MAKERERE UNIVERSITY

DIETARY AFLATOXIN EXPOSURE AMONG CHILDREN (6-24 MONTHS) IN MOROGORO RURAL DISTRICT, TANZANIA

BY

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DECLARATION

I, Modest Beata, do declare that this is my work and that it has never been presented for a degree or any other award in any other university before.

Signature ……………………….... Date………………………

Modest Beata

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SUPERVISORS' APPROVAL

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DEDICATION

This work is dedicated to my Husband, Medichardes Tibamanya and children: George Kamchapa, Leticia Nyamwiza, Francis Muhoza, Monica Tushabe and Fredrick Mwijage and above all, the Lord Almighty God.

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LIST OF ABBREVIATIONS

AFB1	Aflatoxin B1
CFs	Complementary Foods
FAO	Food and Agriculture Organization
HAZ	Height for Age Z-score
NBS	National Bureau of Statistics
NGO	Non-Governmental Organization
PMTDI	Provisional Maximum Tolerable Daily Intake
PACA	Partnership for Aflatoxin Control in Africa
SPSS	Statistical Package for Social Sciences
TDI	Tolerable Daily Intake
TFDA	Tanzania Food and Drugs Authority
TBS	Tanzania Bureau of Standard
WAZ	Weight for Age Z- score
WHO	World Health Organization
WHZ	Weight for Height Z-score

ABSTRACT

In Morogoro Rural District - Tanzania, the majority of the mothers/caregivers use cereal-based complementary foods that are prone to aflatoxin contamination. This study aimed at evaluating aflatoxin exposure in children 6-24 months and its effect on child growth in Morogoro Rural District. The study covered 138 mothers/caregivers having children 6-24 months. A questionnaire was used to collect information from mothers/givers on household characteristics, feeding practices, and food consumption. The samples of cereal-based complementary foods (flours) that the children were feeding on at the time of the survey were collected from each of the households interviewed. The nutritional status of children was assessed by measuring weight and height. The flour samples were analyzed for aflatoxins using an AflaTest Fluorometer. Results for aflatoxin contamination in the complementary foods were used to estimate aflatoxin exposure among the target children. Results showed that 34, 8.7 and 4.3% of children assessed were stunted, underweight and wasted respectively. Male children were more underweight ($p = 0.049$) than female children. About 67.4% of mothers started breastfeeding within one hour after birth while 43.5% of the mothers introduced complementary feeding at 6 months. Only 2.9% of children had minimum acceptable diet while 34.8% had minimum dietary diversity. Child feeding practices did not differ among the two divisions. Most mothers (88%) stored cereal flour for more than two weeks and less than half of mothers processed the cereals by sorting, winnowing and drying before and after milling. Majority of the children (73.2%) consumed porridge from flour with detectable aflatoxin levels (3.40 -78 ppb) above tolerable limit of 10 ppb. The average exposure to aflatoxins among children aged 6-24 months was 67.97 ng/ kg body weight (bw)/day. More than half of the children (67.4%) had aflatoxin exposure level of 8.79 – 549.2 ng/kg bw/day which exceeded the limit of concern (0.017 ng/kg bw/day). Dietary aflatoxin exposure through consumption of complementary foods was found to be significantly associated with stunting ($p = 0.042$). The reported relationship between aflatoxin exposure and stunting indicated the need to undertake long-term studies to further understand the effect of aflatoxin exposure on nutrition status of children. There is also need to design interventions to control fungal growth and aflatoxin contamination in cereal based complementary foods used in rural areas of Morogoro rural district, Tanzania.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Growth impairment in children is among the most serious health problems affecting children throughout the world, it is associated with various factors such as poor hygiene, poor nutrition, socioeconomic status, infectious diseases, environmental toxins and political stability but some regions are more affected than others (Black *et al.*, 2008). Globally, there are 161 million stunted, 99 million underweight, 51 million wasting children, in general malnutrition killed 6.9 million children under-five by 2013 annually (UNICEF, 2015).

Malnutrition is still a public health problem in Sub-Saharan countries, with many countries reporting a high prevalence of stunting and underweight for young children (Stevens *et al*., 2012). About 32.5% of the children in developing countries are stunted as they fail to reach the normal international standard height for their age (Onis *et al*., 2011). The African region has the highest estimated prevalence of stunting (28.2%) and the lowest rate of improvement (Chessa *et al*., 2006). In East Africa, the prevalence of malnutrition is increasing and is becoming a serious public health problem (Sunguya, Koola, & Atkinson, 2006). This problem has serious long-term consequences for children and adversely influences their development. In Tanzania, malnutrition is one of the major public-health problems affecting about 35%, or children under five years especially in rural areas (TFNC, 2014). Morogoro Region, one of the most affected regions in Tanzania, stunting is 36.9%, underweight is 13.7% and wasting is 3.8% (TFNC, 2014). To address the problem of malnutrition in children, one has to address the contributing factors. Such factors include: household economic status, maternal factors, household characteristics, access to good feeding practices and access to safe food.

Good infant feeding practices and healthcare are critical for growth and development of children in their first two years (Kalinjuma & Mafuru, 2013). In Morogoro region, low adherence to exclusive breastfeeding and early introduction of complementary foods is a common practice especially from low-income households (Muhimbula & Issa-zacharia, 2010). The main complementary foods given to children is cereal porridge mostly composed of maize, groundnuts, soybeans, sorghum and rice which are vulnerable to aflatoxin producing fungi particularly

Aspergillus flavus and *A. parasiticus* (Rushunju *et al*., 2013). Aflatoxins are very harmful to human being especially infants (Turner *et al.*, 2009) since they are not only associated with chronic diseases like cancers but also linked to other health problems like malnutrition (Smith *et al*., 2012). Malnutrition is not only attributed to inadequate amounts of food but also to poor nutritional quality of food (Marler & Wallin, 2006; Kulwa *et al*., 2006).

Studies conducted in Kilosa district within Morogoro Region by Gwao (2013) and (Suleiman *et al.*, 2017) reported a high mycotoxin exposure among children due to consumption of maize-based complementary foods as a result of poor post-harvest handling practices. The highest aflatoxin concentration was observed in the Kilosa district with mean concentrations of 19.2ppb by (Suleiman *et al*., 2017). Previous studies in other parts of Sub-Saharan Africa have linked aflatoxin exposure to child malnutrition. In Kenya, Okoth & Ohingo (2005), reported a significant association between numbers of children who were wasted and were being fed flour contaminated with aflatoxin. This implies that children may be exposed to aflatoxins at an early age since most of the complementary foods used by mothers are vulnerable to multiple mycotoxin contamination including aflatoxins (Kimanya *et al*., 2014). This could be the reason for increased cases of malnutrition in Morogoro Region despite successful efforts to reduce childhood malnutrition, such as improved maternal and child health and nutrition in the first 1000 days of life (Safari, Kimambo, & Lwelamira, 2013). This study aimed at evaluating the impact of dietary aflatoxin exposure to children 6-24 months resulting from consuming aflatoxin contaminated home prepared complementary foods on their nutritional status in Morogoro rural district, Tanzania**.**

1.2 Problem Statement

Malnutrition among children 6-24 months remains a big challenge in Morogoro rural district. According to TFNC (2014), about 36.9% of the children 6-24 months in Morogoro rural district are stunted. Studies have reported that the high levels of malnutrition in Morogoro rural district are attributed to the low proportion of mothers (22.3%) practicing exclusive breastfeeding and early introduction of complementary foods, especially from low-income households. In addition, the majority of the mothers in Morogoro rural district feed their children from either their own produced staple foods or those purchased from the local markets such as maize, sorghum, rice, soybeans, wheat, groundnuts and finger millet.

The complementary are made from cereals that are vulnerable to aflatoxin contamination due to poor postharvest handling and storage practices. There is thus a high possibility of exposing children to aflatoxins through consumption of cereal-based complementary foods. High aflatoxin exposure through consumption of contaminated complementary foods could be among the reason for the prevalence of malnutrition in Morogoro rural district. However, no studies have been undertaken to assess aflatoxin exposure among children 6-24 months in Morogoro rural district. This study therefore aimed at assessing aflatoxin exposure among children 6-24 months in Morogoro rural district.

1.3 Objectives of the Study

1.3.1 General objective

The general objective of the study was to determine the levels of aflatoxin exposure in children 6-24 months in Morogoro rural district.

1.3.2 Specific objectives

i. To identify the commonly used complementary foods and infant feeding practices in Morogoro rural district.
ii. To assess the levels of aflatoxin contamination in the major complementary foods used in Morogoro rural district.
iii. To evaluate relationship between the aflatoxin exposure and nutritional status of children 6-24 months in Morogoro rural district

1.4. Hypotheses

i. Complementary foods and infant feeding practices differ amongst different households in Morogoro rural district.
ii. Complementary foods given to children 6-24 months in Morogoro rural district do not have high levels of aflatoxins.
iii. Exposure to high levels of aflatoxins is not associated with poor nutritional indicators among children 6-24 months in Morogoro rural district.

1.5 Justification/Rationale of the study

The relationship between dietary exposure to aflatoxin and nutritional status of children is not clearly understood. Although the effect of aflatoxin exposure on the nutritional status of children has been demonstrated in a few studies, there is no conclusive evidence that aflatoxins have a negative effect on child growth.

In Morogoro rural district, there are poor exclusive breastfeeding practices and the majority of the mother/caregivers use cereal-based complementary foods that are prone to aflatoxin contamination. There is thus a possibility that weaning children may be exposed to high levels of aflatoxins at an early age through consumption of contaminated cereal-based complementary foods. Exposure to aflatoxins could be one of the reasons for the high malnutrition levels of children in the district, despite efforts to reduce childhood malnutrition. Further research is thus needed to evaluate the relationship of consuming aflatoxin-contaminated complementary foods and the nutrition status of children 6-24 months in Morogoro rural district. The outcomes of this study will be used as a basis for the government and Non-Governmental Organizations (NGOs) to design intervention strategies aimed at minimising aflatoxin exposure to children 6-24 months.

1.6 Conceptual Framework

The conceptual framework for this study (Figure 1) is based on the understanding that malnutrition in children is a chronic health issue in developing countries. The framework was adapted from WHO conceptual framework on malnutrition of children. The conceptual framework details the implications of socioeconomic factors which involve household income earning opportunities, demographic, maternal and household characteristics as important factors to consider. These factors influence food handling and preparation, feeding practices, food consumption, and food safety there by affecting the overall nutritional status of the children. Inappropriate feeding practices influenced by socioeconomic factors in the household leads to variations in health and nutrition status of children (Ergin *et al*., 2007). Poor storage and handling of harvested foods especially cereal and legumes lead to aflatoxin contamination and thus exposure to households members (Shabani *et al*., 2015). Previous studies associate aflatoxin exposure to malnutrition though the mechanism is not well known. It has been proposed that aflatoxins damage the intestinal walls thereby interfering with the absorption of important growth nutrients (Smith *et al.*, 2012). Aflatoxins have also been reported to induce immune suppression, leading to increased chances of infection and poor nutrition status (Lombard, 2014).

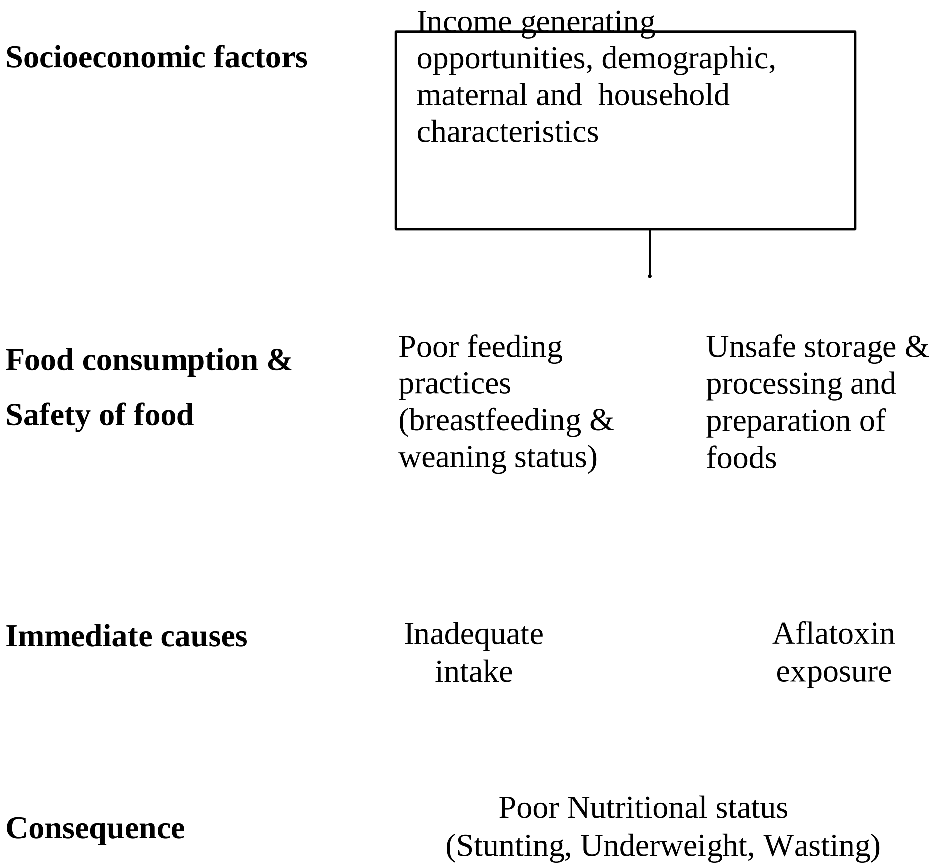

Figure 1: Conceptual framework showing factors affecting nutritional status to children

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Malnutrition refers to disorders resulting from an inadequate diet or from failure to absorb or assimilate dietary elements (Stevens *et al.*, 2012) leading to short-term and serious long-term consequences for children and adversely influences their development (Kandala, *et al*., 2011). Malnutrition rates and incidences are still high globally, as it contributes 11 million deaths that occur each year among children below four years old (Sunguya *et al*., 2006). It commonly affects all groups of people but children are the most vulnerable group because of their greater nutritional requirement for growth and development (Chessa *et al*., 2006).

Child malnutrition includes both undernutrition and overweight of which child undernutrition refers to the outcome of insufficient food intake, inadequate care and infectious diseases (Elisaria, 2009). Undernutrition includes being underweight for one's age, too short for one's age(stunting), thin for one's height(wasting) and deficiencies of essential vitamins and minerals (Black *et al*., 2013). Stunting is defined as a height/length for age below minus two standard deviations (-2SD) from the median of the World Health Organization (WHO) Child Growth Standards (WHO, 2006). Stunting is a physical indicator of chronic or long-term malnutrition and is often linked to poor mental development (Onis *et al*., 2013).

Stunting is a cumulative process of poor growth that primarily occurs before the age of three years and is not easily reversed (Lyell, 2012). This infers that these first years of life provide a window of opportunity for effective nutritional programming. Wasting (low weight-for-height) is an indicator of acute undernutrition. Children below minus two standard deviations (-2SD) of the WHO median for weight for length (WLZ) are considered to be wasted (WHO, 2006).Underweight (low weight-for-age) is an indicator of both chronic and acute undernutrition and refers to children below minus two standard deviations (-2SD) of the WHO median for weight for length (WLZ) considered to be wasted (WHO, 2006).

