EFFECTIVENESS OF MICRONUTRIENTS POWDER IN REHABILITATING ANAEMIC CHILDREN AGED TWO – FIVE YEARS IN MOROGORO RURAL DISTRICT

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF THE MASTER OF SCIENCE IN HUMAN NUTRITION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

Iron deficiency anaemia is a condition where blood lacks adequate healthy red blood cells. In Tanzania, 58 percent of under-five children suffering iron deficiency anaemia. This study aimed to assessing the effectiveness of micronutrients powder in reducing iron deficiency anaemia among under-five children. A longitudinal, randomized study was carried out. A total of 167 children were randomly assigned into three intervention groups which received MNP for 60 days, Group one (n= 56) received one sachet of MNP daily, group two (n = 55) received one sachet of MNP in alternate days while Group three (n= 56) received one sachet per week. Using the HemoCue technique, a finger-prick blood was taken at all period of the intervention and used to determine haemoglobin concentrations. A questionnaire was constructed to solicit information on the perception of mothers/caregivers, dietary diversity score and anthropometric measurements. Data collected using questionnaire were coded and analyzed using SPSS. Comparison of anthropometric measurements was analyzed by ANOVA. Result showed that, at the end of the intervention, haemoglobin concentrations were significantly higher ($P < 0.05$) in participants who received dose one and dose two relative to those who received dose three. At baseline, prevalence of iron deficiency anaemia was 65.5%. There was significant difference ($P < 0.05$) in the prevalence of anthropometric measurements before and after intervention. There was no significant difference ($P > 0.05$) between DDS and increased haemoglobin concentration. Mothers/caregivers perceived some positive effects on their children health behaviours.It was concluded from this study that, MNP is effective in reducing the iron deficiency anaemia to under-five children. It also improved weight for age and weight for height. Based on this study it is recommended that, mothers/caregivers with low income should use dose two in reducing iron deficiency anaemia. Dose three is only effective for mildly anaemia children.

DECLARATION

I, DIANA GODFREY SEHABA, do declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor concurrently being submitted in any other institution.

____________________________ ________________

Diana Godfrey Sehaba Date

(MSc. Candidate)

The above declaration is confirmed by;

____________________________ ________________

Prof. Theobald C. E. Mosha Date

(Supervisor)

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DEDICATION

This work is dedicated to my Parents Bishop Godfrey Sehaba and my late mother Leah Wilson Chiduo who laid the foundation of my education.

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LIST OF ABBREVIATIONS

ANOVA	Analysis Of Variance
DDS	Dietary Diversity Score
HAZ	Height-for-Age Z scores
MNP	Micronutrients Powder
SPSS	Statistical Product Service Solutions
UNICEF	United Nations Children’s Fund
WAZ	Weight-for-Age Z scores
WHO	World Health Organization
WHZ	Weight-for-Height Z scores

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Iron deficiency is a condition where blood lacks adequate healthy red blood cells, which carry oxygen to the body's tissues. It is the most common and widespread nutritional disorder in the world. In the 2000’S Global Burden of Diseases, iron deficiency ranked number 9 among 26 disease risk factors and accounted for 841 000 deaths and 35 057 000 disability-adjusted life years lost, North America bears 1.4 percent of the global burden of iron deficiency (Stoltzfus, 2003), whereas Asia and parts of Africa bear 71 percent of the global mortality burden and 65 percent of the disability-adjusted life years lost. In Tanzania, 58 percent of children aged 6-59 months are suffering from anaemia due to iron deficiency (NBS, 2015).

According to the WHO (2008), the rate of prevalence of iron deficiency, greater than 40 percent is considered a public health problem. Children under the age of five years are most vulnerable to micronutrient deficiency, for this reason; there is a need of giving them foods with high minerals and vitamins in order to support their rapid growth and adequate development (WHO, 2016). Due to low intake of micronutrients in foods, the WHO 2016 recommended used of Micronutrients powder in foods consumed by infants, young children aged 6–23 months, and children aged 2–12 years. This is meant to reduce the burden of anaemia, which is the major cause of iron deficiency. In addition, micronutrients intervention with micronutrients powder is recognized as a cost-effective approach for reducing micronutrient deficiency in low-income countries (Bhutta *et al.*, 2013). Micronutrients powder comes in sachets containing dry powder with micronutrients that can be added to any semi-solid or solid foods that is ready for consumption (HF-TAG, 2012).

