district, Uganda: a cross-sectional study. *BMC pediatrics* 2017; **17**(1): 25.

96.World Health Organization.World malaria report 2013.Geneva:WHO. Available:at: http://www.who.int/entity/malaria/publications/world_malaria_report_2013/report/en/index.html .

97.Yeka A, Gasasira A, Mpimbaza A, et al. Malaria in Uganda: challenges to control on the long road to elimination: I. Epidemiology and current control efforts. *Acta tropica* 2012; **121**(3): 184-95.

98.Jagannathan P, Muhindo MK, Kakuru A, et al. Increasing incidence of malaria in children despite insecticide-treated bed nets and prompt anti-malarial therapy in Tororo, Uganda. *Malaria journal* 2012; **11**(1): 435.

99.Burkot T, Graves P. The value of vector-based estimates of malaria transmission. *Annals of Tropical Medicine & Parasitology* 1995; **89**(2): 125-34.

100.Rowe AK, Steketee RW, Arnold F, et al. Viewpoint: Evaluating the impact of malaria control efforts on mortality in sub- Saharan Africa. *Tropical medicine & international health* 2007; **12**(12): 1524-39.

101.UNAIDS. Latest statistics on the status of the AIDS epidemic "Fact Sheet 2016"Available at:http://www.unaids.org/sites/default/files/media_asset/UNAIDS_FactSheet_en.pdf.

102.UNAIDS. Global AIDS update AIDSINFO. Available at:http://www.unaids.org/en/resources/documents/2016/Global-AIDS-update-2016.(Accessed 06/10/2016).

103.The Uganda HIV and AIDS country progress report July 2015-June 2016.Available at:http://ugandajournalistsresourcecentre.com/uganda-hivaids-country-progress-report-201516/pdf.

104.Qazi SA, Muhe LM. Integrating HIV management for children into the Integrated Management of Childhood Illness guidelines. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 2006; **100**(1): 10-3.

105.UNICEF. Uganda AIDS statistics,2003.Available at:http://https://www.unicef.org/Africas_orphaned_and_vulnerable_generations_Children_affected by AIDS.

106.Brabin BJ, Premji Z, Verhoeff F. Iron-deficiency anemia: reexamining the nature and magnitude of the public health problem. 2000.

107.Semba RD. iron-deficiency Anemia and the Cycle of Poverty among Human Immunodeficiency Virus—infected Women in the Inner City. *Clinical infectious diseases* 2003; **37**(Supplement_2): S105-S11.

108.Chatterjee A, Bosch RJ, Kupka R, Hunter DJ, Msamanga GI, Fawzi WW. Predictors and consequences of anaemia among antiretroviral-naive HIV-infected and HIV-uninfected children in Tanzania. *Public health nutrition* 2010; **13**(2): 289-96.

109.Nakayiwa S, Abang B, Packel L, et al. Desire for children and pregnancy risk behavior among HIV-infected men and women in Uganda. *AIDS and Behavior* 2006; **10**(1): 95.

110.Guay LA, Musoke P, Fleming T, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: HIVNET 012 randomised trial. *The Lancet* 1999; **354**(9181): 795-802.

111.Unicef. Progress for Children beyond Averages: Learning from the MDGS: eSocialSciences, 2015 Jun.

112.UNICEF. The state of the world's children 2008: Child survival: Unicef; 2007.

113.Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. *The lancet* 2013; **382**(9890): 427-51.

114.Imdad A, Herzer K, Mayo-Wilson E, Yakoob MY, Bhutta ZA. Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. 2010.

115.Uganda Bureau of Statistics & ORC Macro (2001) UDHS (Uganda Demographic Health Survey),200-2001. Entebbe,Uganda/Calveron,MD:Uganda Bureau of Statistics and ORC Macro.Available at:http://www.ubos.org/.../ubos/.../Uganda%20DHS%202000-01%20Final%20Report.pdf.

116.Uganda: Nutrition profile |U.S. Agency for International Development.Available at:https://www.usaid.gov/what-we-do/global-health/nutrition/Uganda-nutrition-profile accessed Feb 8,2016.

117.Ministry of Health, Republic of Uganda Anaemia policy. kampala. Uganda: Ministry of Health.Available at:http://library.health.go.ug/publications/...and.../policy.../national-anaemia-policy-february (2002).

118.World Health Organization.World health statistics 2015. Geneva:WHO.161-161.

119.Bakaki p.childhood Anaemia in a rural Ugandan Community:Kiyeyi Target Area:Dissertation for M.Med Paediatrics Makerere University,1994.

120.Kizito H. The prevalence and associated factors of Iron deficiciency among children living in urban slums of Kampala district. Dissertation for M.Med paediatrics:Makerere University;2003.

121.Wharton BA. Iron deficiency in children: detection and prevention. *British journal of haematology* 1999; **106**(2): 270-80.

