Drivers or the driven:

Influence of Diseases on Malnutrition in Goronyo, Goronyo Local Government Area, Sokoto State, north-western, Nigeria.

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A thesis submitted in partial fulfilment of the requirement for the degree of
Master of Science in Public Health

by

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Declaration:

Where other people's work has been used (from either a printed source, internet or any other source), this has been carefully acknowledged and referenced in accordance with academic requirements.

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Signature 

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List of Abbreviations

DHS	Demographic and Health Survey
GAM	Global Acute Malnutrition
ITFC	Inpatient Therapeutic Feeding Center
IYCF	Infant and Young Child Feeding
KIT	Royal Tropical Institute
LGA	Local Government Authority
LGHA	Local Government Health Authority
LMIC	Low-and-middle income countries
LRTI	Lower Respiratory Tract Infection
MAM	Moderate Acute Malnutrition
MSF	Médecins Sans Frontières
MUAC	Mid-Upper Arm Circumference
NAM	No Acute Malnutrition
NGO	Non-governmental organization
NNO	Negative Nutritional Outcome
RUTF	Ready-to-use Therapeutic Foods
SAM	Severe Acute Malnutrition
SD	Standard Deviation
U5	Under-five
UTI	Urinary Tract Infection
WHO	World Health Organization

Definition of Terms

Acute Malnutrition: a height-for-age less Z-score of the median of the WHO growth standards less than or equal to -2 and more than or equal to -3 in children 6-59 months old.[1]

Diarrhoea: Three or more bouts of loose stools in a day.[1]

Global Acute Malnutrition children aged 6-59 who are either severely acutely malnourished or moderately acutely malnourished or have both.[1]

Malnutrition: is inadequate or excess consumption of nutrients and energy, classified as overnutrition or undernutrition.[1]

Moderate Acute: weight-for-height Z-score of the median of WHO growth standards less than or equal to -2 and more than or equal to -3, or mid-upper arm circumference less or equal to 125mm and more or equal to 115mm in a child 6-59 months old.[1]

Severe Acute Malnutrition: The WHO defines severe acute malnutrition as ''very low weight for height (below –3z scores of the median WHO growth standards), visible severe wasting, or the presence of nutritional edema''[1]

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ABSTRACT

Introduction:

Malnutrition globally remains a significant public health challenge, causing illnesses and accounting for 45% of deaths of children under five in low-and-middle-income countries (LMICs). Two million Nigerian children suffer severe acute malnutrition (SAM). Acute infectious diseases and malnutrition cause significant illness and death in under-fives. These acute infections, together with poverty and hunger, are worse in instability. This study on the influence of diseases on malnutrition provides information to enable policy formulation and implementation to reduce acute malnutrition and related illnesses.

Methodology:

This study is secondary data analysis from an earlier research's dataset, which studied intervention effectiveness with nutritional supplements in acutely malnourished children in Goronyo, northwestern Nigeria, over six months. This study assessed the influence of acute infectious diseases on malnutrition in under-five children using multiple logistic regression models and sensitivity analyses.

Results:

Overall, under-fives with diarrhoea ($p<0.001$), LRTI ($p=0.003$) and otitis ($p>0.05$) have a higher likelihood of having negative nutritional outcomes. Other risk factors identified include age <24months ($p<0.001$) being female ($p<0.001$), and food availability ($p=0.046$). A unique finding in this study is the relationship between otitis and negative nutritional outcome.

Discussion:

Recurrent episodes of diarrhoea, LRTI and otitis increase negative nutritional outcome (NNO). The study recommends that relevant authorities improve food and health care access through food aids to low-income households and prompt treatment to positively impact nutritional outcomes in under-fives, especially in conflict settings. In addition**,** further research exploring the temporal relationship between otitis and malnutrition in under-five children in various contexts, be carried out.

Keywords: Acute diseases, acute malnutrition, MUAC, NNO, malaria, LRTI, diarrhoea

Abstract word count: 250 words

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INTRODUCTION

Growing up in Chafe village in Zamfara state, formerly part of Sokoto state, made acute malnutrition normal to my young mind. It was common to see many children with protuberant bellies, thin legs, sagging skin over their bare buttocks or swollen feet or legs. To us, they are "Tatakunji ciki yafi duwwawu" (Tatakunji- a folklore character with a belly that is bigger than the buttocks). We happily sang and danced to those children in our innocence even if they sneered, withdrew, and cried as we did. The brownish sparse, straight hair that some had was fascinating to us as it appeared like the hair of a "white man". We knew it was abnormal, but we did not understand why. We learned and lived amid abject poverty and illiteracy, where getting the next meal was difficult for many families. For the lucky few, it was gruel (kunu or fura), boiled moringa or jute leaves with a paste made from millet or guinea corn powder (locally called rummache).

My undergraduate posting in Paediatrics in Usman Danfodio University Teaching Hospital, Sokoto, launched me on the journey towards understanding the implication and gravity of acute malnutrition. Since then, my interest and passion for childhood malnutrition remain to heighten and burn throughout my work to specialisation years.

The golden opportunity to do my MPH thesis on malnutrition with Médecins Sans Frontières (MSF) was exciting. I greatly admire how MSF goes to great lengths to provide care for children even amid conflicts. MSF presence in Goronyo despite insurgency and banditry attests to that commitment. Furthermore, the collaboration with MSF in this study underscores the organization's contribution to research towards improving nutrition globally.

The interaction of acute diseases and malnutrition occurs as a vicious cycle, with both diseases causing significant morbidity and mortality in children. Of the 45 million cases of severe acute malnutrition (SAM) globally, over two million are Nigerian children. The country's under-five (U5) mortality rate of 132 per 1000 with Sokoto state having a high figure of U5 of 102 per 1000.[2] This study on the influence of diseases on malnutrition provides the much-needed information to enable policy formulation and implementation to curb the stem of acute malnutrition ravaging Goronyo, Sokoto state, Nigeria and globally.

CHAPTER ONE

BACKGROUND

Malnutrition is a spectrum of disorders of undernutrition states.[1] Although malnutrition occurs globally, obesity is common in developed countries, while undernutrition is in Africa, Asia, and the Americas.[1,3] Globally, malnutrition has remained a significant cause of illness and deaths, accounting for 45% of deaths of children under five in low-and-middle-income countries (LMICs).[1,3] Severe acute malnutrition (SAM) ranks among the significant causes of illness and deaths worldwide, with the highest burden seen in sub-Saharan Africa and Asia.[3] In Nigeria, about 2 million children have severe acute malnutrition (SAM). The prevalence of stunting in under-fives is 32% in Nigeria, and the country has the second-highest burden of stunting globally.[3] The situation is further worsened by insecurity, conflicts, and seasonal flooding leading to household food insecurity in north-western and north-eastern Nigeria.[5,6] Undernutrition has remained a challenge to public health globally,[7]particularly in LMICs, sub-Saharan Africa, and Nigeria, especially in the northern part of the country.[6]

Diseases related to malnutrition are a significant cause of illness and death among under-five children in Nigeria.[8] Acute and recurrent diseases such as diarrhoea, malaria, respiratory tract infections, amongst other childhood illnesses, increase during periods of instability.[5,6,9] The diseases, together with background abject poverty, result in undernutrition, especially in northern Nigeria.[9] Acute diseases remain significant influencers of the disorder in children, often tilting those with borderline nutritional status into frank malnutrition.[4] Nigeria contributes disproportionately to the high burden of malnutrition in under-fives globally and sub-Saharan Africa.[8] Reports revealed that 1 in 7 Nigerian children dies before school age due to malnutrition.[1,2,3] Malnutrition is often due to the intricate interaction of multiple factors. Which can be prevented and cured if the underlying diseases and other contributors receive correct and adequate treatment.[7,8] Short-term sequelae of malnutrition and infections lead to increased disease burden, disability, and death in children.[1,3] The long-term effects of malnutrition include poor cognitive ability and reduction in economic productivity and reproductive performance.[10]The impact affects the children and their families and communities, and the country at large.[1]

Médecins Sans Frontières-Operational Centre Amsterdam (MSF-OCA) is at the forefront of managing malnutrition worldwide, caring yearly for over 300,000 children with severe malnutrition.[7]The organization rendered inpatient and outpatient medical and nutrition care for children and antenatal care for women in Goronyo Hospital from 2008 to February 2013.[7]

1.1 Study Setting:

Goronyo Local Government Area (LGA) is one of the 23 LGAs of Sokoto State, north-western Nigeria (fig. 1 and 2). The LGA lies on coordinates 13°27'11"N 5°40'35"E close to the Rima River.[11] The LGA covers an area of 1,704 km^2. According to the 2006 National Population Census figures, 182,296 people inhabit it.[11] Goronyo LGA is located in the Sahel belt and is mostly dry and hot, with an average annual temperature of 28.3°C.[7,11] The rainy season from May to October coincides with when food is scarce and hunger common.[7] Goronyo town, the LGA headquarters, is a rural settlement east to the upstream of the Goronyo dam. The majority of its' people are

subsistence farmers (irrigational and non-irrigational), animal rearers, fishermen, while some are traders.[7,12] The area's agricultural produce are cereals such as rice, millet, guinea corn and maize, legumes (groundnuts, cowpeas), and vegetables (onions, tomatoes, okra, spinach).[7]There are 11 health wards and 39 healthcare facilities (HCFs) in the LGA.[13] The LGA is endemic for malaria; water-borne diseases like diarrhoea, cholera, dysentery, and cerebrospinal meningitis is also common.[2,7,11]

Figure 1: Map of Nigeria highlighting the location of Sokoto State in green within the north-western part of Nigeria. [14]

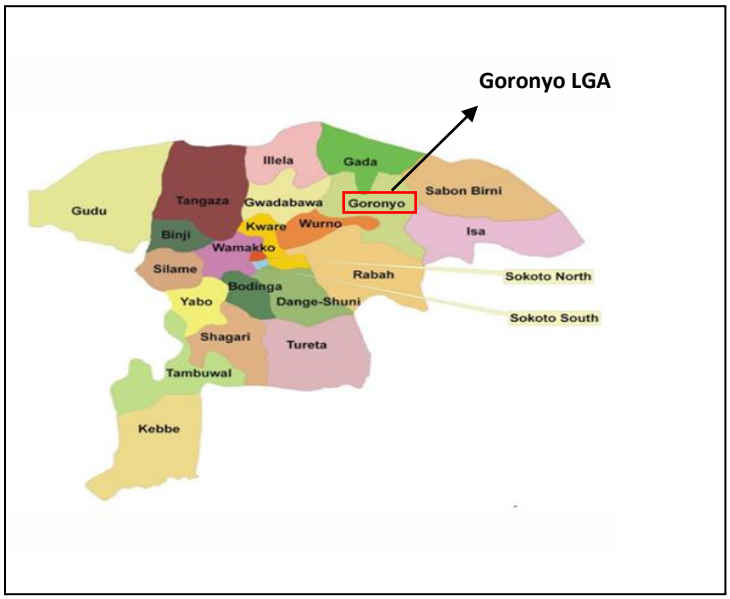

Figure 2: Map of Sokoto showing the location of Goronyo local government. *Adapted from LGA Economic Forum Sokoto State*.[15]

1.2 Socio-demography and Health of Sokoto State

Sokoto state lies between longitude 11° 30' to 13° 50` East and latitude 4° to 6° North.[14] The state shares a northern border with the Niger Republic, Kebbi State to the south and west, and Zamfara State to the East. It has a landmass of 28,232.37sq kilometres.[11] Over 5.3 million people live in the state in 2018,[16,] with Hausa and Fulani as the major indigenous tribes.

The state is the poorest in Nigeria, with a poverty headcount rate of 87.73% and a Gini coefficient of 20.02, which ranks amongst the least developed states in 2019.[17]It is not surprising that the state has poor health indices (table 1). The state's U5 mortality rate of 197 per 1000 and infant mortality rate of 102 per 1000 live births,[2] is the highest at national and global levels. Overall, Sokoto state's health and socio-demographic indicators are worse than the average national figures.[16]

Table 1. Population and Health Indicators of Sokoto State and Nigeria

Demographic indicators	**Sokoto State**	**Federal Republic of Nigeria**
Population	5.22 million	204 million
‡Fertility rate	7.0	5.3
Belonging to lowest national wealth quintile (% of population)	52.0%	20.0%
Poverty Head count rate*	87.73%	40.9%
Mean Household number of children U5	5.6	4.7
Health indicators		
Improved source of drinking water (% of population)	34.4%	65.3%
Median age at first childbirth (women 25-49 years old)	18.3	20.4
Infant mortality (per 1000 live births)	102	67
Under-5 mortality (per 1000 live births)	197	132
% of children with SAM (MUAC<115 or oedema)	2.0%	1.5%
% of children with MAM (MUAC<125 and >115, no oedema)	6.4%	5.5%
% of children stunted (HAZ < 2) (children 6-59mo)	54.8%	36.8%
% of children wasted (WHZ < 2) (children 6-59mo)	17.9%	6.8%
% of any anemia in (<11g/dl) (children 6-59mo)	79.6%	67.9%
% of malaria in children according to RDT (children 6-59mo)	54.7%	37.2%
‡ Basic vaccination coverage in children 12-23 months	5%	31%

‡ Births per woman for the three-year period before the survey. ‡ Basic vaccination coverage includes all eight basic vaccinations-one dose each of BCG and measles vaccine and three doses of DPT Hep B Hib and polio vaccine. *Poverty and Inequality Indices 2019

Nigeria has a disproportionately high burden of childhood malnutrition, with the rates of SAM of 1.5% and MAM 5.5% from the Demographic Health Survey (DHS) survey in 2018.[16] Sokoto state has a SAM rate of 2% above the WHO crisis threshold, indicating emergency.[16] Furthermore, malaria and anaemia are common in U5 children in the state. Additionally, the 2018 DHS reported diarrhoea (episodes within the past 14 days) in 38.1% of U5s, more than double the 14.5% of the country. This high percentage of diarrhoea observed relates to the low percentage (38%) of the population with access to improved water sources, compares to the national figure (table 1). The mean household number of under-five children mirrors the high fertility rate of 7.0 compared to the nationwide. Furthermore, the vaccination coverage percentage of 5% is abysmally low when viewed against the national coverage.[16]

Findings from MSF surveys in Goronyo revealed the prevalence of SAM as 4.9% in 2009 and 2.6% in 2010.[6] Additionally, the global acute malnutrition (GAM) was 14.8% and 11.5% in the same years in the area.[6] Furthermore, of the 51% children reported ill, 23% were malnourished.[12] Goronyo's poor health indices were sequel to poverty, comatose health care, illiteracy, and inequality.

1.3 Activities of Médecins Sans Frontières in Goronyo Town:

Médecins Sans Frontières remains one of the non-governmental organizations (NGO) with a visible presence and impact across northern Nigeria. MSF rendered much-needed support to the Sokoto state government from 2008. However, it withdrew from Goronyo due to intensified conflicts and insecurity in 2013.[6] In collaboration with Sokoto SMoH, MSF-Operational Centre Amsterdam provided antenatal care to women and medical and nutritional care to children in the only secondary health care facility in Goronyo LGA. The facility serves as the main referral centre for 39 Primary health care centres (PHC)[13]in Goronyo LGA. MSF activities were inpatient and outpatient care of children and therapeutic feeding programs for malnourished children.[7]Alongside, and the organization conducted the research upon which this study latched on. The activities of MSF supporting the health care service delivery is still ongoing in states neighbouring Sokoto state (author's knowledge).

CHAPTER TWO

PROBLEM STATEMENT, JUSTIFICATION AND OBJECTIVES

2.1 Aetiology of Malnutrition, acute diseases, and long-term effects:

Malnutrition is a sequel to the interaction between nutritional inadequacy, infections, poor hygiene, adverse environmental conditions, poor socioeconomic status, and ignorance.[3] The lack of food, poor infant and child feeding practices, and recurrent diseases are significant drivers of malnutrition.[10] Most malnourished children are often from households with inadequate and insufficient water, sanitation, and hygiene (WASH) supply and practices in sub-Saharan Africa and Asia.[18]These conditions render them more exposed and susceptible to microorganisms, infections, and diseases.[18] Additionally, children who drink contaminated rainwater or spring water have a higher incidence of diarrhoea-related illnesses, stunting, and being underweight.[19] Conflicts and natural disasters threaten food security, resulting in hunger, increasing the risk of acute malnutrition and diseases.[4,6,9] Therefore, food security is pertinent for preventing malnutrition in fragile and stable contexts, especially in fragile states.[4] Overall, the requirement for nutrients for developing and growing musculoskeletal and nervous systems necessitates the consumption of adequate, quality, nutritious food in the under-fives.[20]

The causes of malnutrition mentioned above are categorised into direct and indirect causes at an individual, household, social and national level in Figure 3. The immediate causes of malnutrition being the interplay between diseases and inadequate diet, enabled by background household food insecurity and environment, poor feeding practices and insufficient healthcare. Overarching and fundamental to the causes mentioned above are: socio-cultural, economic, and political context, and household access to quality education, finances, employment, among others. In Nigeria, effects of economic downturn, disparity in and poor healthcare service delivery, lack of education and other resources,[12,13,16] are more pronounced in the north. Additionally, abject poverty and food insecurity in northwestern Nigeria escalated by insurgency.

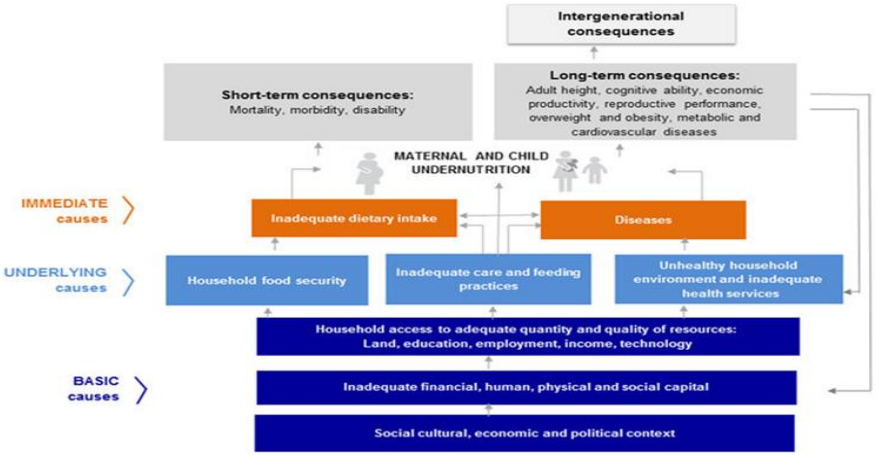

Figure 3: The UNICEF conceptual framework of undernutrition. ***Source: United Nations Children's Fund. Improving Child Nutrition: The achievable imperative for global progress.*** *UNICEF. 2013; p 4.*[10]

Infections and diseases like acute diarrhoeal disease, respiratory tract infections, malaria, measles, HIV/AIDS, and tuberculosis cause inadequate intake, or food intolerance, decreasing the absorption or increase - losses of nutrients (see figure 2).[8,14,19]Disease, ignorance, and poverty are the immediate causes of undernutrition.[8,18,20,21] Abject poverty plays a significant role in malnutrition by influencing education, housing, and healthcare access. Besides, poverty and socio-cultural practices are interwoven in health-seeking behaviour.[8,19]

Health care access by parents or caregivers for malnourished children is often delayed due to financial hardship, distance to the healthcare facility, topography, and conflicts in LMICs; [9,22] the health care system itself is often under-resourced.[11,18] Furthermore, household decision-making, gender inequality, illiteracy, and the poor health-seeking behaviour of caregivers, increase the severity and mortality of malnutrition.[23]

While acknowledging the complex causal pathways, this research focuses on the immediate causes at the individual level, specifically the relationship between diseases and malnutrition, considering the underlying causes at the household level. Overall, the relationship between malnutrition and infection is complex as they reinforce each other and exacerbate poverty, as illustrated in figure 4. This relationship is explored in the following sections.

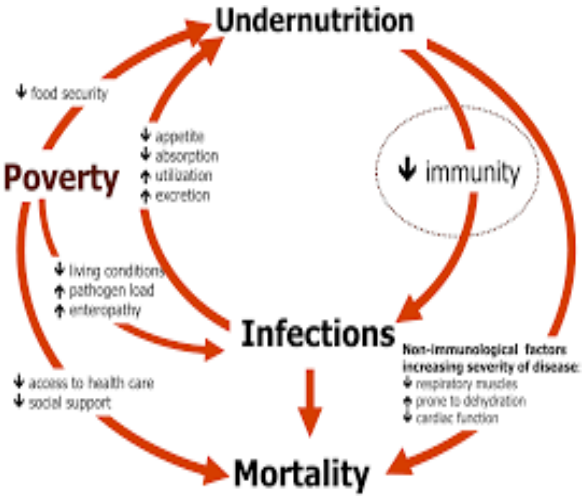

Figure 4: Relationship between malnutrition and infection: *Adapted from Rytter et al.*[24]

2.1.1 Malnutrition and Immunity

Malnutrition negatively influences the host's immune system. It is the most common cause of immunodeficiency, increasing the risk of diseases and death.[3] The causal chain being an interplay of inadequate host immune response with poor feeding, poor socioeconomic and cultural practices, illiteracy, and parents' or caregivers' behaviours and attitude to health.[25,26,27] Additionally, malnutrition predisposes to infection by impairing the host's immune status, enhancing the invasion and spread of pathogens in the body.[23,28,29] Besides, malnutrition can increase the risk of secondary infection, thus driving disease processes and outcomes.[3,23,30]A reduced immunity results in a more severe and longer duration of illnesses predisposing to malnutrition. In turn, infections lead to malnutrition by increasing utilization, inadequate absorption, excess loss of nutrients, and poor appetite, worsening an existent poor nutritional status.[3,31,32] The immune system response to respiratory

infections increases the need and utilization of anabolic energy from metabolism, could potentially adversely affects the nutritional status.[3]

An immunologic entity, the Environment Enteric Dysfunction (EED) syndrome, occurs due to prolonged inflammation, characterized by decreased mucosal barrier function and absorptive ability of the small intestines.[18,32] It leads to poor appetite growth impairment. EED relates to the gut's longstanding inflammation, infection, inadequate micronutrients, poor sanitation and is common in LMICs.[32]

2.1.2 Malnutrition and Infections

Infectious diseases are a common cause of ill-health and deaths, especially in low- and middle-income countries (LMICs), where children are the most vulnerable.[3,33] Globally, frequent diarrhoea occurrences,[33] dysentery, and malaria[5] adversely affect children's health and facilitate severe malnutrition in developing countries.[5] The synergy between infections and malnutrition was reported as early as 1968 by the World Health Organization (WHO).[34] Malnutrition increases the susceptibility to diseases, which in turn could worsen malnutrition in humans as a vicious cycle.[35]

Diarrhoea and malnutrition singly or in combination significantly cause ill health and death in children. Guerrant *et al*., in 1992, observed a cause-and-effect bidirectional relationship between diarrhoea and malnutrition in a study.[33] Recurrent diarrhoea negatively affects weight and height, reducing the catch-up growth that usually occurs following severe malnutrition.[33] Furthermore, malnutrition increases diarrhoeal episodes by 37% and duration by 73%, doubling the diarrhoeal burden.[33] Another study showed that children with moderate to severe diarrhoea are four times likely to die compared to those who were healthy.[36] A multi-center research in Africa and Asia observed children with diarrhoea and impaired growth have a higher death rate after a diarrhoeal illness in the immediate 90 days than those with no diarrhoea.[37] Recurrent diarrhoea in malnourished children could be due to environmental enteric dysfunction syndrome. [32]Together with infections, EED accounts for 56% of all childhood deaths worldwide.[3]

Respiratory tract infections are most typical in the first 2-3 years of life, coincides with a period of low immunocompetence and early exposure to pathogens.[38] Hooli *et al.* reported that 25% of children admitted for severe pneumonia were severely malnourished, with 37% dying after discharge in a study in Malawi39 Malnutrition is strongly associated with deaths in children with respiratory tract infections is a significant risk factor for pneumonia than diarrhoea.[32] Reports from a study in Kenya observed similar findings.[40] Malnutrition and respiratory tract infections are closely linked and interact as a vicious cycle.

Reports by Wurr *et al.* from a study conducted in north-western Nigeria revealed 70% of the children hospitalized for severe acute malnutrition also had concurrent malaria.[5] Similarly, another study reported a higher risk of malaria in malnourished children in Nigeria.[41] The relation between malaria and malnutrition is complex.[38,42] However, the literature is not conclusive. Epidemiologically, malaria and malnutrition are related, but the causal chain might be direct or indirect, increasing malaria incidence through the rainy season. After the rainy season, the hunger season starts as well.[5] A systematic review by Das *et al.* did not show a relationship either.[41] However, recognising that prompt malaria diagnosis and treatment became increasingly available over the years, aiding diagnosis and shortening the disease duration.

2.1.3 Classification of Malnutrition:

Undernutrition manifests in different forms. Stunting results from a longstanding nutrient deficiency resulting in a short stature compared to a standard of healthy peers of the same age (height-for-age) of the WHO reference of the median of the standard curve.[8,43,44,45] Wasting refers to being too thin compared to standard weight-for-height of the WHO standard curve's median. Wasting is usually due to severe or unexpected deprivation of food, insufficient intake, or malabsorption.[8,43,44,45] Underweight refers to weight-for-age below 2SD of the WHO standard curve's median.[8,43,45] Additionally, underweight children can be stunted, wasted, or both stunted and wasted.[8] However, in this study, the interest is in acute malnutrition, meaning too thin and an acute threat to health.

Acute Malnutrition: Acute malnutrition in children aged 6 to 59 months is classified into moderate acute malnutrition and severe acute malnutrition. Anthropometry of the child considered are its' weight-for-height z-score (WHZ) and the mid-upper arm circumference (MUAC), and the presence of nutritional oedema.[1] Moderate acute malnutrition (MAM) is weight-for-height Z-score ≤ -2 and ≥ -3 or mid-upper arm circumference of ≤ 125mm and ≥ 115mm. While severe acute malnutrition (SAM) is weight-for-height Z-score < -3 or MUAC < 115mm or nutritional oedema.[1]

Although the WHO recommends using both WHZ and MUAC for classification, often, either one is used.[46,47]Both anthropometric measures depend on contexts besides their poor correlation.[48]MUAC is often used in field trials and programmes.[18] Furthermore, MUAC is reportedly less influenced by hydration has a better predictive value for death than WHZ.[49,50] Reports by Mwangome *et al.* from a study in Kenya observed MUAC predicted infectious disease outcome and death better than WHZ.[51]However, MUAC is affected by changes in adiposity and skeletal muscle mass; and age,[49] and less sensitive in children below six months and above five years, needs to be age-adjusted in older children and adolescents.[48,52]Additionally, MUAC reportedly fails to identify three-fourth of children with SAM[48,]but identifies females, younger and stunted children more readily.[52,53] Similarly, a report by Grellety *et al.* from a study on Nigeria, Sahel, and West Africa observed that WHZ identified more U5 children with acute malnutrition than MUAC.[54]

Overall, anthropometric measurements remain valuable screening indicators of nutritional status. MUAC is an invaluable tool for assessing nutritional status by proxy, as MUAC programs have better coverage than WHZ also, MUAC is a stronger predictor of mortality[18,49,51,53,54]

2.2 Problem Statement

Malnutrition remains one of the top causes of death in Nigerian children and globally, especially in LMICs. Nigeria contributes disproportionately to the burden of malnutrition in the under-five children globally. The country ranks among countries with poor nutritional indicators, 32% of Nigerian children are stunted, and 2 million have severe acute malnutrition (SAM).[4]The burden of malnutrition varies across the country, being highest in the northern part due to insecurity, poverty, and gender inequalities.[18] Studies relating to malnutrition from the other country regions are more towards common diseases in those areas. Concurrent illnesses are common in children that are malnourished in developing countries.[6,8] Thus, diseases in acutely malnourished children are not limited to Nigeria. However, many studies are more towards diarrhoea, UTI, malaria, anaemia in Nigeria and other LMICs. There is some literature on these " less common" diseases reporting them in varying contexts.

A report from northwestern Nigeria revealed that 14.6% of the children studied had acute malnutrition, with SAM accounting for 83.% of malnourished children.[55] In the study, concurrent illnesses seen include diarrhoea accounting for 61.8 %, anaemia 33.3% and acute infections in 72.3% of the children.[55] In neighbouring Niger Republic, a research in children with SAM by Oldenburg *et al.,* 55.3% of the 2,399 children studied had malaria.[56] Another study in Zaria, reported malaria parasitaemia in 72.2 % of admitted malnourished children.[57] Similar findings were observed in Kenya, 49% of the 1,628 study acute malnourished children had diarrhoea.[58] Pneumonia, malaria, urinary tract infections and malaria were to be common in malnourished children among other diseases reported by Jones et al.[59] In a 2002 study of children with acute malnutrition conducted in Maiduguri northeastern, Nigeria (a conflict area) observed 11.3% prevalence UTI.[60] Trachoma, an eye disease reported closely related to malnutrition, and in areas with high malnutrition burden, in a study in Ethiopia where stunted children have 1.96 times higher likelihood of having the disease compared to the non- malnourished.[61]

Malnutrition is a global public health challenge, and its occurrence in conflict regions poses an even greater risk to children.[3,62] Armed conflicts and insecurity threaten household food security, making nutritious food challenging to many families.[6,18] Additionally, health systems are affected, limiting access to healthcare. Over 112 million malnourished children reside in conflict areas, corresponding to two-thirds of all children with malnutrition in developing countries.[63,64] Residence in a conflict zone has also been strongly correlated with malnutrition in children.[4,6] Northwestern Nigeria in general, especially Sokoto state and Goronyo, has been experiencing instability due to banditry and spate of kidnappings for over a decade, worsening the already high malnutrition burden. Additionally, the already weakened health system is further compromised allowing diseases to thrive in the existing poverty.

Although many studies highlight the interrelationship between malnutrition and illness, as noted above and earlier discussed in section 2.1. However, most studies concentrate on one particular disease, mainly diarrhoea, some LRTI, and malaria. Other diseases are omitted, often considered to be uncommon comorbidities. However, the line is thin between the main diagnosis and comorbidities, specifically when malnutrition is concerned. Malnutrition and infections operate in a vicious cycle. Therefore, the magnitude of the influence of diseases on malnutrition, particularly in relation to each other, is often unclear. Furthermore, diseases and malnutrition are exacerbated by poverty and related contextual factors.

This study aims to quantify the relationship between disease and malnutrition, including other illnesses that are often not investigated in current context.

2.3 Justification of the study

A study conducted in Goronyo by van der Kam *et al.* observed that nutritional intervention for ill children did not decrease malnutrition. The finding suggests the burden of acute diseases might be a more important cause of malnutrition or responsible for the persistence of malnutrition in the children. Thus, highlighting the persistence of or lack of treatment for common acute childhood diseases lessening the region's high malnutrition rates.[16] Goronyo LGA has few healthcare facilities,[13] mostly is non-functional, while those functional are poorly staffed, besides the scarcity of medications, vaccines, and other medical supplies.[7] Besides, the town and local government have been under sporadic and persistent banditry and kidnapping. The burden of malnutrition further overstretches the few health care facilities.

Despite the high burden of malnutrition and acute diseases, there is limited literature relating to the influence of acute diseases on childhood malnutrition in Goronyo, and north-western Nigeria. The current study built on earlier research done by van der Kam *et al.* on the influence of nutritional supplementation on children having one of these three diseases: malaria, diarrhoea, and pneumonia. However, in the earlier research, the impact of other diseases and the influence of illnesses on malnutrition were not investigated. These gaps necessitate this study.[7]

Furthermore, the study findings will contribute evidence-based information towards reducing the knowledge gap on acute diseases' influence on childhood malnutrition in the region. The study results will aid in prioritising the formulation of strategies and interventions, including prompt prevention and management of the diseases to address the high burden of malnutrition. And to policymaking for malnutrition and the related diseases in Nigeria and beyond. Overall, it hoped that these study findings would support attainment of the Sustainable Development Goals (SDGs), SDG 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and SDG 3 (Good Health and well-being).

Justification of Study Approach:

This study aims to identify factors that can cause negative nutritional outcome in children with acute malnutrition to find the contribution of the primary diseases studied in the MSF research and other diseases not studied. Thus, it intends to address a knowledge gap and implies a causal relationship between the diseases and negative nutritional outcomes. The acute diseases-malaria, diarrhoea and LRTI, and other infections, are the main explanatory variables for possible causation of the outcome (NNO).[65] Other explanatory variables are included in the analysis alongside the main variables to avoid bias. Since some of these other variables may be potential confounders and could affect the validity of the findings, it is necessary that the results of this study, analyzed on univariate models, will also be done in a multivariate logistic regression model. Multiple logistic regression enables simultaneous analysis of many explanatory variables reduces confounders. [66]The causal inference could be affected by multicollinearity, making the role of some variables unclear. Also, sensitivity analysis may be required to give robustness to findings of the other models in where some variables are missing, omitted or added.[66] This study used the UNICEF framework (figure 3) to discuss malnutrition from the contextual to the individual level causes.[10] While the causal relationship between malnutrition and infection is explored using the framework in figure 4 adapted from a study by Rytter *et al*.[24]

Research Question: What is the relative contribution of other acute diseases in addition of pneumonia, diarrhoea and malaria and contextual factors on the incidence of malnutrition in Goronyo, northwestern Nigeria?

2.4 Objectives

2.4.1 Main Objective:

To study the influence of acute infectious disease on the incidence of malnutrition in children in Goronyo, north-western Nigeria.

2.4.2 Specific Objectives:

1. To describe the pattern of childhood malnutrition among U5 children in Goronyo, Nigeria.
2. To identify risk factors associated with the incidence of malnutrition in U5 children in Goronyo, Nigeria
3. To examine the effect of co-morbidities (UTI, Otitis Skin and Eye diseases) on the negative nutritional outcomes (NNO) among U5 in Goronyo LGA, Nigeria.
4. To provide evidence-based information to MSF, local, state, and national health authorities for policymaking and formulation of strategies to curb diseases and malnutrition in the region.

CHAPTER THREE

METHODOLOGY

3.1 Médecins Sans Frontières Study (Data Source):

MSF Operational Centre Amsterdam (MSF-OCA) conducted the primary research between February 2012 to July 2012 at Goronyo Hospital Goronyo in Sokoto State, north-western Nigeria.[6] Children aged 6-59 months who presented to the clinic were included in the study based on: parental or caregivers' consent, caregiver or parental age of 18 years and above, presence as single or in combination, of lower respiratory tract infections, diarrhoea (three or more loose stools per day), malaria, or with other acute infections. While the exclusion on failure to meet the inclusion criteria, in addition to incomplete information or data, being lost to follow-up within six months of the study or referral to Inpatient Therapeutic Feeding Center (ITFC) for treatment of severe acute malnutrition (SAM). The MSF research objective was to determine the intervention effectiveness of 14 days nutritional supplements in decreasing negative nutritional outcome (NNO) in children. A cohort of 2,188 participants was followed up at 14 days from the enrolment visit (baseline), then monthly for six months**.** Standardized questionnaires (Appendices A, B and C) were used to obtain information related to children's caregivers and households for the study. Data on their anthropometric and the presence of symptoms (and signs) of the three diseases (and other illnesses) were observed, and the diagnosis made accordingly. A cluster design approach was used for data collection. The current study involved 1,697 children, 143 of whom were malnourished while 1,554 were not.

3.2 Definitions of Primary outcomes and indicators:

Study indicators of malnutrition for the children aged 6-59 months is based on mid-upper-arm-circumference (MUAC). This study adopted the classification of undernutrition as in the primary research using MUAC. [6] The primary outcome indicator is NNO in this study, defined as: Negative Nutritional Outcome (NNO) is deterioration from NAM to MAM or SAM[6], measured using MUAC including oedema. MUAC below 115 mm or presence of oedema.

Table 2: **Study indicators.**

Outcome Indicator	Study Definition	WHO Definitions
Negative Nutritional Outcome[6]	Negative Nutritional Outcome (NNO) is deterioration from NAM to MAM or SAM	-
Improvement from MAM or SAM to NAM	Improving to non-malnourished state within the first month of follow-up and throughout the study period	-
No Acute Malnutrition	MUAC ≥ 125mm	-
Moderate Acute malnutrition	MUAC ≤ 125mm and ≥ 115mm	Weigh-for-Height Z-score (WHZ) ≤ -2 to ≥ -3
Severe Acute Malnutrition	MUAC < 115mm	Nutritional Oedema, WHZ < -3 or presence of oedema

3.3 Data Extraction

The data for this study was extracted from password-protected MSF study data in STATA 15. The primary research was a prospective study conducted in 2,188 children aged 6 to 59 months who presented at the Outpatient Department of Goronyo Hospital, Goronyo, between February 2012 and July 2012. MSF staff oversee the study clinic. The primary data of all children who presented with diarrhoea, lower respiratory tract infection from the MSF study in Goronyo was utilized for this secondary analysis.

Of the 2,188 enrolled at baseline in the earlier study, the data of 1,697 U5 children followed up for six months were analyzed. The primary outcome of this study is Negative Nutritional Outcome (NNO), a study-specific indicator adopted from the MSF study.

3.4 Data Management:

The MSF study provided data for this secondary analysis carried out in this study. The dataset captured the participant's: sociodemographic factors, household characteristics, feeding practices, disease-history and related factors, anthropometric and nutritional-related factors.

In this study, 17 variables were extracted based on their relevance to the stated research objectives and used for data analysis. The factors included were age, sex, history of breastfeeding, caretaker characteristics, the relation of caretaker to the child, educational status of caretaker, marital status of caretaker, occupation of caretaker, occupation of caretaker's partner, household size, household food availability, household possession of assets (watch, radio, generator, motorbike), household possession of livestock (sheep, goat, chicken, cows, donkey, camel), external walls of the household, and breastfeeding status at admission. Medical-related variables extracted from the data include the appetite, duration of illness prior to the clinic visit, type of primary illness at study entry (diarrhoea, LRTI, malaria, UTI, skin diseases, otitis, eye diseases), primary illness at follow-up (diarrhoea, LRTI, malaria) other illnesses, other diagnoses, (UTI, skin diseases, otitis, eye diseases), and anthropometry measurement (MUAC) throughout the study.

To better organize the extracted variables for this study. The age of children was categorized into months (<24 months and ≥ 24 months). Other variables include household size, socioeconomic status, number of children aged 5-17 years, mother's age, caretaker occupation and household food availability due to binning in the data at convenient intervals.

The variables obtained by the author from the earlier study focused on household possessions and assets were used to develop a study-specific index for socioeconomic status (SES) relative to other community members. As there was no data on wealth index in the primary study. The variables regarding household possessions and assets were converted into categorical variables to develop an index for SES. The variables are based on household ownership of the following: wristwatch, radio, motorbike, a generator, livestock and type of external household walls. They were categorized as follows: Low SES were participants that had two or less of the aforementioned household possessions or assets, middle SES were those that had more than two but less than 5, and high SES were those that had 5 or more. Household size was categorized into 4 or less, 5 to 7 and 8 or more people.

Household food availability was grouped into binary forms (0-2 cooked meals a day before and 3 or more cooked meals a day before). While breastfeeding was based on the self-reported history of breastfeeding of the child at the time of admission.

In addition, the history of disease before clinic presentation, the type of primary illness at the time of admission and subsequent illnesses at follow-up were grouped based on the month of data collection. Furthermore, the anthropometric indicator MUAC was included. The MUAC was used to assess malnutrition (NAM, SAM and MAM) with categories no malnutrition- ≥125mm; moderate- 115-≤124mm; and severe- ≤ 115.

The primary outcome variable "negative nutritional outcome2" (NNO) was generated. This was done by first by subtracting the MUAC of the prior visit from the MUAC of the current visit (for example, MUAC month 2- MUAC month 1) to generate 7 indicator values. The seven values obtained were then summed up to generate a variable "negative nutritional outcome" (negative_nutri_outcome). The negative nutritional outcome2 variable was then generated using negative nutritional outcome greater than 0 or less than 0. This was used as a binary variable and formed the primary outcome variable.

Furthermore, 'tnb' the variable for total episodes of malaria, total episodes of diarrhoea and total episodes of LRTI was assessed against NNO. The 'tnb' variables were generated for analysis, by identifying participants with malaria, diarrhoea or LRTI during each of the 7 visits of the study (m0diag1 to m7diag1). The sum of the presentations with these illnesses was calculated as each study participant's total number of episodes. This was used as a continuous variable and measured against the binary primary outcome variable-negative nutritional outcome2.

3.5 Data analysis of current study:

The statistical analysis and management of data related to this study was done using STATA 16.0 software (Stata Corp LLC Lakeway Drive, College Station, Texas).

For the first objective, which was to describe the pattern of childhood malnutrition among the under-five children in Goronyo, Nigeria, a descriptive analysis was conducted using frequencies and percentages. Also, to explore the association between the primary outcome NNO and the total number of episodes of primary illnesses (malaria, diarrhoea and LRTI) in each participant, univariable and multivariate logistic regression models were used. Furthermore, to address the second and third objectives, which were to identify risk factors associated with the incidence of malnutrition in under-five children, and to examine the effect of co-morbidities (UTI, otitis, skin and eye diseases) on the negative nutritional outcomes (NNO) among the under-five children in Goronyo, respectively, chi-square analysis, univariable and multivariate logistic regression models were used.

The association between the primary outcome NNO and child, caretaker and household characteristics were demonstrated using Chi-square analysis. In addition, univariable and multivariate logistic regression models were used to investigate the association between NNO and potential risk factors- sociodemographic, household and caretaker characteristics and diseases (history of NNO at first month, diarrhoea, LRTI, Malaria, UTI, Skin diseases, Otitis and eye diseases) in several models. The first model included only caretaker and household characteristics, the second model only primary illnesses, while the third was a combination of caretaker, household characteristics and primary diseases.

Furthermore, a sensitivity analysis was done using a generalized linear model to investigate the association between NNO and caretaker, household characteristics and primary illnesses. Additionally, to explore the association between the primary outcome NNO and the total number of episodes of primary illnesses (malaria, diarrhoea and LRTI) in each participant, univariable and multivariate logistic regression models were used.

3.6 Ethical Consideration

The ethical consideration in the current study was in line with the original study's objective: to know why the children are malnourished. The primary research went through rigorous ethical procedures, with clearance obtained at all required levels (Goronyo LGA, Sokoto SMoH, and national level) before the study's commencement. Additionally, the principal investigator for the MSF study was trained in compliance with the Nigerian National Code for Health Research Ethics with registration number **NHREC/TR/08/10/2013A.** Furthermore, the MSF registered the study at **clinicaltrials.gov** with registration number **NCT01154803.**

The MSF researchers obtained informed consent from all the children's caretakers and their spouses before enrolment into the study. The data obtained was password coded to ensure data security. Additionally, for confidentiality, the personal identifiers of study participants were removed. Nutritional supplements and treatment of illnesses were given to the participants on presentation to the clinic from the baseline throughout the study period, as the need arise. After their study, MSF disseminated the findings to the Goronyo community through the LGHA, the Sokoto SMoH and FMoH.

The current study leveraged the afore approvals and procedures. However, the investigator obtained approval from the MSF Ethical Review Committee and the MSF study local co-investigator Dr NMA Jiya of Usmanu Danfodio University Teaching Hospital, Sokoto, before this study's commencement. Additionally, a data-sharing agreement was signed between the author and MSF before the start of this study. And dataset was received on the 8th of July 2021 from Saskia van der Kam.

CHAPTER FOUR

RESULTS

4.1 Characteristics of the Study Participants

The study participants were characterized into the patient, caregiver, family, and household characteristics as indicated in table 2. At baseline, the MSF study enrolled 2,188 participants, of which 1,697 participants (77.6%) reached the endpoint at six months, had their data analysed in this study (figure 5). The mean of the MUAC of the participants analyzed in the current study was 142.25mm (SD 10.41) range was between 108 and 190mm.

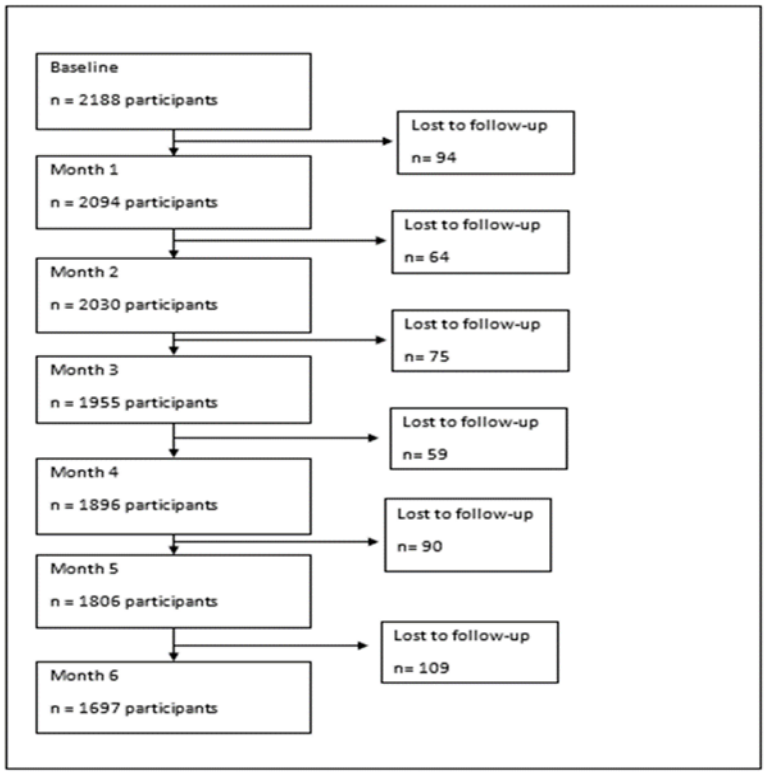

Figure 5: **Study flow chart**

The mean age of under-five participants was 20.19 (SD: ±11.31), and the majority were females (50.56%), while the median age was 18 months. There was a history of being breastfed in 55.1%, while 44.9% did not breastfeed. In addition, most of the children who participated in the study, presented at clinic visits with their mothers (97.05%) as caretakers, while 2.59% presented with their grandparents. About 79.26% of caretakers had received Islamic education, and 12.55% did not receive formal education. The mean age of the caregivers was 25.03%, over 96% of them were married, and 40.9% were traders or shop owners. Similarly, over 51% of the caregivers' spouses were also traders or shop owners. Twenty-two per cent of the caregivers had 22.98%

agriculture as occupation, while only 2.77% of their partners were in agriculture. Furthermore, 79.2% of participants had eaten 3 or more cooked meals a day before presentation at baseline, 20.8% had 2 or less meals cooked in the household (table 3).

Table 3. Characteristics of the study participants.

Variable	n (%)	Variable	n (%)
Child characteristics		**Caretaker's partner occupation**	
Mean age in months (± SD)	20.19 (11.31)*	Livestock	2 (0.12)
Median age in months (IQR, 25%-75%)	18 (11-26)	Agriculture	47 (2.77)
Sex		Trading/shop owner	868 (51.15)
Male	839 (49.44)	Seasonal daily labor	85 (5.01)
Female	858 (50.56)	Regular work	63 (3.71)
History of breastfeeding		Housewife	3 (0.18)
No	762 (44.9)	Student	626 (36.89)
Yes	935 (55.1)	Other	3 (0.18)
I don't know	0(0)	**Household characteristics**	
Caretaker characteristics		**Household size**	
Relation of caretaker to child		Number of children <5 years in the household	241 (14.20)
Mother	1647 (97.05)	Children between 5 to 17 years	429 (25.28)
Father	3 (0.18)	Adults (≥18 years)	1027 (60.52)
Grandparent	44 (2.59)	**Household ownership of livestock**	
Brother/ Sister	1 (0.06)	No	385 (22.69)
Other	2 (0.12)	Yes	1312 (77.31)
Mean age of caretaker (± SD)	25.03 (6.63)*	I don't know	0 (0)
Highest level of Education of caretaker		**Household ownership of wristwatch**	
None	213 (12.55)	No	399 (23.51)
Incomplete primary education	31 (1.83)	Yes	1298 (76.49)
Complete primary education	49 (2.89)	I don't know	0 (0)
Incomplete secondary education	42 (1.71)	**Household ownership of motor bike**	
Complete secondary education	29 (1.36)	No	681 (40.13)
Incomplete Higher Institution	1 (0.06)	Yes	1016 (59.87)
Complete Higher Institution	3 (0.18)	I don't know	0 (0)
Islamic school	1,345 (79.26)	**Household ownership of radio**	
Other	3 (0.18)	No	365 (21.51)
Marital status of caretaker		Yes	1332 (78.49)
Single	2 (0.12)	I don't know	0 (0)
Married	1637 (96.46)	**Household ownership of generator**	
Cohabitating	0 (0)	No	1304 (76.84)
Divorced	40 (2.36)	Yes	393 (23.16)
Widow	17 (1.00)	I don't know	0 (0)
Others	1 (0.06)	**What are the external walls?**	
Child Caretaker's occupation		Improvised, plastic, cloth	20 (1.18)
Livestock	36 (2.12)	Wood, mud, bamboo	1358 (80.02)
Agriculture	390 (22.98)	Stone, brick, cement	315 (18.56)
Trading/shop owner	694 (40.9)	I don't know	4 (0.24)
Seasonal daily labor	85 (5.01)	**Household food availability?**	
Regular work	412 (24.28)	0-2 cooked meals a day before	353 (20.8)
Housewife	6 (0.35)	3 or more cooked meals a day before	1344 (79.2)
Student	24 (1.41)	I don't know	0 (0)
Other	16 (0.94)	-	-
I don't know	34 (2.00)	-	-

*SD- Standard deviation.

4.2 The pattern of childhood malnutrition among U5 children in Goronyo LGA, Nigeria

4.2.1 Malnutrition in study participants:

At baseline 1,554 (91.6%) presented with no acute malnutrition (NAM), while at baseline, MAM was seen in 143 children, but SAM not observed as they were excluded from the original study. However, SAM was observed in 0.06-0.18% of the children from the first month and the end of the study period (figure 6). A total of 15 children had SAM in the study period, with the highest number (4) observed in the third month of the study (see Appendix D table 1). Participant who has SAM at any point are referred to ITFC for nutritional supplements and treatment.

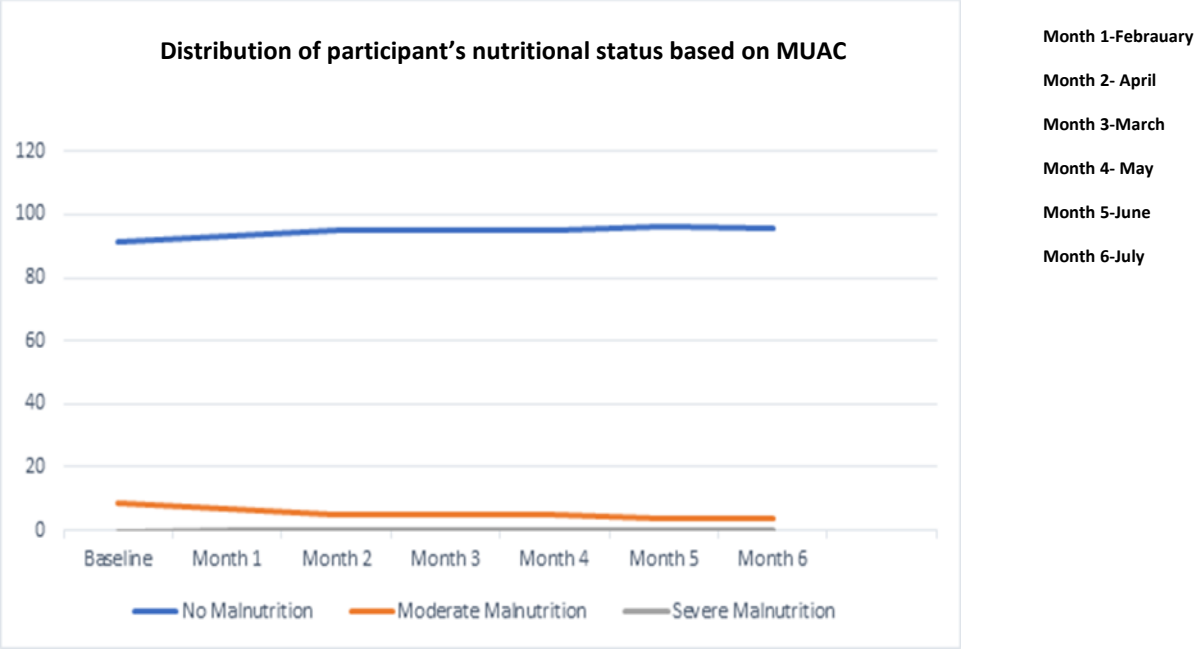

Figure 6: Distribution of nutritional status based on MUAC

4.2.2 Negative Nutritional outcome in study participants:

Of the 1,697 children studied, 1.12% had negative nutritional outcome (NNO) within the first month, 1.53% in the fourth month, while 1.89% had NNO in the sixth month (figure 7). The lowest NNO was in the first month (19 children); however, by the last month of the study, 32 participants had NNO, the highest number seen in the study (Appendix E table 2). The NNO was higher in the month of March, May, and July. The May and July are within the 'Hunger months' the rainy season.

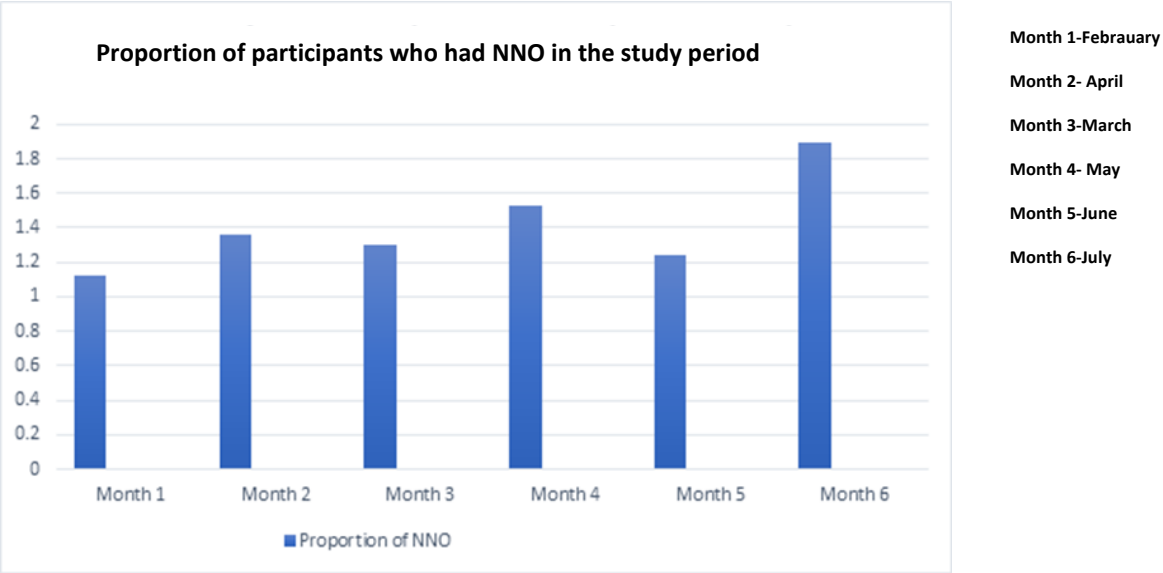

Figure 7: The proportion of participants with NNO in the study period

4.2.3 The proportion of diseases and disease episodes:

The proportion of primary diseases (malaria, diarrhoea and LRTI) and all other diseases in all the study participants irrespective of nutritional status over the six-month study period are in figure 8. At baseline, the most common disease among the participants was diarrhoea 61.11% (1,037), followed by malaria at 24.10% (409), UTI was 16.32%, and eye diseases 15.26%. There was a sharp decrease in the proportion of diarrhoea to 21.39% in the first month, followed by a gradual increase by the second and third months, stabilizing to the sixth month of the study. Similarly, malaria also showed a sharp decrease by the second month, then increased steadily and had the highest proportion (18.27%) compared to the other diseases at the end of the study. The proportion of otitis (3.24%) was the lowest at baseline and remained low compared to the others throughout the study period. At the end of the study, 52 participants had otitis, 247 had diarrhoea, and 310 had malaria (Appendix D Table 3). Although, some study participants possibly had more than one disease simultaneously during the study months. However, the sharp decrease observed in diarrhoea and malaria from baseline to end of the first study month could be due to treatment the children received during enrolment and the first follow-up visit at the clinic. Malaria steadily increased from March to the end of the study.

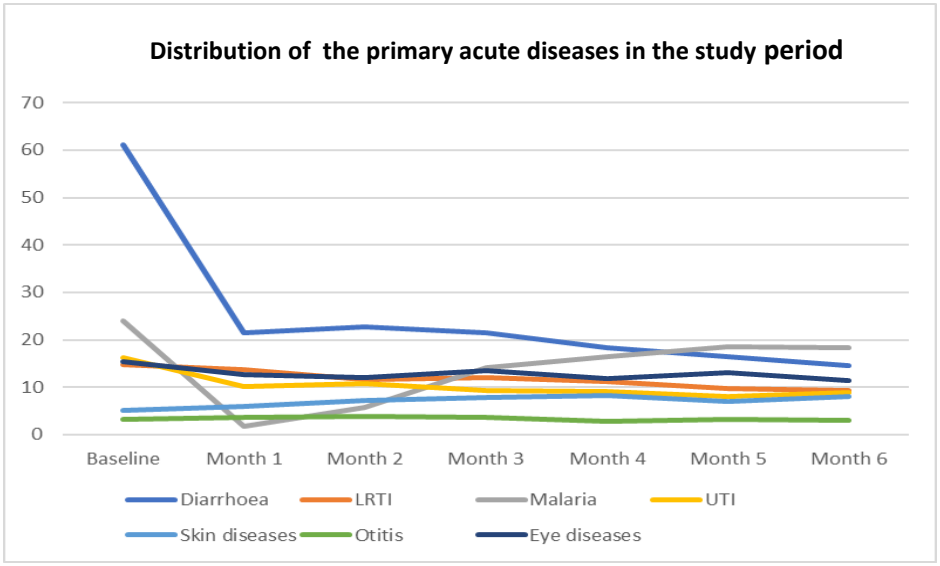

Figure 8: Distribution of all primary acute diseases in the study period

4.2.4 The number of episodes of the primary diseases experienced by the children in the study period:

Figure 9 illustrate the number of episodes of primary diseases (diarrhoea, LRTI and malaria) in the entire study population throughout the study. Most participants who had these diseases presented with one to two episodes. Of the 1,697 children studied, 26.6% (452) had two episodes of diarrhoea, while 14.8% (251) had malaria twice. Three per cent 3.01% (51) children had five diarrhoeal episodes, and 0.9% (15) have had 5 malarial episodes (Appendix E table 4). Although the number of disease episodes may seem to appear less, it is important to recall that the presence of diseases was one of the inclusion criteria of the MSF study.

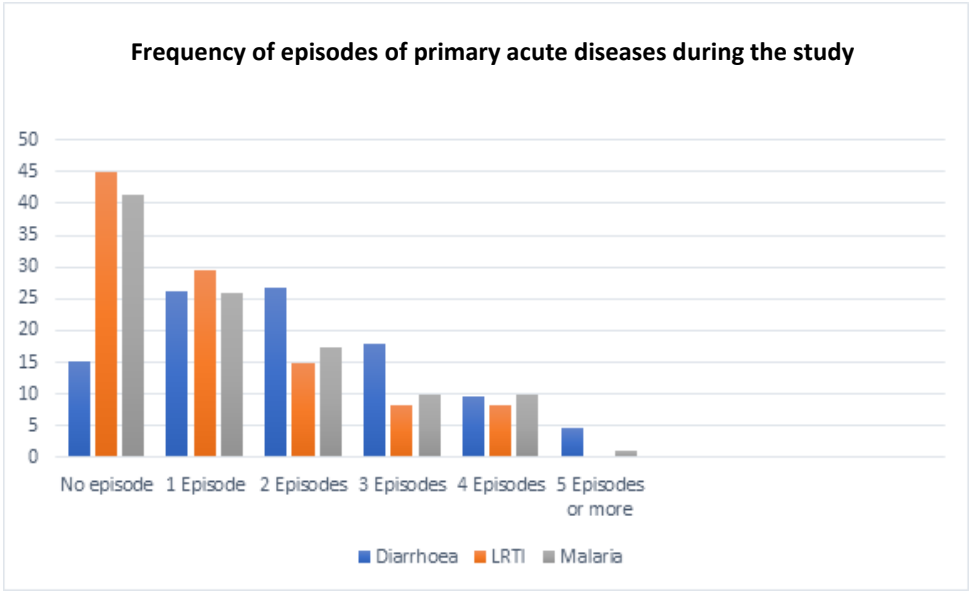

Figure 9: **Episodes of Diarrhoea, Malaria and LRTI in study participants during the study period**

4.2.5 Association NNO and episodes of primary diseases in the study period:

The logistic regression model in table 4 demonstrates on the univariable model reduced odds of NNO for every unit increase in episodes of malaria over the study period [OR: 0.84; 95% CI: 0.72,0.98; p: 0.03]. There was a 19% decreased likelihood of NNO for every unit increase malarial episodes [p=0.03]. On the other hand, there was increased odds of NNO for every unit increase in episodes of diarrhoea [OR: 1.36;95%CI :1.21,1.53; p: <0.001] and LRTI [OR:1.22:95%CI: 1.05,1.42; p: <0.001] over the study period, respectively.

However, on the bivariate model, there was increased odds of NNO for every unit increase in episodes of malaria [OR: 1.05;95%CI: 0.88,1.26; p:0.56], diarrhoea [OR: 1.46; 95%CI: 1.28,1.66; p: <0.001] and LRTI [OR: 1.38;95%CI: 1.16,1.63; p: <0.001] over the study period. This finding suggests that the study participants who had more episodes of illnesses during the study period were more likely to develop NNO at the end of the study period.

Table 4: Association between NNO and episodes of primary diseases using univariate and multivariate logistic regression.

	Univariate			Multivariate	
Variable	**Range of episodes**	**OR [95% CI]**	**p-value**	**aOR [95% CI]**	**p-value**
Total episodes of Malaria	0-8	0.84 [0.72,0.98]	0.03*	1.05 [0.88,1.26]	0.56
Total episodes of Diarrhea	0-7	1.36 [1.21,1.53]	<0.001*	1.46 [1.28,1.66]	<0.001*
Total episodes of LRTI	0-6	1.22 [1.05,1.42]	0.01*	1.38 [1.16,1.63]	<0.001*

*p<0.05. OR: Odds ratio. aOR: adjusted odds ratio. NNO: Negative Nutritional Outcome. Pseudo R2 on the multivariate logistic regression model- 0.043.

4.2.6 Negative nutritional outcome and sociodemographic characteristics:

The association between socio-demographic factors and negative nutritional outcome using a chi-square analysis is shown in table 5. There was a higher proportion of NNO among child participants aged <24 months (10.17%) compared to those ≥ 24 month (2.85%). Similarly, females (11.31%) had a higher rate of NNO compared to males (3.81%). Further, participants (6.23%) with a household size of 8 or more accounted for the highest rate of NNO compared to those from a household with 7 members or less. In addition, participants who reported having only 2 or less meals (10.2%) a day before had a higher proportion of NNO compared to those who reported having at least 3 meals (6.92%). The p-values of age less than 24 months (p<0.001), being male (p<0.001), household size of 4 or less people (p=0.023), households with no other children above 5 years(p=0.015), having mother as caretaker (p=0.044), and 2 or less cooked meals in day (p=0.039) were statistically significant. However, there was no relationship between socio-economic status and NNO (p=0.398), participants caretakers age (p=0.108), SES with Education (p=0.685), occupation of caretaker (p=0.887), and the occupation of caretaker's partner (p=0.554).

Table 5. Relationship between NNO and child, caretaker and household characteristics using Chi-square

	NNO		
Characteristics	**No (%)**	**Yes (%)**	**p-value**
Age			
< 24 months	989 (89.83)	112 (10.17)	<0.001*
≥ 24 months	579 (79.15)	17 (2.85)	
Sex			
Male	807 (96.19)	32 (3.81)	<0.001*
Female	761 (88.69)	97 (11.31)	
[+]SES			
Low	802 (91.55)	74 (8.45)	0.398
Middle	433 (93.32)	31 (6.68)	
High	333 (93.28)	84 (6.72)	
Household size			
0-4	215 (89.21)	26 (10.79)	0.023*
5-7	390 (90.91)	39 (9.09)	
≥8	963 (93.77)	64 (6.23)	
Number of children aged 5-17 years			
None	332 (89.25)	40 (10.75)	0.015*
1-2	508 (92.70)	40 (7.30)	
3-4	417 (95.21)	21 (4.79)	
≥5	311 (91.74)	28 (8.26)	
Caretaker's age			
18-24 years	770 (91.12)	75 (8.88)	0.108
25-34 years	644 (93.33)	46 (6.67)	
≥35 years	154 (95.06)	8 (4.94)	
Relation of caretaker to child			
Mother	1521 (92.35)	126 (7.65)	0.044*
Father	2 (66.67)	1 (33.33)	
Grandparents	43 (97.73)	1 (2.27)	
Brothers/ Sisters	1 (100.0)	0 (0)	
Others	1 (50.0)	1 (50.0)	
SES with Education			
Low	1437 (92.23)	121 (7.77)	0.685
Middle	78 (93.98)	5 (6.02)	
High	53 (94.64)	3 (5.36)	
Occupation of caretaker			
Regular worker or shop-owner	861 (92.48)	70 (7.52)	0.887
Other work	707 (92.30)	59 (7.70)	
Occupation of caretaker's partner			
Regular worker or shop-owner	1025 (92.68)	81 (7.32)	0.554
Other worker	543 (91.88)	48 (8.12)	
Household food availability			
0-2 cooked meals a day before	317 (89.80)	36 (10.20)	0.039*
3 or more cooked meals a day before	1251 (93.08)	93 (6.92)	

* Significant p-value

4.3 Risk factors associated with the incidence of malnutrition in U5 children in Goronyo LGA, Nigeria

4.3.1 Risk factors associated with the incidence of malnutrition

4.3.1.1 Association between NNO and sociodemographic, household and caretaker characteristics as potential risk factors

A multivariate logistic regression model was used to adjust the findings to demonstrate the association between NNO and potential risks of the children's sociodemographic, caretaker and household characteristics.

On the univariate model, children aged 24 months or older had reduced odds (3.8 times lower) of NNO compared to those aged less than 24 months [OR: 0.26; 95% CI: 0.15,0.44; p:<0.001]. Female participants had significantly higher odds (3.21 times) of NNO compared to males [OR: 3.21; 95% CI: 2.13,4.85; p:<0.001]. Likewise, participants who came from a household size of 8 or more members had significantly reduced odds of NNO compared to those from households of 4 or less members [OR: 0.55; 95% CI: 0.34,0.89; p: 0.014]. Similarly, participants who had 3 or more cooked meals a day before review had 1.61 times lower odds of NNO compared to those who had 2 or less meals [OR: 0.65; 95% CI: 0.44,0.98; p: 0.04]. However, participants not breastfed had significantly higher odds of NNO compared to those breastfed [OR: 2.23; 95% CI: 1.50,3.31; p: 0.001].

On the multivariate regression model (Table 6), which adjusts for influences of all other variables (child, caretaker, and household characteristics) being older (24 months or older) remained significantly associated with NNO, while being female, and the history of 3 or more cooked meals a day prior to presentation at the clinic remained significantly associated with higher odds of NNO.

However, the household SES relative to other community members, household SES with caregiver's education, caregiver's age, caregiver's relation to the child, occupation of caregiver and partner did not show significant association with NNO on both univariate and multivariate models.

Table 6. Association between NNO and sociodemographic, household and caretaker characteristics as potential risk factors using univariate and multivariate logistic regression models.

	Univariate model			Multivariate model		
Variables	**OR**	**CI [95%]**	**p- value**	**aOR**	**CI [95%]**	**p- value**
Age						
< 24 months	1 [ref]			1 [ref]		
≥ 24 months	0.26	0.15-0.44	<0.001*	0.25	0.13-0.51	<0.001*
Sex						
Male	1 [ref]			1 [ref]		
Female	3.21	2.13-4.85	<0.001*	3.31	2.18-5.04	<0.001*
SES						
Low	1 [ref]			1 [ref]		
Middle	0.78	0.50-1.20	0.253	0.84	0.53-1.33	0.462
High	0.78	0.48-1.26	0.311	0.86	0.51-1.44	0.557
Household size						
0-4	1 [ref]			1 [ref]		
5-7	0.83	0.49-1.40	0.477	1.11	0.56-2.19	0.761
≥8	0.55	0.34-0.89	0.014*	0.72	0.32-1.60	0.417
Number of children aged 5-17 years						
None	1 [ref]			1 [ref]		
1-2	0.65	0.41-1.03	0.070	0.77	0.41-1.45	0.426
3-4	0.42	0.24-0.72	0.002*	0.61	0.28-1.33	0.214
≥5	0.75	0.45-1.24	0.260	1.10	0.49-2.47	0.825
Caregiver's age						
18-24 years	1 [ref]			1 [ref]		
25-34 years	0.73	0.50-1.07	0.111	0.84	0.56-1.26	0.394
≥35 years	0.53	0.25-1.13	0.100	1.10	0.48-2.55	0.821
Relation of caretaker to child						
Mother	1 [ref]			1 [ref]		
Father	6.04	0.54-67.02	0.143	7.89	0.58-107.14	0.121
Grandparents	0.28	0.04-2.06	0.211	0.40	0.05-3.42	0.404
Others	12.07	0.75-194.14	0.079	21.20	0.75-599.97	0.073
SES with caregiver's Education						
Low	1 [ref]			1 [ref]		
Middle	0.76	0.30-1.92	0.562	0.76	0.29-1.99	0.581
High	0.67	0.21-2.18	0.509	0.54	0.16-1.83	0.325
Occupation of caregiver						
Other work	1 [ref]			1 [ref]		
Regular worker or shop-owner	0.97	0.68-1.40	0.887	1.16	0.78-1.70	0.463
Occupation of Father						
Other work	1 [ref]			1 [ref]		
Regular worker or shop-owner	0.89	0.62-1.30	0.555	0.91	0.61-1.35	0.628
Household food availability						
0-2 cooked meals a day before	1 [ref]			1 [ref]		
3 or more cooked meals a day before	0.65	0.44-0.98	0.040*	0.65	0.42-0.99	0.045*
Breastfeeding						
Breastfed	1 [ref]			1 [ref]		
Not breastfed	2.23	1.50-3.31	<0.001*	0.96	0.56-1.64	0.875

Notes: *p<0.05. OR: Odds ratio. aOR: adjusted odds ratio. Ref: reference value. NNO: Negative Nutritional Outcome. SES: Socioeconomic status (SES). Brother and Sisters of a variable under 'relation of caretaker to child' were excluded because of collinearity. Regular worker- Traders, shop owners and regular workers. Other workers- Livestock, Agriculture, seasonal daily labour and student. Pseudo R^2 on the multivariate logistic regression model- 0.103.

4.4 Effect of co-morbidities on the negative nutritional outcomes (NNO) among under-five children in Goronyo LGA, Nigeria

4.4.1 Association between NNO and co-morbidities:

Furthermore, the effect of history of NNO at first month and diseases (diarrhoea, LRTI, Malaria, UTI, Skin diseases, otitis, and eye diseases) on the likelihood of NNO among study participants using univariate and multivariate regression models is as shown in table 7. On the univariate model, participants with diarrhoea [OR: 1.36; 95% CI: 1.21,1.53; p: <0.001], LRTI [OR: 1.22; 95% CI: 1.05,1.42; p: 0.011] and malaria [OR: 0.84; 95% CI: 0.71,0.98; p: 0.03]) had significantly higher odds of NNO than those without these diseases. Likewise, on the multivariate regression model, participants with diarrhoea and LRTI remained statistically significantly associated with higher odds of NNO than those without it. In both models, otitis is showed higher odds of NNO; however, the relationship was not statistically significant (p:>0.05).

Table 7: **Association between NNO and co-morbidities using univariate and multivariate logistic regression models.**

	Univariate			Multivariate		
Variables	**OR**	**CI [95%]**	**p-value**	**aOR**	**[95% CI]**	**p-value**
NNO at the first month						
Absent	1 [ref]			1 [ref]		
Present	1.03	0.99-1.09	0.164	1.03	0.98-1.08	0.229
Diarrhoea						
Absent	1 [ref]			1 [ref]		
Present	1.36	1.21-1.53	<0.001*	1.47	1.29-1.68	<0.001*
LRTI						
Absent	1 [ref]			1 [ref]		
Present	1.22	1.05-1.42	0.011*	1.43	1.20-1.70	<0.001*
Malaria						
Absent	1 [ref]			1 [ref]		
Present	0.84	0.71-0.98	0.032*	1.09	0.91-1.30	0.358
UTI						
Absent	1 [ref]			1 [ref]		
Present	1.15	0.95-1.39	0.159	1.19	0.98-1.46	0.082
Skin diseases						
Absent	1 [ref]			1 [ref]		
Present	1.04	0.85-1.28	0.684	1.09	0.89-1.34	0.406
Otitis						
Absent	1 [ref]			1 [ref]		
Present	1.24	0.99-1.55	0.063	1.25	0.99-1.58	0.064
Eye diseases						
Absent	1 [ref]			1 [ref]		
Present	0.99	0.84-1.19	0.997	0.96	0.80-1.14	0.636

Notes: *p<0.05. OR: Odds ratio. aOR: adjusted odds ratio. Ref: reference value. NNO- Negative Nutritional Outcome. SES: Socioeconomic status (SES). Lower Respiratory Tract Infection. UTI: Urinary Tract Infection.

4.4.2 Association between NNO and all potential risk factors

The relationship between NNO and a combination of potential risk factors such as child, caretaker, household characteristics, and disease co-morbidities (diarrhoea, LRTI, malaria, UTI, otitis, skin, and eye diseases) was assessed using a multivariate logistic regression model (Table 8). The results suggest that older children (aged 24 months or more) [OR: 0.28; 95% CI: 0.14,0.57; p:0.001] are 72% less likely to have NNO than children 24 months or less. Furthermore, children from households having 3 or more cooked meals a day before assessment [OR: 0.64; 95% CI: 0.41,0.99; p:0.046] have a 36% lower likelihood of having NNO than those from households with 2 or less cooked meals. Thus, both potential risk factors are associated with significantly lower odds of NNO. On the other hand, being a female child [OR: 3.71; 95% CI: 2.41,5.72; p:<0.001] has a 3.71% higher likelihood of NNO than being male. Similarly, a clinical history of diarrhoea [OR:1.47;95%CI:1.27,1.70; p:<0.001], LRTI [OR: 1.36; 95% CI: 1.13,1.64; p:0.001] and otitis [OR: 1.34; 95% CI: 1.04,1.74; p:0.029] were significantly associated with higher odds of NNO.

Table 8. **Association between NNO and all potential risk factors using a multivariate logistic regression model.**

Variables	OR	CI (95%)	p-value
Age			
< 24 months	1 [ref]		
≥ 24 months	0.28	0.14-0.57	0.001*
Sex			
Male	1 [ref]		
Female	3.71	2.41-5.72	<0.001*
SES**			
Low	1 [ref]		
Middle	0.90	0.57-1.44	0.671
High	0.91	0.53-1.55	0.725
Household size			
0-4	1 [ref]		
5-7	1.11	0.56-2.22	0.759
≥8	0.64	0.28-1.44	0.281
Number of children aged 5-17 years			
None	1 [ref]		
1-2	0.82	0.43-1.55	0.543
3-4	0.65	0.29-1.45	0.289
≥5	1.22	0.53-2.82	0.634
Caretaker's age			
18-24 years	1 [ref]		
25-34 years	0.90	0.59-1.37	0.617
≥35 years	1.45	0.61-3.43	0.401
Relation of caretaker to child			
Mother	1 [ref]		
Father	5.81	0.30-111.22	0.242
Grandparents	0.42	0.05-3.57	0.424
Others	19.35	0.50-754.93	0.113
SES with caretaker's education			
Low	1 [ref]		
Middle	0.78	0.29-2.07	0.618
High	0.68	0.20-2.33	0.538
Occupation of caretaker			

Variables	OR	CI (95%)	p-value
Other work	1 [ref]		
Regular worker or shop-owner	1.10	0.74-1.64	0.641
Occupation of caretaker's partner			
Other work	1 [ref]		
Regular worker or shop-owner	0.90	0.60-1.36	0.624
Household food availability (number of cooked meals a day before)			
0-2	1 [ref]		
≥ 3	0.64	0.41-0.99	0.046*
Breastfeeding			
Breastfed	1 [ref]		
Not breastfed	0.82	0.47-1.43	0.482
NNO at baseline			
Absent	1 [ref]		
Present	1.04	0.98-1.09	0.178
Diarrhoea			
Absent	1 [ref]		
Present	1.47	1.27-1.70	<0.001*
LRTI			
Absent	1 [ref]		
Present	1.36	1.13-1.64	0.001*
Malaria			
Absent	1 [ref]		
Present	1.17	0.96-1.41	0.117
UTI			
Absent	1 [ref]		
Present	1.15	0.93-1.43	0.198
Skin diseases			
Absent	1 [ref]		
Present	1.07]	0.85-1.33	0.581
Otitis			
Absent	1 [ref]		
Present	1.34	1.04-1.74	0.029*
Eye diseases			
Absent	1 [ref]		
Present	0.92	0.76-1.11	0.380

Notes: *p<0.05. OR: Odds ratio. Ref: reference value. SES**: Socioeconomic status (SES) relative to others in the community. Brother and sister of variable under 'relation to child' were excluded because of collinearity. Regular worker- Traders, shop owners and regular workers. Other worker- Livestock, Agriculture, seasonal daily labour and student. NNO- Negative Nutritional Outcome. Lower Respiratory Tract Infection. UTI: Urinary Tract Infection. Pseudo R^2 on the multivariate logistic regression model- 0.144.

The General Linear Model (Table 9) shows sensitivity analysis for the earlier obtained results in tables 7 and 8. Diarrhoea, LRTI otitis, and being a female remain stastically significant.

Table 9. Association between NNO and all potential risk factors using a Generalized Linear Model.

Variables	β	95% CI	p-value
Age			
< 24 months	1 [ref]		
≥ 24 months	-0.10	-1.13,0.92	0.841
Sex			
Male	1 [ref]		
Female	0.67	0.07,1.27	0.028*
SES			
Low	1 [ref]		
Middle	-0.42	-1.13,0.30	0.256
High	0.04	-0.77,0.85	0.926
Household size			
0-4	1 [ref]		
5-7	-0.35	-1.58,0.89	0.584
≥8	-0.02	-1.38,1.33	0.973
Number of children aged 5-17 years			
None	1 [ref]		
1-2	0.50	-0.60,1.60	0.376
3-4	1.07	-0.19,2.33	0.096
≥5	-0.02	-1.37,1.33	0.978
Mother's age			
18-24 years	1 [ref]		
25-34 years	0.47	-0.18,1.13	0.156
≥35 years	-0.26	-1,50, 0.97	0.675
Relation of caretaker to child			
Mother	1 [ref]		
Father	-6.57	-13.69,0.55	0.07
Grandparents	0.43	-1.70,2.56	0.693
Brother/ Sister	-2.47	-14.79,9.83	0.693
Others	-2.09	-10.79,6.61	0.638
SES with Education**			
Low	1 [ref]		
Middle	0.32	-1.08,1.72	0.652
High	-0.25	-1.96,1.47	0.777
Occupation of caregiver- mother			
Other worker	1 [ref]		
Regular worker or shop-owner	0.19	-0.43,0.82	0.542
Occupation of Father			
Other worker	1 [ref]		
Regular worker or shop-owner	0.45	-0.20,1.09	0.175
Household food availability			
0-2 cooked meals a day before	1 [ref]		
3 or more cooked meals a day before	-0.45	-1.20.0.29	0.231
Breastfeeding			
Breastfed	1 [ref]		
Not breastfed	0.78	-1.75,0.18	0.111
NNO at baseline			

Variables	β	95% CI	p-value
Absent	1 [ref]		
Present	0.06	-0.03,0.16	0.201
Diarrhoea			
Absent	1 [ref]		
Present	-0.86	-1.10, -0.62	<0.001*
LRTI			
Absent	1 [ref]		
Present	-0.47	-0.77, -0.16	0.003*
Malaria			
Absent	1 [ref]		
Present	-0.16	-0.44,0.13	0.279
UTI			
Absent	1 [ref]		
Present	-0.38	-0.72, -0.04	0.028*
Skin diseases			
Absent	1 [ref]		
Present	0.12	-0.23,0.48	0.500
Otitis			
Absent	1 [ref]		
Present	-0.04	-0.51,0.42	0.850
Eye diseases			
Absent	1 [ref]		
Present	0.31	0.01,0.61	0.041*

Notes: *p<0.05. OR: Odds ratio. 95% CI: 95% Confidence Interval. Ref: reference value. SES**: Socioeconomic status (SES) relative to other households in the community. Brother and sister of variable under 'relation to child' were excluded because of collinearity. Regular worker- Traders, shop owners and regular workers. Other worker- Livestock, Agriculture, seasonal daily labour and student. NNO- Negative Nutritional Outcome. Lower Respiratory Tract Infection. UTI: Urinary Tract Infection.

CHAPTER FIVE

DISCUSSION

The current study assessed the influence of acute infectious disease on malnutrition in under-five children in northwestern Nigeria over six months. We identified a significant relationship between three acute infectious diseases; diarrhoea, LRTI, otitis and malnutrition in the population studied. Our findings suggest that children with these diseases had an increased likelihood of malnutrition than those who did not. These findings indicate that improving access to health care and prompt and appropriate treatment may positively impact nutritional outcomes in children.

Negative Nutritional Outcome in study participants

Prior studies have demonstrated the influence of disease on nutritional outcomes, with an increased likelihood of malnutrition in children with infectious diseases.[7,49,59,67] These findings corroborate the results. In addition, we identified the presence of otitis in children as a possible risk factor for malnutrition, not previously reported to our knowledge. The observations may be due to immune deficiency from a poor diet resulting in acute infectious diseases in the population. However, another explanation may be loss of appetite or metabolic dysfunction from illness, resulting in malnutrition. Thus, a bi-directional relationship may exist between acute infectious diseases and malnutrition in children.[18,35] Nonetheless, both conditions would be amenable to concurrent measures that increase healthcare and food aid access, especially in underserved populations.

Acute Infections and Malnutrition in study participants:

Concerning the diseases observed in children with malnutrition in this study, the majority presented with diarrhoea and malaria, while the least common was otitis. Children with malnutrition reportedly have higher gut mucosal surface compared to their body weight. This condition contributes to their vulnerability to increased frequencies with higher stool output during episodes of diarrhoea, which exacerbates their state of malnourishment.[68,69] Furthermore, children in the region Goronyo experience high diarrhoeal morbidity, likely due to poor sanitation and water access: these conditions impact nutritional status, especially children.[7] Besides, diarrhoea is endemic in the area.[7]

The influence of infectious disease and malnutrition in children has been suggested to be unrelated to enteric pathogens and instead may be associated with household characteristics or immunological in origin.[69] However, household and caretaker characteristics may also be related to immunologic factors. For example, household food availability, socioeconomic status and a history of breastfeeding will likely impact immune status and nutrition in a child.[18,23,70,71] In this study, household food availability was significantly associated with malnutrition in the population studied, before and after adjusting for diarrhoea, malaria, LRTI, skin and eye diseases. These findings support reports from the Gambia, where children from households with poor feeding practices had higher malnutrition rates.[72] Future studies could assess malnutrition prospectively in a healthy cohort of children at baseline to further explain this relationship.

There was a significant association between malaria and malnutrition in the population studied. Children who presented with malaria had higher odds of malnutrition compared to those without malaria. Our findings agree with other studies in sub-Saharan Africa (SSA) that detail poor anthropometric measures and nutritional outcomes in children with malaria.[72-76] The lack of temporality observed precludes an inference on the direction of the relationship between malaria and malnutrition. Because malnutrition can increase the risk of malaria with anaemia, and vice-versa malaria the risk of malnutrition, interestingly, older studies have suggested chronic malnutrition might confer protection against malaria.[77-79] However, more recent studies,[19] including the present study, refute the reports.

Negative Nutritional Outcome and acute infections in study participants

To further explore the relationship between malnutrition and primary illnesses (malaria, diarrhoea and LRTI), the study assessed the relationship between the NNO and the total number of episodes of each disease. The findings suggest that malaria was protective against malnutrition independently, with participants who had more episodes of malaria having a lower likelihood of NNO. However, after adjusting for diarrhoea and LRTI, the relationship changed, and there was a higher likelihood of malnutrition for every unit increase in malaria episodes over the study period. Likewise, for diarrhoea and LRTI, our results indicate higher odds of malnutrition for every unit increase in the number of episodes that occurred. Interestingly, to support our finding with malaria in the univariable model, older studies have suggested chronic malnutrition might confer protection against malaria.[76-79] However, this has been refuted by more recent studies,[80] including the present study after adjusting for other illnesses (diarrhoea and LRTI).

Additionally, we assessed the effect of sociodemographic factors such as age on malnutrition. The study findings suggest that children aged 24 months or less are more likely to have malnutrition than those older. The results regarding age and malnutrition are similar to other studies conducted in SSA,[76, 81-83,] which detail those older than two years have a lower malnutrition risk than those younger. This finding could be attributed to inadequate breastfeeding, which is crucial at this age to confer immunity, which, if absent, might result in acute infections and malnutrition. Furthermore, lack of exclusive breastfeeding in the first six months of life, mixed feeding amongst other poor weaning practices. It is common practice to stop breastfeeding when a mother is pregnant abruptly[47]and a suckling child is taken to grandmothers or other relatives to enable the cessation of breastfeeding.[24,84,85] Average exclusive breastfeeding rate in Nigeria was 7.1% for infants at 5months of age.[16] Similarly, the increased nutritional needs for growth and development that the age group requires may contribute to the higher proportion of malnutrition seen in this study.[79] Besides, traditional birth attendants (TBAs), grandmothers and husbands are key decision-makers and gatekeepers to breastfeeding and young child feeding practices in Sokoto state.[18] Communal eating is common practice in some households, and a one-year-old child may eat together from the same bowl of food with much older children.

The finding of negative outcomes being higher in females than males is similar to a study in Sokoto state using MUAC.[85,86] Gender equality could have played a role with the males receive more food than the females.[18] The findings of more females with malnutrition than males could lend credence to the report by Dalglish *et al.*[48]

A large household size often serves as a source of readily available cheap labour for farming in agricultural communities in Nigeria.[87] However, the large number size negatively affects the household's food availability increasing food requirements and dependence on the breadwinners.[88,89] With Goronyo dam, irrigational farming and fishing are the major occupation of the community,[7] although, in this study, most of the caregivers and their partners were into trading. The large household size is in keeping with the 2018 DHIS report.[16]

Overall, the influence of acute infectious disease on malnutrition is complex. Our findings suggest that children under five years of age with acute diseases, diarrhoea, malaria, and LRTI are more likely to malnutrition. Other risk factors identified included younger age (<24 months), reduced food availability and (<2 meals a day before presentation). A unique finding in this study is the relationship between otitis and malnutrition. The symptoms of otitis, such as refusal of feeds, poor appetite, and vomiting, may contribute to malnutrition due to inadequate nutrient intake coupled with increased losses from vomiting and the metabolic effects of fever.[8] Future studies could explore the temporal relationship between otitis and malnutrition in similar populations. The current study necessitates developing measures to curb malnutrition, which contributes to increased childhood mortality[7] Goronyo, the study setting of conflict.

5.2 Applicability and Operationalization of the Findings

This study aimed to provide evidence to guide interventions targeted at curbing malnutrition in under-five children in Goronyo LGA. The findings suggest that children with diarrhoea and LRTI had a higher likelihood odd of malnutrition. As mentioned earlier, caution in interpretation is necessary because of the possibility of a bi-directional relationship between illness and malnutrition.

Further, we found that an increased number of episodes of diarrhoea and LRTI are associated with an increased likelihood of malnutrition. Although this finding can support nutritional and health interventions targeted at these illnesses, it remains unclear if the cases diagnosed as LRTI were artefactual or not. Although the diagnosis relied on self-reported symptoms from the child's mother or caretaker, diarrhoea and LRTI could be used as predictive markers to identify children at risk of moderate to severe malnutrition.

Lastly, the current study identified risk factors such as being 24 months or older, female and having three or more meals within 24 hours of clinic visit were protective against malnutrition. While the age could predict malnutrition, breastfeeding practices in the community or the stratification applied in the current study could have impacted this finding. Stratifying using children under 12 months of age and those above could provide more insight into the relationship between age and malnutrition in children with illness. Future studies could explore both strata to corroborate or disprove our findings

5.3 Limitations

The limitations observed in this study cut across the primary study's scope, objectives, and methodology, which are quite different from those of this study. Although vast, the questionnaire for the MSF study did not capture some variables or proffer answers that are pertinent to the current research. Variables related to socio-economy and dietary factors were not validated against standard tools like the Demographic and Health Surveys Wealth Index nor validated to the study context.[16] Most significantly, considering Goronyo as fragile, household food diversity and security assessment was necessary. Tools for assessing acute malnutrition, like the Household Food Diversity Score or Household Food Insecurity Assess Scale (HFIAS), remain invaluable.[90]Although, study-

specific socioeconomic status 'relative' to the setting based on household possessions and external walls was generated by the author. Validated and standard tools would make it more sensitive and reliable. Besides, household ownership of vehicles and horses, as status symbols, was inadvertently not captured in the questionnaires. It is not surprising that the SES relative to other community members did not yield a statistically significant relationship with NNO.

The MSF study is clinic-based and may not be entirely representative of the community. Very low-income families who cannot afford or access healthcare facilities could have been missed. Furthermore, household decision-making rests on the husbands, as the household heads and mothers have to take permission to take the children to the health centre. Besides, caregivers may have patronized traditional healers or patent medicine vendors before healthcare facilities. Also, caregivers may not have reported some symptoms or episodes of illnesses due to recall bias.

As with other studies, all context-specific factors, or effects, may not have been exhaustively reported in the earlier study. In northern Nigeria, early marriage is common. The exclusion of children with caregivers under 18 years could have left out many malnourished children. Considering, first-time mothers in Sokoto state are often just above 18 years.[16] These young caregivers may be inexperienced in child feeding and care. Although, this study did not observe a significant relationship between NNO and caregiver's age. The inclusion of these mothers is desirable. The ethical issues may be complex and might have led to their exclusion in the MSF study.

Regarding breastfeeding, caregivers' history of exclusive breastfeeding may not be entirely objective, as the community has intricated complex intra-family relationships. A child belongs to all extended family members and can be fed or breastfed by other nursing mothers living in the family compound; this may have led to information bias. Additionally, the absence of a history of vomiting and diagnosis of anaemia significantly limits the clinical findings. Vomiting is a non-specific symptom in several illnesses in under-fives and often accompanies diarrhoea. Also, vomiting incredibly protracted or recurrent results in loss of nutrients and can enable malnutrition. While anaemia is known to prevent optimal growth in children.[18]

5.4 Strengths:

Despite the gaps observed in the primary study data and its limitations, the MSF study questionnaire and data were robust, covering hundreds of variables. Their research intended to study interventional outcomes for acute malnutrition in under-fives. Although it may not necessarily include all information relevant to this study, it was a valuable data source.

The study sample size was reasonably large, giving the study findings more credence, as demonstrated by the sensitivity of the analysis with repeatedly similar results bolstering the strength of our study findings across the models used. Furthermore, trained and qualified health care workers managed the study participants supervised by specialists in child health and nutrition from a well-known and accredited tertiary health institute. Thus, making the possibility of observer recall bias lower. Additionally, clinical findings, diagnosis, and definition of the illnesses in the primary study are credible and reliable done using appropriate approved guidelines.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In conclusion, this study's findings reveal aside from malaria, diarrhoea and LRTI, other acute infectious diseases like UTI, otitis, skin and eye diseases were common through the six months. However, otitis was significantly related to NNO. Similarly, the findings reiterate diarrhoea and LRTI as being related to NNO in the study. Overall, the relationship between acute diseases and malnutrition could be a vicious cycle. The presence of acute diseases in the U5s should be considered a 'high risk' factor for NNO.

Additionally, recurrent episodes of the acute diseases in the U5 children could have prevented full recovery or tilted them from MAM to SAM or persistence of either. Also, regarding recovery from acute malnutrition, the frequent episodes of the acute disease could have triggered malnutrition despite nutritional intervention with supplements. Other potential risk factors related to NNO are children aged 24 months or less, being female, not being breastfed, large household size with eight or more individuals, and having less than two cooked meals in the house. The study suggests health workers should actively look for and promptly treat acute diseases (besides malaria, LRTI and diarrhoea) in all U5s presenting with NAM or MAM in general, especially in the conflict contexts like Goronyo. Additionally, to give more insights and weight to this study, answers are needed for the following questions:

What is the association between weaning practices to NNO?

What is the association between vomiting in U5s and NNO?

What is the association between measles, pertussis (vaccine preventable childhood illnesses), intestinal worm infection and NNO?

What is the association of maternal or caregiver's health and wellbeing to NNO?

What is the difference in SAM incidence in U5s in OTC and ITFC programmes in conflict contexts like Goronyo?

What is the association between MUAC and the presence of oedema (as indicators) with acute diseases? What if compared to MUAC-only and Weight-for-Height only anthropometric measurements?

6.2 Recommendations:

Further research recommended by the study based on the findings include the following:

- Comparative quantitative and qualitative studies of under-five children (U5s) having MAM with and without acute infectious diseases using MUAC, Weight-for-height and oedema. This approach could give more insights into the relationship between acute diseases and negative nutritional outcome.
- Community-based studies using MUAC identify children under five years with; moderate acute malnutrition (MAM), severe acute malnutrition SAM, or those at a 'high-risk' of SAM for the institution of prompt

interventions and monitoring. It would aid early identification to prevent negative nutritional outcome (NNO) and doubles reaching under-fives from disadvantaged households and in settlements with no access to health care facilities.

- More prospective studies (and retrospective) on the relationship between otitis and negative nutritional outcome (NNO) be conducted.

The recommended studies could be done in various contexts because some of the acute diseases in this study, like malaria, differ according to contexts. Similarly, the causative organisms of LRTI and diarrhoea vary according to age categories within the U5s, seasons and may be specific to particular contexts. Additionally, findings from this study on a setting of insecurity may differ from that of stable contexts.

Recommendations for policies in child health and nutrition:

The study recommends that all relevant stakeholders create awareness among healthcare workers at the 3-tier healthcare facilities in Nigeria to promptly identify, and treat acute infectious diseases, including otitis. Furthermore, the study solicits all actors at Goronyo health clinic, Goronyo local Government Health Authority (LGHA), Sokoto SMoH and the Federal Ministry of Health (FMoH) to consider formulating policies inclusive of otitis as an acute infectious disease influencing the outcome of acute malnutrition in under-fives. The actors should consider including community-based counselling to mothers in infant and young child feeding practices, using trained community health volunteers and nutritionists. Furthermore, the Nigerian government should consider prioritizing Community-Based Management of Acute Malnutrition (CMAM) programmes. Increasing funding, human resources, and a regular supply of nutritional supplements (RUTFs or powders) for MAM treatment. Additionally, the government should deploy agricultural health extension workers to teach and supervise household gardening to improve household food security. Overall, the Nigerian government should consider free access to health care and food aid for poor households to change the current narratives of the country in childhood malnutrition.

Recommendations for Nutritional programmes:

The community and LGA level actors should support community farming associations to boost food production jointly. State and LGA stakeholders could consider setting up Foodbanks for the disadvantaged in the community and individuals encouraged to donate food. Formulation of locally sourced therapeutic foods could be employed.

Additionally, awareness creation for health care workers and nutritionists for timely and adequate intervention in fragile and stable settings is needed. Strong partnership and collaboration against malnutrition between the government and international donors, NGOs and community-based organizations (CBOs) as stakeholders. The collaboration would help improve and sustain CMAM programs to reduce malnutrition.

For nutritional programmes globally, the study recommends further research be carried out in different contexts using the other anthropometric indicators, singly and according to WHO recommendation and various study designs to study the relationship of otitis and negative nutritional outcome.

Recommendations for Peace:

Conflicts worsen malnutrition as a public health challenge, with children bearing the brunt of actions not directly taken to mitigate both. This study suggests that the Nigerian government's primary prevention strategy in managing root causes of conflict include addressing illiteracy, unemployment, small arms flow, and corruption.[92] Secondary measures to prevent malnutrition entail food support programs for children, while tertiary prevention would include peace-keeping efforts and reconstruction of health and educational facilities. This approach might help mitigate the vicious cycle of acute infectious disease and malnutrition in children.

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APPENDICES

APPENDIX A: SCREENING FORM

RUTF/Micronutrient convalescent study Screening for inclusion/exclusion

Date (dd/mm/yy): _____

Child is 6-59 months of age?

Yes	→ **Continue**
No	→ **Do not enrol in the study**

Child accompanied by guardian or close relative 18 yrs of age or older?

Yes	→ **Continue**
No	→ **Do not enrol in the study**

A. Illness upon presentation (circle all OPD diagnoses)

1. Lower respiratory tract infection (LRTI)	Yes	No
2. Diarrhoea	Yes	No
3. Malaria	Yes	No

None of 3 targeted diseases diagnosed? → Do not enrol in the study

B. General danger signs (incl. severe malaria and/or severe pneumonia)

1. Unable to drink/breastfeed	Yes	No
2. Vomiting everything	Yes	No
3. Unable to sit or stand (too weak)	Yes	No
4. Lethargy or unconsciousness	Yes	No
5. Recent history of convulsions	Yes	No
6. Severe respiratory distress (e.g. head nodding)	Yes	No
7. Central cyanosis	Yes	No
8. Any signs of severe malaria (Specify:)	Yes	No
9. Signs of severe dehydration?	Yes	No

Any of the questions above answered with Yes? → Do not enrol in the study and refer for immediate treatment

C. Signs of severe anaemia

1. Some or severe palmar pallor	Yes	No
2. Mucous membrane pallor	Yes	No
3. Respiratory distress	Yes	No

Any of the questions above answered with Yes? Test Hb; if Hb<5 g/dL → Do not enrol in the study and refer for immediate treatment

D. Malnutrition

1. Bilateral oedema	Yes	No
2. MUAC < 115 mm	Yes	No

3. Weight-for-Height < -3 z-score, WHO 2006 reference	Yes	No

Any of the questions above answered with Yes? → Do not enrol in the study and refer to TFP for immediate treatment

E. Other criteria - please tick:

1. Serious concomitant illness (Specify:)	Yes	No
2. History of allergy to anti malarial drugs	Yes	No
3. History of allergy to peanuts or milk	Yes	No
4. Exclusive breastfeeding	Yes	No
5. Sibling enrolled in this study	Yes	No
6. Lives further away than 60 min walking distance (check name of village)	Yes	No

Any of the questions above answered with Yes? → not eligible for study

F. Consent:

If eligible, explain the study and read out consent form

Consent from guardian or close relative 18 yrs of age or older?	Yes	No

Included?	Yes	No

Study ID number	GO-	

If not included, please record the reason: _____

_____

Name of patient and OPD number: _____

Sex: .....

Weight: ..... kg

Height: ..... cm

Z score: .....

MUAC: ..... mm

TIME: .....

Oedema: .....

Body temperature: ..... ^{o}C

APPENDIX B: ABRIDGED STUDY QUESTIONNAIRE

STUDYID ####
----------GENERAL QUESTIONNAIRE ----------

Adate Date of admission <dd/mm/yyyy> day/month/year eg 08/06/2011
Asex Gender # (1,2) 1=boy 2=girl
ADoB Birth date <dd/mm/yyyy> day/month/year eg 08/06/2007
Aage Age of child ## months fill in either birthdate or age in months

AnbU5 Number of children Under 5years ## children below 5 years
Anb517 Number of children 5-17 years ## children 5-17 years
Anbadu Number of adults ## adults
Arela Relation to the child # (1,2,3,4,5) 1=mother, 2=father, 3=grandparent, 4=brother/sister, 5= other
AageCRT Caretaker age? ## years
Aedu Highest level of education # (0,1,2,3,4,5,6,7,9) 0=none, 1=prim incompl, 2=prim compl, 3=sec incompl, 4=sec compl, 5=high incl,
6=high compl, 7=islamic school, 8=other(fill in note), 9=don't know
Amari Marital Status # (1,2,3,4,5,6,9) 1=single, 2=maried, 3=cohabitante, 4=divorced, 5= widow, 6=other, 9=don't know
Aprtocc Husband/partner business # (1,2,3,4,5,6,9)1=livestock, 2=agricult, 3=trading/shop owner, 4=seasonal, daily labor, 5=regular work,
6=housewife/no business, 7=student, 8= other (fill in note), 9=Don't know
Aocc Your business # (1,2,3,4,5,6,9)1=livestock, 2=agricult, 3=trading/shop owner, 4=seasonal, daily labor, 5=regular wor,
6=housewife/no business, 7=student, 8= other (fill in note), 9=Don't know

Awat Does any member of your household own a Watch # (0,1,9)0=no, 1=yes, 9=don't know
Abic Does any member of your household own a Motorbike # (0,1,9)0=no, 1=yes, 9=don't know
Arad Does any member of your household own a Radio # (0,1,9)0=no, 1=yes, 9=don't know
Agen Does your household has generator # (0,1,9)0=no, 1=yes, 9=don't know

Alvst Does any member of your household own livestock? # (0,1,9)0=no, 1=yes, 9=don't know
Agoat How many of Goats does the household own? ### goats
Asheep How many of Sheep does the household own? ### sheep
Achick How many of Chicken does the household own? ### chickens
Acamel How many Camels does the household own? ### camels
Adonk How many Donkeys does the household own? ### donkeys
Acow How many of Cows does the household own? ### cows

Awall What are the external walls of your house? # (1,2,3,9) 1=improvised,plastic,coth, , 2= wood, mud, bamboo, 3= stone,brick, cement, 9=don't know
Ameals How many cooked meals did you have yesterday? # (0-8) is number of meals 9=don't know

==========MEDICAL FOLLOW UP QUESTIONANNAIRE========== REPEATED==========

WEIGHING AND MEASURING
M0date Measuring date <dd/mm/yyyy> day/month/year eg 08/06/2011
W0weight Weight ##.### kg.gr
W0Height Height ###.# cm.mm
W0MUAC MUAC ### mm
W0OEDEMA Oedema # (0,1) 0=no, 1=yes
W0WH W/H score # (1,2,3) 1=above -2zscore, 2=between -3 and -2zscore, 3=below -3zscores
W0BF Breastfeeding # (0,1,2,9) 0=not breastfeeding, 1=yes breastfeeding, 2=stopped breastfeeding, 9=don't know whether child is breastfed

MEDICAL QUESTIONNAIRE

M0reas Reason for visit # (1,2,3) 1=enrolement, 2=planned followup visit, 3=unplanned followup visit
M0ill Child ill today? # (0,1,9) 0=no, 1=yes, 9=don't know
M0start Days ago illness start? ### days
M0fever Fever in the last 2 weeks? # (0,1,9) 0=no, 1=yes, 9=don't know
M0cough Cough at any in the last 2 weeks? # (0,1,9) 0=no, 1=yes, 9=don't know
M0diarr Diarrhoea in the last 2 weeks? # (0,1,9) 0=no, 1=yes, 9=don't know

M0cli Seek for treatment? # (0,1,2,3,4,5,9) 0=no, 1=MoH clinic/hospital, 2=traditional healer, 3=pharmacy, 4=self medication, 5=other (note), 9=don't know
M0disease What disease # (0,1,2,3,4,5,9) 0=none, 1= diagnosis, (fill in note), 2=fever, 3=cough, 4=diarrhoea, 5=malaria, 9=don't know
M0drug What drug # (0,1,9) 0=none, 1= yes, (fill in note), 9=don't know

M0appe Eating as usual? # (1,2,3,9) 1=less, 2=about same, 3=more, 9=don't know

M0diag1 Primary diagnosis, study disease # (0,1,2,3) 0=none, 1=malaria, 2=LRTI, 3=Diarrhoea
M0diag2 Secondary diagnosis, study disease # (0,1,2,3) 0=none, 1=malaria, 2=LRTI, 3=Diarrhoea
M0diag3 Tertiary diagnosis, study disease # (0,1,2,3) 0=none, 1=malaria, 2=LRTI, 3=Diarrhoea

M0diagOt1 Other diagnosis 1 # (0,1,2,3,4,5,6) 0=none, 1=URTI, 2=Eye infection, 3=Otitis, 4=Skin disease, 5=other (specify
M0diagOt1s Other 1, specify _____
M0diagOt2 Other diagnosis 2 # (0,1,2,3,4,5,6) 0=none, 1=URTI, 2=Eye infection, 3=Otitis, 4=Skin disease, 5=other (specify
M0diagOt2s Other 2, specify _____
M0diagOt3 Other diagnosis 3 # (0,1,2,3,4,5,6) 0=none, 1=URTI, 2=Eye infection, 3=Otitis, 4=Skin disease, 5=other (specify
M0diagOt3s Other 3, specify _____

APPENDIX C: MEDICAL FOLLOW-UP QUESTIONNAIRE

For data entry staff	
Cross when data entered in computer	
Follow-up number	

RUTF/Micronutrient convalescent study
Medical Follow-up questionnaire

Part 1. Completed at reception

Study ID No	GO-	
Date (dd/mm/yy):		

Part 2. Completed by anthropometric team

Weight (##,###)					Kg,grams
Height (###.#)					Centimetres,mm
MUAC (###)					milimeteres
Oedema (yes/no)	0	No	1	Yes	

Weight/height z-score	1	> or = –2 z-score
	2	Between –3 and –2 z-score
	3	< -3 z-score

Ask caretaker on each Planned Visit:
Is the child currently breast-fed?
If the answer is "NO" on previous visit, PLEASE SKIP this question.

0	No
1	Yes (Partial)
2	Stopped since last visit
9	Don't know

Part 3. Completed by medical team

1. Reason for visit (Check one)

1	Enrolment, first visit
2	Planned follow-up visit
3	Unplanned follow-up visit

2. Is your child ill today?

0	No
1	Yes
9	Don't know

3. If yes, how many days ago did **this** episode of illness start?

	days

4. Has your child been ill with a **fever** at any time during the **last 2 weeks**?

0	No
1	Yes
9	Don't know

5. Has your child been ill with a **cough** at any time during the **last 2 weeks**?

0	No
1	Yes
9	Don't Know

6. Has your child been ill with **diarrhoea** during the **last 2 weeks**?

0	No
1	Yes
9	Don't now

7. Did you seek (need) for any treatment **since your last visit** here?

0	No
1	Yes, MoH clinic, hospital, etc.
2	Yes, traditional healer
3	Yes, pharmacy
4	Self medication
8, 5	Other, specify:
9	Don't know

(If the answer is NO go to question 9)

8. If yes, what was the disease?

0	None
1	Yes (specify)
2	Fever
3	Cough
4	Diarrhoea
5	Malaria
9	Don't know

9. Has your child taken any medication during the **last 2** weeks?
(other than that prescribed from this study clinic)

0	No
1	Yes (specify)
9	Don't know

Question 10 to be asked only at day 0, 14 and 28.

10. During last 2 weeks, how was the appetite (food or breast milk) of your child?
Was it less, more or the same as usual?

1	less
2	About the same
3	more
9	Don't know

Part 4. Clinical findings (completed by medical team)

Primary diagnosis, study diseases:	0. None	1. Malaria	2. LRTI	3. Diarrhoea (NBD or BD)
Secondary diagnosis, study diseases:	0. None	1. Malaria	2. LRTI	3. Diarrhoea (NBD or BD)
Tertiary diagnosis, study diseases:	0. None	1. Malaria	2. LRTI	3. Diarrhoea (NBD or BD)

Other diagnosis 1:	1. URTI	2.Eye infection	3. Otitis	4.Skin disease	5.Other (specify:
Other diagnosis 1:	Text:				
Other diagnosis 2:	1. URTI	2.Eye infection	3. Otitis	4.Skin disease	5.Other (specify:
Other diagnosis 2:	Text:				
Other diagnosis 3:	1. URTI	2.Eye infection	3. Otitis	4.Skin disease	5.Other (specify:
Other diagnosis 3:	Text:				

Initials of staff who filled out this form:

Initials:

APPENDIX D: TABULAR PRESENTATION OF FIGURES IN RESULTS

Table 1: Distribution of nutritional status of study participants based on MUAC over study period.

Variables	Baseline	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
MUAC	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
No malnutrition	1554 (91.57)	1579 (93.05)	1610 (94.87)	1614 (95.11)	1614 (95.11)	1631 (96.11)	1627 (95.88)
Moderate malnutrition	143 (8.43)	116 (6.84)	86 (5.07)	79 (4.66)	81 (4.77)	63 (3.71)	67 (3.95)
Severe malnutrition	0 (0)	2 (0.12)	1 (0.06)	4 (0.24)	2 (0.12)	3 (0.18)	3 (0.18)

MUAC: Mid upper arm circumference.

Table 2: Proportion of study participants with NNO per month.

Variable	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
NNO	19 (1.12)	23 (1.36)	22 (1.30)	26 (1.53)	21 (1.24)	32 (1.89)

Table 3: Distribution (frequencies and proportions) of disease in study participants per month.

Variables	Baseline	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Disease	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Diarrhoea*	1037 (61.11)	363 (21.39)	378 (22.27)	364 (21.45)	313 (18.44)	280 (16.50)	247 (14.56)
LRTI *	251 (14.79)	234 (13.79)	196 (11.55)	204 (12.02)	188 (11.08)	164 (9.66)	160 (9.43)
Malaria*	409 (24.10)	30 (1.77)	99 (5.83)	240 (14.14)	278 (16.38)	315 (18.56)	310 (18.27)
UTI	277 (16.32)	172 (10.14)	184 (10.84)	158 (9.31)	157 (9.25)	135 (7.96)	150 (8.84)
Skin diseases	89 (5.24)	101 (5.95)	123 (7.25)	134 (7.90)	140 (8.25)	118 (6.95)	135 (7.96)
Otitis	55 (3.24)	62 (3.65)	64 (3.77)	62 (3.65)	48 (2.83)	54 (3.18)	52 (3.06)
Eye diseases	259 (15.26)	214 (12.61)	204 (12.02)	231 (13.61)	201 (11.84)	220 (12.96)	194 (11.43)

* Primary diseases of study interest in MSF RCT study. LRTI-Lower Respiratory Tract Infection. UTI-Urinary Tract Infection.

Table 4: Episodes of primary diseases in study participants during the 6-months study period.

Positive cases	0 Episode	1 Episode	2 Episodes	3 Episodes	4 Episodes	5 Episodes	6 Episodes	7 Episodes	8 Episodes
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Diarrhea	256 (15.09)	443 (26.10)	452 (26.64)	305 (17.97)	164 (9.66)	51 (3.01)	15 (0.88)	10 (0.59)	1 (0.06)
LRTI	762 (44.9)	501 (29.52)	252 (14.79)	141 (8.31)	36 (2.12)	5 (0.29)	1 (0.06)	0 (0)	(0)
Malaria	701(41.31)	441 (25.99)	296 (17.44)	170 (10.02)	69 (4.07)	15(0.88)	4 (0.24)	1 (0.06)	0 (0)
Total (n)	**1719**	**1385**	**1000**	**616**	**269**	**71**	**20**	**11**	**1**