The consequences of iron deficiency anaemia in children include a change of behaviour and the reduction of cognitive performance in schools (Gwetu *et al.,* 2019). Iron deficiency anaemia is caused by poor dietary intake of iron rich food such as meat, yogurt, and poor absorption of iron in the body due to inhibitors such as caffeine, malaria, and worms. The main complementary meal for Tanzanian children is porridge whose common ingredients include maize flour, sorghum, pearl millet, and finger millet, which are generally poor in iron minerals (Kulwa *et al.,* 2015).

1.2 Problem Statement

Iron deficiency is a global health problem affecting most children under the age of five years. Data indicate that, 47.4 percent of under-five children worldwide were anaemic and 67.6 percent in Africa (Gebreweld, 2019).

In developing countries, 3.0 million deaths of children were caused by iron deficiency (WHO, 2015). Children have higher demand of iron due to increased growth rates and development. Lack of iron in children affects motor and cognitive development and immunity function leading to poor school performance as well as increase in morbidity and mortality (WHO, 2001). In Tanzania, 58 percent of children aged 6-59 months are suffering from anaemia due to iron deficiency (NBS, 2015). According to Simbaulanga *et al.* (2015) and Kejo *et al.* (2018), the prevalence of anaemia among under five children in Mwanza is 77.2 percent while in Arusha District it is 84.6 percent. WHO (2016) recommends the use of micronutrients powder for point-of-use fortification of foods consumed by infants and young children aged 6–23 months, and 2–12 years in order to reduce the burden of anaemia caused by iron deficiency. Studies show that, micronutrients powder significantly improves haemoglobin level and reduces the prevalence of anaemia among children (Kounnavong *et al.*, 2011; Salam *et al.*, 2013).

According to Tanzania Demographic and Health Survey 2015−2016 (MoHCDGEC, 2016) the prevalence of iron deficiency in Morogoro region among children aged 6-59 months was 65.7 percent, which was higher than the National average level of 58 % (NBS, 2015). Since, the diets for children in Morogoro area are predominantly cereal-based porridges with low nutrient density and poor mineral bioavailability, their complementary foods typically lack dietary iron (Dewey, 2013).

The Ministry of Health and social welfare in Tanzania implemented a health programme through RCH to control anaemia by provided education to mothers to continued breastfeeding and provided adequate complementary feeding also preventing and treating malaria and taking deworming pills to children (MoHSW, 2015). Despite these efforts, the problem of iron deficiency still persists. This study aims at assessing the effectiveness of micronutrients powder supplement in reducing iron deficiency among children aged 2 to 5 years. Despite the recommendations, many households are not able to afford one sachet per day as recommended by WHO (2016). There have been frequent proposals that, one sachet may be given to the under five children once in every two days. Others recommend that, if children were given only two sachets per week for a year, then they would most likely get the same benefits as those receiving one sachet per day for 60 days and go without supplement for the following 90 days.

1.2.1 Study justification

This study would be useful in reducing the problem of iron deficiency anaemia among children age 2 to 5 years in Morogoro (R) District. It also helped to determine the best dose per week, especially for the households that cannot afford a sachet for every child daily basis. This micronutrients powder contain 16 micronutrients namely vitamins A and C which help to facilitate iron transport, metabolism, and storage within the body (Lynch, 2018). Vitamin C also enhances iron absorption such as capturing non-heme iron, stores, and makes it easily absorbed in the body (Hurrell *et al.,* 2010). The iron absorption problem in fruits and vegetables is solved by introducing vitamin C. For the people who cannot afford animal foods, which are good sources of iron, may obtain iron from the supplements. This study also contributed to the sustainable development goals (SDGs) 2030 where goal number 2 that focus on “Ending hunger, achieve food security, improve nutrition and promote sustainable agriculture” while goal number 3 focus on “Ensuring healthy lives and promote well-being for all at all ages” (UN, 2015). This study also generated recommendations on the best schedule of using iron supplement for children with iron deficiency anaemia.

1.3 Objectives of the Study

1.3.1 Overall objective

To assess the effectiveness of micronutrients powder supplement and the best intake schedule in reducing iron deficiency anaemia among children aged 2 to 5 years in Morogoro (Rural) District, Tanzania.

1.3.2 Specific objectives

i. To determine haemoglobin status of children aged 2 to 5 years in Morogoro (R) District.

ii. To assess the perceptions of child caregivers towards the use of micronutrients powder for their children to address the problem of iron deficiency anaemia.

iii. To determine the effectiveness of micronutrients powder supplement in rehabilitating iron deficiency among children aged 2 to 5 years receiving the MNP daily (control), once in alternate days and once per week in Morogoro (R) District.

iv. To assess dietary diversity of children aged 2 to 5 years in Morogoro (R) District.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Complementary Feeding Situation in Tanzania

World Health Organization (WHO) defines complementary feeding as "a process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants and therefore other foods and liquids are needed, along with breast milk" (WHO, 2003). Thus, breastfeeding for two years and beyond is recommended. Complementary foods must provide relatively large proportions of micronutrients such as iron, zinc, phosphorus, magnesium, calcium, and vitamin B6 (Abeshu *et al.,* 2016). In many developing countries, complementary feeding, which is required in meeting micronutrients requirements, is still a big challenge. Porridge which is low in micronutrients is the main complementary meal in Tanzania (Kulwa *et al.,* 2015). The main factors associated with poor complementary feeding practices in Tanzania include low level of paternal/maternal education, limited access to mass media, lack of postnatal checkups, and poor economic status (Victor *et al.,* 2014). 26 percent of children, aged 6-23 months in Tanzania receive nutritionally adequate complementary foods (Khamis *et al.,* 2019). Due to this situation, opening the window of commercial fortification to manufactured fortified foods will help to reduce micronutrients deficiency to under-five children.

2.2 Use of Micronutrient Powder in Reducing Iron Deficiency Anaemia

Micronutrients powder showed significant improvement in haemoglobin levels and in the reduction of the prevalence of anaemia among children (Kounnavong *et al.,* 2011; Salam *et al.,* 2013). A study conducted in South Africa showed that, MNP enhanced the absorption of iron in complementary foods based in cereals, legumes, and reduced iron deficiency by 30.6 percent (Troesch *et al.,* 2010). A study among young children in the Kyrgyz Republic showed that, taking 60 Sprinkles micronutrient powder sachets daily for 2 months, is effective in improving haemoglobin levels and reducing iron deficiency anaemia from 72 percent at baseline to 52 percent after intervention period (Lundeen *et al.,* 2010). Another study carried out in Western Kenya also showed that, the children improved haemoglobin concentrations (Suchdev *et al.,* 2012). Other studies conducted in Tanzania showed that, the use of micronutrient powder resulted in significant reduction of iron deficiency anaemia among under five children (Mosha *et al.,* 2014; Kejo *et al.,* 2018).

2.3 Perceptions of Caregivers/Mothers in Using MNP

According to caregivers, there are many benefits in giving MNP to their children including increased appetite, weight, and growth, reduction in diarrhoea, and improved skin colour of the children. On the other hand, some caregivers mentioned constipation, vomiting and diarrhoea among negative effects, as well as the concern that some children had not recovered from anaemia despite taking MNP (Kanashiro *et al.,* 2016). A study done in Ethiopia showed that, the caregivers/mothers reported positive changes and negative side effects of MNP among their children (Tumilowicz *et al.,* 2017). Caregivers/mothers' perceptions toward the provision of MNP helped to determine negative and side effects of MNP and success of intervention among children.