122.van Hensbroek MB, Morris-Jones S, Meisner S, et al. Iron, but not folic acid, combined with effective antimalarial therapy promotes haematological recovery in African children after acute falciparum malaria. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1995; **89**(6): 672-6.

123.Choi H-J, Lee H-J, Jang HB, et al. Effects of maternal education on diet, anemia, and iron deficiency in Korean school-aged children. *BMC public health* 2011; **11**(1): 870.

124.Treadwell MJ, Law AW, Sung J, et al. Barriers to adherence of deferoxamine usage in sickle cell disease. *Pediatric blood & cancer* 2005; **44**(5): 500-7.

125.Obai G, Odongo P, Wanyama R. Prevalence of anaemia and associated risk factors among pregnant women attending antenatal care in Gulu and Hoima Regional Hospitals in Uganda: A cross sectional study. *BMC pregnancy and childbirth* 2016; **16**(1): 76.

126.Totin D, Ndugwa C, Mmiro F, Perry RT, Jackson JB, Semba RD. Iron deficiency anemia is highly prevalent among human immunodeficiency virus–infected and uninfected infants in Uganda. *The Journal of nutrition* 2002; **132**(3): 423-9.

127.Gonzalez MA, Menendez C, Font F, et al. Cost-effectiveness of iron supplementation and malaria chemoprophylaxis in the prevention of anaemia and malaria among Tanzanian infants. *Bulletin of the World Health Organization* 2000; **78**(1): 97-107.

128.Ahmad MS, Farooq H, Maham SN, Qayyum Z, Waheed A, Nasir W. Frequency of Anemia and Iron Deficiency among Children Starting First Year of School Life and Their Association with Weight and Height. *Anemia* 2018; **2018**.

129.Uganda regions map.Available at:http://www.emapsworld.com/Uganda-regions-map.html.

130.Green HK, Sousa-Figueiredo JC, Basanez M-G, et al. Anaemia in Ugandan preschool-aged children: the relative contribution of intestinal parasites and malaria. *Parasitology* 2011; **138**(12): 1534.

131.Custodio E, Descalzo MÁ, Roche J, et al. Nutritional status and its correlates in Equatorial Guinean preschool children: results from a nationally representative survey. *Food and nutrition bulletin* 2008; **29**(1): 49-58.

132.Asobayire FS, Adou P, Davidsson L, Cook JD, Hurrell RF. Prevalence of iron deficiency with and without concurrent anemia in population groups with high prevalences of malaria and other infections: a study in Côte d'Ivoire–. *The American Journal of Clinical Nutrition* 2001; **74**(6): 776-82.

133.UNICEF. UNICEF Statistics and Monitoring-Multiple Indicator Cluster Survey (MICS) website; 2012.

134.Simbauranga RH, Kamugisha E, Hokororo A, Kidenya BR, Makani J. Prevalence and factors associated with severe anaemia amongst under-five children hospitalized at Bugando Medical Centre, Mwanza, Tanzania. *BMC hematology* 2015; **15**(1): 13.

135.Karkar P, Kotecha P. Prevalence of anemia among students of Nursing School of Vadodara. *Nursing Journal of India* 2004; **95**(11): 257.

136.Kilbride J, Baker TG, Parapia LA, Khoury SA. Incidence of iron- deficiency anaemia in infants in a prospective study in Jordan. *European journal of haematology* 2000; **64**(4): 231-6.

137.Hernell O, Lönnerdal B. Is iron deficiency in infants and young children common in Scandinavia and is there a need for enforced primary prevention? *Acta Paediatrica* 2004; **93**(8): 1024-6.

138.Cusick SE, Mei Z, Freedman DS, et al. Unexplained decline in the prevalence of anemia among US children and women between 1988–1994 and 1999–2002. *The American journal of clinical nutrition* 2008; **88**(6): 1611-7.

139.Dubois L, Girard M. Social position and nutrition: a gradient relationship in Canada and the USA. *European Journal of Clinical Nutrition* 2001; **55**(5): 366.

140.Crawley J. Reducing the burden of anemia in infants and young children in malaria-endemic countries of Africa: from evidence to action. *The American journal of tropical medicine and hygiene* 2004; **71**(2_suppl): 25-34.

141.Zlotkin S. Clinical nutrition: 8. The role of nutrition in the prevention of iron deficiency anemia in infants, children and adolescents. *Canadian Medical Association Journal* 2003; **168**(1): 59-63.

142.Dallman P. Changing iron needs from birth through adolescence. Nestle nutrition workshop series (USA); 1992; 1992.

143.Ngesa O, Mwambi H. Prevalence and risk factors of anaemia among children aged between 6 months and 14 years in Kenya. *PLoS One* 2014; **9**(11): e113756.

144.Osorio MnM, Lira PI, Ashworth A. Factors associated with Hb concentration in children aged 6–59 months in the State of Pernambuco, Brazil. *British Journal of Nutrition* 2004; **91**(2): 307-14.