2.2 Infant Young Child Feeding (IYCF) Practices

Feeding practices directly affect the nutritional status of children under two years of age and, ultimately, impact child survival. Improving infant and young child feeding practices in children 0–23 months of age is therefore critical to improved nutrition, health and development of children (Chessa *et al.*, 2006). WHO (2008) set eight (8) core indicators to assess IYCF practices worldwide to improve children nutritional status. These are: early initiation of breastfeeding, exclusive breastfeeding under 6 months, continued breastfeeding, the introduction of solid, semi-solid or soft foods, minimum dietary diversity, minimum meal frequency, minimum acceptable diet and consumption of iron-rich or iron-fortified foods.

Feeding practices were considered appropriate if the mother practices among the selected indicators above, as recommended and inappropriate complementary feeding practice if at least one indicator among them was not fulfilled.

2.2.1 Breastfeeding

Breastfeeding is one of the most effective ways to ensure child health and survival. Breastfeeding a child within one (1) hour after delivery, exclusive breastfeeding for six months and continue breastfeeding up to two years, will save their lives (TFNC, 2014). Breast milk provides half or more of the child's nutritional needs, and at least one-third of the nutritional needs of children aged between 12-24 months; provide protection to the child against many illnesses and provides closeness and contact that helps psychological development (Black *et al*., 2008).

2.2.1.1 Initiation of breastfeeding

The new born is usually fed for the first time within twelve hours after being born. Studies carried out in central, northern and eastern Tanzania about initiation of breastfeeding, reported that, the interval between delivery and initiation of breastfeeding ranged from one hour to a few hours or for the entire day (Hussein, 2005).

It is recommended by WHO and UNICEF that children be put to the breast immediately or within one hour after birth. The first liquid to come from the breast, known as colostrum is produced in the first few days after delivery (Rathe *et al*., 2010). It is an important source of nutrition and provides natural immunity to the infant (White *et al.,* 2012). Initiation of breastfeeding soon after birth also helps stimulates milk production (Afrose *et al*., 2012). The prevalence of breastfeeding has risen from 72% in 1991 to 93.4% 2011, though exclusive breastfeeding has not improved only 17.9% practiced it for the first 6 months (Motee *et al*., 2013).

2.2.1.2 Exclusive breastfeeding

Breastfeeding exclusively for six months from birth is of well-known importance for saving children's lives and enough to support optimal growth and development for the six months of life of children (Nkala & Msuya, 2011). WHO/UNICEF recommends that children receive nothing but breast milk (exclusive breastfeeding) for the first six months of life. A cross-section study by (Maseta *et al.*, 2008) carried out in Morogoro to compare nutritional status of the children aged 6-36 months revealed that exclusive breastfeeding is about two months (32 to 50 days); and infants were breastfed immediately (in less than one hour) after birth. After the initial period of exclusive breastfeeding during the first six months of life, breast milk continues to be an important source of energy, protein, and micronutrients for older infants and young children, in addition to the nutrients they get from complementary foods.

Further, the study conducted in two districts of Zambia on children feeding practices and nutritional status reported that 65 % of the mothers initiated breastfeeding at the first hour of birth as recommended by WHO. In the same study, mothers were found to introduce complementary foods early before six months of age and were usually not of adequate quality and quantity (Katepa-Bwalya *et al.*, 2015).

Breastfeeding is widely practiced in Tanzania 98% (TDHS, 2015). Approximately 51% of children are breastfed within the first hour after birth and 94% within the first 24 hours after birth (TDHS, 2015). Exclusive breastfeeding is not widespread (51%) for infants under 6 months (TDHS, 2015). By the fourth month of life, 77% of children will have started receiving complementary food (NBS, 2010). According to Safari, Kimambo, & Lwelamira (2013), Morogoro Municipality breast feeding practices are largely suboptimal, and only 22.3% of children age below 4 months were exclusively breastfed. Education level and occupation of respondents were important predictors of exclusive breastfeeding practices.

2.2.2 Introduction to complementary foods

Complementary feeding is the process of introducing solid and liquids foods into the child's diet when breast milk alone is no longer sufficient to meet nutritional requirements of the growing child (Burdette *et al.,* 2006). The target age range for complementary feeding is generally 6 to 24 months of age although breastfeeding may continue well beyond the second year (Dewey & Adu-afarwuah, 2008). In the transition to eating the family diet, children from the age of about 6 months are fed small quantities of solid and semi-solid foods throughout the day. During this transition period (ages 6-24 months), the prevalence of malnutrition increases substantially in many countries because of increased infections and poor feeding practices (Mahgoub, Nnyepi, & Bandeke, 2006).

The complementary feeding period is the time when malnutrition starts in many infants contributing significantly to the prevalence of malnutrition in children less than 5 years of age worldwide (FAO,2011). Timely introduction of appropriate complementary foods promotes good nutritional status and growth in infants and young children (Committee *et al*., 2008). Nutritional deficiencies are very prevalent in populations consuming high levels of cereals, particularly children as they start earlier to receive complementary food up to three years (Bankole & Adebanjo, 2003). Sub-optimal infant feeding practices, poor quality of complementary foods, frequent infections and micronutrient deficiencies contribute to the high prevalence of malnutrition and mortality among infants and young children (Black *et al*., 2008).

Feeding practices such as time of introduction and type of complementary food quality and quantity of food given have been identified as one of the most important factors for the child's nutritional status (Kulwa, Kinabo, & Modest, 2006)**.** Children in Sub-Saharan Africa start receiving cereal-based weaning foods before the recommended age of 6 months (Muhimbula & Zacharia, 2010). In Mauritius, Motee *et al*. (2013), found that complementary feeding was more commonly initiated around 4–6 months and practiced by about 75.2% of the mothers. According to TDHS (2015), complementary feeding generally starts at an early age and recorded 14% of infants given prelacteal feed before initiating breastfeeding, contrary to WHO recommendations and 42% of children under the age 6 months were given complementary foods.

Variation in the period for feeding practices depends on various factors such type of delivery, parity, alcohol consumption, occupation and breast problems (Motee *et al*., 2013). Higher parity leads to short birth interval for mothers hence short time for breastfeeding. Alcohol consumption by the mothers reduces the time for breastfeeding their children and can expose their children to alcohol (Nascimento *et al*., 2013). Maternal occupation may result in mothers giving more time to their jobs than to their children reducing the period for breastfeeding (Motee *et al*., 2013). Breast problems such as cracked nipples, low milk supply, and breast engorgement reduce the mothers' confidence to nurse their infants, hence stops breastfeeding (Horta & Victora, 2013).

2.3 Aflatoxin Contamination in Complementary Foods

Cereals can be contaminated with mycotoxin-producing fungi and pathogenic bacteria during crop growth, pre-harvesting, post-harvesting, drying, transportation and storage (Shabani *et al*., 2015). Aflatoxin contamination adversely affects the quality and nutritional value of the cereal and hence the produced flour (Hell, Mutegi, & Fandohan, 2010). Mycotoxins are toxic chemical products formed as secondary metabolites of fungal origin that can contaminate crops in the field and during storage (Turner *et al*., 2009).

The most abundant mycotoxins associated with grains are the aflatoxins produced by *Aspergillus* species especially *Aspergillus flavus* and *A. parasiticus* (Manjula *et al*., 2009) that cause growth retardation in animals and humans (Wild & Gong, 2010). Aflatoxins are poisons and contaminate various crops in the field and stores making food unsafe for consumption (Pitt *et al*., 2013). Aflatoxins are the most known potent hepatogenic chemicals besides their carcinogenic, mutagenic and teratogenic effects. They cause health complications and growth retardation in children (Losada, Caro, & Marteache, 2011) and are thought to be a contributing factor to the diseases (Turner *et al*., 2003). Mycotoxin moulds produce toxins in cereal-based foods under favourable conditions of temperature, relative humidity (Okoth *et al*., 2012; Strosnider *et al*., 2006). Although flour made from cereals is generally regarded as a safe product due to its low water activity, a variety of pathogenic and non-pathogenic microorganisms contaminate the flour during processing (Victor *et al.*, 2013).

Pathogens that contaminate flour survive for extended periods and produce toxins, even though their growth is retarded under low moisture conditions. The moisture content of flour ranges from 11-14% (Batool *et al*., 2012) but the stipulated limit is 15% above which, flour is susceptible to microbial attack which causes food poisoning and off-flavours (Shobha *et al*., 2011).

Consequently, the storage conditions after milling and packaging are very important for the quality of the flour since they affect the shelf life and safety of the consumer. The quality of cereals and postharvest handling practices of the produce play an important role in the shelf life of the flour (Victor *et al*., 2013).

Many children consume large amounts of cereals (especially maize-based) in their weaning diets, which can increase aflatoxin exposure. Complementary foods in Sub-Sahara Africa are usually made of maize, groundnuts, sorghum, millet and maize (Lopriore & Muehlhoff, 2005). In East Africa maize is a major complementary food. In Uganda, 89% of children are fed maize porridge regularly while about 24.5% of children aged 3 to 28 months have maize porridge 7 days a week (Kikafunda, Walker, & Tumwine, 2004). Gruels prepared from maize are used as complementary foods in Kenya and Tanzania (Kinyuru, 2012; Mamiro *et al*., 2005). Sorghum, millet, rice, cassava, potatoes and yams are common complementary foods in Tanzania (Mamiro *et al.*, 2005), sorghum and millet are common in Kenya, barley and wheat in Ethiopia and sorghum in Sudan (Dicko *et al*., 2006).

Since aflatoxin exposure in children increases markedly following complementary feeding (Gong *et al*., 2005), reducing aflatoxin level in complementary foods is crucial. Aflatoxin contamination problems are minimized with management, such as thorough hand sorting and cleaning that play a vital part in reducing contamination during preparation of complementary foods. Other food processing procedures that can reduce contamination in flour include: winnowing, drying, milling, dehulling, roasting, and fermentation (Hell, Mutegi & Fandohan, 2010).

2.3.1 Presence of aflatoxin contamination in complementary foods

Aflatoxins may be present in a wide range of foods, particularly cereals, oilseeds, spices and tree nuts especially from warmer regions of the world. In Kenya, Okoth & Ohingo (2005), reported that 29% of complementary flour foods were contaminated with aflatoxins (concentration range 2-28 μg / kg), with some exceeding the acceptable limit. In Tanzania, previous studies found high levels of aflatoxins in maize-based complementary foods in rural areas (Kimanya *et al.*, 2014, Kimanya *et al*., 2008). In Rombo District Kimanya *et al*. (2014) reported that 32% of children consumed flour with detectable aflatoxin levels (range, 0.11–386 μg/kg). Rushunju *et al.* (2013), reported 30% of the homemade complementary foods had levels above the maximum tolerable limit of 10 ppb for total aflatoxin. Children consuming maize-based complementary foods are placed at high risk of exposure to aflatoxin (Shirima *et al*., 2013).

2.4 Effect of Aflatoxin Exposure on Child Nutritional status

Child growth retardation is a large public health problem in Africa, with many countries reporting a high prevalence of stunting and underweight in children (WHO, 2014). Childhood growth performance is usually measured by one or more of three indicators: height for age, weight for age and weight for height; children whose heights for ages, weight for ages and weight for heights are 2 standard deviations or more below WHO growth standards (Z-score less or equal to 2) are considered to be stunted, underweight and wasted respectively (WHO & UNICEF, 2009).

It has been demonstrated that chronic aflatoxin exposure at high levels during infancy was associated with growth faltering (Gong *et al*., 2005). There are three (3) biologically plausible pathways through which aflatoxin may affect growth namely; i) inhibition of protein synthesis leading to impaired metabolism, ii) altering the cellular and biochemical functions of the intestine leading to micronutrient deficiencies like zinc deficiency (PACA, 2014; Lombard, 2014) and iii) aflatoxins may also cause mal-absorption of various nutrients thus leading to nutritional deficiencies, impaired immune function, malnutrition and stunted growth in children (PACA, 2014; Lombard, 2014).

2.4.1 Aflatoxin and growth impairment

Various studies have demonstrated that aflatoxin exposure through maternal breast milk, utero and in weaning diets is associated with child growth impairment. Okoth & Ohingo (2005), examined food rather than biomarkers of aflatoxin exposure, in Kisumu District Kenya, they reported that aflatoxin levels in household maize flour correlated with wasting in children. Aflatoxins also were also detected in the flour used for feeding stunted and underweight children compared with normal children although there was no significant association between numbers of children who were stunted or underweighted (Okoth, 2005).

Gong *et al*.(2002), showed that stunted and underweight children had an average of 30 to 40 percent higher levels of aflatoxin-albumin (AF-alb) levels in the blood than children with a normal body weight. In Ghana a cross sectional study by Shuaib *et al*.(2012), showed that mothers with high AF-alb levels were associated with low weight babies at birth. In Iran, Mahdavi *et al.* (2010), Aflatoxin MI (AFM1) levels in mothers' breast milk were associated with lower length and weight of infants at birth. Shirima *et al*. (2014), also reported that aflatoxin exposure had a negative effect on child growth. Several animal and human studies that describe associations between aflatoxin exposure and growth impairment were reviewed by Khlangwiset *et al*.(2011).

2.5 Other Factors Affecting Nutritional Status of Children

Poor nutritional status reflects an imbalance in dietary intake and/or infectious diseases, and therefore is affected by multiple environmental and socioeconomic factors (Pongou *et al*., 2006). Other factors which affect nutritional status include demographic and socioeconomic factors of the household. The most significant socioeconomic factors directly related to child nutrition includes mothers' level of education, household economy, head of household, household size, maternal age, number of children among others. These factors are likely to cause variations in health and nutrition status of children (Hien & Kam, 2008). Maternal education is an important factor for child growth educated mothers to acquire of health information more and adhere to recommended feeding practices for children (Makoka, 2013). Household economic status is one of the most important determinants of child nutritional status, the higher the level of economic status of household, the lower chances of child malnutrition (Pongou *et al.*, 2006)

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study was conducted in Morogoro Region in Tanzania (Figure 2). The region has seven (7) administrative districts namely: Morogoro Urban district, Gairo district, Mvomero district, Ulanga district, Kilombero district, Kilosa district and Morogoro rural district (NBS, 2010). This study was conducted in Morogoro rural district, which covers 19,056 square kilometres (approximately 7,358 sq.m) with a population of 286,248 inhabitants (NBS, 2013). Morogoro rural district is bordered to the north and east by the Coast Region, to the south by Kilombero district, to the southwest by Kilosa district and to the west by the Mvomero and Morogoro urban districts (Figure 2).

Morogoro region had high prevalence (36.9%) of child malnutrition (TFNC, 2014) despite its high potential for food production. Most of the households in Morogoro rural district practice subsistence farming (Wild & Gong, 2010) and majority of the households in Morogoro feed their children on own produced staple foods. The caregivers use traditional methods for handling, processing and storage of staple foods. Furthermore, the staple foods are stored for a long time, which exposes them to mold infection and aflatoxin contamination. Morogoro rural district also has high temperatures (above 25 degrees Centigrade) and relative humidity ranging from 50%-90% (Mkoma *et al*., 2010) both of which favor mold growth and aflatoxin contamination.

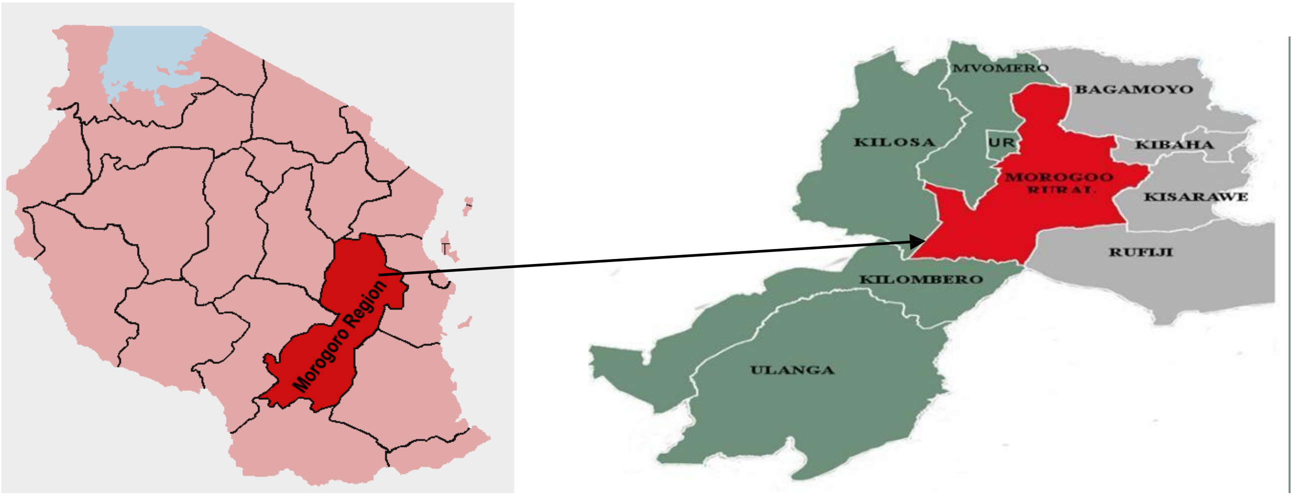

Figure 2 : Tanzania map showing Morogoro Region (Source: NBS, 2010)

3.2 Sample Size Determination

Sample size was calculated according to the method proposed by Kasiulevičius *et al.*, (2006).

The following formula was used;

$$n = \left[\frac{Z^2 P(1-P)}{d^2} \right]$$

Where;

n = sample size,

Z = statistic for level of confidence; (1.96 at confidence level of 95%),

P= prevalence of stunting (36.9%) (TFNC, 2014) (Stunting prevalence was used commonly because it gives picture of the health status of population)

d = Maximum error (8% was assumed).

Therefore, $$n = \left[\frac{1.96^2 \times 0.369(1-0.369)}{0.08^2} \right]$$

$$n = \left[\frac{1.96^2 \times 0.369(0.631)}{0.08^2}\right] = 138$$

The calculated sample size was 138 children at weaning age (6-24 months). An additional 6 children (5% of 138) was added to take care of the dropouts. The final sample size for the study was 144 children 6-24 months.

3.3 Study Design

A cross-sectional study design was used which allows data to be collected at a single point in time. The reason for the choice of this design is that it is economical in situations where there are resource constraints (Mann, 2005).

3.4 Sampling Procedure

In this study, different sampling techniques were employed. Multistage sampling technique was used to select the villages (Figure 3). Two (2) divisions namely Mikese and Mkuyuni were purposively selected. From the divisions, two (2) wards namely Mikese and Mkambarani for (Mikese division) and Mkuyuni and Kiroka wards (Mkuyuni division) were randomly selected. Further, 14 villages were randomly selected from the four (4) wards using a table of random numbers. Simple random sampling was further employed to get a proportional number of households with children 6-24 months of age. The households with children 6-24 months were obtained from the list of children attending the village health clinic (an assumption that all children below five years were attending the village health clinic). Overall at least 10 households (Figure 4) were selected from each village.

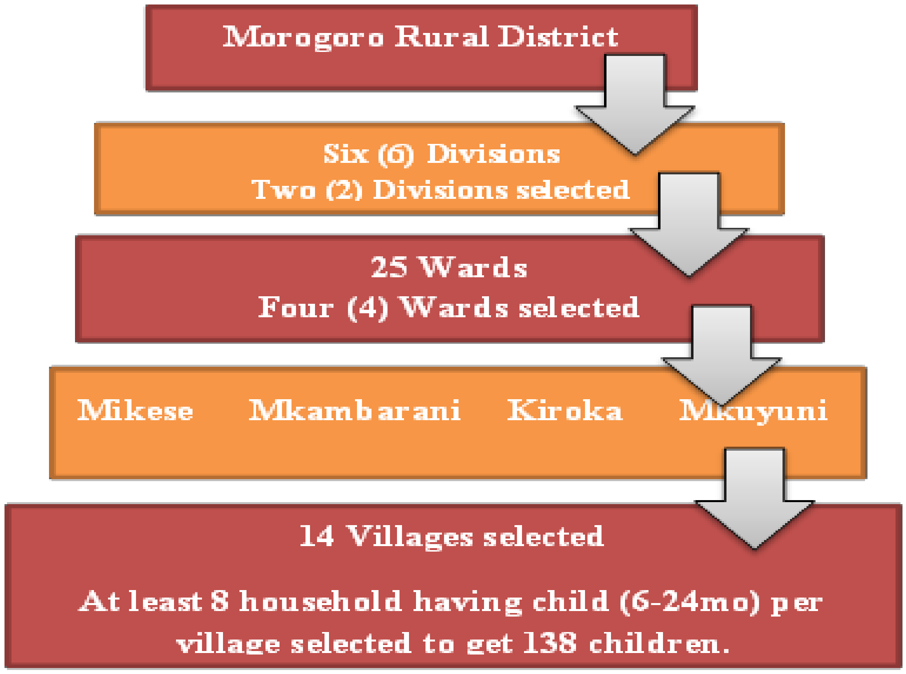

Figure 3: Schematic layout of the sampling procedure

3.5 Sampling Frame

The sampling frame was constituted of households with children between 6 -24 months within the selected villages. For households with more than one child in the target group, only one child small in age within 6-24 months was selected for the study. This particular group of children (6-24 months) was selected because it is the most vulnerable to malnutrition due to increased infection and poor feeding practices (Mahgoub *et al*., 2006) and is also the target for complementary feeding (Dewey & Adu-afarwuah, 2008).

3.6 Data Collection

3. 6.1 Data collection tools

Data was collected using an enumerator administered structured questionnaire having both open and closed-end questions. The questionnaire was pretested in 10 randomly selected households in Gwata village, in Morogoro rural district which was out of the selected villages but had similar characteristics. Ambiguous and unclear questions were corrected before starting actual data collection. The information collected using the questionnaire included: 24-hour dietary recall, socio-demographic and socio-economic information, the feeding practices and procedures for preparation of complementary foods for the children. Information was taken from household heads and/or their spouses.

3.6.2 Data collection procedures

The household survey was conducted using two enumerators who were trained for two days on interviewing techniques and how to fill the questionnaire. Data was collected through household visits. Each sampled mother/caretaker having a child taken aged 6-24months was interviewed and anthropometric measurements of the child conducted. From each household that was interviewed, the enumerators also collected information on the complementary foods consumed by the target children in the 24 hours preceding the survey.

Mothers/caregivers were the primary sources of information on the foods consumed by the target children. The amounts consumed were estimated in terms of bowels, cups or spoons and then converted into weight in grams. The information collected on amounts of food consumed was used to calculate the mean of the estimated intake for the three recall days; two weekdays and one weekend day and used as the consumption data of the food item for a child.

The mothers/caregivers were also requested to provide 125 g of cereal-based food sample the child was feeding on at the time of the survey. The mother was asked to mix the food sample well before taking. The collected food samples were packed in paper bags, marked, sealed and then stored in a refrigerator (4-7^{o}C) until they were analyzed for aflatoxin. The consumption data obtained through the 24-hour recall was used to estimate the aflatoxin exposure resulting from consumption of the cereal-based complementary food by the child.

3. 6.3 Indicators for feeding practices

Among the core recommended indicators for feeding practices by WHO/UNICEF, five (5) indicators selected for assessing whether the child met at least three of them. Those indicators were: continued breastfeeding, the introduction of complementary foods, minimum dietary diversity, minimum meal frequency and minimum acceptable diet, calculated for the age ranges 6–11, 12–17 and 18–23 months of age, and based on a 24-h recall of the child’s dietary intake. These indicators include.

- **Continue breastfeeding for 2 years**. This is defined as the continue breastfeeding the children for the two years of life
  For this study, the proportion of children 20–23 months of age who are fed breast milk was used was the indicator for analysis

- **Timely introduction of solid foods**. This is defined as the time of giving solid foods to a child at 6months.
  For this study, the proportion of children 6–23 months of age who started complementary foods at 6 months was used as an indicator for analysis.

- **Minimum dietary diversity.** This is defined as the taking of at least four (4) food groups among the seven (7) food groups for children 6-23 months. For this study, it was assessed by proportion of children 6–23 months who receive four or more food groups during the previous day. Food groups used for assessing this indicator were cereals, legumes, dairy products (milk, yoghurt, and cheese), flesh foods (meat, fish, and poultry), eggs, fruits and vegetables.

- **Minimum meal frequency**. This is defined as feeding two times for breastfed infants aged 6-8 months, three times for breast children aged 9-23 months; and four times for non-breastfed children of 6-23 months. For the study, it was assessed by proportion of children aged 6–23 months who receive solid, semisolid, or soft food three times or more in the previous day.

- **Minimum acceptable diet.** This is defined as the taking of at least four food groups as well as having three meals or more in the previous day. For this study, it was assessed as the proportion of children 6–23 months of age who had at least the minimum dietary and the minimum meal frequency during the previous day (WHO, 2008).

Appropriate feeding practices were quantified using a composite indicator comprising three of the WHO indicators as recommended by (WHO, 2008). Feeding practices for a child were considered appropriate if the mother practices three indicators among the above selected indicators, and inappropriate feeding practice if less than three indicators among them.

3.6.5 Anthropometric measurements

Anthropometric variables such as weight, recumbent length, age and sex were assessed for each of the target children. The anthropometric measurements were used in the computation of nutritional status indices namely weight for age, weight for height and height for age, according to World Health Organization (WHO) standard procedure (WHO, 2006).

3.6.5.1 Recumbent length measurements

The measuring board was used for measuring children who were less than 24 months of age. Before taking the length, the measuring board was placed on a hard flat surface. With the mother’s help, the child was gently laid on the board with the crown of the head against the fixed head board facing directly up so that the child’s line of sight was perpendicular to the measuring board. The research assistant held the child to ensure the child was placed with crown touching the headboard, the child’s shoulders and hips at the right angles to the long axis of the body. The measurement was read and recorded to the nearest 0.1 centimetre. Each measurement was done in duplicate and the mean value calculated.

3.6.5.2 Weight measurements

Weight was measured by using SECA electronic weighing scale (0-150 kg) (SECA- Germany), which was placed on a flat surface. The scale was adjusted to zero before taking measurements. The mother/caregiver or father was asked to measure his/her weight first. While still on the scale, the scale was tared and the mother/caregiver or father was given the child. The weight of the child was recorded to the nearest 0.1 kg. Each measurement was done in duplicate and the mean value calculated.

3.6.5.3 Age

The exact age in months of children was obtained by asking the mother/caregiver. This was later verified by checking the child’s health card.

3.6.5.4 Nutritional status indices

The nutritional indices used for assessing the nutritional status of children in this study were weight- for-age z-score (WAZ), height-for-age z-score (HAZ) and weight-for-height z-score (WHZ). According to (WHO & UNICEF, 2009), children whose WHZ, WAZ or HAZ was < -3SD were classified as being severely wasted, underweight or stunted respectively while those whose WHZ, WAZ or HAZ was between -3SD and -2SD of the standard were regarded as moderately wasted, underweight or stunted respectively. Children whose WHZ, WAZ or HAZ was between -2SD and -1SD were considered as mild wasted, underweight or stunted respectively. Children whose WHZ, WAZ or HAZ was between -1SD and +2SD were classified as normal.

3.7 Aflatoxin Analysis

Total aflatoxins were quantified using the AflaTest Fluorometer, following methods recommended in Manufacturer's Manual (VICAM L. P. 313 Pleasant Street, Watertown, MA 02472, USA)(VICAM, 1999).The AflaTest Fluorometer method was approved by the Association of Analytical Communities (AOAC, 2006).

3.7.1 Procedure

Aflatoxins were extracted from the cereal flour sample by mixing 50 g of cereal flour sample with 100 ml 80% methanol/water and 5 g of non-iodized salt (NaCl) followed by mixing well using laboratory blender for 1 minute. The mixture was filtered through fluted filter paper. Further 10 ml of filtered extract was diluted with 20 ml of distilled water and filtered through a microfiber filter. One (1) ml of filtered extract was transferred directly to the AflaTest column through a glass syringe barrel reservoir attached to a pump. The entire extract was eluted slowly through the column. The column was then washed twice with one (1) ml of distilled water. One (1) ml of HPLC grade methanol was added to the reservoir and slowly allows running through the column (1drop/second) to elute the aflatoxins. Exactly one (1) ml of AflaTest developer was added to the eluate in a cuvette and mixed thoroughly. The cuvette and its contents were placed in a calibrated Fluorometer. The total aflatoxin concentration (ppb) was read off the screen after 60 seconds and recorded. The limit of detection was 3 ppb for total aflatoxin.

3.7.2 Recovery test

To evaluate the suitability of the method, a blank sample of the complementary flour was spiked with a known concentration of aflatoxin B1 standard (5µg/kg) and the percentage recovery of the toxins determined. Two samples spiked give on average 4.2 ppb and 7.9 ppb leading to average AFB1 recovered by 120%. The recovery value exceeded 80% (Zheng *et al*., 2010) demonstrating a good performance of the method used.

3.8 Estimation of Children's Exposure to Aflatoxins

Aflatoxin exposure was estimated for children who consumed complementary flour with detectable aflatoxin (> 3 ppb) Aflatoxin exposure for each child was calculated by multiplying aflatoxin levels and consumption of the homemade flour per kg body weight of a child as estimated in this study. Complementary homemade flour consumption was estimated from the measured weight of the flour used to prepare the volume of thin porridge taken by a child.

Thus:-

$$\text{Exposure assessment } (\mu g/kg\ Bw/day) = \frac{\text{Consumption level of food (kg/day) x Level of contamination of food } (\mu g/kg)}{\text{Body weight of the child (kg Bw)}}$$

3.9 Data Analysis

Survey data collected were coded, summarized and analyzed using Statistical Package for Social Sciences (SPSS) version 20 computer programme (Corp., 2011). Descriptive statistics such as frequency or proportions and means were calculated for continuous variables. Chis-quare-test was used for identifying the complementary foods; One- sample T-Test and Independent T-Test was performed to compare means for food samples analyzed. Binary logistic regression analysis was used to determine the factors affecting child nutritional status. The independent variables (child sex, child age, child sickness, childbirth weight, maternal age, household status, maternal occupation, the area of residence and exposure to aflatoxin) that were likely to be associated with stunting and underweight were included in the model.

Model formula used:

$$p(x) = \frac{e^{\alpha + \beta x}}{1 + e^{\alpha + \beta x}}$$

Where α =constant or intercept, βx = coefficient for variable, P (x) = probability of event (Stunting or underweight) occurring.

The association between the variables was assessed using odds ratio and 95% confidence interval (CI). The statistical association was declared significant if the p-value was less than or equal to 0.05. Z Scores for anthropometric indices (WAZ-underweight, WHZ-wasting, and HAZ-stunting) were calculated using Anthro Software version 3.2.2, January 2011 (ANTHRO, WHO, Geneva). The nutritional status indicators, weight-for-length (WLZ), length-for-age (LAZ) and weight-for-age (WAZ) were compared with reference data from (WHO & UNICEF, (2009).

3.10 Ethical Consideration

The researcher sought the consent of the respondents before enrolling their children in the survey sample**.** This was after the study was fully explained to them and no respondent was forced to participate in the study.

CHAPTER FOUR

RESULTS

4.1 Demographic and Socio-economic Characteristics of Respondents

4.1.1 Household characteristics

The characteristics of the households involved in the study are summarized in Table 1. The results indicate that majority of the mothers/caregivers (61.6%) were between 20-30 years of age and were married (78.3%) in both divisions. The results in Table 1 further indicated that (67.7%) of mothers/caregivers were subsistence farmers, differing in their level of education ($p = 0.006$) between the two division. Majority of the household (78.3%) were headed by the fathers with some (17.4%) having no formal education and being employed as subsistence farmers (59.4%). Majority of households ($p = 0.003$) from Mikese division were most poor compared to those households from Mkuyuni division.

Table 1: Socio demographic characteristics of the study population in the study area

Characteristics	General study area	Division		p-value
		Mikese (n=71)	Mkuyuni (n=67)	
Maternal age (Years)				
Below 20	9.4	7	11.9	
20-30	61.6	60.6	62.7	
31-40	23.9	26.8	20.9	
Above 40	5.1	5.6	4.5	0.685
Maternal education				
No primary school education	27.1	26.7	28.4	
Primary school education	58.7	64.8	52.2	
Secondary school education	13.8	8.5	19.4	0.006*
Maternal occupation				
Farmer (Subsistence)	67.7	63.4	70.1	
Civil servant	2.2	0	4.5	
Housewife	13.8	22.5	11.9	
Trader/businesswoman	16.3	14.1	13.4	0.13
Maternal marital status				
Not married	21.7	25.4	17.9	
Married	78.3	74.6	82.1	0.289
Household head education				
No primary education	18.1	23.9	11.9	
Primary school education	70.2	67.6	73.1	
Secondary education (form 4)	11.6	8.5	14.9	0.194
Household head employment				
Farmer (subsistence)	59.4	54.9	64.2	
Civil servant	1.5	0	3	
Private sector employee	2.2	2.9	1.5	
Housewife	1.4	2.8	0	
Self employed	35.5	39.4	31.3	0.247
Household socio-economic status				
Most Poor	73.9	61.2	85.9	
Less Poor	26.1	38.8	14.1	0.003*

* Significant at $p < 0.05$ (Chi-square test)

4.1.2 Characteristics of the children

4.1.2.1 Age and Sex

The mean age of the children surveyed was 14.7 ± 5.4 months. The majority (52%) of the children were female but regarding age groups, majority (65.2%) aged 12-23 months being male children (Figure 4).

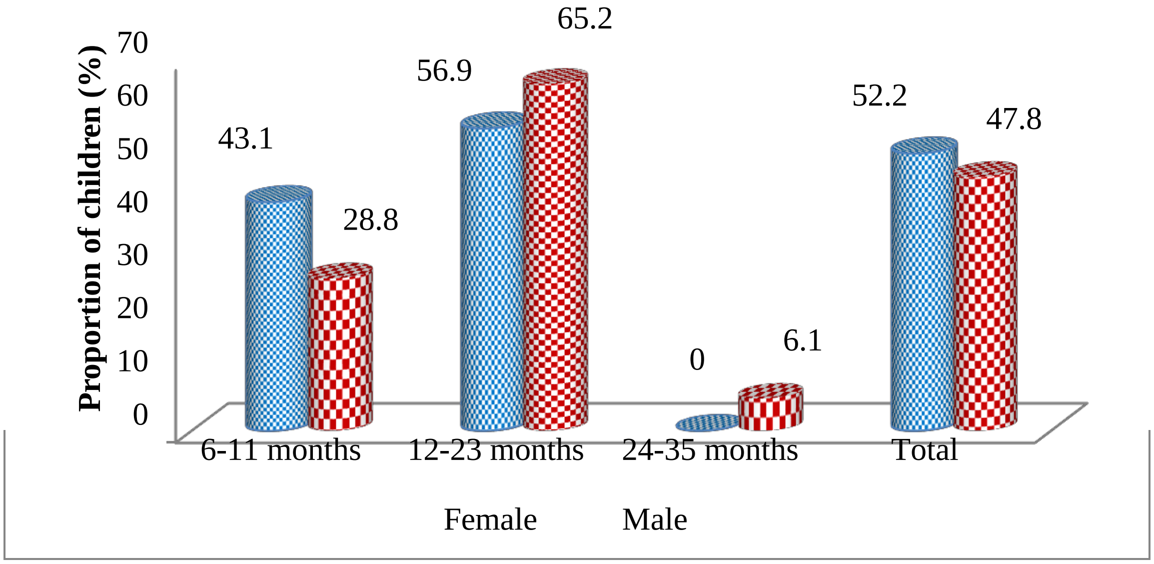

Figure 4: Distribution of children in various age groups by sex

4.1.2.2 Birthweight

The mean birth weight of the children surveyed was 3.29 ± 0.75 kg. Figure 5 indicated that only 10.9% of the children assessed were born with low birth weight (less than 2.5 kg).

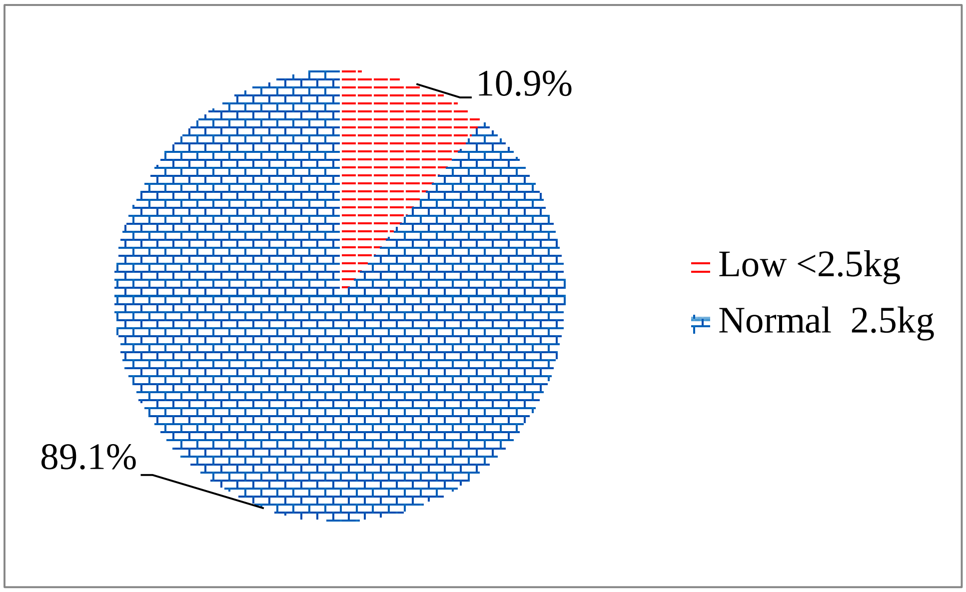

Figure 5: Proportion of birth weight categories for children aged 6-24 months in study area

4.1.2.3 Child illness

A high proportion of children (79.0%) were reported ill during the past 14 days before the survey. The most common illnesses reported include: malaria (34.4%), cough (27.5%) or diarrhea (17.5%) (Table 2).The reason for this frequent illness could be contributed to their poor feeding practices to these children.

Table 2 **: Common child illnesses observed for children 6-24 months in Mikese and Mkuyuni division**

Illnesses	Proportion (%)*
Malaria	34.4
Coughing	27.5
Diarrhoea	17.5
Flu	10.6
Stomach pain	3.1
Urinary Tract Infection (UTI)	2.5
Skin Rashes	1.9
Anaemia	1.3
Pneumonia	0.6
Ear Infection	0.6

* Total number of children = 138

4.2 Child Feeding Practices

4.2.1 Breastfeeding

4.2.1.1 Initiation of breastfeeding

The results in Figure 6 indicated that the time for initial breastfeeding after delivery ranged from within 1 hour after delivery to more than 12 hours. The majority (66.7%) of the mothers initiated breastfeeding within 1 hour after delivery as recommended.

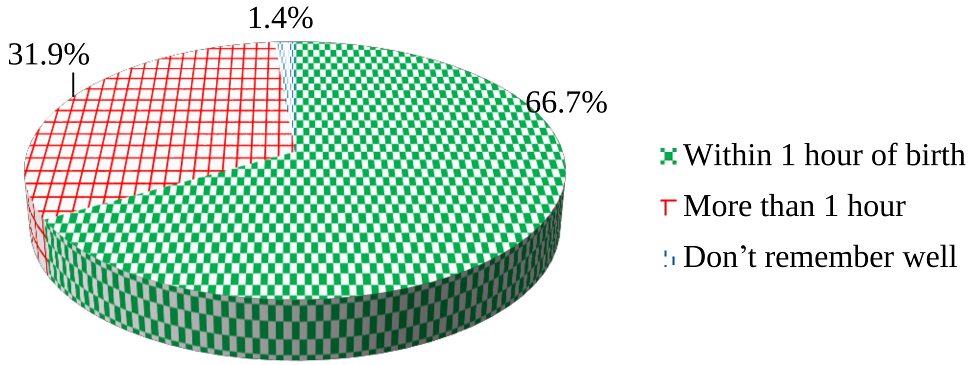

Figure 6: Proportion of mothers initiated breastfeeding after birth in the study area

4.2.1.2 Exclusive breastfeeding

Results in Table 3 showed the breastfeeding practices in the study area. Few of the children (32.6 %) were exclusively breastfed for six months while the majority (67.4%) did not meet the recommendation of exclusive breastfeeding for the first six (6) months. Mothers were reported not aware to a recommendation for breastfeeding and frequent crying of the child.

Table 3: Breastfeeding practices among the children 6-24 months in Mikese and Mkuyuni division

Practice	Proportion (%)*
Exclusively breastfed	
For 6 months.	32.6
Less 6 months	67.4
Continue breastfeeding for 1-2 years	87.7
Frequency of breastfeeding	
1-3 times	3.3
4-6 times	6.6
7-9 times	14
More than 10 times	43
On demand	33.1

* Total number of children = 138

4.2.2 Complementary feeding practices

4.2.2.1 Introduction of liquid or semi-solid foods to children

The study findings indicated that over half of the children (56.5%) were introduced to complementary foods below six (6) months of age (Figure 7). Most of the mothers (72.5%) used cereal porridge composed of maize, groundnut, sorghum, rice & millet (Figure 8) to wean their children before six (6) months with more than half (57.2%) of the children were fed on cereal porridge more than once per day (Figure 9).

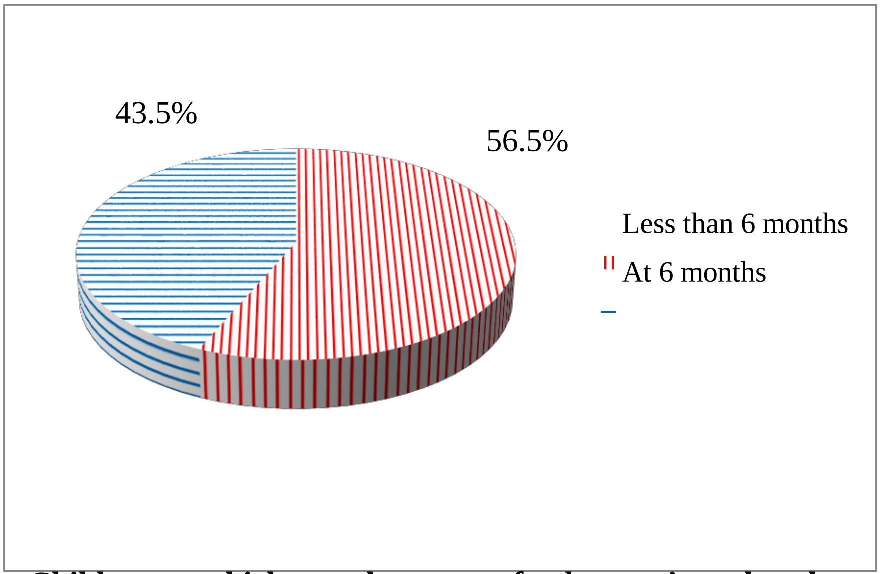

Figure 7: Child age at which complementary foods were introduced

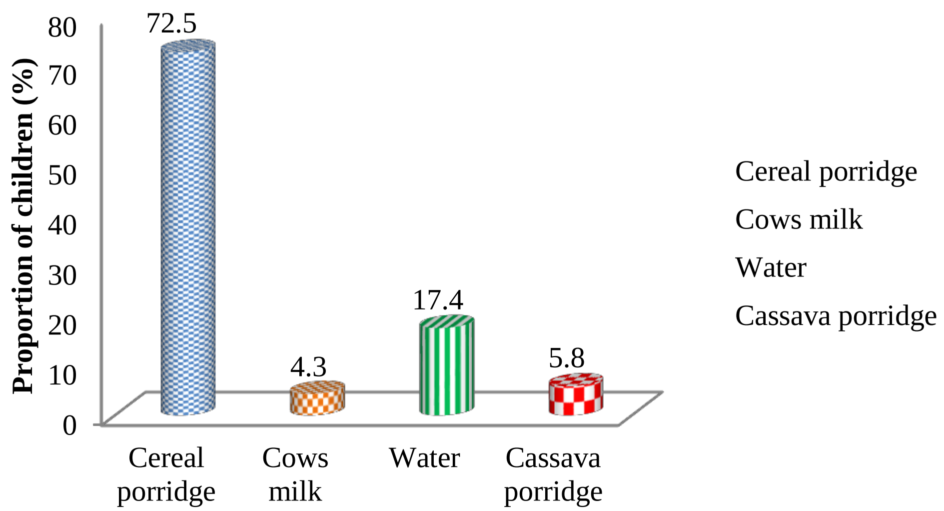

Figure 8: Types of complementary foods given to children before 6 months

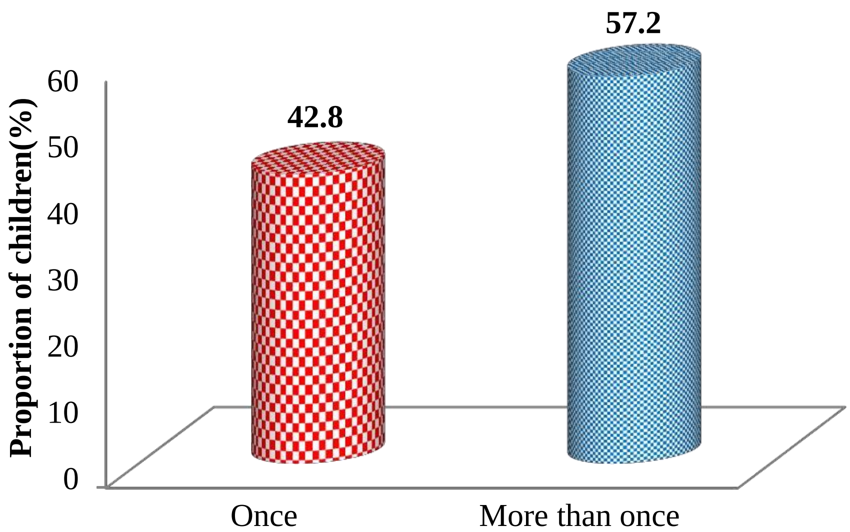

Figure 9: Frequency of feeding complementary foods per day for children (6-24 months)

Results further indicated (Table 4) that mothers also gave their children other food types like *ugali*, rice (grains) and banana prepared as family dish and served with vegetables, fruits, legumes like beans and sardines/fish/meat. From the food types in Table 4, mean intake (g/child/day) for cereal grains (46.74), legumes (66.64), flesh foods (55.52), eggs (30), vegetables (56.43) and dairy products (177.78)

Table 4: : Intake of different complementary foods by children in the study area

Food group	**Proportion of children eating the food /day (%)**	**Range(g/child /day)**	**Mean in take + SD (g/child/day)**
Cereal grains	100	11.25-104.43	46.74 + 21.03
Legumes	66.7	19-152.50	66.64 + 26.2
Vegetables & fruits	60.9	17-105.50	56.53 + 17.4
Flesh foods (meat, fish)	42.8	20-150.00	55.52 + 25.7
Dairy(milk, yoghurt)	6.5	125-200	177.78 + 34.1
Eggs	2.2	0-30	30 + 0

Results in Table 5 indicated that foods given to children in the two divisions were different. Almost twice as many children (p=0.043) in Mkuyuni division took thin porridge as complementary food compared to those in Mikese division (Table 5). For other food types, more children in Mikese division were fed on beans (p=0.002), flesh foods like meat, fish (p=0.005) and dairy foods like milk (p=0.02) compared to those from Mkuyuni division.

Table 5: Comparison of complementary feeding in the study area

Practices	**Division**		**p-value***
	Mikese(n=71)	**Mkuyuni(n=67)**	
Type of food provided to a child			
Porridge only	15.5	29.9	
Porridge and family food	84.5	70.1	0.043*
Use of maize & groundnuts for porridge making			
Yes	18.3	6	
No	81.7	94	0.027*
Dietary assessment using 24 h recall			
Grains			
Yes	100	100	
No	0	0	
Legumes and nuts			
Yes	78.9	53.7	
No	21.1	46.3	0.002*
Vegetable and fruits			
Yes	60.6	61.2	
No	39.4	38.8	0.94
Flesh foods			
Yes	53.5	29.9	
No	46.5	70.1	0.005*
Dairy products			
Yes	11.3	1.5	
No	88.7	98.5	0.02*
Eggs			
Yes	2.8	1.5	
No	97.2	98.5	0.594

* significance at $p < 0.05$ (Chi-square test)

4.2.2.2 Frequency of feeding on complementary foods

The number of meals given to children in the study area per day ranged between two to more than four meals per day with a mode of three meals per day. Thus, the majority of mothers (63%) reported to give food to their children three times per day (Figure 10) which was below the recommended five meals per day.

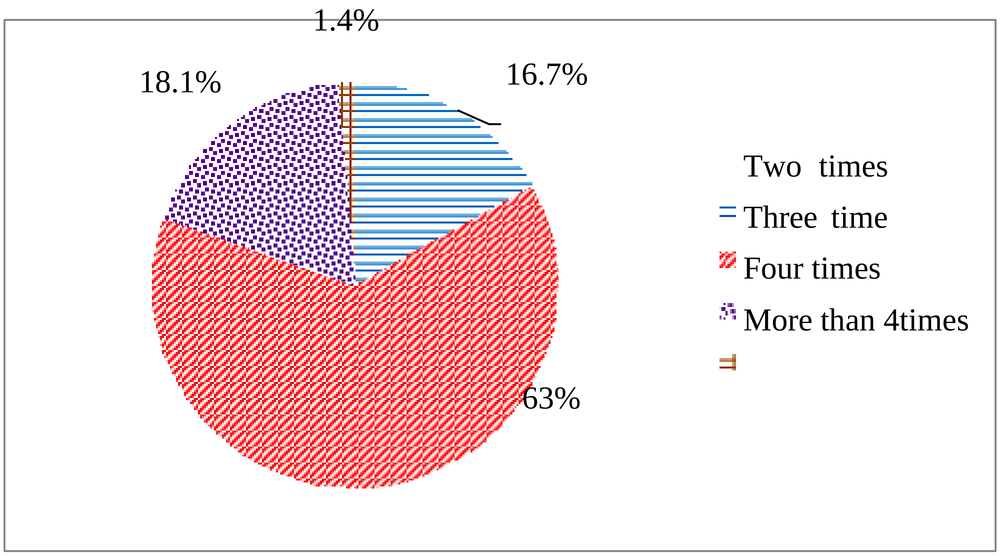

Figure 10: Meal frequency of the children (6-24months) in Mikese and Mkuyuni division

4.2.2.3 Preparation and storage methods for complementary foods in Mikese and Mkuyuni divisions

The methods used for preparation and storage of complementary foods in the two divisions are indicated in Table 6. The majority (> 81%) of the mothers in both divisions did not sort the cereals before preparing complementary foods. Only a small proportion (18.3 and 4.5% of the mothers on Mikese and Mkuyuni division, respectively) sorted the grains. The results further indicated that dehulling was practiced by only 33.8 and 16.4 % of the mothers in Mikese and Mkuyuni division respectively. The majority (> 87%) of the mothers in both divisions used unroasted cereals in preparation of complementary foods.

The results further indicated that food composition and the methods used to prepare complementary foods within the study area differed. A significantly higher proportion of mothers (p=0.02) residing in Mikese division used maize and groundnuts to prepare complementary foods for their children compared to those in Mkuyuni division. Low proportion of mothers (p=0.036) in Mikese division (12.7%) used roasting groundnuts as a treatment method during preparation of complementary foods in comparison with 3% in Mkuyuni division.

Majority of mothers (70.4%) in Mikese division stored their prepared complementary foods (p=0.023) for more than two weeks compared to those in Mkuyuni division (Table 6). Majority of the mothers (88%) stored the complementary foods in plastic buckets though no significant different observed**.** This indicates that mothers/caregivers awareness to aflatoxin contamination to the cereal foods was not adequate.

Table 6: Methods for preparation and storage of complementary in study area

Practices	**Proportion of mothers (%) ****		
	Mikese Division	**Mkuyuni Division**	**p-Value**
Sorting			
Yes	18.3	4.5	
No	81.7	95.5	0.011*
Dehulling			
Yes	33.8	16.4	
No	66.2	83.6	0.093
Roasting			
Yes	12.7	3	
No	87.3	97	0.036*
Storage period of the flour			
Less than two (2) weeks	29.9	44.8	
More than two (2) weeks	70.4	55.2	0.023*
Storage container			
Plastic bucket	92.9	83.5	
Polythene bags	2.8	6	
Tin	4.2	0	
Basket	1.5	1.5	
Not storing (buying from shop)	0	7.5	0.079

**Total =138 mothers (Mikese division = 71, Mkuyuni division = 67)

* Significant at $p < 0.05$ (Chi-square test)

4.2.2.4 Infant feeding indicators in the study area

The results in Table 7 indicated that the feeding practices within the study did not differ, as only for one indicator shows the significant different. A significantly higher proportion of mothers (p=0.045) residing in Mkuyuni division met for continue breastfeeding indicator their children compared to those in Mikese Division.

Table 7: Proportion of children feeding practices in the study area

Practices	General study area	Division		p-value
		Mikese (n=71)	Mkuyuni (n=67)	
Continue breastfeeding (2 years)				
Yes	88.4	83.1	94	
No	11.6	16.9	6	0.045 *
Timely weaning				
Yes	43.5	45.1	41.8	
No	56.5	54.9	58.2	0.698
Met minimum meal frequency				
Yes	13.8	16.9	10.4	
No	86.2	83.1	89.6	0.271
Met dietary diversity				
Yes	34.8	40.8	28.4	
No	65.2	59.2	71.6	0.124
Met Acceptable Diet				
Yes	2.9	2.8	3	
No	97.1	97.2	97	0.953

* Significant at $p < 0.05$ (Chi-square test)

Among the selected indicators for feeding practices (Table 7) revealed that only 34.8% of the mothers offered four or more food groups to their children thus meeting the minimum dietary diversity criteria on the day before the study. Almost half (45.1 %) of the mothers initiated complementary feeding at 6 months (timely initiated complementary feeding). The proportion of children that met minimum acceptable diet was 2.9 % only. Majority (88.4 %) of the mothers from Mkuyuni division (p= 0.045) were continued breastfeeding within 24 months of age than those from Mikese division. This can be explained by the different levels of mothers' education observed as mothers from Mkuyuni division were more having a secondary education than those from Mikese division that can contribute to their feeding practices habit to their children.

Table 8 shows factors associated with appropriate feeding practices of children aged 6-24 months. These variables were mothers' occupation, the age of a child, household economic status and age of the household head. Child age (p= 0.037) and mothers' occupation (p=0.013) were only associated with appropriate feeding practices. Mothers whose main occupation was farming were six times more likely to meet appropriate feeding practices than those who were engaged in other forms of employment (OR: 6.423, 95 % CI: 1.477-27.936). Another predictor variable was child age indicating that children above 12 months in age were 1.158 times more likely to meet appropriate feeding practices than those below 12 months (OR: 1.158, 95 % CI: 1.009-1.328)

Table 8 : Factors associated with feeding practices of children 6–24 months in the study area

Variable	Odds Ratio	95% Confidence Interval	p-value
Age of the child (> 12 months)	1.158	1.009-1.328	0.037*
Household head age (year)	1.003	0.932-1.080	0.931
Mothers' occupation as farmers (Yes)	6.423	1.477-27.936	0.013*
Household economic status (Most Poor)	1.591	0.381-6.649	0.525

* Significant ($p < 0.05$)

These results from the complementary and breastfeeding practices by mothers/caregivers imply that they were not following the WHO recommendation for child feeding which led to poor nutritional status of the children.

4.3 Nutritional Status of Children

In this study, the prevalence of malnutrition curves (Appendix 2) observed to deviate from the standard normal distribution of healthy child. The curves for underweight and stunting prevalence show a shift to the left from the reference curve, this is an indication of low nutritional status as compared to the reference children population. While for wasting shifted to the right indicating that wasting is not very much prevalent among the studied children compared to other indices.

The nutrition status of children covered by the study is summarized in Figure 11. The results indicated that the prevalence of wasting, underweight and stunting (chronic malnutrition) was 4.3, 8.7, and 34.1%, respectively. There were no cases of oedema among the children examined.

For underweight, stunting and wasting indices, malnutrition prevalence rates for male children was higher (13.6%, 37.9%, and 4.5%, respectively) than for females although the differences among them were not significant ($p > 0.05$) (Table 9). Children from Mikese division were more stunted ($p=0.026$) than those from Mkuyuni division. This can be explained by the fact that households were poor that may affect the availability of foods for their household members.

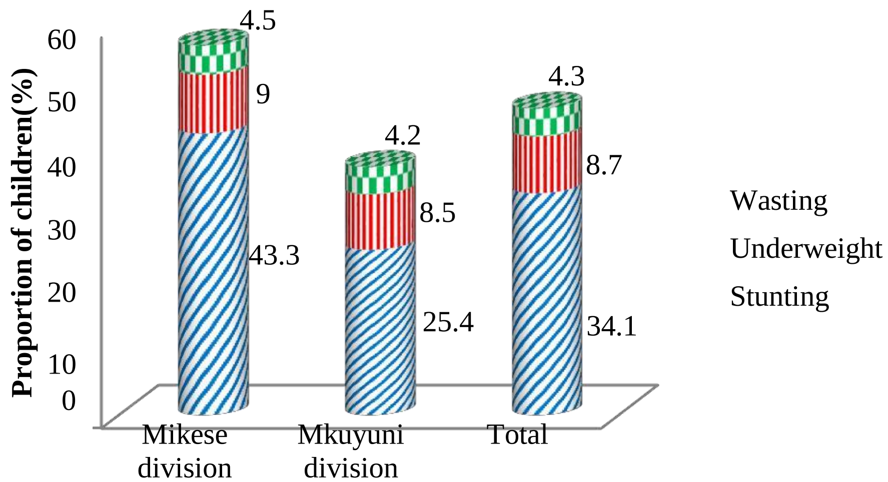

Figure 11: Prevalence of malnutrition among children (6-24months) in study area

The results in Table 9 indicated that children in the age above 12 months were most affected by stunting ($p=0.049$) compared to those below 12 months of age. This can be explained by the early introduction of solid foods to the majority of children leads to frequent illness hence growth retardation. Inappropriate feeding practice to children above 12 months also can lead them to stunting, as shown in (Table 8). Those children who were reported to frequent illnesses were more stunted (p=0.004) than those without illnesses (Table 9).

Table 9 : Nutritional status of children 6-24months in the study area

Characteristic		**N**	**Normal**	**Stunted**	
Overall Prevalence (%)		**138**	**65.9% (n=91)**	**34.1 % (n= 47)**	**p-values**
Sex	Male	66	62.1	37.9	0.365
	Female	72	69.4	30.6	
Age	(6-11 months)	51	76.5	23.5	0.046*
	> 12 months	87	59.8	40.2	
Child Sickness	No	28	89.3	10.7	0.004**
	Yes	110	60	40	
Area of residence (Division)	Mkuyuni	67	74.6	25.4	0.026*
	Mikese	71	56.7	43.3	
Characteristic		**N**	**Normal**	**Underweight**	**p-values**
Overall Prevalence (%)		**138**	**91.3% (n=126)**	**8.7 % (n= 12)**	
Sex	Male	66	86.4	13.6	0.049*
	Female	72	95.8	4.2	
Age	(6-11 months)	51	94.1	5.9	0.369
	> 12 months	87	89.7	10.3	
Child Sickness	No	28	96.4	3.6	0.281
	Yes	110	90	10	
Area of residence (Division)	Mkuyuni	67	91.5	8.5	0.916
	Mikese	71	91	9	
Characteristic		**N**	**Normal (%)**	**Wasting (%)**	**P-values**
Overall Prevalence (%)		**138**	**91.3% (n=132)**	**4.3 % (n= 6)**	
Sex	Male	66	95.5	4.5	0.913
	Female	72	95.8	4.2	
Age	(6-11 months)	51	98	2	0.292
	> 12 months	87	94.3	5.7	
Area of residence (Division)	Mkuyuni	67	95.8	4.2	0.942
	Mikese	71	95.5	4.5	
Child Sickness	Yes	110	96.4	3.6	0.821
	No	28	95.5	4.5	

* Significant at $p < 0.05$, ** Significant at < 0.005 (Chiqsquare test)

4.4 Levels of Aflatoxin in Complementary Foods

The result for aflatoxin contamination in complementary foods is summarized in Table 10. In total, 67.3 % (n=93) of the samples collected tested positive for aflatoxin. The levels of aflatoxin in the samples that tested positive ranged from 3.4 to 78.0 ppb. These samples were compared to the Tanzania standard limit (p=10ppb) for testing their contamination status. This found that total aflatoxin levels for the food samples in the study area were higher (p =0.006) than the standard limit for total aflatoxin. The mean total aflatoxin level for the food samples (13.64 ± 1.28 ppb) was higher than the total aflatoxin standard limit of 10ppb (Tanzania Bureau of Standard, 2014). Results in Table 10 indicated that out of 93 food samples 47.3% (n=43) had total aflatoxins levels that exceeded 10 ppb set as the maximum limit of total aflatoxins by Tanzania Standard. Since there was a statistically significant difference between means ($p < .05$) and, therefore, the null hypothesis rejected and accepted the alternative hypothesis, that the food samples in this study area were contaminated to high levels of aflatoxin. Mean total aflatoxin levels detected from those three different compositions were compared. The result found that the composite flour made with maize, groundnuts had higher aflatoxin concentrations (p=0.020) compared to other food sample composition.

Table 10 :Mean total aflatoxin content in cereal based complementary foods

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Food Sample	**No of Samples**	**No. of positive samples**	**Samples with aflatoxin content >10ppb**	**Total Aflatoxin(>10ppb)**	
				Mean	**Range**
Maize flour only	115	81	34	20.14	10-45
Composite flour (maize, other grains* and groundnuts)	17	9	6	34.33	11-78
Composite flour (maize, other grains* and without groundnuts)	6	3	3	19.00	16-21
Total	**138**	**93**	**43**	**22.04**	**10-78**

*Other grains = rice, finger millet and sorghum

4.4.1 Comparing the aflatoxin levels of food samples between the two divisions

Results in Table 11 indicated that food samples from Mikese division had the highest level of aflatoxin compared to those from Mkuyuni. The food samples from Mikese division that contained maize, groundnuts, and other cereals reported the highest mean aflatoxin levels (30.10 ppb) compared to those of the same composition from Mkuyuni division (19.35 ppb). The high aflatoxin levels in food samples from Mikese division were associated with the high proportion of mothers reported to use maize and groundnuts in the preparation of complementary foods.

Table 11: Aflatoxin levels in food samples collected from Mikese and Mkuyuni divisions.

Food sample composition	Mikese Division			Mkuyuni Division		
	N	Mean (ppb)	Range (ppb)	N	Mean (ppb)	Range (ppb)
Maize only	40	11.39	3.4-32	41	13.76	3.6-49
Maize, other grains and GNT	5	30.10	6.8-78	4	19.35	6.4-49
Maize, other grains without GNT	2	18.5	16-21	1	20	0

GNT = Groundnuts, other cereals=rice, finger millet and sorghum

4.5 Aflatoxin Exposure to Children

The daily aflatoxin exposure per kilogram body weight (kg/ bw) in children 6-24 months ranged from 8.78 to 549.2ng/day with an average of 67.97ng/ kg bw day. All the children (n=93) who consumed aflatoxin contaminated complementary foods exceeded the exposure limit of 0.017ng/ kg bw/day (Benford *et al.*, 2010) for total aflatoxin, hence categorized into the high exposure group. The remaining number of children whose food samples were not tested positive to aflatoxin was categorized into the low exposed group to aflatoxin).

Dietary exposure for the children was associated with the child age (p=0.014) (Table 12), age group 12-24months of children were more exposed to aflatoxin than the rest, implying that as the child increase in age the more the child likely to get exposed to aflatoxin from the food they consumed. Details of aflatoxin exposure per child are indicated in Appendix 4.

Table 12: Mean AFs exposure by age group of children (6-24months) in the study area

Child Age Group	N	Mean (ng/kgbw/day)	Range (ng/kgbw/day)	P-Value
6-11 months	35	43.91	8.8-164	
12-24 months	54	85.95	17.4-549.2	0.014
24-35 months	4	25.23	19.6-36.3	

*Significant at p < 0.005, Independent sample Test

Table 13 indicated the comparison for the average exposures to aflatoxin from the three food sample composition consumed by the children. The results indicated that, higher average exposure to aflatoxin (p < 0.005) was from that food sample composed of maize plus other grains and groundnuts compared to other food composition samples (Table 13).

These results (Table 10 & 11) imply that most of the cereal complementary foods were contaminated with aflatoxin. Children were thus highly exposed to aflatoxin since cereals were mostly used in the preparation of weaning foods.

Table 13: Food samples composition to aflatoxin exposure for children in study area.

: Food samples composition to aflatoxin exposure for children in study area.

Food samples composition	Mean	Std. Error	Range (ng/day)	P- value*
Maize only	96.85	11.64	23.6-327	
Composite flour with groundnuts	214.49	90.93	54-549.2	0.000
Composite flour without Groundnuts	60.98	20.76	37.2-123.1	

*Significant at p < 0.005, Independent sample Test

Regarding their area of residence and aflatoxin exposure (Table 14) results indicated that those children residing at Mikese division had higher average exposure (p=0.025) compared to those children from Mkuyuni division.

Table 14: Area of residence to aflatoxin exposure for children in study area

Area of Residence	Mean	Std. Error	Range (ng/day)	P- value*
Mkuyuni Division	30.66	5.41	10.2 -327	
Mikese Division	71.11	16.5	8.8-549.2	0.025

*Significant at $p < 0.005$, Independent sample Test

4.5.1 Aflatoxin exposure associated with early introduction of complementary foods

The results in Figure 12 showed that non-exclusively breastfed children (49.3%) were more at risk of aflatoxin exposure than those children breastfed exclusively. Non-exclusively breastfed children were exposed to higher levels of aflatoxin compared to those exclusive breastfed. The high exposure among children who were not exclusively breastfed could be attributed to the fact that these children started consuming other types of foods, including cereals, earlier than those who were exclusively breastfed, hence at a much higher risk of aflatoxin exposure.

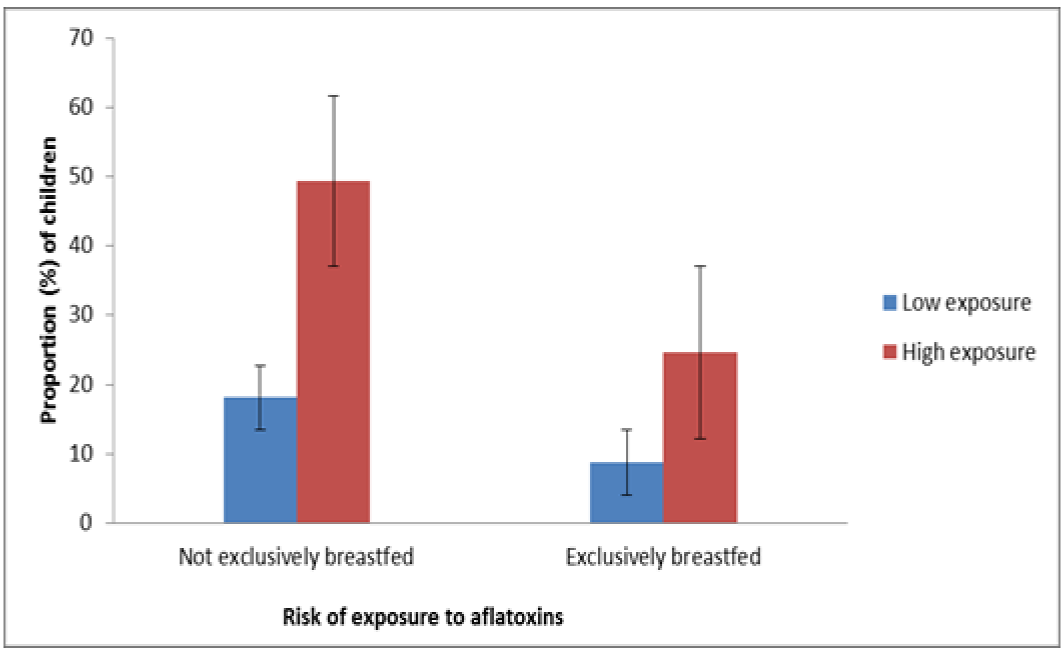

Figure 12: Relationship between exclusive breastfeeding and exposure to aflatoxin

4. 6 Factors Affecting Child Nutritional Status

The different factors affecting the nutrition status of children are summarized in Table 15 & 16. The results indicated that childbirth weight, child sickness, area of residence and dietary aflatoxin exposure were significantly associated with stunting. Increasing in childbirth weight was associated with the reduction of likelihood of being stunted for children (OR: 0.167, 95 % CI: 0.059-0.476), children who fall sick for the past two weeks before survey were 2.39 times less likely to be stunted than those who were not fall sick before survey (OR: 0.091, 95 % CI: 0.016-0.516). Children from Mikese division were 1.33times at lower risk to stunting than those from Mkuyuni division (OR: 0.263, 95 % CI: 0.080-0.862) while increasing exposure to aflatoxin for children was associated with the likelihood of having to stunt (OR: 1.010, 95 % CI: 1.000-1.020).

Table 15: Factors associated with stunting in children (6-24months) in study area

Characteristics	**Beta**	**p-value**	**Odds ratio**	**95% C.I.for EXP(B)**	
				Lower	**Upper**
Sex of the child (male)	0.519	0.384	1.680	0.522	5.408
Child sickness-past 2wks)	-2.397	0.007*	0.091	0.016	0.516
Child birth weight (kg)	-1.790	0.001*	0.167	0.059	0.476
Child age(months)	0.093	0.118	1.098	0.976	1.234
Maternal Age (years)	0.045	0.303	1.046	0.960	1.141
Household economic status	0.008	0.989	1.008	0.315	3.224
Maternal Occupation(Farmer)	-1.073	0.116	0.342	0.090	1.305
Area of residence (Mikese Division)	-1.337	0.027*	0.263	0.080	0.862
Aflatoxin exposure(ng/kg bw/day)	0.010	0.042*	1.010	1.000	1.020
Constant	3.358	0.098			

*Significant ($p < 0.05$)

The results in Table 16 showed that exposure to aflatoxin was not significantly associated with underweight (p=0.715). However, childbirth weight, maternal age and maternal occupation were significantly associated with underweight. Increasing childbirth weight was associated with a reduction in the likelihood of being underweight for children (OR: 0.092, 95 % CI: 0.02-0.46). Increasing maternal age was associated with an increased risk to underweight for children (OR:

1.180, 95 % CI: 1.02-1.36). Mothers who were self-employed as farmers were 2.49 times were less likely to have underweight children than those who were not (OR: 0.083, 95 % CI: 0.01-0.74).

Table 16: Factors associated with underweight in children (6-24months) in study areas

Characteristics	Beta	p-value	Odds ratio	95% C.I.for EXP(B)	
				Lower	Upper
Sex of the child (male)	1.103	0.201	3.013	0.56	16.36
Child sickness-past 2wks)	-0.105	0.931	0.900	0.08	9.83
Child birth weight (kg)	-2.386	0.004*	0.092	0.02	0.46
Child age(months)	-0.046	0.634	0.955	0.79	1.15
Maternal Age (years)	0.165	0.022*	1.180	1.02	1.36
Household economic status	0.020	0.983	1.020	0.18	5.87
Maternal Occupation(Farmer)	-2.492	0.026*	0.083	0.01	0.74
Area of residence (Mikese Division)	-0.278	0.754	0.757	0.13	4.29
Aflatoxin exposure(ng/ kg bw/day)	0.002	0.715	1.002	0.99	1.02
Constant	1.799	0.512	6.046		

* Significant ($p < 0.05$),Binary Logistic Regression

CHAPTER FIVE

DISCUSSION

5.1 Children Feeding Practices

According to (UNICEF, 2015) poor feeding practices are known to have adverse consequences on the health and nutritional status of children, which in turn affects the development of the child both physically and mentally. Appropriate feeding practices are often inadequate in developing countries, resulting in a significant nutritional decline between 6 and 24 months of age (WHO, 2014).

5.1.1 Breastfeeding practices

Breastfeeding initiation, the start of breastfeeding within the first one hour after delivery (Edmond *et al*., 2006) was practiced by more than half of the mothers interviewed. The results of this study posted better results as being very close to the current national nutrition survey as 62% of children were breastfed within 1 hour of birth (TFNC, 2014).This is because most of the mothers give birth in the hospitals where they are told to initiate breastfeeding on time by the health workers. Starting breastfeeding on time enables the child to get the immunological and nutritional benefits of colostrum, and is less likely to increase the risk of neonatal mortality and retarded growth (Horta & Victora, 2013).

Exclusive breastfeeding is among the poor feeding practices by mothers in the study area that might be contributing to the poor nutrition status of children as reported by Muhimbula & Issa-zacharia, (2010). Exclusive breastfeeding for six months from birth as recommended by WHO is key to saving children's lives and support optimal growth and development (WHO, 2008). A small proportion of children exclusively breastfed for first 6 months in this study differed slightly with the nutrition survey report by TFNC (2014). A possible explanation for this is mothers interviewed in the study believed that the required time for giving their children other foods apart from breast milk is when the infant is 3 months of age unless a child experiences health problems. Majority of the mothers were not aware of the WHO recommendation of exclusive breastfeeding. However, mothers also believed that a child crying was the sign of being hungry hence needed to be fed with porridge in addition to breast milk. Low adherence to exclusive breastfeeding is common in

Tanzania as was further reported in Mwanza (Chale, Fenton, & Kayange, 2016) and Morogoro Municipality (Safari *et al*., 2013). The low prevalence of exclusive breastfeeding is not limited to Tanzania alone. Studies in Uganda (Poggensee *et al*., 2005) and South Africa (Siziba, Jerling & Hanekom, 2015) reported 4 months and 1month of exclusive breastfeeding for children respectively.

Continued breastfeeding for two years was among the indicator assessed for this study population to receive appropriate feeding practices. Majority of interviewed mothers continued breastfeeding their children from less than a year to two years. A study by Lutter *et al*.,(2006) reported that 61% and 52% proportion of continue breastfeeding indicator for African countries and worldwide. Despite the fact that majority of mothers introduced their children to other foods earlier than the recommended 6 months, they adhered to the WHO recommendation on continuing to breastfeed their children for two years.

5.1.2 Complementary feeding practices

These complementary feeding practices comprise of the remaining four indicators assessed to these children timely weaning, minimum dietary diversity, minimum meal frequency, and minimum acceptable diet. Provision of complementary foods to children at an appropriate time at (6months) helps them to acquire good nutritional status (Saaka, 2015). However, this study survey revealed the low proportion of children who were introduced to complementary foods at 6months. Mothers introduced complementary foods earlier than the recommended 6 months because they believed that they did not have enough breast milk. The early introduction of complementary foods could partially explain the poor nutrition indicators observed in this study as explained by Kimiywe & Chege (2015).

The findings of this study were different from the current nutrition survey report by TFNC (2014). The report showed that at the national level, 89.5% of children (6-8 months) and 77.4% in Morogoro Region had a timely introduction to complementary foods. These findings further agree with other studies in Tanzania (Kissa *et al.*, 2015; Hussein, 2005) that reported the early introduction of solid foods.

In this study less than half of the children had met the minimum dietary diversity of four or more out of seven groups. The diets served to the children comprised mostly of starchy foods (cereal grains) and legumes with less vegetables, fruits, flesh foods and dairy products. The low dietary diversity could be attributed to limited food production at household level and lack of funds to buy some of the items that are not produced at household level. The findings of this study are consistent with other studies in Tanzania (Victor *et al*., 2014) and Ghana (Saaka, 2015).

The proportion of children aged 6-24 months who met minimum meal frequency and acceptable diet in this study were lower compared data recorded by national level : 20% (TFNC, 2014) and :21% (NBS, 2010) and Lutter *et al*.,(2006) reported 10% acceptable diet and 42% for meal frequency in African countries. Generally possible explanations to these children in the study area not to receive appropriate feeding indicators might be due to lack of supportive environment for mothers to allow them to adopt the recommended feeding practices. Even poor economic status observed to those households that affect the availability to food within their household in quantity and quality hence affecting feeding practice like dietary diversity.

Maternal occupation as a farmer showed a strong association with good feeding practices for the child. Mothers whose major occupation was farming were more likely to practice appropriate feeding practices compared to mothers who were employed in other sectors like business and civil service. This could be attributed to the fact engaging in business or formal employment in civil service denies the mothers a chance to stay with their children and have no option but to initiate early introduction of complementary foods to their children. The findings of this study are consistent similar studies conducted elsewhere (Agede *et al*., 2014; Molla *et al*., 2017).

Age of a child was found to have an influence on the feeding practices of children. Wasting, underweight and stunting were high in children aged 12-23 months. The high prevalence of poor nutritional indicators among this age group is certainly associated with poor feeding observed in the study area. Although still vulnerable, children in this age category are usually given less attention either due to another pregnancy or busy schedules of the mothers. Similar observations have been reported previous studies in Tanzania (Victor *et al*., 2014) and Ethiopia (Mekbib, 2014).

5.2 Nutritional Status of Children (6-24 months) in Morogoro Rural District

The results of this study suggest that malnutrition remains a problem within Morogoro Region. While the results focus on only one district, Morogoro rural district, they agree with national nutrition surveys that rural populations have higher rates of malnutrition than urban populations within Tanzania.

Nutritional status of children on the basis of height-for-age (stunting), weight-for-age (underweight) and weight-for-height (wasting) show variations when compared with most recent national averages TFNC (2014). The present study shows that proportion of children who were underweight in Morogoro Rural District was lower than that of Morogoro region (11.5%) and the national average (13.4%) (TFNC, 2014). However, the study findings indicated a higher proportion of wasted children in Morogoro rural than in Morogoro region (3.7%) and the national average of 3.8% (TFNC, 2014). The prevalence for stunting was almost the same as that reported at regional level (36.7%) and national level (34.7%) (TFNC, 2014) but classified to be high according to WHO classification (range 30-39% threshold). By comparing stunting prevalence with other countries in the world as this is major under nutrition problem in the world. Stunting prevalence of this study was lower than that reported by UNICEF report in which the prevalence was 40% and 39% in Sub-Saharan Africa and in South Asia, respectively (UNICEF, 2012). Comparing to studies report from other countries shown the prevalence of stunting in this study is higher such as Ethiopia (Amare *et al*., 2016) was 24.9% and in South Africa (UNICEF, 2012), was 18% .These variation might be due to sample size different, period of study and economic development of the respective country.

The variations observed at district and national level could be due factors associated to nutritional status. Nkuba (2009) and Hien & Kam (2008) reported stunting or underweight to increase with age. Older children mostly reported to have stopped breastfeeding earlier than younger ones, hence they don't have protective effect of breast milk. Children above 12months of age were more stunted due to poor feeding practices resulting into inadequate quality and quantity of the weaning foods (Tamiru, Aragu, & Belachew, 2013; Kimiywe & Chege (2015). Further early introduction of weaning foods increases susceptibility of children to illness and infections (Muhimbula & Issa-zacharia, 2010), so frequent illness in the study area was associated to early introduction of weaning foods. Children with frequent illness were mostly stunted in the study area, but on contrary, Nkuba, (2009) reported frequent illness was associated to wasting rather than stunting. Frequent to illness for children to this study area possibly due to poor household economic status which affects food accessibility and health service (Schellenberg *et al.*, 2005). Further area of residence observed to have association to stunting that can be explained by the economic reason of these household as Mikese division having most poor households. This agrees with Hien & Kam (2008) who reported children from poor household in rural areas of Vietnam were at risk to stunting.

Male children were more stunted than female children this is in line with the study by Singh *et al*., (2013); and (Kiarie *et al*., 2015). This can be explained by the physiological fact that male children have higher metabolic rate and are more at risk to health problems than female children (Asfaw *et al*., 2015).

5.3 Aflatoxin Contamination Levels in Cereal Based Complementary Foods

The major cereal based complementary foods contained high levels of aflatoxins ranging from 3.4 to 78.0 ppb. These findings are in agreement with those studies conducted in Kilosa district by (Suleiman *et al*., 2017), reported the mean contamination level of 19.2ppb for Kilosa district and by Kimanya *et al*., (2014) reported range of 0.11-386ppb. Study by (Kiarie *et al*., 2015) in Kenya reported highest aflatoxin concentration of 88.85ppb that related closely to this study. Food samples from Mikese division were reported to contain higher levels of aflatoxins compared to those from Mkuyuni division. The variation to these contaminations could be explained by storage and handling practices together with weather conditions of the studied area. During my data collection period (November, 2015) temperature was high (>25°C) in Morogoro rural district that favours the mould growth for toxin production. Even the variation may be due to the nature of the food sample composition as some in this study together with maize composed of rice, millet, sorghum and groundnut. The higher levels of aflatoxins in cereal based complementary foods assessed in the study could be attributed to poor handling and storage methods (Waliyar *et al*., 2015). In this study mothers mostly reported to use plastic buckets kept in the kitchen to store the processed flour for their children. Storage of complementary foods in the kitchen where cooking takes place every day provides a warm conducive environment for fungal growth and subsequent aflatoxin contamination. Furthermore, majority of the mothers reported that they stored the flours for more than two weeks period which is known to be effective to fungal infection in milled maize and groundnuts (Hell *et al*., 2010). The use of un-sorted grains could be another pathway for fungal infection of complementary foods used by mothers in Morogoro rural district (Shabani *et al*., 2015).

5.4 Aflatoxin Exposure for Children

In this study the aflatoxin exposure value was extremely high compared to limit of concern of 0.017 ng/kg bw/day that range from 8.8 to 549.2ng/day with an average of 67.97ng/ kg bw/day. Compare to other studies, in Kilosa district (Gwao, 2013) reported high exposure for children to aflatoxin from 99.597ng/ kgbw/day to 111.467.97ng/ kgbw/day. In Rombo district Kimanya *et al*., (2014) reported range from 1 to786 ng/kg bw/day. The high exposure can be possibly explained by the reason of starting taking cereal foods earlier leading to high intake of those cereal foods as their age increase. Increase in age to this study associated to dietary exposure as reported by Shirima *et al*., (2013). Their food composed of maize plus other grains and groundnuts compared to other food composition samples showed to be associated to high exposure to this children. This agrees with other studies where strong evidence showing exposure to aflatoxins is common among children in several sub-Saharan African countries where maize & groundnuts are dietary staples and included in complementary foods for infants (Khlangwiset *et al*., 2011).

In this study, a further number of children who were non-exclusively breastfed children were associated with exposure to higher levels of aflatoxin compared to those exclusive breastfed as getting weaned early complementary foods. Several factors have been reported to affect the quality of breast milk, among which maternal consumption of contaminated food is considered to be the main cause of breast milk contamination. So even those who were exclusively breastfed could also be exposed to aflatoxins in cases where the mothers consume aflatoxin contaminated food as reported by (Ishikawa *et al*., 2016) that children in Brazil were exposed to aflatoxin though at low concentration.

5.5 Factors Associated with Children Nutritional Status

The study findings indicated that majority of children in Morogoro rural district were exposed to higher levels of aflatoxins. Exposure to aflatoxins and area of residence were significantly associated with stunting. Children from Mikese division which reported high proportion of complementary foods contaminated with aflatoxins had higher rates of stunting compared to those from Mkuyuni division. The results reported in this study are consistent with those reported in recent studies conducted in a nearby district (Gwao, 2013) and in Rombo district, Tanzania (Kimanya *et al*., 2014) which also reported high exposure to the children consuming complementary foods to that respective area. Underweight not associated to aflatoxin exposure as reported by (Basma *et al*.,2011), implying that it was associated to other factors though aflatoxin exposure might be the reason as previous studies reported the linkage between aflatoxin exposure and child growth (Khlangwiset *et al*., 2011). This study illustrates relation between aflatoxin exposure and reduced growth, but do not prove causation or pathways for impact.

The mechanisms through which aflatoxins inhibits growth in children are yet to well explained. Smith *et al*., (2012) hypothesized that; aflatoxins induce intestinal damage which results to; increased intestinal permeability, reduced absorption capacity of the intestine and limited protein synthesis. Aflatoxins have also been associated with immune suppression and could increase children’s susceptibility to infections such as diarrhoea (Lombard, 2014). Relationship between child nutrition and infection is known to be bidirectional (Dewey & Mayers, 2011). Frequent illness due to infection can impair nutritional status and poor nutrition can increase the risk of infection. Therefore; chronic exposure to aflatoxin together with other factors like infection could lead to mal-absorption of nutrients which will have a negative impact on child growth.

This study indicated that apart from the aflatoxin exposure associated to child growth; others included child birth weight, child sickness before survey, maternal age, maternal occupation and area of residence. Other comparable reports in Vietnam (Hien & Kam, 2008) and in Ethiopia (Amare *et al*., 2016) indicated that area of residence, mother’s age and occupation, child weight at birth and child recent sickness like diarrhoea were found to be significantly related to malnutrition. Maternal age associated to underweight in that, older mothers are at increased chance of giving birth to children with low birth weight than the young ones hence leading to underweight children (Black *et al.*, 2013).

Child sickness for the children in two weeks before survey can be explained by the poor feeding practices observed hence if a child has diarrhoea as an infectious disease child's nutritional status will be affected as they work interchangeably (Checkley *et al.*, 2008). Many studies reported current illness to be associated to wasting and not stunting as this study (Hien & Kam, 2008). This could be due to less number of wasted children for the association to occur i.e. sample size.

Birth weight affect the child growth to children, in this study majority of children were having normal birth weight so they at low risk of getting stunting expect for the few children observed in this study. Upon early introduction to complementary foods together with frequent illness like diarrhoea to this children putting them at more risk to stunting (Eugênia *et al*., 2010).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The following final conclusions can be drawn from this study:

i. The majority of the mothers/caregivers in Mikese and Mkuyuni divisions used maize flour and groundnuts as complementary foods for children 6-24 months. However, mothers/caregivers used different methods for preparing and handling the complementary foods.
ii. Feeding practices for most children 6-24 months in both Mikese and Mkuyuni divisions did not meet the WHO recommendations.
iii. The complementary foods given to children 6-24 months in both Mikese and Mkuyuni divisions were contaminated with aflatoxins beyond acceptable levels
iv. Consumption of aflatoxin contaminated complementary foods increased the risk of aflatoxin exposure among children 6-24 months and aflatoxin exposure was significantly associated with stunting.

6.2 Recommendations

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

i. Recommended WHO feeding practices indicators such as dietary diversity need to be promoted as the majority of the children rely on the single type of foods mainly maize cereal-based complementary foods. Encouraging the consumption of other foods will reduce over-dependence on cereal-based complementary foods and reduce children exposure to aflatoxins.
ii. There is need to put in place strategies for reducing aflatoxin contamination in complementary foods such as conducting training to mothers/caregivers on food handling, processing and storage techniques that reduce mold growth and aflatoxin contamination in complementary foods.

iii. A longitudinal study using biomarkers to further understand the relationship between dietary aflatoxin exposure and nutritional status of children in Morogoro rural district also recommended.

iv. There is also need for further investigations on the occurrence of other types of mycotoxins in the complementary foods that are likely to affect the nutrition and health of children 6-24 months.

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APPENDICES

Appendix 1: Questionnaire

Name of the Ward …………………Village………………………

Consent Form:

My name is..

Could you please tell us your names? ………………………

Do you have children aged 6-36 months 1.Yes 2.No ....

(If No, discontinue interview if child is <6 months or > 3 years of age)

We are conducting a study on how we can improve the nutrition and health status of young children in Morogoro Rural District. So, I would like to get your participation in the study. This interview will take about 40 min of your time whereby my assistants will be asking you a few questions using a questionnaire and take your child body measurements. I will also ask you to give us some of the complementary food your child is currently feeding on. Feel free to ask questions and take a break in-between interview as you may wish. Any information about you or your child will not be released to anyone else without your permission.

Would you like to participate in this survey Ms. /Mrs. ___________? (Yes/No).

If NO thank you for your decision (end the interview).

(If **YES**) Thank you Ms. /Mrs.____________ for accepting to participate in this study. Please Sign or put your thumbprint here:

_________________________________ ________________________Participant's Full Name

Signature or Thumbprint of Participant

_________________________________ _______________________________

Interviewer's Name Interviewer's Signature

Date _____________________ Time _____________________

A.CHILD INFORMATION AND ANTHROPOMETRIC MEASUREMENTS

1. Full name…………………….......
2. Sex (M/F)………………………..
3. Date of birth…………………………
4. Birth weight…………………………… (check from the clinic card)

5. Measurements

Resp.No	Age in months	Weight(kg)	Height(cm)	MUAC(mm) Above 6mon	Oedema
					○ Yes ○ No

Oedema: check if depression or pits stays for a least 3second on both feet

6. In the two preceding weeks, what illnesses did your child suffer from?

1) Malaria/Fever
2) Diarrhea
3) Flu
4) Coughing
5) Other (Specify).........................

B. SOCIO-DEMOGRAPHIC AND ECONOMIC STATUS OF THE HOUSEHOLDE

1**.** Tribe..................................

2. Marital status of the household (1) Single…... (2) Married/living together…... (3) Widow…....

(4) Divorced/Separated (5) Others (Specify) …………

3. Who is the household head 1.Male 2.Female ....

4. How old is the household head? Age…..........years

How old is the mother/caregiver? Age.......................

5. Education level for the child's parents (Tick one for each parent)

Mother	Father
(1) No education................... (2) Primary school (std………..) (3) Secondary (form…………) (4) Tertiary education.....................	(1) No education................... (2) Primary school (std………..) (3) Secondary (form…………) (4) Tertiary education...................

6. Number of births………..

7. How many persons above 5years live in this household and share the same resources?.........

8. How many children below 5years old live in a household? ....

9. Working status of the child parent's (Tick one for each parent)

	Mother	Father
What is your main occupation? (Tick one)	(1) Farmer (2) Civil Servant (3) Casual labourer (4) Trader/Business woman (5) Private sector employee (6) Housewife (7)Other (specify)................	1) Farmer (2) Civil Servant (3) Casual labourer (4) Trader/Business man (5) Private sector employee (6) Other (specify)..........................

10. Does your household possess any of the following assets?

Asset	1. Yes 2. No (**Write 1.for Yes and 2.for No**)	Number and type
House		
Vehicle		
Bicycles		
Motorcycles		
Land for crops(estimate acres)		
Cattle		
Goat		
Ship		
Chicken		
Pigs		

C. COMPLEMENTARY FOODS AND CHILD FEEDING PRACTICES

1.	When did you start breastfed your baby after birth **(Tick one).**	1) Within1hr of birth…….............. 2) More than 1 hour......................
2	Is your child still breast feeding? (Tick one)	1) Yes……. 2) No ……..
3.	If yes, how many times do you breastfed your child per day? **(Tick one)**	1) Less than 10 times................ 2) At least 10 times............. 3) More than 10 times................
4	If no, after what age did you stop/exclude your child from breastfeeding? **(Tick one)**	1) Less than 6 month……... 2) At 6 months……............. 3) After 2 years…….........
5.	At what age did you introduce complementary (liquid/solids) food to your child? **(Tick one)**	1) Less than 6 months……… 2) At 6 months...... 3) More than 6 months ..……...
6	What types of complementary foods cereals do you commonly give to your child in a week (**Tick every food you use in this selection list).**	1) Maize.................... 2) Finger millet................ 3) Sorghum.................. 4) Rice....................... 5) Soybean.................. 6) Groundnuts.................. 7) Other specify..................................
7.	What is the source of your children complementary food? **(Tick one)** .	1) Home grown (I process and prepare in the house).......... 2) From the market, I process and prepare in the house................ 3) Commercial infant formulae (already processed and I only prepare in the house)............ 4) Other (please mention) ………………....................

8.	Have you reduced quantity of food served to children in this household in the last seven day**? (Tick one)**	1) Never..................... 2) Rarely (once)..................... 3) From time to time....................... 4) Often (5 or more)..........................
9.	If yes why did you reduce the quantity of food given to your child?	1) Child is sick.......................... 2) Child does not like food........................... 3) Did not have enough food.................... 4) Other specify................
10.	How many times did you give your child cereal based complementary food per day? **(Tick one)**	1) Once………......... 2) 2 times……………..... 3) 3 times……………..... 4) 4 times........................ 5) Other (specify)…….....
11.	How do you process cereals used for feeding your child? **(Tick every step you use in this selection list).**	1) Sorting……................. 2) Washing……............... 3) Soaking ……............... 4) Remove husks ....…… 5) Roasting........................ 6) Malting.............................. 7) Milling…….......................... 8) Other (specify)..........................
12	How did you store the flour you prepared**? (Tick one)**	1) Plastic Bucket ………………. 2) Polythene bags ………………. 3) Tin ……………… 4) Basket................... 5) Other (specify)……………………………
13	For how long do you store the flour? **(Tick one)**	1) 1 week maximum……………. 2) More than 2 weeks………… 3) More than 5 weeks ……………… 4) Other (specify)…………………

14	Did you see any changes in the quality of the flour? **(Tick one)**	1) Yes………. 2) No…….
15	If yes, what kind of quality changes did you observe**(Tick one)**	1) Change in colour………… 2) Caking……….. 3) Change in smell………. 4) Other (specify)………….
16	After observing that the flour was spoilt, what action did you take? **(Tick one)**	1) Stopped using ………….. 2) Did not take any action…………… 3) Other (specify)………………..

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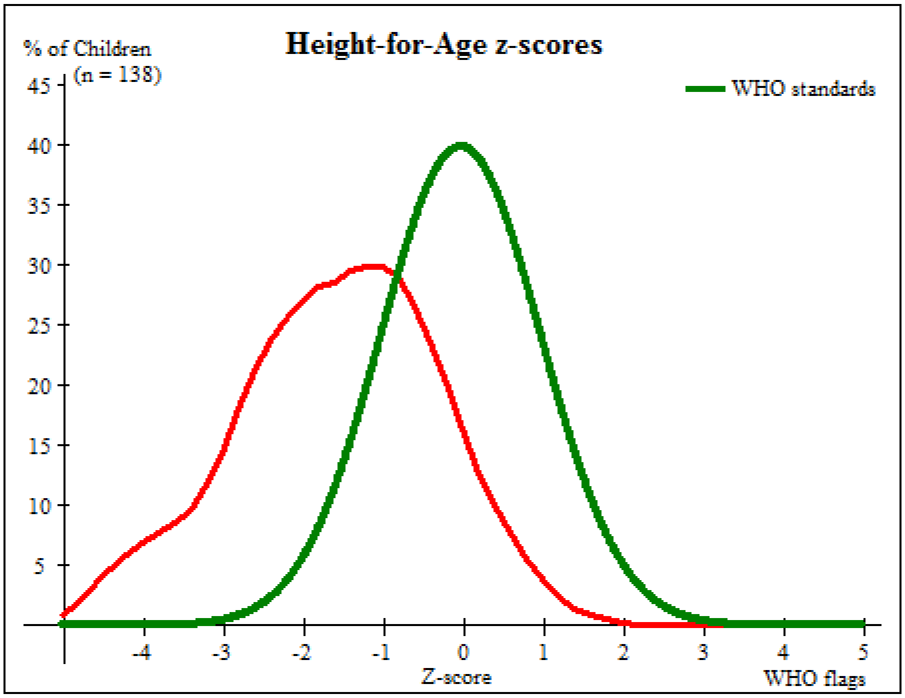
D.24 HOUR FOOD RECALL QUESTIONNAIRE

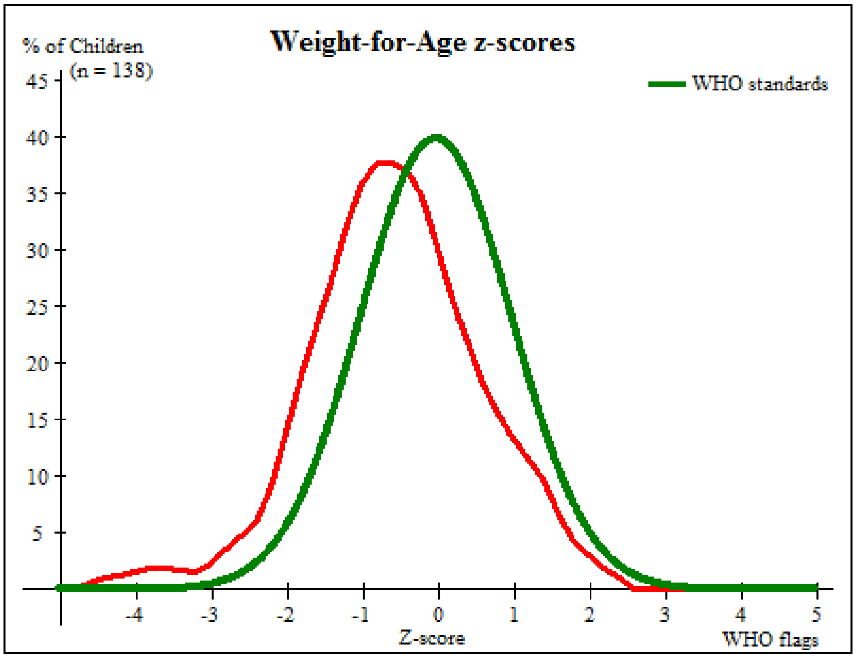
	1st Day		**2nd Day**		**3rd Day**	
What type of food did your child ate in 24hrs and amount(mention all and tell amount**)**	**Type**	**Amount**	**Type**	**Amount**	**Type**	**Amount**

Appendix 2: Children Z-score curves

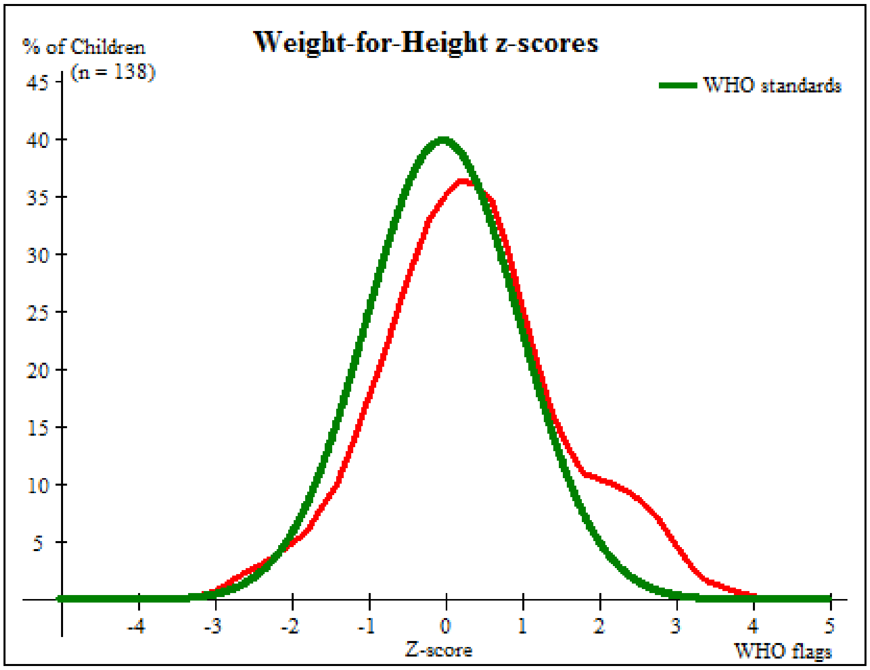
HAZ scores compared to WHO growth standards (2006)



WAZ scores compared to WHO growth standards (2006)



WLZ scores compared to WHO growth standards (2006)



Appendix 3: Names of the villages surveyed

1. Kiziwa village(10 households)
2. Banga village (11)
3. Fulwe village(6)
4. Diovuva village (12)
5. Kibwaya village (7)
6. Mfumbwe village (9)
7. Kiroka village (10)
8. Mkuyuni village (8)
9. Mkambarani village (10)
10. Mikesemjini village (14)
11. Lubungo village (11)

12. Mungamkola village (10)
13. Pangawe village (9)
14. Kizinga village(11

Appendix 4:Children aflatoxin exposure estimation

(a) Estimated amount of aflatoxin in children take (Age 6-11 months)

Child no.	Aflatoxin contamination level(ppb)	CFs intake amount (g/day)	Weight of a child (kg)	Child estimated AFs exposure(ng/kg bw/day)	Child number	Aflatoxin contamination level(ppb)	CFs intake amount (g)	Weight of a child (kg)	Child estimated AFs exposure(ng/kg bw/day)
					81	5.5	13.75	5.65	13.38
10	28	12.5	6.8	51.47	**84**	20	12.5	6.3	39.68
14	16	23.75	8.65	43.93	**87**	7.9	45.25	10.85	32.95
15	16	25	8.7	45.98	**91**	4.3	47.5	10.7	19.09
20	13	15	8.25	23.64	**93**	4.3	18.75	5.2	15.5
28	6.7	42.2	9.9	28.56	**97**	7.4	60.28	10.1	44.16
29	19	11.25	7	30.54	**107**	7.1	21.25	8.35	18.07
31	47	18.75	7.1	124.12	**113**	5.5	35.63	7.65	25.61
38	13	31.5	10	40.95	**114**	4.2	69.59	8.65	33.79
41	19	25.43	8.95	53.97	**115**	23	25	10.75	53.49
45	9.3	43.33	9.05	44.53	**119**	4.4	34.75	8.4	18.2
46	7.2	71.25	9.4	54.58	**122**	11	24.38	8	33.52
58	11	49.29	8.7	62.33	**123**	26	30	7.55	103.31
60	4	17.14	7.8	8.79	**124**	9.8	18.75	8.1	22.69
61	17	18.13	8.1	38.04	**126**	15	18.75	6.65	42.29
65	7.9	43.77	10	34.58	**131**	35	50.87	7.7	231.22
					134	49	21.25	6.35	163.98
74	7.6	13.75	8.65	12.08	**137**	4	18.75	7.35	10.2

75	5.6	17.92	7.05	14.23

(b) Estimated amount of aflatoxin intake in children(Age 24-35 months)

Number of children	**Aflatoxin contamination evel(ppb)**	**CFs Intake amount (g/day)**	**Weight (Kg)**	**Estimated AFs exposure(ng/kg bw/day)**
76	5	45.13	11.45	19.71
109	3.6	66.75	12.25	19.62
117	11	45.09	13.65	36.33

(c) Estimated amount of aflatoxin children take (Age 12-23 months)

Child number	Aflatoxin contamination level(ppb)	CFs intake amount (g/day)	Weight of a child(Kg)	Child estimated AFs exposure(ng/kg bw/day)	Child number	Aflatoxin contamination level(ppb)	CFs intake amount (g)	Weight of a child(Kg)	Child estimated AFs exposure(ng/kg bw/day)
1	38	68.25	10.55	245.84	**56**	28	54.87	8.95	171.65
3	21	57.75	9.85	123.13	**57**	11	60.22	7.8	84.92
5	4.6	42.34	7.1	27.43	**62**	3.5	51.59	10.35	17.44
6	4.8	77.75	10.95	34.08	**63**	12	65.84	13.25	59.63
7	8.7	86.59	8.9	84.64	**64**	20	33.45	11.35	58.95
8	20	78.84	8.2	192.29	**66**	3.4	56.67	8.8	21.9
11	14	97.75	9.7	141.09	**69**	5.8	28.85	8.55	19.57
13	6.4	54.34	8.9	39.07	**71**	32	68.75	14.3	153.85
16	4.8	75.75	7.95	45.74	**78**	11	35.05	9.95	38.75
17	12	70.84	10.9	77.98	**83**	12	30.01	8.95	40.24
18	8.8	66.75	9.6	61.19	**89**	7	30	9	23.33
22	4.6	104.43	8.6	55.86	**92**	9.7	39.38	10.2	37.45
23	7	87.5	10.25	59.76	**95**	11	47.28	8.75	59.44
24	4.3	67.29	9.15	31.62	**99**	44	78.41	10.55	327.04
					100	7.1	53.74	10.85	35.17
27	8.1	63.25	10.3	49.74	**102**	7.2	52.25	9.6	39.19
30	3.5	64.59	10.45	21.63	**103**	6.4	40.89	9	29.08
32	17	82.84	8.1	173.85	**108**	45	27.5	7.95	155.66
					112	22	53	7.6	153.43
35	14	74.11	11.15	93.05	**116**	31	59.25	8.9	206.39
37	78	66.54	9.45	549.22	**121**	4.8	45.37	6.6	33

39	9.1	60.25	11.7	46.86	**125**	8.7	72.92	11.9	53.31
					127	29	48.97	9.8	144.91
49	6.8	42.3	7.75	37.11	**128**	30	44.59	9.95	134.43
50	10	45.83	9.05	50.65	**129**	7.8	33.75	9.15	28.77
					130	11	25	7.4	37.16
					135	5.9	47.92	10.25	27.58
53	5.4	30.42	7.9	20.79	**136**	6.5	38.27	9.9	25.13
54	23	42.29	10.7	90.91	**138**	8.1	69.95	11.25	50.37
55	3.6	56.92	10.35	19.8					