2.4 Dietary Diversity and Family Income

Dietary Diversity is defined as the number of different foods or food groups consumed over a given period (Ruel *et al.,* 2013,). Diets of households with low income are based on few food groups. Such households consume the available foods based on their environments resulting in low dietary diversity (French *et al.,* 2019). Several studies have shown that, dietary diversity is a good proxy of dietary quality among people living in both industrialized and developing countries (Morseth *et al.,* 2017). Socioeconomic status is a major determinant of healthy diets and studies have indicated that, high socioeconomic status may be associated with overall healthier dietary patterns (Mayen *et al.,* 2014). According to the World Bank Group (2016), 28.2 percent of the Tanzanian population (12 million) lives in poverty with 70 percent of the people living with income of less than 2 USD per day. The majority of Tanzanians therefore are poor resulting in poor dietary diversity especially animal food products, which are good sources of iron and other micronutrients such as selenium, zinc, and copper. A study done in Morogoro region showed that, majority of the people consumed cereal food groups compared to other food groups and consumed low protein from animal sources (Kinabo *et al.,* 2016).

2.5 Iron Deficiency Anaemia

Iron-deficiency anaemia is caused by a lack of iron in the body. Without enough iron, our bodies cannot produce enough haemoglobin in the red blood cells, and that enable them to carry oxygen. Iron deficiency anaemia is caused by poor dietary intake of iron especially from animal food products such as meat, yogurt, and poor absorption of iron in the body due to iron inhibitors such as caffeine, malaria, and worms. The major complementary meal for Tanzanian children is porridge whose common ingredients include flours of maize, sorghum, pearl millet, and finger millet, which are poor in iron minerals (Kulwa *et al.,* 2015).

Signs and symptoms of iron deficiency anaemia include extreme fatigue, weakness, pale skin, chest pain, fast heartbeat, or shortness of breath. Others are headache, dizziness or light-headedness, and poor appetite, especially in infants and young children (Lopez *et al.,* 2016). The consequences of iron deficiency anaemia to children include alteration of behaviour and poor cognitive performance especially in school performance (Gwetu *et al.,* 2019). The prevalence of iron deficiency anaemia among children aged 6-59 months is 58 percent (NBS, 2015). According to scholars, (Simbauranga et al., 2015; Kejo *et al.*, 2018), the prevalence of anaemia among under five children is 77.2 percent in Mwanza and 84.6 percent in Arusha District.

2.6 Indicators of Anthropometric Measurements

According to TNNS (2018), the Anthropometric indicators are interpreted using a Z-score cut-off point of < -2SD to categorized low weight-for-age, low height-for-age, and low weight-for-height as moderate under-nutrition, and < -3 SD to describe severe under-nutrition. The cut-off point of > + 2SD categorizes high weight-for-height and overweight in children.

2.6.1 Prevalence of wasting, stunting and underweight among under-five children

In 2016, an estimated 155 million children under the age of 5 years suffered from stunting, while 41 million were overweight or obese (WHO, 2016). In India, the prevalence of stunting was 36.1 percent, wasting was 44 percent, and underweight was 53.9 percent (Hemalatha *et al.*, 2020). According to Tanzania National Nutrition Survey

(2018), the prevalence of stunting among under-five children was 26.4 percent; wasting was 3.5 percent while underweight was 9.4 percent. Tanzania is making efforts to reduce the prevalence of malnutrition among children through the provision of education to mothers/caregivers at RCH and initiation of programs of integrating nutrition-sensitive agricultural activities and nutrition specific interventions (USAID, 2017).