145.Deribew A, Birhanu Z, Sena L, et al. The effect of household heads training on long-lasting insecticide-treated bed nets utilization: a cluster randomized controlled trial in Ethiopia. *Malaria journal* 2012; **11**(1): 99.

146.Protopopoff N, Wright A, West PA, et al. Correction: Combination of insecticide treated nets and indoor residual spraying in Northern Tanzania provides additional reduction in vector population density and Malaria transmission rates compared to insecticide treated nets alone: a randomised control trial. *PloS one* 2016; **11**(1): e0146629.

147.Ssewanyana S, Kasirye I. Food insecurity in Uganda: a dilemma to achieving the hunger Millennium Development Goal. 2010.

148.Carvalho AGC, Lira PICd, Barros MdFA, et al. Diagnosis of iron deficiency anemia in children of Northeast Brazil. *Revista de saude publica* 2010; **44**(3): 513-9.

149.Brooker S, Peshu N, Warn P, et al. The epidemiology of hookworm infection and its contribution to anaemia among pre-school children on the Kenyan coast. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 1999; **93**(3): 240-6.

150.Foote EM, Sullivan KM, Ruth LJ, et al. Determinants of anemia among preschool children in rural, western Kenya. *The American journal of tropical medicine and hygiene* 2013; **88**(4): 757-64.

151.Prentice AM. Iron metabolism, malaria, and other infections: what is all the fuss about? *The Journal of nutrition* 2008; **138**(12): 2537-41.

152.Stoltzfus RJ. Research needed to strengthen science and programs for the control of iron deficiency and its consequences in young children. *The Journal of nutrition* 2008; **138**(12): 2542-6.

153. World Health Organization.Iron deficiency anaemia: assessment, prevention and control: a guide for programme managers Available at:http://www.who.int/iris/handle/10665/66914. 2001.

154.Semedo RM, Santos MM, Baião MR, Luiz RR, da Veiga GV. Prevalence of anaemia and associated factors among children below five years of age in Cape Verde, West Africa. *Journal of health, population, and nutrition* 2014; **32**(4): 646.

155.Baranwal A, Baranwal A, Roy N. Association of household environment and prevalence of anemia among children under-5 in India. *Frontiers in public health* 2014; **2**: 196.

156.Siimes MA, Salmenperä L, Perheentupa J. Exclusive breast-feeding for 9 months: risk of iron deficiency. *The Journal of pediatrics* 1984; **104**(2): 196-9.

157.Dewey KG, Cohen RJ, Rivera LL, Brown KH. Effects of age of introduction of complementary foods on iron status of breast-fed infants in Honduras. *The American journal of clinical nutrition* 1998; **67**(5): 878-84.

158.A Mbule M, Byaruhanga Y, Kabahenda M, Lubowa A. Determinants of anemia among pregnant women in rural Uganda; 2012.

159.Zlotkin SH, Schauer C, Christofides A, Sharieff W, Tondeur MC, Hyder SZ. Micronutrient sprinkles to control childhood anaemia. *PLoS Medicine* 2005; **2**(1): e1.

160.de Almeida CA, Ricco RG, Del Ciampo LA, Souza AM, Pinho AP, Oliveira JE. Factors associated with iron deficiency anemia in Brazilian preschool children. *Jornal de pediatria* 2004; **80**(3): 229-34.

161.Ngui R, Lim YAL, Kin LC, Chuen CS, Jaffar S. Association between anaemia, iron deficiency anaemia, neglected parasitic infections and socioeconomic factors in rural children of West Malaysia. *PLoS neglected tropical diseases* 2012; **6**(3): e1550.

162.Silla LMdR, Zelmanowicz A, Mito I, et al. High Prevalence of Anemia in Children and Adult Women in an Urban Population in Southern Brazil. *PLoS ONE* 2013; **8**(7): e68805.

163.Yeka A, Nankabirwa J, Mpimbaza A, et al. Factors associated with malaria parasitemia, anemia and serological responses in a spectrum of epidemiological settings in Uganda. *PLoS One* 2015; **10**(3): e0118901.

164.Muchie KF. Determinants of severity levels of anemia among children aged 6–59 months in Ethiopia: further analysis of the 2011 Ethiopian demographic and health survey. *BMC Nutrition* 2016; **2**(1): 51.

Appendix 1. Plagiarism declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I **Muhammad Mustanser Ali** (Student number: **1109902**) am a student

registered for the degree of **MSc (Epidemiology and Biostatistics)** in the academic year **2016**.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: MMustanser Ali Date: 28 February 2018

26/04/2015
1

Appendix 2. Ethics clearance certificate

R14/49 Mr Muhammad Mustanser Ali

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170402

NAME: (Principal Investigator)	Mr Muhammad Mustanser Ali
DEPARTMENT:	School of Public Health
PROJECT TITLE:	Risk Factors Associated with Anaemia among Under Five Years of Age in Uganda
DATE CONSIDERED:	05/05/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Tobias Chirwa and Gill Nelson
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	10/05/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in April and will therefore be due in the month of April each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES