

Determinants of Undernutrition for Children Under Five in Sudan

**Maha Ali Mohammed Al-Areeqi
Yemen**

55th Master of Public Health/International Course in Health Development

KIT (Royal Tropical Institute)
Vrije Universiteit Amsterdam (VU)

Determinants of Undernutrition for Children Under Five in Sudan

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Master of Public Health

By
Maha Ali Mohammed Al-Areeqi
Yemen

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List of Abbreviations

ANC	Antenatal Care
ARI	Acute Respiratory Infections
CMAM	Community-based Management of Acute Malnutrition
DALYs	Disability-Adjusted Life Years
ENP	Essential Nutrition Package
FAO	Food and Agricultural Organization
FMoH	Federal Ministry of Health
FP	Family Planning
GDP	Gross Domestic Product
IDPs	Internally displaced persons
IMCI	Integrated management of childhood illness
IRS	Indoor Residual Spraying
ITNs	I insecticide-treated bed nets
IYCF	Infant and Young Child Feeding practice
LLIN	Long Lasting Insecticidal Nets
LMICs	low and middle income countries
MAM	Moderate Acute Malnutrition
MUAC	Mid-Upper Arm Circumference
MICS 2014	Multiple Indicator Cluster Survey 2014
OTP	Outpatient Therapeutic Program
OOP	Out Of Pocket
PHC	Primary Health Care
SAM	Severe Acute Malnutrition
TFC	Therapeutic Feeding Centres
UNICEF	United Nations Children’s Emergency Fund
WFP	World food program
WHA	World Health Assembly
WHO	World Health Organization

Glossary

- **Acceptable food consumption:** "Households that are consuming cereals and vegetables every day, frequently accompanied by oil and pulses and occasionally meat and dairy" (1).
- **Bottle feeding:** "Percentage of children age 0-23 months who were fed with a bottle during the previous day" (1).
- **Cachexia:** "weight loss and muscle wasting" (2).
- **Community Management of Acute Malnutrition (CMAM):** "Is a decentralized community-based approach to treating acute malnutrition. Treatment is matched to the nutritional and clinical needs of the child, with the majority of children receiving treatment at home using ready-to-use foods. In-patient care is provided only for complicated cases of acute malnutrition. CMAM consists of four components: (1) stabilization care for acute malnutrition with complications, (2) out-patient therapeutic care for severe acute malnutrition without complications, (3) supplementary feeding for moderate acute malnutrition and (4) community mobilization" (3).
- **Complementary feeding:** "The feeding of children after the age of 6 months with solid or semi-solid foods. Because breast milk or milk substitutes alone are no longer sufficient to meet the need of the child after the age of 6 months" (4).
- **Early Initiation breastfeeding:** "Proportion of children born in the last 24 months who were put to the breast within one hour of birth" (4).
- **Exclusive breastfeeding:** "The feeding of an infant only with breast milk from the mother or a wet nurse, or expressed breast milk, and no other liquids or solids except vitamins, mineral supplements, or medicines in drop or syrup form" (4).
- **Food insecurity:** "Is defined as 'limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire food in socially acceptable way" (5).
- **Goiter:** "A noncancerous enlargement of the thyroid gland" (6)
- **Low birth-weight:** "Is defined as a weight of less than 2,500 grams at birth" (7).
- **Micronutrients:** "Essential vitamins and minerals required by the body throughout the lifecycle in miniscule amounts" (8).
- **Micronutrient deficiency:** "Occurs when the body does not have sufficient amounts of a vitamin or mineral due to insufficient dietary intake and/or insufficient absorption and/or suboptimal utilization of the vitamin or mineral" (8).
- **Minimum acceptable diet:** "The Percentage of breastfed children age 6–23 months who had at least the minimum dietary diversity and the minimum meal frequency during the previous day; OR Percentage of non-breastfed children age 6–23 months who received at least 2 milk feedings and had at least the minimum dietary diversity not including milk feeds and the minimum meal frequency during the previous day" (1).
- **Minimum dietary diversity:** "Percentage of children age 6–23 months who received foods from 4 or more food groups during the previous day" (1).

- **Minimum meal frequency:** "Percentage of children age 6-23 months who received solid, semi-solid and soft foods (plus milk feeds for non-breastfed children) the minimum number of times or more during the previous day" (1).
- **Moderate acute malnutrition (MAM):** "Defined as weight for height is below minus two standard deviations or MUAC between 115mm and below 125mm " (9).
- **Predominantly breastfeeding:** "The feeding of an infant only with breast milk from the mother or a wet nurse, or expressed breast milk as the predominant source of nourishment, other liquids like water, fruit juice and ritual fluids and vitamins, mineral supplements, or medicines in drop or syrup form" (4).
- **Sever acute malnutrition (SAM):** "Defined as weight for height is below minus three standard deviations or mid-upper arm circumference (MUAC) below 115mm or the presence of bilateral pitting edema or both" (9).
- **Stunting:** "Reflects chronic undernutrition during the most critical periods of growth and development in early life. It is defined as the percentage of children aged 0 to 59 months whose height for age is below minus two standard deviations" (7).
- **Underweight:** "Is a composite form of undernutrition that includes elements of stunting and wasting. It is defined as the percentage of children aged 0 to 59 months whose weight for age is below minus two standard deviations" (7).
- **Undernutrition:** "Is defined as the outcome of insufficient food intake and repeated infectious diseases. It includes being underweight for one's age, too short for one's age (stunted), dangerously thin for one's height (wasted) and deficient in vitamins and minerals (micronutrient malnutrition)" (10).
- **Wasting:** "Reflects acute undernutrition. It is defined as the percentage of children aged 0 to 59 months whose weight for height is below minus two standard deviations" (7).

Abstract

Introduction: Undernutrition is a crucial public health problem among children under five in Sudan. The prevalence of stunting, wasting, and underweight is 38.2%, 16.3%, and 33%.

Objective: This literature review is conducted to explore the determinants of undernutrition for children under five and make recommendations for better interventions in Sudan.

Methodology: A literature review was done and guided by using the UNICEF conceptual framework to reach the objective.

Findings: Inadequate dietary intake and diseases like diarrhea were among the main immediate causes of undernutrition in children under five. Household food insecurity, inadequate feeding practices, and lack of access to a healthy environment and health services were the underlying causes. Moreover, poor access to resources like land and education, cultural beliefs, poverty, and political issues were the main basic causes that led to undernutrition in children under five in Sudan. Best practice and evidence-based interventions are present in Sudan; however, they lack adequate implementation due to the lack of coordination and capacity and improper management.

Conclusion and recommendations: Undernutrition in children under five in Sudan is a problem, particularly in rural and conflict areas where poverty is dominant, and services and resources are limited. Multi-sectoral interventions, raising funding for nutrition programs, enhancing good feeding practices, improve health services, and community mobilization is among the main recommendations to tackle undernutrition.

Key words: Undernutrition, Determinants, Children under five, Sudan.

Word count: 13,145

Introduction

Undernutrition in children under five is an issue of public health concern globally; the situation is particularly critical in low and middle-income countries due to limited health resources and a high burden of diseases. Undernutrition can manifest in four forms, stunting, wasting, underweight, and micronutrient deficiency. And they are all underlying causes for the mortality, morbidity, and disability for children under five.

Undernutrition is still alarming worldwide; stunting reduction is very slow, and wasting also affects the lives of a lot of children (11). Undernutrition is also considered as one of the main social injustices and iniquities at this time (8). Each minute of every day, there are four children who die due to undernutrition. And from those who survive, one in every four has stunting and is physically and mentally growth damaged (8).

After my graduation from the faculty of medicine, with a bachelor of Medical Laboratories Sciences, I worked for three years with the local and international organization as a health and nutrition officer. During this period, I was specifically in charge of the nutrition segment, I have seen the suffering of little children as young as one year from undernutrition; I have also seen the long term consequences for both family and the affected children, as long hospital stays, risks of diseases and in some cases poor attention in schools. Because of all these, I developed special interest about childhood nutrition and became more curious to understand factors that play a role in undernutrition among children under five so that I can create awareness about them in the community.

Chapter 1: Country Background

1.1 Geographical Information:

Sudan is situated in the northeast of Africa; it shares borders with seven different countries, which are: Egypt, South Sudan, Ethiopia, Eritrea, Chad, Liberia and Central African Republic (12). Sudan was considered as the third-largest country in Africa and had an area of 1,882,000 square kilometers (13). The River Nile and its tributaries, which is the second-longest river in the world, cross over the country from the south to the north (12,13). In the eastern part of the country, Sudan has a coastal border formed by the red sea that is estimated to be around 550 miles, and through that portion, Sudan has served as a linking point between Africa and the Middle East (13).

The topography in Sudan varies from flat mountains lands to desert areas. The climate swings between tropical and arid (14). The raining season which differs from one region to another usually starts from April to November (14). In the desert areas, the climate is characterized by dust storms and regular flooding and droughts, which increases the risk of soil erosion and desertification in the country (13,14).

Figure 1: Map of Sudan



Source: Geographic guide, Africa, Sudan(15)

1.2 Demographic Information:

According to the world population review of 2019, Sudan has a total estimated population of around 42.81 million people; the current population growth is 2.4% (16). The majority of the people in Sudan are living in rural areas, with only about 33% living in urban areas (14,16). And because of the conflicts and natural disasters, Sudan has approximately 7% internally displaced persons (IDPs) of its population; also, there is 8% nomadic population (14). The demographic pattern shows that about 46% of the total population is aged 15 years old and below. In addition, there are around 16% under five (14). Women in Sudan have a fertility rate of 5.2 and sometimes higher in rural areas (1), and the average life expectancy in Sudan is 62 years (13). Communities in Sudan are of different tribes and

ethnicities, but the majority are Muslims and use Arabic as their primary language (14).

1.3 Political information:

Sudan has experienced multiple political instabilities which led to civil war and armed violence for decades; some notable conflicts are the armed conflicts in Darfur, Blue Nile, and South Kordofan states (12,14). In July 2011, Sudan signed referendum based on comprehensive peace agreement of 2005, and as a result, the country was divided into two countries, South Sudan and North Sudan, which ended the long civil war in the country (12–14). However, very recently, another political instability has started under the Movement for Political Transition which aims to change the three-decade military regime of the president Omar el Bashir due to the growing economic crisis in the country like the inflation of the prices of food items and fuel (17). In April 2019, president Omar el Bashir and his government have been removed (18) Generally, Sudan operates the federal system of government, which consists of three levels: the central (federal), states, and localities (14,19). At the central level, there are the president of the country, national assembly and ministries, and in the state level, there are 18 states led by governors (14,19).

1.4 Economic information:

Sudan is blessed with a number of natural resources like petroleum, minerals, animals, and agriculture resources (13,14). Oil production is among the major sources of government revenue and contributes to about 30 % of the government budget. With the secession of South Sudan; however, the country lost about 75% of its oil production (14). This has resulted in a significant reduction of government revenue, which affects the provision of all services, including the availability of health care (14). Sudan incurred a high amount of external debt of 45 billion USD at the end of 2014, which hinders the country development The poverty rate in Sudan is estimated to be around 47% with disparities between urban and rural areas, with 58% and 27% respectively (20). The rate of unemployment is nearly 20% on the average, but it is high among youth (34%), there are also disparities between the regions as areas like Khartoum has a poverty rate of 12% while conflict areas like Darfur have 67% (21).

1.5 Educational information:

The attendance rate for students in Sudan differs between primary (72%) to secondary schools (34%) (22). Despite the continuous improvement in primary education, there is still a high number of children who are out of school, especially in rural areas, conflict areas, and nomadic population(19). Another parity is across gender that the ratio of school attendance between girls and boys in primary school is 0.98 but 1.07 in secondary school (1). The literacy rate was estimated to be 88% for the youth aged between 15 -24 years, as indicated in 2012. Moreover, the total literacy rate for adults was 73% but slightly lower among female adults (65%)(23).

1.6 Health system:

In Sudan, the health system was built based on comprehensive primary health care (PHC) and referral support. Policies were developed at the national level in line with the vision and mission of the government (24). The latest health policy was formulated in 2007 following the peace agreement that ended the long period of conflict and other social unrest in the country (24). And because of the disruption of the health institutions that occurred during that period, health policies were tailored towards economic growth in different sectors of human endeavors (24). The policy was also based on local government acts of 2005, state laws, and decrees that are introduced to decentralize the federal system (24).

The National Health Policy was used to build a health system that ensures equity, quality, accountability, and professionalism. The whole objective is to have a system that satisfies the interest of both the demand and supply site factors using the principles of citizenship, solidarity and universal health coverage (24).

1.7 Governance and leadership:

In order to achieve the health system goals, Sudan's government developed and strengthened a national health system in line with the provisions of the constitution by ensuring good governance, stakeholder's partnerships and community participation as the key parameters that are used to design health interventions and strategic plans (24). Emphasis was also given to other important issues like transparency, accountability, and innovation as well as maintaining the core values of ethics in practices, equity in gender and team spirit in the workplaces (24).

There are three levels of the health system: the federal level, which is responsible for developing the national policies, guidelines, plans, and strategies. In addition, the federal level also has the overall functions in monitoring, coordinating, training, and external relations (24). In the federal level, federal ministry of health (FMoH) is given the mandate to provide health services at the national level through public health institutions which include: the universities, military, and police health services as well as national health insurance based on the existing national health policy (24).

The states and regional levels are responsible for developing local policies, strategies, and action plans using federal guidelines. They also share some responsibilities in funding and implementing regional health plans (24).

The local or county levels have been implementing responsibilities and delivery services based on national/state guidelines through the PHC approach (24).

1.8 Health Care Financing:

Health financing in Sudan operates through the mechanism of raising revenues by collecting and pooling resources as well as purchasing the needed services. These approaches are made through different sources like tax based, health insurances, and user fees (14). A major defect in the financing of the health system is weak coordination, which affects the efficiency of the system. Government has been making efforts to improve funding of public health care. However, current government allocation for health is still below the Abuja Declaration of 15%. A report in 2014 shows that health spending in Sudan is about 6.5% of the Gross Domestic Product (GDP), and about 70% is out of pocket (OOP) (25). A very low number of Sudanese are enrolled in the health insurance schemes, but there is an ongoing plan by both federal and states ministries of health to review the current situation and increase population coverage (24).

1.9 Human Resources for health:

The health workforce is an essential element for health care services delivery. In Sudan, about 49% of the general government health expenditure goes for the human resources for health (14). Sudan is facing many challenges inequitable distribution of the health workers between the regions of the country. For example, about 70% of the health workers are working in urban areas, but only 30% of the total population are living in urban areas; the remaining population lives in rural areas (14). Another challenge is the misdistribution of health workers between health care levels (14). About 67% of health workers are working in the secondary and tertiary level leaving only 33% in PHC. These facts led to having nonfunctional PHC facilities, particularly in rural areas, and can affect the availability and quality of the services provided at the primary level (14).

The majority of the health workers serve under the public sector, with only 9.8% that serve under the private sector. However, some of the health workers who serve in the public sector also serve in the private sector, thereby practicing in dual direction (14). Lack of a good system that enhances the performance and retention of the health cadres led to a continuous brain drain of doctors in Sudan. Because of the shortage in the health workforce in Sudan, current health workers to population ratio is 1.23 per 1000, and this is lower than the World Health Organization (WHO) recommendation which is 2.28 per 1000 (14).

1.10 Health service Delivery:

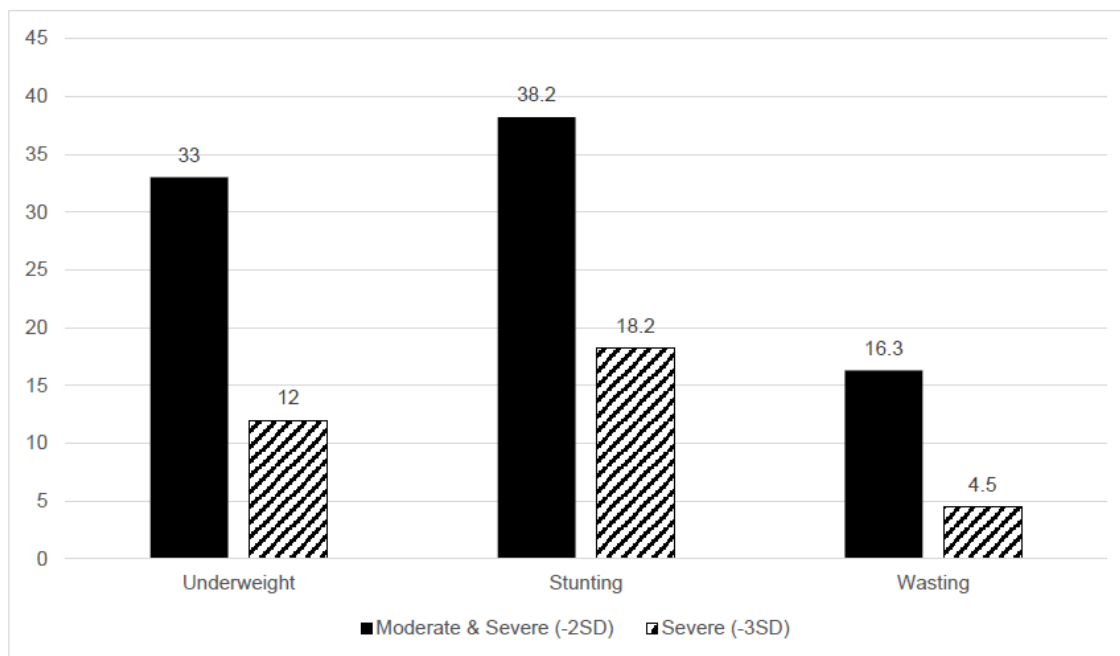
Delivery of health services is based on the national health policy of Sudan, which aims to ensure an accessible, affordable, efficient, and effective way for the population (24). This is done through public and private sectors, private for-profit and for nonprofit; also, through sectors which are in alliance with health like the ministry of higher education, army and the traditional sector (14).

PHC and emergency services are delivered for free based on the constitutional provisions (24). Health care package in the primary level consists of the components of health promotion like child health, school health, reproductive health, environmental sanitation as well as the control of endemic diseases such as malaria and tuberculosis. In the secondary and tertiary level, health care package uses high technological assessment (24).

1.11 Health profile:

In Sudan, disease profile is divided based on communicable diseases, non-communicable diseases, and injuries, and has the following burden of 53%, 34% and 13% respectively (23). The most common communicable diseases are malaria, measles, Pneumonia, HIV, tuberculosis, and neglected tropical diseases such as leishmaniasis and soil-transmitted helminths (STH) (23). For non-communicable diseases, diabetes mellitus, cardiovascular diseases, cancer, and respiratory diseases are among the top four main disease causes. Malnutrition is another major problem affecting many people in Sudan; undernutrition has been persistently high for more than two decades (23). Figure (2) shows the prevalence of the three forms of undernutrition (Underweight, stunting, and wasting) for 2014 (1).

Figure 2: Prevalence of undernutrition for children under five years in Sudan



Source: Multiple Indicator Cluster Survey 2014 (1)

Chapter 2: Problem statement, Justification and Methodology

2.1 Problem Statement

Addressing child undernutrition remains one of the major public health concerns in the global community today, especially in low and middle-income countries (LMICs) (26,27). In 2017, for example, global estimates on malnutrition show that the prevalence of stunting and wasting for children under five years old were 22.2% and 7.5% respectively (11). Undernutrition also accounts for 21% of deaths and disability-adjusted life-years (DALYs) for each child under five, which is 7% of the total DALYs globally (26).

Undernutrition is a type of malnutrition that comprises of “wasting (low weight for height), stunting (low height for age), underweight (low weight for age)” and micronutrient deficiencies (inadequate essential vitamins and minerals) (28).

Sudan has one of the most critical nutritional crisis in the world, and the burden of undernutrition for children under five is unacceptably high (1). The prevalence of wasting is 16.3%, and it is far above the 15% of WHO standard reference of emergency threshold (1). For stunting, the prevalence shows an increasing trend over the years, from 32.5% in 2006 to 38.2% in 2014 (1). The nutritional condition for children under five is deteriorating in Sudan. For example, the rate of stunting reduction has remarkably decreased from 2.23% in 2012 to 0.03% in 2016. As a result, Sudan was unable to achieve the government target in 2018, which is to reduce the number of stunted children from 2.21 million to 1.92 million. If the trend continues, another 2.5 million children will be stunted in Sudan by 2025, and according to this prediction, Sudan will also not be able to achieve the World Health Assembly (WHA) target by 2025 which aimed to reduce the number of stunted children to 1.14 million (29).

Children undernutrition in Sudan differs from rural to urban areas, and mostly, the prevalence is high in rural areas compared to urban areas. For instance, underweight prevalence is 23.2% in urban areas while it is 37.1% in rural areas; moreover, the same situation is for the prevalence of wasting in urban areas which are 13.4% compared to rural areas which are 17.4%. The difference is even higher with stunting that the prevalence is 43% in rural areas, and it is 27.1 % in urban areas. Children undernutrition also varies from state to state, and it is present mainly in states that suffered from conflicts and had internally displaced persons (IDPs). States like North Darfur, Central Darfur, East Darfur, West Kordofan, and Kassala have a high prevalence of stunting, wasting, and underweight compared to Northern, Khartoum, and Whit Nile (12). Table 1 illustrates the prevalence of undernutrition (Stunting, Wasting, Underweight) differences between the states (1). Table 1 illustrates the prevalence of undernutrition (Stunting, Wasting, Underweight) differences between the states.

Table 1: The prevalence of undernutrition (Wasting, Stunting, Underweight)

The State	Stunting	Wasting	Underweight
Northern	22.6%	11.4%	21.9%
River Nile	29.5%	20.1%	32.2%
Red sea	45.4%	14%	33.6%
Kassala	48.8%	18.5%	42.0%
Gadarif	46%	15.4%	37.7%
Khartoum	21.9%	14.5%	23.2%
Gezira	41.6%	14%	32.4%
Whit Nile	36.6%	14.4%	29.8%
Sinnar	38.1%	16%	36.4%
Blue Nile	46.7%	11.1%	35.3%
North Kordofan	40.8%	14.8%	32.4%
South Kordofan	40.6%	16.3%	34.8%
West Kordofan	42.5%	18.7%	38.7%
North Darfur	45.9%	27.9%	44.9%
West Darfur	35.2%	19.1%	29.4%
South Darfur	34.2%	15.9%	29.4%
Central Darfur	47.5%	17.8%	41%
East Darfur	46.6%	15.3	40.2%

Source: Based on "Multiple Indicator Cluster Survey 2014" (1)

Managing nutritional challenges for children in the context of Sudan is crucial for their survival and for the country's economic growth (1). Children undernutrition requires urgent attention, and if not properly mitigated, it can result in a number of devastating effects in the long and short terms. For example, undernutrition for children under five is one of the main factors that contribute to child mortality, morbidity, and disability (7). Children who are severely stunted have four times the risk of dying compared to children with good nutritional status. In the case of severely wasted children, the risk is nine times higher (7). Stunting increases the risk of irreversible cognitive growth failure, low school attendance and performance, and the reduction in income, productivity, and the economics of the country as a whole (7,11,27). Wasting, on the other hand, weakens child's immunity and increases vulnerability for diseases as well as the risk of death (11). Other effects for the long term undernutrition is increasing the risk of obesity and chronic diseases such as coronary heart diseases, hypertension, and type two diabetes among stunted children (7). Micronutrients deficiency can also contribute to devastating children development. Micronutrients play a major role in the functioning of cellular signaling, the response of the immunity, cognitive functions, and learning and working capacity (27).

Girls who are undernourished are more likely to become undernourished mothers, and they have more possibilities to have low birth weight infants. This is called the intergenerational cycle where young mothers, particularly girls in the adolescent age, give birth before getting the appropriate development. Having a lot of children with short spacing between pregnancies can aggravate the nutrition deficiency and transfer it to children (7).

2.2 Justification

Most of the studies conducted about undernutrition for children under five in Sudan have focused on quantitative analysis such as incidence, prevalence, distribution, and trend of undernutrition over the years. Scarcely information is available about the determinants of childhood undernutrition in the context of Sudan. Therefore, this study aims to explore the factors that are influencing undernutrition in children under five and helping to address the knowledge gap as well as providing a clear understanding of the role and contribution of these factors or their consequences in Sudan. The study will also review evidence-based interventions, recommend and suggest effective intervention changes in the nutritional service in Sudan.

2.3 Study Objective:

2.3.1 General Objective

To explore the determinants of undernutrition for children under five in Sudan in order to make recommendations for better intervention.

2.3.2 Specific objectives:

1. To describe and analyze the determinants of undernutrition for children under five in Sudan.
2. To describe and compare public health interventions in Sudan and in similar settings that aimed to address the problem of undernutrition among children under five.
3. To make recommendations to suggest effective nutritional interventions based on evidence.

2.4 Methodology:

2.4.1 Literature review:

A literature review was conducted using PubMed, Google, Google scholar, and VU online library to get peer-reviewed articles in this study. Also, gray literature and reports from official and national websites like FMoH in Sudan, WHO, United Nations International Children's Emergency Fund (UNICEF), and others were used. Literature and reports with full access and published from 2000 to 2019 were included in this study. The English language was used in search of literature and reports. Keywords like undernutrition (wasting, stunting, underweight, micronutrient), Sudan, malnutrition, under five, diseases, dietary intake, feeding practices, food security, developing countries, middle east, interventions, best practice and other words shown in the research table (2) were used in combination by using logic connectors (OR/ AND) or separated to achieve the objectives.

Table 2: Search Table

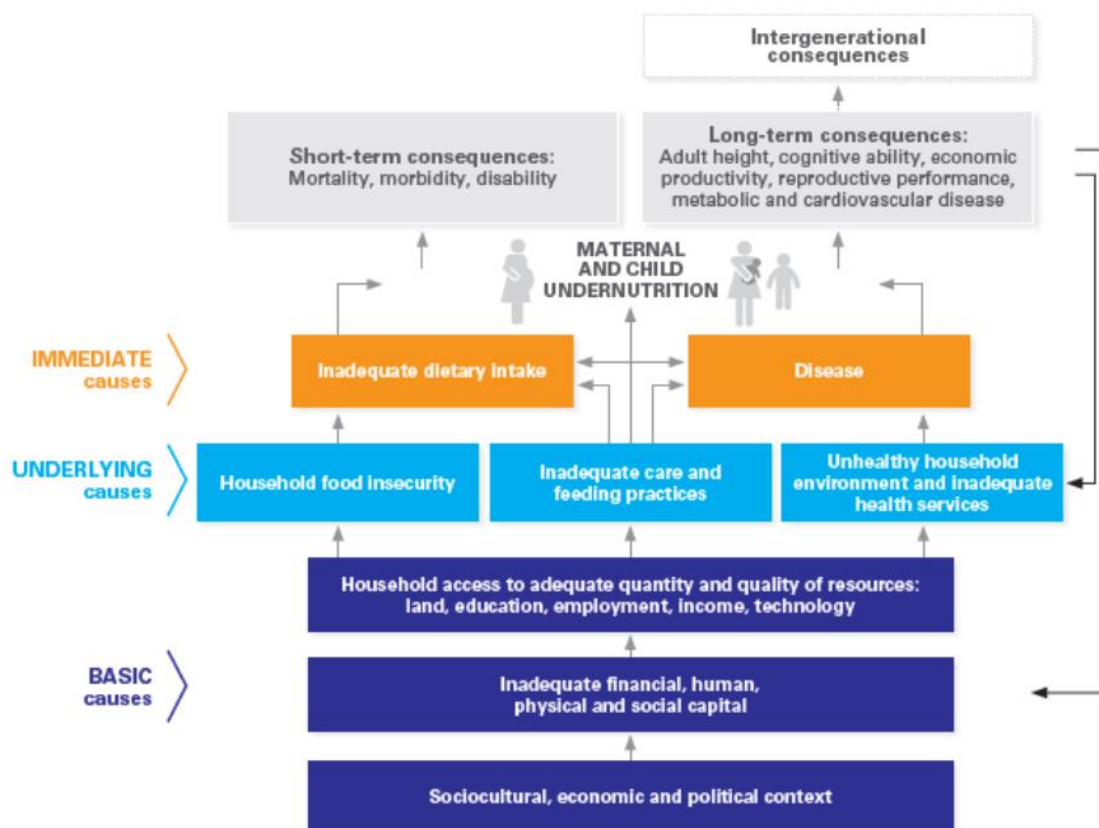
Type of Study	Source	Objective 1	Objective 2
		Key words	
Scientific publication "Peer reviewed Literatures"	VU library Google scholar PubMed	Undernutrition, Stunting, Wasting, Micronutrients deficiency, Under five, Sudan, Middle East , Sub-Saharan Africa, Developing countries, Infectious disease, Diarrhea, Malaria Respiratory tract infection, Parasitic infections, dietary intake, Household food insecurity, Feeding practices, Breastfeeding, Unhealthy environment, Water and Sanitation, Health services, Education, employment, Agricultural, income, financial capital, human capital, social capital, physical capital, social cultural, Economic context, Poverty, Conflict, Political context.	Sudan, Sub-Saharan Africa, Nutrition programs, Nutrition intervention, Best practices, Policies, Strategies, Undernutrition.
Gray literatures and Reports	Google WHO UNICEF FAO UN Humanitarian response Federal ministry of Sudan	Sudan, Undernutrition, Survey, Report, Fact sheet, News release, Data, bulletins.	Sudan, Developing countries, Sub-Saharan Africa, UNICEF programs, Nutrition Interventions, Nutrition, strategies, policies, Undernutrition

2.4.2 Conceptual framework:

The latest UNICEF conceptual framework was used in this study figure (3). This conceptual framework gives the ability to analyze multiple causes of undernutrition for children from different levels; immediate, underlying, and basic causes (30). The framework also gives the opportunity to identify and discuss the consequences of childhood undernutrition based on identified causes. In addition, it provides information about indirect causes such as political instability which is currently a major problem in Sudan. Furthermore, Sudan has a long history of political instabilities and economic hardships; thus, this framework helps to analyze the roles of political factors as it relates to undernutrition.

The immediate causes can be a result of inadequate dietary intake and diseases; these factors can be grouped or known as individual factors. The underlying causes are referring to factors like the community, household environment, and the level of care and health care services. The last layer of the framework is the basic causes which are related to the political, economic, and sociocultural context. Basic causes also include other factors like resources, culture, and financial situation.

Figure 3: UNICEF conceptual farmworker



Source: Improving Child Nutrition: The achievable imperative for global progress. UNICEF (7)

Chapter 3: Findings

This chapter includes the study findings according to the framework (figure3).

3.1. Immediate causes:

Inappropriate dietary intake (not limited to the quantity but also the quality) and sickness are the primary causes of undernutrition. These two causes are interlinked in a reciprocal relation which tends to make a detrimental cycle: a malnourished child has a compromised resistance to sickness; therefore, is more prone to sickness and even worse malnourishment (31).

3.1.1 Inadequate dietary intake

Findings from a study conducted in the Alrawakeeb valley, a rural area in southwestern of Khartoum with a high prevalence of undernutrition (28% of severe malnourished and 35% mild to moderate malnutrition), revealed that there is a probability of a relationship between the food intake and malnourished status of the children (32). The WHO report of 2008 identified the dietary diversity and meal frequency for infant and young children aged 6-23 months as important influencing factors for child nutrition. In the report, WHO recommended that at least four out of the seven food varieties should be included in a child's diet (grains, legumes and nuts, milk and cheese, meat, eggs, fruits, and vegetables). Meal frequency represents the energy obtained from food excluding breast milk (only non-liquid feeds for breastfed children while milk feeds are also considered for those who are not breastfed) (4).

The MICS 2014 indicated that for children aged 6-23 months in Sudan, the percentage of children getting the "minimum dietary diversity", or consuming food from a minimum of 4 different food classes is 28.0%. This means that almost 70.2% of the children do not have diverse food diet that gives protein, fiber, and micronutrients(1). In addition, 40.7% of children receive the "minimum meal frequency" which means 50.3% of the children do not receive food sufficient quantity to cover their energy requirements. This emphasizes the necessity of more attention directed towards improving the dietary diversity and frequency for this important age group (1). In the same report, the "minimum acceptable diet" was used as an indicator assessing both diversity and frequency. The assessment utilizing this indicator showed that in Sudan, a percentage of only 15.1% of children were receiving a sufficient diet in terms of both diversity and frequency (1).

As shown in table (3) the "minimum acceptable diet", results varied among different states, educational status of the mother, and different conditions of the household. For instance, it has been found that a small percentage of children in Kassala state (3.4%) were getting a sufficient diet in both quality and frequency while Northern state had a high percentage of 48.4% (1). In terms of mother's educational status, only 10.8% of children of mothers with no schooling education received a "minimum acceptable diet" compared to 30.1% of children of mothers with higher education. In addition, only 6.4% of children from the poorest households received a "minimum acceptable diet" compared to 29.6% of children from the wealthiest households (1). The reasons behind these differences will be discussed more in details in the discussion section.

Table 3: The minimum acceptable diet

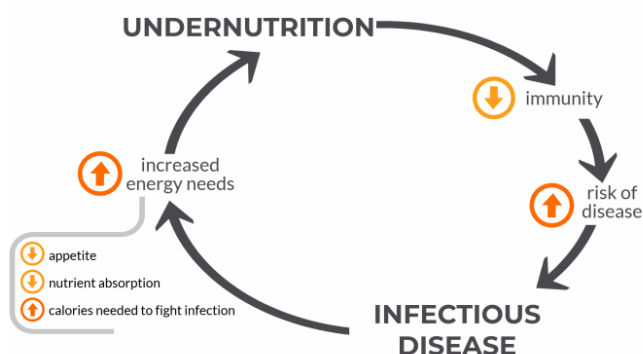
Background characteristics	Percent of children aged 6-36 months who received minimum acceptable diet
Sudan	15.1%
States	
Northern	48.8%
River Nile	29.4%
Red sea	13.2%
Kassala	3.4%
Gadarif	19.9%
Khartoum	13.5%
Gezira	18.1%
Whit Nile	20%
Sinnar	21.5%
Blue Nile	22.1%
North Kordofan	9%
South Kordofan	13.9%
West Kordofan	19.2%
North Darfur	6.6%
West Darfur	14.7%
South Darfur	6%
Central Darfur	6.9%
East Darfur	9.3%
Area	
Urban	18.4%
Rural	13.9
Mother's Education level	
Non	10.8%
Primary	11.7%
Secondary	24.3%
Higher	30.1%
Wealth index quintile	
Poorest	6.4%
Richest	29.6%

Source: Based on Multiple Indicator Cluster Survey 2014 (1)

3.1.2 Diseases

Diseases and undernutrition are interconnected. Undernutrition makes a person more prone to infections as a person's resistance to sickness is weakened; in addition, infections negatively affect a person's appetite and ability to absorb nutrients which may worsen undernutrition. Figure (4) shows the vicious cycle of undernutrition and infectious diseases. Up to 70% of the burden of infectious diseases like diarrheal diseases, malaria, respiratory infections, and measles can significantly contribute to undernutrition (33).

Figure 4: The vicious cycle of undernutrition and infectious diseases



Source: Voice, the vicious cycle of undernutrition and infectious diseases (34)

Diarrhea

Diarrhea is defined as two or more loose or liquid stool per day (35,36). Diarrhea has been reported to be one of the causes of undernutrition in children under five (35,36). Diarrheal diseases can result in loss of nutrients and lack of absorption of essential elements. At the age of two, a child’s risk of becoming stunted rises with diarrheal incidence. An effect of “dose-response” is present between children’s diarrheal incidence and stunting; as diarrheal incidence rises, the risk of stunting rises as well (37). Similar findings were also suggested in a study that was done in Sudan in 2000 (38).

Diarrhea remains one of the causes of child morbidity and mortality in developing countries. Sudan is one of these countries, which has high prevalence rates of diarrhoea (35). The MICS 2014 found diarrhoea to be of high prevalence among children under five (29%). Just like in dietary diversity and meal frequency, the difference between states was also observed regarding diarrhoea. For example, the state of West Darfur had a diarrhoeal prevalence of 9% while Khartoum had a prevalence of 42.7%. The reasons behind these differences will be discussed more in details in the following section (1).

Acute Respiratory Infection (ARI) (Pneumonia)

In Sudan, a rise in the rates of morbidity and mortality rates among children under five is attributed to pneumonia. About one million children are estimated to be infected with pneumonia annually. Also, around 50% are treated in the outpatient departments, and 30% require hospitalization (39). Based on the MICS 2014, the percentage of children with symptoms of ARI and were given antibiotics in the last two weeks when the survey has been done is different between states, areas, and wealth quintile. Details were given in table (4) (1).

Table 4: Percentage of children who have symptoms of ARI and were given antibiotics

Background characteristics	Percentage of children who have symptoms of ARI and were given antibiotics on the last two week before the
Sudan	59%
States	
Northern	71.6%
River Nile	78%
Red sea	*
Kassala	63.4%
Gadarif	72.8%
Khartoum	61.4
Gezira	65.5%
Whit Nile	75.4%
Sinnar	60.8%
Blue Nile	62.6%
North Kordofan	66.7%
South Kordofan	68%
West Kordofan	59.2%
North Darfur	46.5%
West Darfur	54.2
South Darfur	49%
Central Darfur	54.1%
East Darfur	42%
Area	
Urban	64.3%
Rural	57%
Wealth index quintile	
Poorest	43.3%
Richest	76.5%

Source: Based on Multiple Indicator Cluster Survey 2014 (1)

Undernutrition can be caused by poor intake or the increase in demand for nutrients, as highlighted above (40). Disease conditions like ARIs can either cause low intake due to loss of appetite in children or stimulate the increase of demand of nutrients through the pathogenesis of this infection (40). It has been reported that certain infections in children like pneumonia caused undernutrition through some of these pathways. For example, a child with respiratory infections like pneumonia for long duration is at high risk of developing cachexia (40). Pneumonia mostly happens within the first 24–36 months of life when the child’s body immune system is not fully developed (40). Exposure to infections stimulates the immune response, which requires increasing metabolic energy; as a result, children infected with pneumonia can have adverse nutritional consequences. Moreover, these infections can lead to a significant loss of stored proteins in the body leading to undernutrition (40). In a multivariate community-based cross-sectional study conducted in Somali region, it was revealed that ARIs in children under five years of age is the only disease among all common childhood illness that shows a significant association with wasting (COR=1.85 95% CI=1.19, 2.87). The results found that children who had ARI two weeks before the survey were 1.96 times subjected to a higher risk of being wasted compared to those who are not suffered from ARI(AOR=1.96 95% CI=1.20,3.18) (41).

Parasitic infection

Globally, parasitic infections, especially intestinal helminthes, cause hundreds of thousands of deaths every year and also affect nutritional status, which is more severe in children under five (42). For Sudan, because of the temperate climate and the scarcity of

water supply, this problem is endemic (43). There is no data about the prevalence of parasitic infections at the national level in Sudan. However, a couple of studies have been done in different regions to determine the prevalence. For example, a cross-sectional study conducted in Al Kalakla in the south of Khartoum with 200 children, shows that the prevalence is about 30% (44). Infections with intestinal helminthes usually cause undernutrition and micronutrient deficiency like stunting, wasting, and iron deficiency (45). These intestinal helminths feed on the tissues of the host's body, such as blood. This leads to iron and protein loss; also, some parasites like hookworms cause chronic bleeding in the intestine, which results in anemia. In addition, they increase the risk of malabsorption of nutrients and loss of appetite, which affect the intake, and some can cause diarrhea (46). The transmission of the infection is mostly associated with the socioeconomic status; for example, poor sanitation conditions and illiteracy level are the most prominent risk factors (44). A study that has been done in Ethiopia found that there is a significant association between undernutrition and parasitic infections. It was found that the prevalence of stunting in children with parasitic infections (69%) is higher than those without parasitic infections (61.2%). These findings are also similar for underweight, where children who are underweight and have parasitic infections (70.5%) were higher than those without parasitic infections (54.1%). Moreover, parasitic infections were higher among wasting children (74%) than non-wasting children (52.2%) (47).

Malaria

The most recent data available about malaria in Sudan was formed in 2009, which shows a decrease in the prevalence of malaria (1.8%) compared to 2005 (5.4%) (48). Table (5) shows the progress that has been achieved between 2001 and 2009 (48). In 2012, the proportion of houses with insecticide-treated bed nets (ITNs) was 51%, and 16.5% of houses had at the minimum one Long Lasting Insecticidal Nets (LLIN) per 2 persons. The target for the annual indoor residual spraying (IRS) for 2015 was 85%; however, this was exceeded (90%) in two states, Gezira and Sennar in 2012 (49). Children under five were among the groups that suffer from the highest burden of malaria (morbidity and mortality) (50).

In a cohort study that was conducted in Ethiopia, malaria was found to be a major risk factor in increasing the risk of stunting and wasting in children (51). Malaria has the potential to reduce food intake and increase the need for energy requirements. In addition, an infected child with malaria requires more protein and calories for speed recovery (51). The study shows that children with malaria infection were at higher risk of stunting (AOR = 1.9; 95% CI, 1.2±2.9) and more likely to be wasted (AOR = 8.5; 95% CI, 5.0±14.5) (51).

Another cross-sectional study also done in Ethiopia about the association between malaria and undernutrition in children under five, found that children who have a history of malaria infection are more likely to have undernutrition (OR=1.87, CI=95%, 1.115- 3.138, P-value of 0.02). Also, there were disparities based on the type of species of malaria; for example, undernutrition was found to be much higher in children with Plasmodium vivax (41%) compared to Plasmodium falciparum 28% (52). Similar studies from Ghana (53) and Kenya (54) also confirmed these findings that malaria increases the risk of undernutrition in children under five.

Table 5: The achievable progress to reduce the burden of malaria in Sudan from 2001 to 2009

	2001	2009
Reported cases	3,987,702	2,491,376
Reported deaths	2,252	1,142
Estimated cases	7.5 million	3.3 million
Estimated deaths	35,000	9,788

Source: Five years strategic plan for the national malaria control program 2011-2015 (48)

3.2 Underlying causes:

The underlying causes are those factors that lead to the immediate causes of undernutrition, which include: household food insecurity, inadequate care, and feeding practices, unhealthy household environment, and inadequate health services. They have been aroused from basic causes or as a result of the consequences of their management.

3.2.1 Household food insecurity:

In Sudan, people who are in urgent need for food assistance are projected to be 14% (6.2 million) (55). This number has been increasing over the years, from 3.8 million in 2017 (56) to 5.5 million in 2018 (55). This increase is due to several humanitarian challenges facing the country, the political conflict for over a decade, and the ongoing uprising in the country (55). It is estimated that there is already about 80% of people who may not be capable of affording daily food requirements, which can have negative effects on good health (56). Accessing food in most locations has become a crucial problem because of the huge increase in food basket prices. In 2018, this increase reached up to 215% in some clusters, and at the same time, there was a decreasing rate of the purchasing power (55). In Sudan, the acceptable food consumption level is about 81.5% leaving around 18.5% of the household with food consumption insecurity. This acceptable food consumption varies between states, and the most vulnerable states are Central Darfur, North Darfur, and West Darfur with 50.4%, 59.4%, and 62.7%, respectively (1). Darfur state has the highest percentage of people who are facing the problem of food insecurity (43%); this can be due to the long history of conflict in the state (55). Other states that have a high proportion of people facing food insecurity in Sudan are: Blue Nile, White Nile, Southern Kordofan, Kassala, Gedaref, and Red sea due to the economic shock which resulted in the devaluation of currency, high inflation rate and raising the prices of food and non-food commodities (57). It was mentioned previously that about 70% of children do not have a diverse variety of food. In addition, Sudan has a cultural diversity with a different pattern of diet habit, climate change, poverty, and food insecurity, which leave them prone to micronutrient deficiency (58).

There are over a million refugees living in Sudan; the majority are coming from South Sudan and other bordering countries as well as countries in the Middle East like Syria and Yemen. These refugees are affected by limited resources and limited access to opportunities of the livelihood in the country (55,57). Also, refugees number in Sudan is more likely to increase as conflicts persist in South Sudan, which in turn can contribute to increased food demand and competition for chances of income and resources (55).

Gender also plays a critical role in households' food insecurity in Sudan. For example, most households headed by females are having food insecurity problems compared to households headed by males. This was obvious among the IDPs in Darfur and Central, Eastern and Three Area (CETA) where 72% of the females-headed households and 55% of males-headed household are not food secured (59).

Children under five develop undernutrition, especially underweight, due to the effect of household food insecurity. This was shown in a comparative cross-sectional study conducted in Ethiopia which found that the only risk factor associated with underweight is household food insecurity (AOR = 2.25; 95% CI = 1.29, 3.94, $p < 0.01$). No association was found between either stunting or wasting with household food insecurity (60). However, this finding was counteracted by another study conducted in Kenya, which found that household food insecurity also increases the risk of stunting among children (61).

Household food insecurity can be connected to access to food, agriculture, and other contexts related to the political and economic situation which will be discussed in deep in the basic causes.

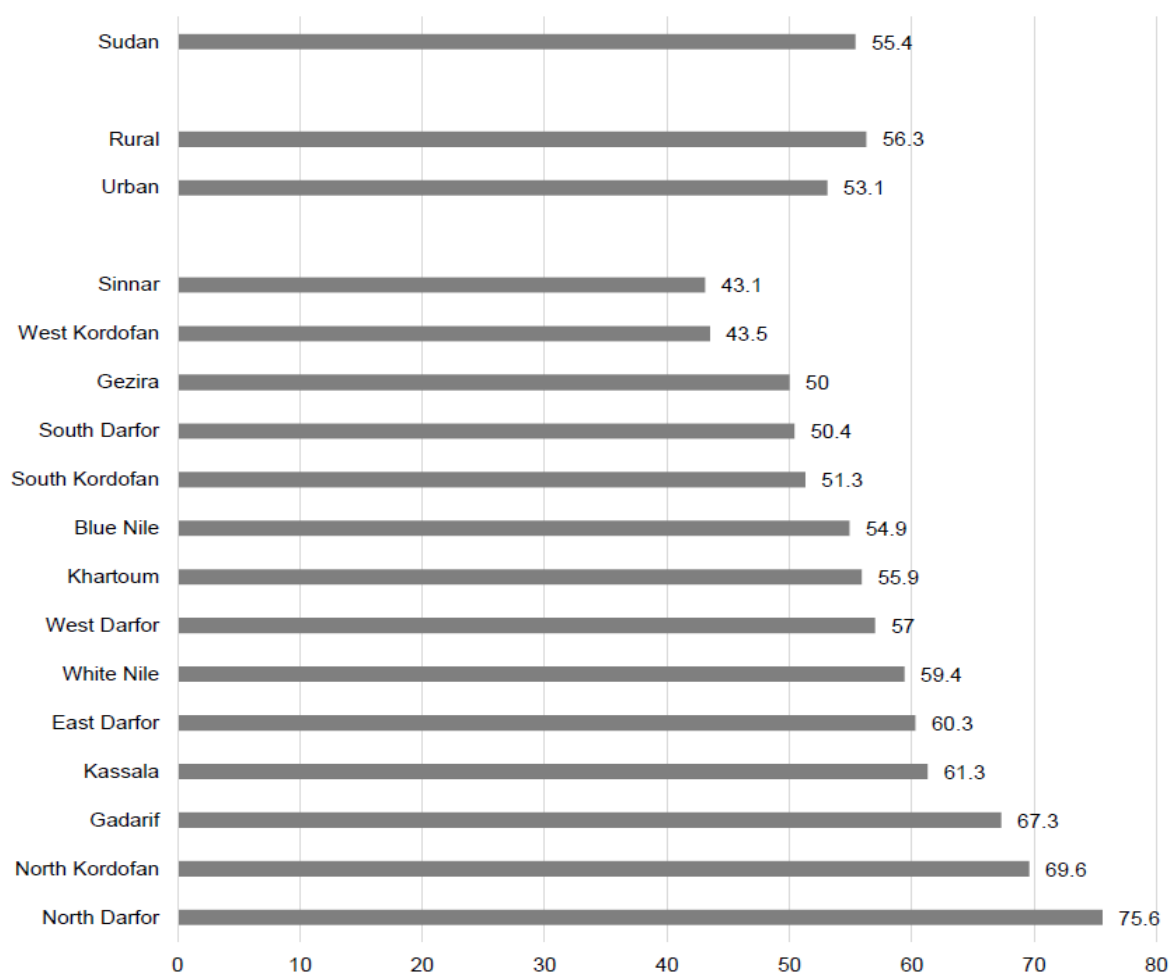
3.2.2 Inadequate care and feeding practice

Appropriate feeding practices and childcare remain critical components of children health and survival (62). With about 60% of children dying from undernutrition worldwide, more than two-thirds of these deaths are attributed to inadequate breastfeeding practice and care (33).

Breastfeeding

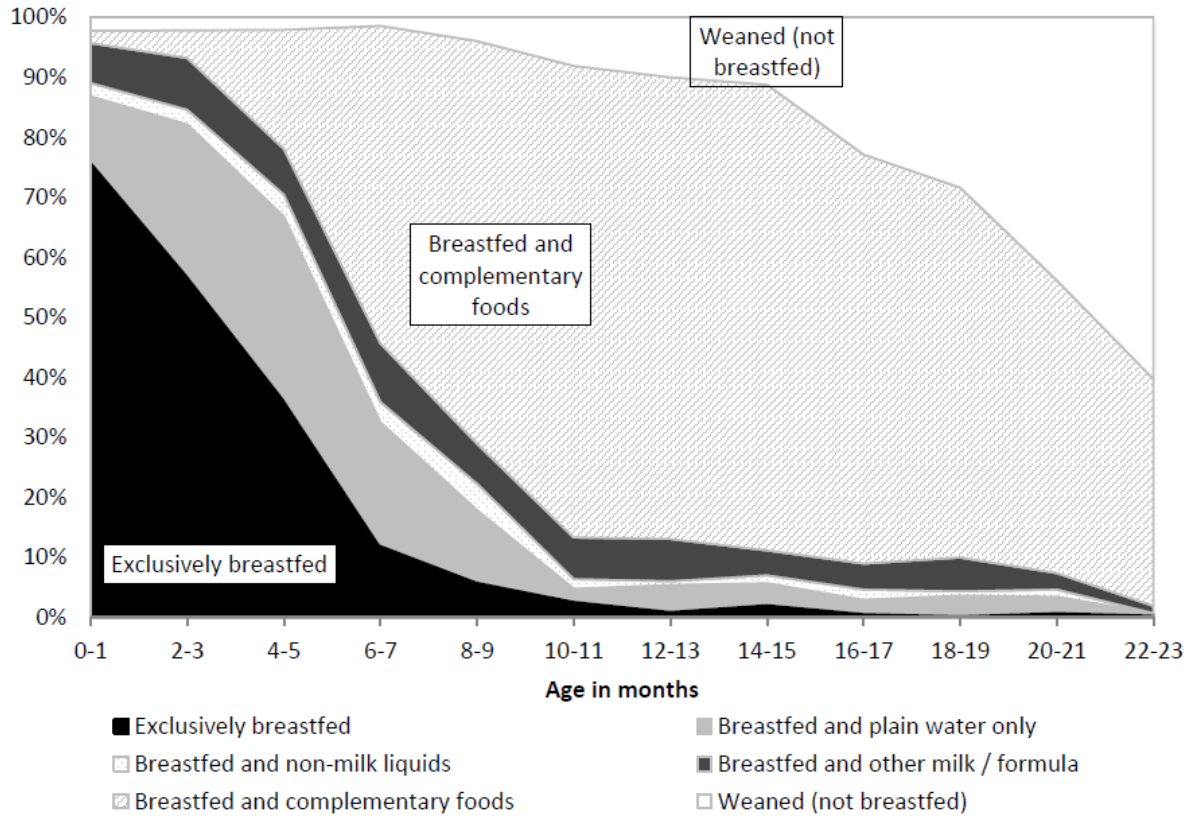
Exclusive breastfeeding is recommended by the global public health actors (WHO and UNICEF) in the first six months of child life and up to 2 years with an appropriate, nutritional and safe complementary food (33,63,64). Breastfeeding for infants and young children promotes growth and healthy development (33,65). It has also been found that breastfeeding can protect children from infectious diseases like diarrhea and pneumonia compared to children who are fed using infant formulae (63). However, only around 55% of children below six months of age are getting exclusive breastfeeding in Sudan with some disparities between girls (54%) and boys (57%). Another disparity is between urban (53%) and rural (56%) areas and also between states see figure (5) (1). About 80.8% of the children are predominantly breastfed where they receive other watery liquids food like "Salega/Marage" in addition to the breast milk even as early as the first month of age. In addition, there is usually a preference to introduce infant formula (1). This might be because women lose their confidence in the ability to practice only breastfeeding, such as Yemeni women (66). The pattern of infant feeding by age is also significant in Sudan, where less than 20% of the children aged 4-5 months are exclusively breastfed see figure (6) (1).

Figure 5: percentage of the exclusive Breastfeeding in the first 6 months of a child's life



Source: Based on Multiple Indicator Cluster Survey 2014 (1)

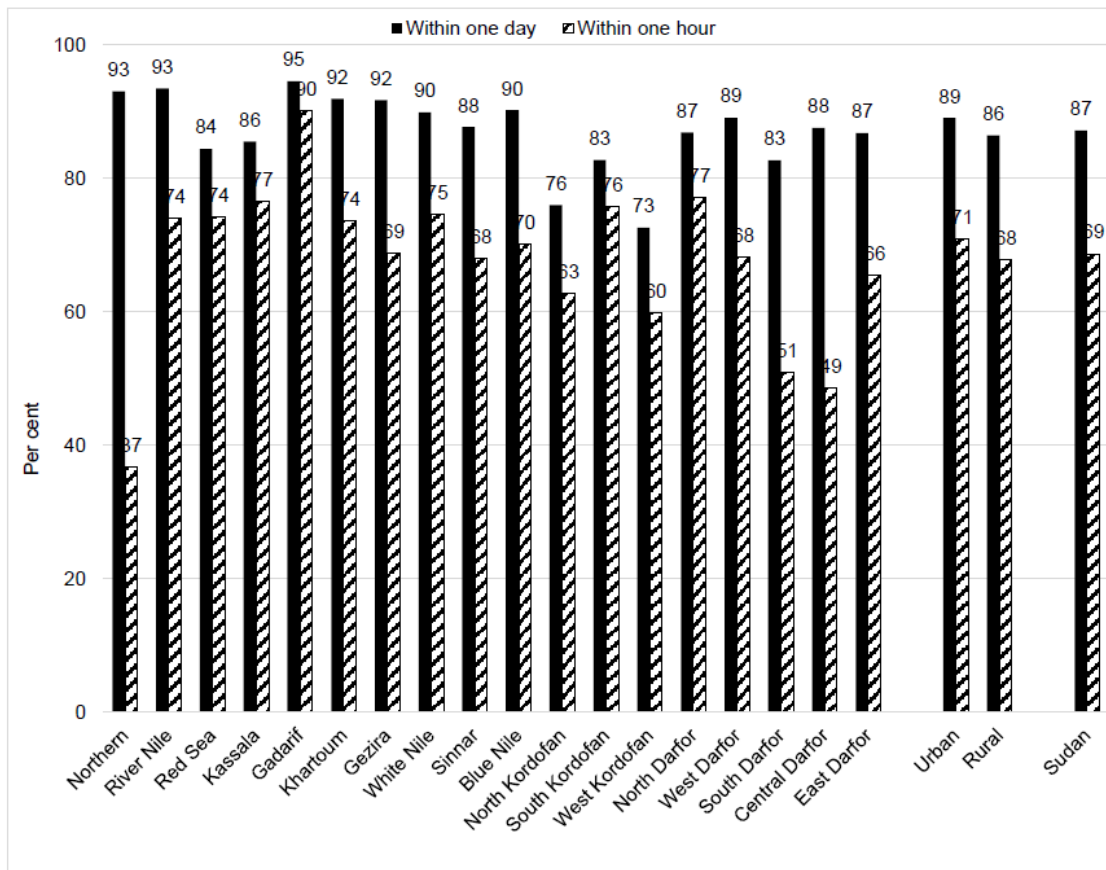
Figure 6: Infant feeding patterns by age



Source: Based on Multiple Indicator Cluster Survey 2014 (1)

The initiation of breastfeeding within the first hour after the childbirth is very vital on a child's health and immunity. If not commenced within the first hours of life, this could put the child at higher risk of mortality from infections (63). Nevertheless, only about 69% of children in Sudan receive the first breastfeeding within one hour after delivery, and 87% within one day after the delivery (1). The percentage of the initiation of breastfeeding is different from state to state as it is illustrated in figure (7).

Figure 7: The percentage of the initiation of breastfeeding



Source: Based on Multiple Indicator Cluster Survey 2014 (1)

In a cross-sectional study that was carried out in Khartoum from July 2008 to July 2010 to study the relationship between breastfeeding practices and undernutrition in children aged 6-59 months, it was found that there is a significant correlation between the period of breastfeeding and undernutrition. The prevalence of undernutrition among children in 780 households was found to be significantly high among non-breastfed children (68%) with a P-value of 0.000 for all manifestations of undernutrition (65).

It was recorded in the MICS 2014 that the median duration for children aged 36 months to be breastfed is around 21 months, three months exclusively and almost six months predominant breastfeeding. No significant difference was observed of the breastfeeding duration according to the geographical areas, the mother's level of education and the wealth quintile. However, there were some conditions with a highly low duration of exclusive breastfeeding that were recorded in Northern and West Kordofan, River Nile and Central Darfur with 0.7 months, 1.4 months and 1.9 months respectively (1).

Complementary Feeding

The practice of exclusive breastfeeding is not only essential, but it ensures healthy growth and development in children. However, breastfeeding alone may not be adequate after the age of 6 months, and introducing complementary food is very important to ensure good nutrition in children and avoid stunting (64).

The early period of complementary feeding (6 to 24 months) is an equally important time that can influence childhood nutritional status. This period is a critical time because of the risk of faltering growth in children, especially within the first six months (age of 6-12 months) period (67,68). During this period, the quality and frequency of complementary feeding that is introduced to replace breast milk can affect child growth. It can also increase the risk of diseases like diarrhea through feeding on contaminated complementary food, which is likely to occur during preparation. And when diarrhea

continues to occur frequently, it can result in stunting, which may be difficult to be reversed after the age of 2 years (68).

Although breast milk is the most acceptable and major source of nutrients and energy for children, there is a progressive decline in breastfeeding and increased need of complementary food for children above the age of 6 months in the developing countries currently (68).

WHO recommends that any child of 6 months and above should be introduced to complementary food which aims to address the problems that may arise from rising nutritional requirements as the age increases. However, an ideal complementary feed should be given on time, inadequate volume, and in a safe and hygienic manner. This means the frequency and quality of complementary nutrients are very crucial in ensuring good health and preventing diseases (33).

Practices of complementary feeding like bottle feeding can be a problem, especially in ensuring the hygiene of the feeding method. In Sudan, food contamination is very likely due to unsafe clean water and poor hygiene practices. Moreover, about 7.3% of infants are fed using a bottle, another 7.4% of children under six months are fed by using a bottle with nipple. This practice of using feeding bottle for child feeding is not symmetrical across the states and regions in Sudan. For example, the prevalence of bottle feeding practice for children is high in Red sea state (20.7%), Northern state (16.7%) and Central Darfur state (16.2%). It is also more popular in the urban areas, among mothers with a high level of education, and in rich quintile (1). A community-based cross-sectional study in Somalia reported that bottle feeding was found to be a significant risk factor for stunting in children (AOR = 3.83, 95 % CI: 1.69-8.67) (69).

Micronutrients deficiency

Vitamins and minerals are known to be micronutrients, and they are essential elements that are required by the body in certain quantities. The cause of micronutrient deficiency or undernutrition is the low food intake, which has a number of consequences like increasing the mortality and morbidity in children. Among the most common micronutrients are vitamin A, Iodine, and Iron (70).

In Sudan, around 76% of the children have gotten vitamin A in the past six months before the survey of MICS 2014 has been conducted. This percentage varies from one state to another starting from central Darfur (58%) to Khartoum (87%) and from urban areas (84.5%) to rural areas (75.6%) (1). Another disparity was found between the richest quintile (84.8%) and the poorest quintile (67.7%). Moreover, mother education level was also associated where women with higher education increase the uptake of vitamin A (83.9%) compared to non-educated women (73.8%) (1). Vitamin A plays an important role in preventing blindness in childhood and also in the reduction of mortality related to measles and diarrhea (71).

For example, in the case of iodine intake, around 7.6% of the households in Sudan are using appropriate iodized salt. This percentage is much lower in West Kordofan (2.9%), Blue Nile (3.1%), Red sea (3.2%) and Khartoum (3.3%). The low disparity between urban (9%) and rural areas (7%) and no disparity between the rich households (8.8%) and the poor households (8.1%) (1). Deficiency of iodine is associated with the risk of miscarriage and stillbirth during pregnancy. It can also cause impaired mental growth, the low performance of children in school and work and mainly attributed to goiter (1).

In 2016, the prevalence of anemia in children under five was about 57%. The main cause of anemia is an iron deficiency and infectious diseases such as malaria. Anemia can lead to mortality and morbidity of children under five as well as impaired cognitive development and poor performance at school (72).

3.2.3 Unhealthy household environment and inadequate health services

Unhealthy household environment

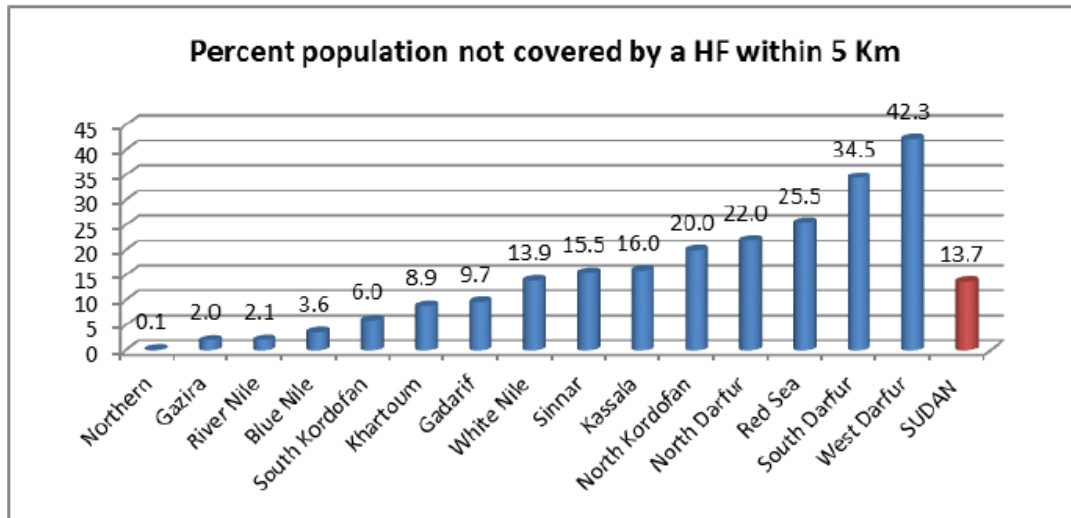
Living in a hygienic environment that has a clean water supply and the good sanitary system is vital for a healthy life, optimal growth, and economic development (73). Outcomes of inadequate water supply and poor sanitation contribute to about 50% of childhood undernutrition worldwide. There is a direct relationship between poor environment and diarrheal diseases because each one can be a risk for the other (73). Multiple studies and reports suggest that poor sanitation and diseases are risk factors and cause undernutrition, particularly in children under five (74). Diarrheal and parasitic diseases, lack of water, and poor sanitation have a mutual and complicated relationship with undernutrition in children (75). A systematic review done in Sub-Saharan Africa found that among the factors that can play a major role in undernutrition in children under five was unsafe drinking water and poor sanitation (76). Another systematic review studied the association between stunting and water sanitation and hygiene. It was found that living in the good sanitary environment can help prevent stunting in 70.6% of the articles (24 out of 33 of the studies), while access to improved and safe water sources for drinking can reduce stunting in 48% of the articles (16 out of 33 of the studies). Finally, the relationship between stunting and hygiene practice was studied in two studies, and both of them found that good hygiene practices like good hand washing and availability of soap and water next to latrine were attributed to the reduction rate of stunting (77). Improved water, sanitation, and hygiene can be one of the factors that decrease infectious diseases like diarrhea and intestinal worms as well as improving the health in the environment. Frequent diarrheal episodes and intestinal infections by worms can lead to impaired absorption of nutrients and loss of appetite that leads finally to undernutrition and stunting specifically (7).

Clean and safe drinking water, good personal hygiene, and waste disposal remain important components of avoiding infectious diseases like diarrheal diseases which is one of the key determinants of undernutrition in children especially those in rural areas. This is one of the major problems in Sudan because only 68% of the population is having access to clean and safe drinking water (1). The situation in Gadarif state is the most critical because only about 28% of people have access to clean and safe water. In addition, the situation in environmental sanitation in Sudan is not much better as compared with clean water supply; this is because only about 41% of the population live in an improved sanitation household. There are also differences between urban (69.3%) and rural (28.2%) areas (1). These differences are also seen in other states; for example, the use of improved sanitation in West Kordofan is 11.6% while in the Northern states is 95%. Another area where differences occur is between the poor and the rich households; the poorest quintile households lies at 6.2% while the richest quintile lies at 91.9% (1).

Inadequate health services

Health care can be inadequate from lack of access or due to the provision of poor quality of health services. In both cases, it can increase the risk of diseases and undernutrition in children (37). And despite the government efforts of ensuring health equity following Alma-Ata declaration for PHC which aimed to increase health services for all, access to primary health services such as antenatal care (ANC) and immunization still remains a major challenge in Sudan (78). For example, around 50% of the population in Sudan have limited access to essential health services. And about 20% of the population has to walk long distances in order to access health facilities, which is beyond the WHO recommendation of not exceeding more than 5 Km from a functional health facility. These problems are greater in the in rural areas compared with urban areas (14). Figure (8) shows the percentage of people who are not covered by health facilities within 5 Km(14).

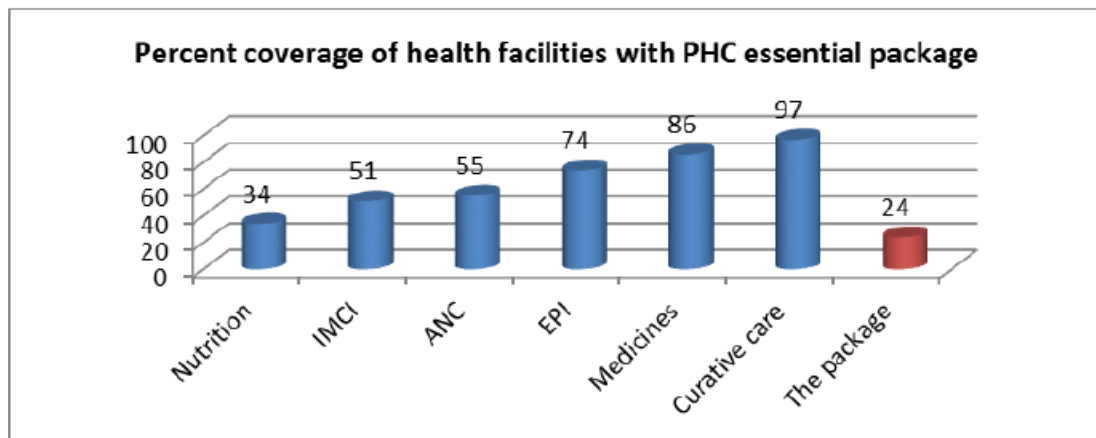
Figure 8: percentage of people who are not covered by health facilities within 5 Km



Source: National Health Sector Strategic Plan II (2012-16) (14)

Availability of complete functional health facilities is found only in about 13% of the localities. And, around 51% of the primary health facilities are in disrupt or malfunctioning states (79), which is either from absents of physical structures or inadequate workforce(14). About 24% of the total PHC facilities are providing the essential services of PHC across Sudan except for Khartoum, as shown in figure (9) (14). The physical primary health facilities are different between the states, with an average of 1:6816 higher than the planned 1:5000 population (80).

Figure 9: Percentage of coverage of the health facilities with PHC essential package



Source: National Health Sector Strategic Plan II (2012-16) (14)

In addition to disrupting and absent physical health facilities, low access and service coverage in the PHC services (curative and preventive) can also be associated with inadequate funding for health care in the country (14). Currently, only 5% of the GDP is spent on health care; therefore, the cost of health care is largely OOP (75.5%). This has affected both access and the utilization of mainstream health services. In particular, it has also resulted in very low coverage of childhood prevention programs, especially nutrition services (14).

In the background, it was indicated that significant percentage of the population is living below the poverty line; this has also contributed to the financial barrier in the poor majority of people and resulted in limiting the access to health care services for the population. Moreover, government funding for health is largely allocated for the curative services, and very limited funding goes to preventive services, especially the PHC services (81). This

has serious negative consequences on child growth because services like immunization, which is an important component of children health, is not adequately provided in Sudan (14).

ANC is another essential service that can ensure good health and increase chances for survival of pregnant women and children (1,82). In Sudan, about 79.1 % of all pregnant women attended ANC with the skilled provider, but 19.9% did not (1). Service coverage between rural and urban areas is also not similar; for example, only 47.9% of the pregnant women living in the rural areas had up to 4 ANC visits, but 90.8% of those in the urban areas did. Another major disparity was found based on wealth index households; about 97.2% of women from the rich household received optimal ANC, but only 61.7% of their counterpart in poor households did (1). A cross-sectional study that was conducted in Ekpoma, Nigeria to identify the relationship between utilization of ANC and the nutrition status of children under five found that the odds of undernutrition are 2.82 times higher among children whose mothers did not use the ANC services during pregnancy period than in children whose mothers did utilize the services.(82).

Another important factor is access to family planning (FP) services. These services have been found to be very useful in improving mother and child health (1). Despite the benefit, access to FP is still a big problem in Sudan. In addition, the political and economic crisis in the country has increased the demand for such services in order to reduce mortality and promote healthy family life through child spacing (1). The contraceptive prevalence rate in Sudan is estimated to be around 12.2%, which is far below the unmet need of 26.6% (1). The most common method used is pills with a prevalence of 9% (one in every ten married women). This prevalence is different between states starting from 2.9% in the Central of Darfur to 26.5% in Khartoum and from urban areas with 20.1% to rural areas with 9% (1). A study in Ethiopia found that children from mothers who have not used FP are 2.5 times more likely to develop stunting than children from mothers who have used FP (AOR=2.54; 95%CI=1.12,5.77) (83). These findings were similar to those of another study which found an association between wasting and FP among children whose mothers have not used FP are 3.8 times more at risk of wasting compared with children from mothers who used FP (84).

Programs for undernutrition in Sudan

Sudan government commits to improving the nutritional status of children. This commitment comes with some actions that the government is committed to like the Millennium declaration and Millennium (85). Most of the undernutrition interventions are curative, and there is a slow movement towards preventive once. However, main challenges are impeding in the implementation of these programs such as the lack of coordination, weak management, a low fund for nutrition programs, low coverage, inappropriate supplies and staff, cultural and behavioral acts related to seeking for health, and feeding practices and food diversification (78).

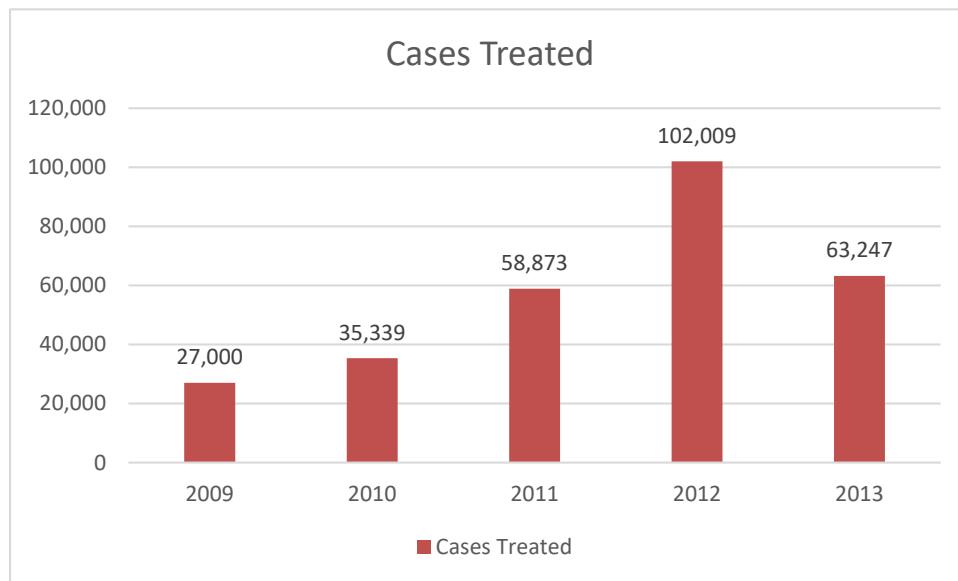
Community-Based Management of Acute Malnutrition CMAM:

CMAM has been implemented in Sudan as an emergency response intervention. It was piloted first in 2001 in the three states of Darfur by the UN agencies, and in 2009 the program expanded as stated by the national guideline (85).

CMAM program is composed of four components including the treatment of Severe Acute Malnutrition (SAM) without complications (out therapeutic program, OTP), treatment of Severe Acute Malnutrition (SAM) with complications (stabilization center, SC), treatment of Moderate Acute Malnutrition (MAM) by targeted supplementary feeding program (SFPs) and outreach workers (85,86). In some cases, the program can also provide food for pregnant and lactating women who have acute malnutrition (86). CMAM program nowadays is found in 7 other states in addition to the five states of Darfur (85). Around 29,000 children have been admitted and treated for SAM with a coverage of about 11% of children with SAM that leaves the rest (90%) without coverage and has no access to this program (85). The figures below (10, 11) show the number of beneficiaries and the CMAM function centers. A weak component in the program is community outreach due to

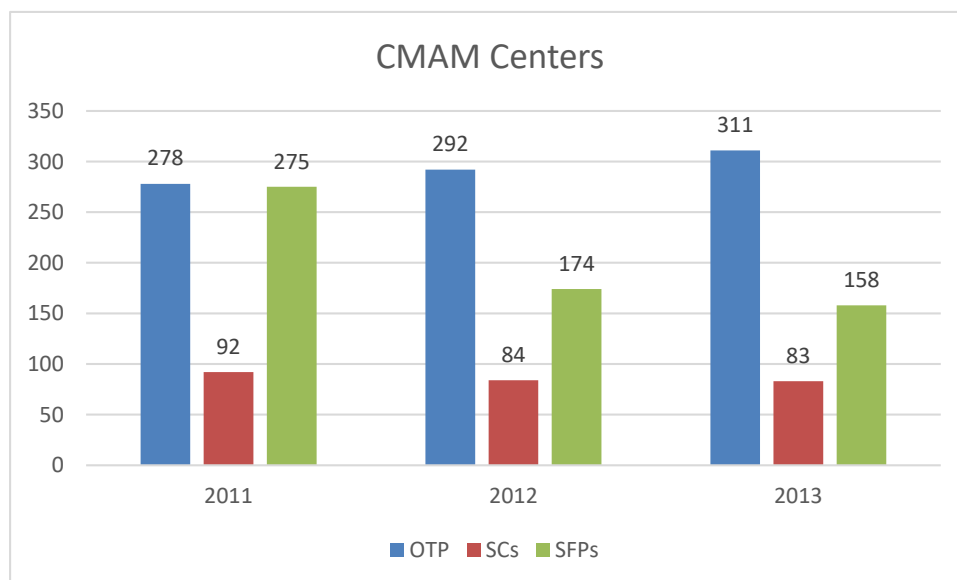
the low incentive for the volunteers. Another problem is the inappropriate medical care in the SCs due to the lack of medical staff. In addition, the essential drugs are chargeable and are not for free and lack of supplies such as blankets and mosquito nets (86).

Figure 10: Number of beneficiaries from CMAM program



Source: Based on National Nutrition Strategy Paper: Sudan, Second International Conference on Nutrition ICN2(85)

Figure 11: Number of functional CMAM centers



Source: Based on National Nutrition Strategy Paper: Sudan, Second International Conference on Nutrition ICN2 (85)

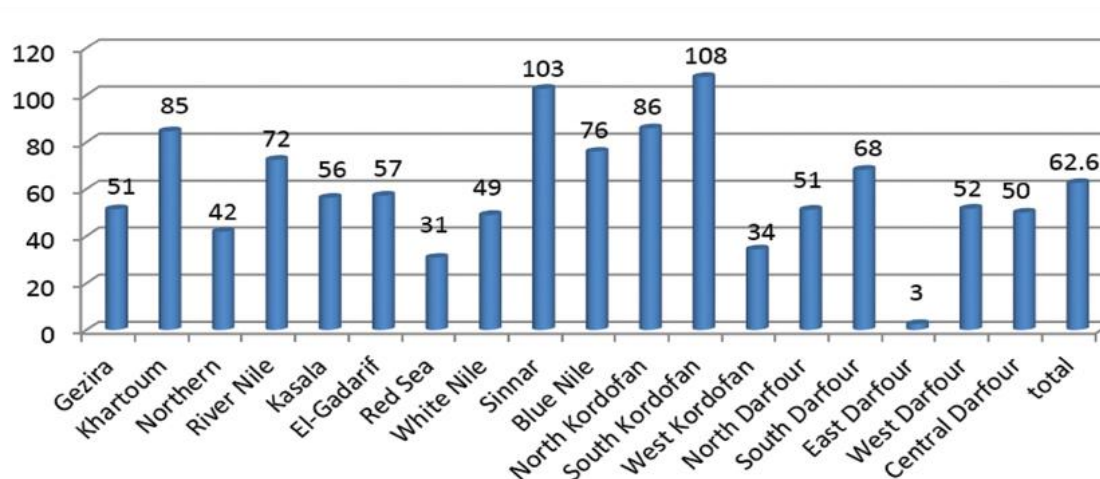
Essential Nutrition Package ENP:

ENP has been implemented to address malnutrition, particularly mother and child malnutrition (31). This package contains some improvements for maternal nutrition, infant and child feeding (IYCF), child spacing, micronutrient supplement, growth monitoring, care for a sick child with referral services; also, it improves the diversity of diet and optimized the hygiene and sanitation (31,85). The ENP covers the whole 18 states of Sudan and delivered by the public health facilities. However, only 36% of the health facilities are providing this service (85).

Integrated Management of Childhood Illnesses IMCI:

IMCI was first implemented in 1997 by WHO and UNICEF to manage popular diseases in children under five. IMCI was introduced to tackle multiple diseases that can cause death for children like diarrhea, malaria, pneumonia, and malnutrition. The program has gone in many stages of implementation to reach all children in Sudan's states. There are some remarkable efforts to implement this intervention to address the main causes of mortality in children under five and to identify the main key to health promotion and prevention. However, the coverage and the implementation are still poor, and the access of the population is also still limited (87). Figure (12) shows the number of health facilities which implementing IMCI program by state.

Figure 12: Health facilities which implement IMCI program by state



Source: The "Ten in Five" strategy 2016-2020 (87)

3.3 Basic causes:

Basic undernutrition causes include the availability of resources like land, access to livelihood, education, access to technology, economic situation, political issues, and social and cultural issues at the community and country level. These factors lead to the emergence of the underlying causes of undernutrition in children under five, which in turn lead to the immediate causes at the later stages.

3.3.1 Household access to adequate quantitative and qualitative resources: land, education, employment, income, and technology

Land and agriculture play a major role in reducing undernutrition (88). Agriculture is the foundation source of food and essential nutrients. However, reduction in agriculture production and poor harvesting due to drought can lead to serious food scarcity and severe undernutrition (70). Agriculture can also contribute to the general wellbeing and good livelihood by increasing income and creating

employment, especially for the poor who are at risk of undernutrition and diseases (88).

In Sudan, agriculture is considered the main source of income, contributing to about 31% of the GDP, and it offers about 57% of job opportunities (20,89). Reports by the government in 2014 showed an estimate of about 70% of the population in Sudan is dependent on agriculture for their means of livelihood (89). In the past, a greater part of the land in Sudan was used for farming. However, the loss of oil revenue due to the secession, local conflicts, and climate change had negative impacts on the agriculture sector in the country. These negative aspects can be seen in increasing prices of food production, increasing the imports and reducing the exportation of goods and food products (89).

Mother education is another major influencer of child nutrition and its health outcomes (90). Mothers with a high level of education also have a decreased mortality rate of their children. Several studies confirmed the fact that there is a significant association between mother's education and the health of the child. Educated mothers have more knowledge about child nutrition, immunization, and good treatment during diseases. Some studies from LMICs show that there is an association between parental education level (mother and father) with the risks of undernutrition in children (91). In Sudan, there was a study done in the White Nile state, which found that the higher level of parent's education, the lower the prevalence of undernutrition in children (92). It was mentioned previously that women have less literacy level in Sudan, and it also varies according to the urban (79.8%) and rural (50%) areas. And around 43.7% only of women in Sudan have primary school certificate as their highest level of education (1). A systematic review that was done in Sub-Saharan Africa reported that the high level of education for the mothers was correlated to more health care utilization, application of modern medicate practices and increasing the female autonomy which influences the decisions making and improves the outcome of child health and nutrition (76).

The nutritional status of children under five in Sudan depends on the household's income. A child who lives with a family with limited access to recourses and low economic situation is at higher risk for having undernutrition (93). Poverty is a general phenomenon in Sudan. And with a predominantly young population, pressure for jobs creation and employment remains a serious challenge. The total unemployment rate in 2011 was 18.5% with variation between males (13.3%) and females (32.1%); moreover, another variation is between urban areas (16%) and rural areas (22.9%). The rate of unemployment is expected to be higher because of the diminishing in national income and weakness of investment (94). In a systematic review within Sub-Saharan Africa that was done to see the associated factors with undernutrition in children under five, showed that the high level of education of the father was associated with high household income and food security. The family has been able to access adequate food that can guarantee good health and promote good nutrition state in children (76). Parents without education are more likely to have low income, and they also spend less amount of food, which affects the quality and frequency of nutrition within the household. In addition, children in this type of household have limited access to essential health care services and have a higher risk of diseases from poor living conditions which make them more vulnerable to growth failure (76).

The use of information technology, like the media within the household, has been found to contribute to reducing undernutrition. A study that was done in Bangladesh to identify the determinants of undernutrition in urban slum found that mothers who have access to information using media showed a significant effect in preventing child undernutrition. Mothers with regular exposure to media are 20% less likely to have an underweight or stunted child compared to those with irregular exposure (95). This was also suggested in a cross-sectional study that was done in Khartoum, Sudan about the effect of health awareness of the mothers through the means of information technology like television, radio, and internet which has shown an association of those awareness means with a good status of children health (96).

3.3.2 Inadequate financial, human, physical and social capital

As indicated in the background, the majority of people in Sudan are living below the poverty line. Conflicts and civil war have contributed to a massive loss of government revenue and destruction of the financial, physical, human, and social capital (94). Conflicts have affected the government's investment in human and physical capital like job creation as well as the ability of school enrolment (94). Currently, a lot of human capital in Sudan, like medical professionals and other skilled people have immigrated out of the country due to poor job opportunities (97). Given the current circumstances of the low level of literacy in many places of the country and the instability, as it was mentioned previously, the country is in a difficult situation that requires medical cadres. Violence eruption associated with the conflicts led to negative impacts on the social capital and the stability of the institution within the community (94). The country has poor physical capital like infrastructure, roads, and transportation, which affects accessibility and service coverage through the limitation of mobility (14).

3.3.3 Social, cultural, economic and political context

In the background, it was highlighted that Sudan has different geographical components and diverse culture as well as different languages and religions. These multicultural environments operate in line with traditional practices, customs, and value systems of its different constituencies. Addressing the public health needs within the accepted practices of the people remains a serious challenge especially in the areas of gender and equitable distribution of resources considering the current political, economic or cultural norms of the population (98).

Some of the traditional practices that can be harmful or result in negative health consequences is not allowing pregnant women to have some kinds of food (98). A study that was done in Sudan showed that pregnant women particularly young married girls living in rural areas with a low level of education and inappropriate ANC have avoided some kinds of food during pregnancy because of cultural and normative beliefs (99). Such practices can affect the health outcomes of the mother and her child by causing problems like maternal anemia, preterm deliveries, and underweight babies (99,100). Breastfeeding mothers who are not having adequate nutrition will not be able to have enough breast milk for their children (100).

Another harmful practice is early marriage. Early marriage is highly practiced in rural areas due to cultural and economic reasons (98). Societies in Sudan generally prefer that a girl child remains at home without formal education in the school system. This does not only increase early marriage but also affects women low literacy rate (98). And this can contribute to increasing the risk of a child to be malnourished due to the low level of knowledge and poor health practices as it was discussed previously. In addition, young mothers still require nutrients to grow, and the fetus at the same time also has nutritional needs, which leads to a competition between them for nutrients. This is one of the causes why every 1 in 3 babies in Sudan are underweight and undernourished when they are born (101). A study that was done in LMICs showed that a child of a mother aged 19 years or less has 20-30% increased risk of being low in weight at birth and 30-40% increased risk of being stunted at the age of 2 years and failed to finish secondary school (102).

Early marriage in Sudan is more common among certain age groups than others; for example, 11.9% of women in the reproductive age (15-49 years) got married before the age of 15 years. And 38% of women aged 20-49 years got married before the age of 18. Currently, around 21.2% of young women aged between 15-19 years are married. These figures also differ significantly between young women who live in urban areas (11.2%) and those living in rural areas (26.0%). Another disparity is seen between the states. In Khartoum, for example, the percentage of young women who are married is 12.0%, but it is 33% in Gadarif state (1).

Beside the cultural practices that have been mentioned above, the food sharing and distribution within the household gives more priority to men and boys (78). Gender

role in the Sudanese society gives men (fathers) the right to head the house and make all the decisions related to the family (98). Decision-making power for women and gender equality have the potential to improve maternal and child health through accessing health services. It was found that if a woman has high decision-making power, she is likely to have a good body mass index. Also, they are likely to have good health-seeking behavior for their children. Therefore, they tend to have treatment for childhood infections like ARIs, malaria, and complete child immunization (103).

The current economic challenges in Sudan is leading to weakening the macro and micro economy of the country (104). As it was mentioned previously, the secession of South Sudan decreased the production of the oil causes a loss of 55% of the fiscal revenues (89). This unstable economy caused an increase in commodities prices, inflation, and currency devaluation. All these have resulted in financial hardships to many families who are living in poverty. And because of the declined purchasing power, a large number of families are now unable to purchase food within the households (105). It has been widely reported that undernutrition is increasing with the increase of the poverty rate, particularly in unstable communities. Sudan is one of the countries with a high prevalence rate of poverty, and that contributes to the high prevalence rate of undernutrition (106).

The political situation of Sudan is full of multiple armed conflicts during the last two decades. Around 1.5 million people lost their lives, and the livelihoods in rural areas have been destructed (55). There is an increase in the number of IDPs and limited access to farmlands, which is forced by the conflicts. These conflicts are still ongoing especially around the border areas like Darfur and Eastern Regions (Blue Nile, South Kordofan, and Western Kordofan) and these states record the highest prevalence of undernutrition as shown in table (1) (55). A study that was done in Western Darfur where there is a conflict showed that children and mothers have limited access to healthcare services, clean water for drinking, improved sanitation, and food. These factors contribute to the increase in the risk of undernutrition for children and mothers (107). Another study that was done in South Darfur showed that there was an increasing rate of child mortality and undernutrition in children under five in IDPs (108).

Chapter 4: Best and evidence-based practices and interventions

This chapter highlights intervention for undernutrition from other LMICs as evidence-based practices and interventions.

4.1 Infant and young child feeding (IYCF):

Among all the available interventions of prevention of child health undernutrition, IYCF has been reported to be the most effective because it can reduce the mortality and morbidity in children. Hence, it should be commenced early for children who need it. Optimal IYCF practices, like exclusive breastfeeding, were able to prevent around 1.4 million deaths out of 10 million in children under five annually (109). It is also considered to be the core prevention of all kinds of child undernutrition because of its crucial advantages. However, in LMICs, practices like exclusive breastfeeding are very low that only 40% of children under the age of 6 months received exclusive breastfeeding and 29% of children aged between 2 to 23 months received complementary food to meet the minimum needed diet for good development and growth (110).

The core element of the strategy of IYCF program is community-based counseling. Since 2000, UNICEF has provided guidelines for community counseling package for IYCF. This program has been implemented in Nigeria by UNICEF and the federal ministry of health in Kaduna state. In the local government areas where the program was running, there was an increase of the exclusive breastfeeding rate from 23% to 50% compared to the local government areas where there was no implementation for the program (the rate increased from 22% to 35%). And for the initiation of the breastfeeding within the first hour, it was increased by 12% where the program was running and remained stable where there was no program. Lastly, children aged 6-23 months who received complementary food, the percentage remains stable where the program was running and decreased where there was no program by 13% (110).

4.2 Micronutrient supplementation and food fortification:

Micronutrients like vitamins and minerals are crucial components of a child's physical and mental growth. These micronutrients are required in small quantities; however, they are important and can cause death or undernutrition for the child if they have not been given correctly (110). To prevent micronutrient deficiencies, food should be diverse. However, good and diverse nutrition of all families is still critical to achieving (110). UNICEF has used some strategies to save children lives, protect them, and assure equity by delivering micronutrient supplementations for children like Vitamin A supplement. As it is known that Vitamin A deficiency can weaken child immunity and make him vulnerable to diseases like measles and diarrhea; also, it can cause blindness and hearing loss (110). A successful example of increasing the coverage of vitamin A supplement is what happened in Ethiopia. In 2015 and 2016, the coverage of vitamin A dropped down in some regions of Ethiopia and UNICEF with the assistance of nutrition international advocacy to prioritize the programs of nutrition to deliver vitamin A in the routine health services instead of only delivering it in the national immunization days. By 2017, the coverage of vitamin A increased up to 80%, and with the administration of the ministry of health of Ethiopia, the delivery of vitamin A through the routine health system is now implemented and continued in 430 districts out of 800 (110).

4.3 Care for children with severe acute malnutrition and nutrition in emergencies:

Emergency settings like conflict and fragile context are usually associated with the appearance of undernutrition in children under five, especially severe wasting. Such context is characterized by poverty, poor food, and water sources, poor health states with many infectious diseases and poor practices of good feeding. All these factors leave an impact on the children and cause undernutrition. Usually, they get treated by using medications, care, and therapeutic food (110). Ethiopia's experience in treating children from severe acute malnutrition is very successful. With the support from UNICEF, the Ethiopian government was able to increase the

sites of treatment and maintain the good quality of SAM treatment with the international standers (the cure rate is more than 90%, and the death rate is less than 5%) (111).

Multi-sectoral intervention:

Determinants of undernutrition are various, and addressing them requires a multi-sectoral approach (85,112). There is an urgent need to join, monitor, and evaluate multi-sectoral interventions in order to address undernutrition (31). However, in Sudan, the multi-sectoral programs to address undernutrition are not linked to the interventions of the health sector, and there is no planning or implementing of nutritional interventions with other sectors (31). The federal ministry of health has made an effort to develop plans and strategies to address the undernutrition problem with multi-sectors like agricultural, water and sanitation and education but they are only theoretical strategies, and there is no evidence that they are really implemented (31).

Chapter 5: Discussion

This thesis aims to analyze and describe the determinants of undernutrition in children under the age of five in Sudan. The study also aims to identify the available interventions of childhood undernutrition in Sudan as well as best practices from other contexts using the UNICEF framework figure (1). Findings of this study are used to make recommendations and propose effective interventions based on evidence. Studying the determinants of undernutrition in Sudan shows different influencing factors at different levels on the layers of the framework, which are contributing or causing undernutrition in children under five.

In the immediate causes, dietary intake was found to be a major determinant of undernutrition in children under five in Sudan as described in the findings, only about 15% of the children under five received minimum acceptable diet in Sudan which makes more children vulnerable to undernutrition and diseases. It was also found that some states have even an extremely low level of minimum acceptable diet compared to other states. These states are mainly localized in the conflict areas, which shows a direct association between conflict and inadequate dietary intake among children leading to a high level of undernutrition. In addition, the minimum acceptable diet varied for children among the different educational levels of their mothers and the wealth in their households. The results suggest that children of mothers with higher school educational background and/or wealthier houses received better dietary intake in terms of diversity and frequency.

Diseases are other major determinants of immediate causes of undernutrition in children under five. In Sudan, diseases like diarrhea, pneumonia, and parasitic infections are among the most common infectious diseases that are found to be associated with the risk of undernutrition for children five. However, there was an unusual finding related to diarrhea where the prevalence of diarrhea in Khartoum, which is an urban and non-conflict area, is much higher than West Darfur, which is within the conflict area. But the prevalence of undernutrition (stunting, wasting and underweight) was found to be higher in West Darfur than in Khartoum. This can be due to the high level of mothers' education and awareness about the availability of health services in Khartoum, which promotes their health-seeking behavior higher than people living in West Darfur. In addition, conflict, the poor state of health infrastructures, lack of health services are also major factors in West Darfur that are contributing to the worsening undernutrition.

In the underlying causes, household food insecurity is a major determinant for undernutrition in children under five in Sudan and was interlinked directly with dietary intake leading to undernutrition and micronutrients deficiency. Sudan is facing multiple developmental issues which hinder people from being food secured like conflicts, hosting of a huge number of refugees and IDPs, and deterioration of the economic situation and devaluation of local currency. All these factors have been found to be associated with increased demand for food, while the current situation negatively affects the availability of food. This has contributed to undernutrition among children in Sudan.

The unhealthy environment of the household is another underlying determinant for undernutrition in children under five. In this study, Sudan has been found to have limited access to safe water and sanitation, especially in rural areas which have the majority of the population. This factor is found to cause diarrheal diseases through

food contamination and other water-borne diseases, especially from unhygienic preparation of complementary food.

In the study, IYCF practices have been found to be insufficient compared to what is recommended by the WHO. Initiation of breastfeeding within the first hour after delivery and the practice of exclusive breastfeeding in the first six months of a child's life in Sudan is low. This was shown in the MICS report where about half of children in Sudan are not on exclusive breastfeeding. Children in Sudan are found to be introduced to other liquids and food other than breast milk even in the first few months, and that could be due to culture and beliefs as it was found in Yemen (66). It was also found that there are some states with a very low duration of breastfeeding compared to others which could be explained by the conflict affecting those states (West Kordofan, River Nile, and Central Darfur). In times of conflict, stress could contribute to decreased breast milk production or negatively affects a mother's breast milk composition; consequently, the use of breastfeeding and the breast milk quality is reduced (113). In addition, the dynamics of a family can also be affected by conflict putting more responsibilities on women in the house accompanied by activities to seek income outside the house which ultimately contributes to decreasing their tendency to breastfeeding (114). The study showed some unexpected findings for children in the Northern state, where the prevalence of undernutrition was low despite the extreme low duration of exclusive breastfeeding. This can be related to good access to services like health, water, and sanitation.

Coverage of health facilities and services is a major determinant that is contributing to undernutrition in children under the age of five in Sudan. This study found that there is the inequitable distribution between states and regions in Sudan, and also most of the available nutrition services are curative with very limited preventive services. This can create inequity in distribution that can make more children and women vulnerable to undernutrition and diseases.

In the basic causes, poverty has been found to be a major determinant for undernutrition in children under the age of five in Sudan. Huge numbers of the population in Sudan are living under the poverty line, which influences the underlying causes like households' food insecurity, which in turn negatively affects direct dietary intake and health. Moreover, the study found that poverty is associated with education, income, and undernutrition. This can be explained by the ability of the educated head of the family to get a job and subsequently has the ability to get food and good living conditions. In addition, cultural beliefs and gender were among the impeded factors that can be determinants for undernutrition. Early marriage and the low power of decision-making in Sudan were also the main basic causes of undernutrition.

In terms of interventions and best practices for tackling undernutrition, it is best to provide complete preventive and curative services. It is found in this thesis that preventive nutrition programs like IYCF, micronutrient supplement, and curative services like CMAM are considered to be as the core interventions to address undernutrition in children under five. Sudan nutrition programs have also been found to have similar components to best practices interventions; however, the implementation is not adequate due to the lack of capacity, management, and coordination.

Limitation of the study:

Literature about the determinants of undernutrition in Sudan was scarce, and updated information was not available. The most recent data was from 2014 and may not reflect the real situation now. Searching for micronutrients data was actively done, but there was very limited data or no results.

Chapter 6: Conclusion and Recommendation

6.1 Conclusion

Undernutrition in children under five in Sudan remains a major public health problem contributing to morbidity and mortality in children and affecting the development of the country. The situation is very critical in Sudan due to the current economic challenges like the increase of the commodities prices, inflation, and currency devaluation. These factors have resulted in financial hardships; hence, many families in Sudan are living in poverty. It has been shown in this thesis that increased rate of poverty is associated with an increase in undernutrition. Perhaps that could explain the high prevalence rate of undernutrition and high rates of poverty. The economic hardship, such as the lack of funding, has also negatively affected the outcomes of interventions tackling undernutrition.

Inadequate dietary intake and diseases are two important factors found to be related to undernutrition levels in Sudan. Household food insecurity has also been found to be a critical underlying determinant, which is also linked with dietary intake. In addition, the thesis reported differences in levels of household food insecurity and dietary intake inadequacy between different states in Sudan. It has also been found that the number of people who need food assistance has increased due to unstable political and economic conditions. There is an increase in prices and demand for food due to a large number of IDPs and refugees.

Inappropriate feeding practices like the lack of the immediate initiation of breastfeeding within the first hour of delivery and the lack of use of exclusive breastfeeding in the first six months of life are also underlying factors affecting the nutritional status of a child in Sudan. The thesis has also highlighted disparities in the use of appropriate feeding practices among different states in Sudan with states in conflict areas being more prone to inappropriate practices

Limited access to health services and poor living environments like water and sanitation are the other underlying determinants for undernutrition in children under five in Sudan, especially in rural areas.

The political context, like the continuous conflicts, is the main contributor to undernutrition in children under five in Sudan. Cultural and gender issues were also found to be important determinants which are not to be neglected when considering undernutrition in the context of Sudan.

6.2 Recommendations

Based on the findings of the study, the following recommendations are made and suggested:

At the National level:

- Increase the funds of nutrition programs.
- FMOH should collaborate and work with other sectors to enhance a healthy environment like:
 - Improve access to clean water and proper sanitation.
 - Advocate for girls education.
 - Advocate for laws that ban early marriage for girls, especially under the age of 18 years old.
 - Increase the access to nutritional information through public media like television, radio, and newspaper.
 - Maintain the household food security for the vulnerable groups through food basket programs.
- Create job opportunities and increase the income of the families.
- Conduct further qualitative researches to get a better understanding of the cultures and norms of the feeding practices in the society of Sudan.
- Conduct qualitative and quantitative researches to fill the gap of undernutrition in Sudan, especially researches that focus on micronutrients deficiency.
- Conduct regular surveys to follow up with the nutritional situation.
- Ensure monitoring and evaluation of the nutrition programs to be more strengthened and improved.

At the health services delivery level:

- Promote IYCF practices by expanding the counseling services through all health facilities, especially rural areas and training health workers.
- Strengthen the IMCI programs.
- Strengthen the CMAM program by training the community volunteers and ensuring the provision of incentives.
- Strengthen the referral system of the treatment of acute undernutrition.
- Enhance the access to health facilities by reducing the hardships of distance, especially for rural communities and ensuring the provision of the health services.
- Improve maternal health services like ANC, PNC, and FP.

At the community level:

- Ensure community participation and engagement.
- Promote behavior change and communication programs in the community.
- Encourage good traditional practices and discourage harmful ones.
- Establish women groups in the community where women can discuss their problems and voice out for assistance.

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