2.6.2 Effect of micronutrients powder in reducing stunting, wasting and underweight

The prevalence of stunting, wasting, and underweight decreased among under five children due to the use of micronutrients powder (Caulfield *et al.,* 2006). The powder showed effectiveness in reducing anthropometric measurements during short time intervention **(**Mukunda *et al.,* 2017). In addition, in Kilosa and Mvomero Districts, micronutrients powder showed to have reduced wasting and underweight, and stunting, though it was small reduction in the case of stunting (Rehema, 2018; Mosha *et al.,* 2014).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

This study was conducted at Kibungo Juu Ward, in Morogoro (R) District due to the higher prevalence of iron deficiency anaemia. Morogoro (R) District is one of the six administrative districts of Morogoro region, Tanzania. Morogoro Rural District covers an area of 19,056 square kilometres. It is bordered by the Tanga Region to the North and East, Kilombero District to the South, Kilosa District to the Southwest and Mvomero District to the West. According to the National population census (2012), Morogoro (R) District has a population of 6,304 people. A mong these, 3,060 are males while 3,244 are females (URT, 2012). Agriculture is the major economic activity in the study district. In term of health services Kibungo Juu has only one dispensary. The study area is presented in Fig. 1.

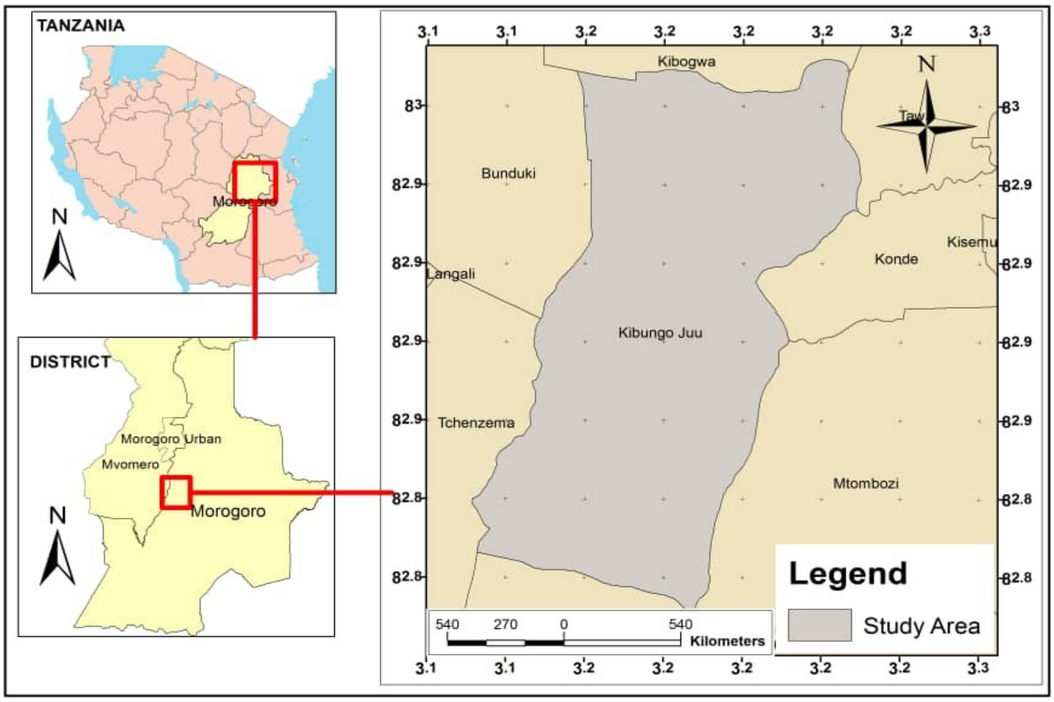

Figure *1*: The map of study area

3.2 Study Design

A randomized longitudinal study design was carried out, with the intent of treating anaemia among children aged 2 and 5 years. Children aged 2 to 5 years were screened at the baseline to identify those who were anaemic with haemoglobin levels between 8-10.9 g/dl. Children who were identified as anaemic were randomly assigned into three groups to receive micronutrients powder. The treatments for the three groups were as follows.

- Group1: Received one sachet of 1g daily for 60 days
- Group 2: Received one sachet of supplement in alternate days for 60 days, and
- Group 3: Received one sachet of supplement per week for 60 days

Data were collected at baseline, mid-line, and end line of the intervention period (60 days) to monitor effectiveness of micronutrients powder in reducing iron deficiency anaemia at the different levels of iron supplement consumption. All anaemic children were given anti-malaria and anti-helminth (melbendazole) to control malaria and hookworms before the start of the supplementation.

3.3 Sampling Frame and Study Population

All children aged 2 to 5 years living in Morogoro District were eligible for the study.

3.3.1 Inclusion criteria

All children aged 2 to 5 years who lived in the district and attending monthly RCH clinics, with haemoglobin levels ranging from 8 to 10.9 g/dl were included in the study.

3.3.2 Exclusion criteria

All children aged 2 to 5 years with haemoglobin levels above 10.9 g/dl and with haemoglobin level of less than 8 g/dl were excluded from the study. Children who had records of inborn errors of metabolism such as phenylketonuria (PKU), chronic illnesses such as sickle cell anaemia, tuberculosis (TB), and human immunodeficiency virus (HIV) were excluded from the study.

3.4 Sampling technique and procedure

Random sampling technique was applied during the selection of the ward and villages to be included in the study. Using a table of random numbers Kibungo Juu Ward was selected. At the RCH level, a list of children aged 2 to 5 years was obtained. The villages with children aged 2 to 5 years were randomly selected by using simple random sampling technique. To obtain a representative sample of villages, a table of random numbers was used to facilitate the randomization.

3.5 Sample size

Sample size was determined by using a formula by Fisher *et al*. (1991).

$N = Z^2 * Pq / d^2$

Where:

N = The desire sample size

d = Degree of accuracy desired (precision level) (acceptable error 0.05 or 5%)

P = Prevalence of iron deficiency among under-five children in Morogoro District - 65.6% (NBS, 2015)

Q= 1-P

Z = the standard normal deviate (which was 1.96 corresponding to 95% Confidence Interval

$N = 1.96^2 \text{ x } 0.657 \text{ x } (1-0.657) / 0.05^2 = 346$

Ten percent attrition, equivalents to 35 children, were added to the sample size to compensate for the dropouts. A total sample size of 381 children was selected. This sample was sub-divided into three groups; Group 1:127 children, Group 2:127 children and Group 3:127 children.

3.6 Nutritional composition of MNP

3.6.1 Nutritional value of MNP/complementary food

"Virutubishi" multiple micronutrients powder is manufactured by Manisha Pharmo Plast Pvt. Ltd. Umbergaon-396 171. Gujarat, India and distributed by SOLEO Tanzania. One sachet contains 17 vitamins and minerals. The nutrient content of 1g of micronutrient powder was vitamin A (400 µg), vitamin D (5 µg), vitamin E (5 mg), vitamin B1, B2, and B6 each (0.5 mg). Others was folate (0.15 mg), niacin (6 mg), vitamin B12 (0.9 µg), vitamin C (30 mg), iron (10 mg), zinc (4.1 mg), selenium (17 µg), copper (0.56 mg), iodine (90 µg), silicon dioxide (20 mg), and maltodextrin (817 mg). These MNP sachets were provided to each of the selected children according to the feeding regimen of groups 1, 2, or 3.

3.6.2 Preparation of foods

After the preparation of complementary food such as porridge, banana pap or other semi-solid foods at acceptable temperature, the caregiver/mother opened one sachet carefully and poured all the powder onto a bowl containing the food. The food and powder were mixed thoroughly well to ensure uniform distribution of the nutrients in the food.

3.7 Feeding regime and dosage

All children who received the MNP supplement were screened for malaria and those who had malaria trophozoites were given a dose of ant-malaria drugs. Likewise, all children received a de-worming drug (albendazole) before the intervention. The MNP was added to a semi-solid food, which the child consumed at home. No new foods were introduced for the children. The MNP was used in the homemade foods so as to increase micronutrients intake without changing the normal diet of the children. Feeding regimes were in the following order:

Group 1: One sachet of MNP was given daily for 60 consecutive days.

Group 2: One sachet was given in alternate days for 30 days

Group 3: One sachet was given to a child once per week for 9 weeks.

3.7.1 Amount of food mixed with the MNP

The micronutrients powder was mixed with food portion that a child could consume and finish in a single sitting.

3.7.2 Administration of the MPN

Preferences of food to be fortified with MNP were semi-solid, or liquid foods consumed by the child at the household. Such foods were given to the child in the morning hours.

3.7.3 Duration of intervention

Children were given micronutrients powder supplement according to their food regime for 60 days

3.8 Monitoring Compliance and Follow-up Visits

Four Community Health Workers (CHWs) were recruited to monitor the compliance to the consumption of MNP. The CHWs visited the children in their households frequently to encourage caregivers/mothers to feed their children the supplements. Compliance was monitored through calendars, which were given to caregivers/mothers and were requested to put an X on each date that the child received the MNP supplement and through counting empty sachets, which the caregivers/mothers returned at the end of the month before collecting another set of MNP for the subsequent month.

3.9 Data Collection

3.9.1 Construction of a questionnaire

A questionnaire was constructed to solicit information on the perception of caregivers/mothers towards the provision of MNP to their children, preparation of foods for children, uses of micronutrients powder in children food, and feeding practices. The questionnaire was divided into five sections A to F. Section A solicited socio-economic and demographic information of the caregivers/mothers. Section B solicited information about food preparations and feeding practices. Section C solicited information about compliance to the use of MNP in children food. Section D solicited information about the perception of caregivers/mothers towards the provision of MNP to their children and Section E gathered information on biochemical measurements of haemoglobin levels (g/dl) and anthropometric measurements namely weight (cm) and height (cm). Dietary diversity score questions consisted of 7 food groups that were used to assess dietary diversity such as (i) cereals, roots, and tubers, (ii) vitamin A rich fruits and vegetables, (iii) other fruits and vegetables, (iv) meat and fish, (v) eggs, (vi) legumes, nuts and seeds, and (vii) milk and milk products. Caregivers/mothers were asked to recall the foods, which were consumed in the previous 24 hours prior to the survey. The questionnaire was translated into Kiswahili to facilitate communication with the respondents during data collection.

3.9.2 Administration of the questionnaire

Enumerators were trained on how to administer the questionnaire and take biochemical measurements. They were also taught ethics during interviews, proper recording of the responses and confidentiality of the data. The administration of the questionnaire to mothers with children aged 2 to 5 years was done by face-to-face interview during home visits. Interviews were conducted during the morning hours of the day.

3.9.3 Pre-testing the questionnaire

The questionnaire was pre-tested prior to data collection. Pre-testing involved a sample of 10 mothers/caregivers selected in Mikese Ward, Morogoro. Mikese Ward had similar characteristics with the study ward, information from the pre-testing was not included in the main study. Pre-testing enabled the researcher to make some corrections in the questionnaire.

3.9.4 Determination of Haemoglobin levels/concentration

Haemoglobin concentration was determined from a finger prick capillary blood sample. The middle finger was cleaned with methylate spirit and pricked with a sterile disposable safety lancet. A drop of blood was picked by a micro-cuvette. The cuvette full of blood was cleaned by cotton wool and inserted into the Hemo-Cue photometer. The reading was determined. Haemoglobin value in g/dl was recorded in the nearest 0.1g/dl.

3.9.5 Anthropometric measurements

The study used standard techniques and equipment (weighing scale for weight, and height board for height) to collect anthropometric measurements. The measurements included weight and heights, and these measurements were compared with (URT, 2018) reference values.

3.9.5.1 Weight

The weight of the child was measured by SECA weighing scale. The scale was placed on a hard flat surface. The scale was then turned on and adjusted to zero. Mothers/Caregivers were requested to remove their children’s shoes and heavy clothes before stepping on the scale with bare feet. Then, the weight was read and recorded to the nearest 0.1 kg.

3.9.5.2 Height

Height measurement was taken by height board. Height board was positioned on a flat surface. The child was placed on the height board while facing upward with the bare feet touching the immovable fixed end of the board. The movable headpiece was then carefully fitted at the top of the head, pressing the hair slightly. The height was read on the stadiometer and recorded to the nearest 0.1 cm.

3.9.5.3 Age

Age of the child was determined by recording the birth date, month and year. RCH card was used if not available mothers/caregivers were asked to provide this information of the child.

3.10 Data Analysis

The data collected using questionnaires were coded and analyzed using Statistical Package for Social Sciences (SPSS) version 21 whereby descriptive statistics such as frequencies and percentages were obtained. The comparison of haemoglobin levels for the 3 groups receiving the various doses of MNP were analyzed by ANOVA. Anthropometric measurements namely weight and length were entered in WHO Anthro software (2010 Version) to generate anthropometric indices of weight for age, weight for height, and height for age Z-scores (URT, 2018). The comparison of height for age (HAZ), weight for age (WAZ), and weight for height (WHZ) with haemoglobin concentration after intervention was analyzed by (ANOVA). Individual dietary quality was assessed using diversity scores based on seven food groups recommended by FAO (2011) namely grains, roots and tubers, legumes and nuts, dairy products, flesh foods (meats/fish/poultry) and vitamin A rich fruits and vegetables. Diversity score ranged from 0 – 7. Zero means that none of the food groups listed was consumed in the previous 24 hours, while 7 means that, the child consumed foods in all the food groups in the previous 24 hours. If the child consumed less than four food groups, he/she was regarded as having low dietary diversity score (WHO, 2008).

3.11 Ethical Considerations

This study received ethical clearance from the Ethics Committee of the National Institute for Medical Research (NIMR), Tanzania. Written informed consent was obtained from the mothers/caregivers at the time of intervention and for those who can’t write they used finger print to sign the consent form which was well explained the objective and confidentiality of the study. Permission was also obtained from the Regional and District Health authorities and the District Executive Director (Morogoro District) to conduct this research in the selected wards.

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-economic and Demographic Characteristics of the Respondents

Table 1 shows that, more than half (61.7 %, n=103) of the children involved in the study were females and 38.3 percent (n=64) were males. In terms of age, 43.7 percent (n=73), were two years of age, 29.9 percent, (n=50) were three years, 15.0 percent (n=25) were four years, while 11.4 percent (n=19) were five years of age. As for the mothers/caregivers 51.5 percent were aged between 26 -35 years, 6 percent were <18 years, while 6 percent were >45 years.

Table 1: Age and sex distribution of the respondents at baseline

Age and sex	Number of respondent	Percent
Sex of children		
Female	103	61.7
Male	64	38.3
Total	**167**	**100**
Age of children (years)		
2	73	43.7
3	50	29.9
4	25	15.0
5	19	11.4
Total	**167**	**100**
Age of mothers (years)		
Less than 18	1	6.0
18-25	46	27.5
26-35	86	51.5
36-45	33	19.8
> 45	1	6
Total	**167**	**100**

Results in Table 2 indicate that, most (76.0 %, n=127) mothers /caregivers attended primary school education, 15.6 percent, (n=260 had informal education, very few (8.4 %, n=14) attended secondary education and none attained higher education.

For marital status, majority (66.5%, n=111) of mothers/caregivers were married, 18.0 percent (n=30) were singles, 10.8 percent (n=18) were co-habiting, 4.2 percent (n=7) were divorced, while 6 percent (n=1) were widows.

Regarding household income, most mothers/caregivers (76.0 %, n=127) expended less than 39,000 TZS per month, 18.6 percent (n=31) earned 40,000-59,000 TZS, very few (4.2%, n=7) earned 60,000-99,000 TZS and only 1.2 percent (n=2) earned greater than 100, 000 TZS per month.

Table 2: Socio-demographic characteristics of the caregivers/mothers

Socio-economic attribute	**N**	**Percent**
Education		
Informal	26	15.6
Primary	127	76.0
Secondary	14	8.4
Higher level	0	0.0
Total	**167**	**100**
Marital status		
Single	30	18.0
Marriage	111	66.5
Divorced	7	4.2
Widow	1	0.6
Cohabitated	18	10.8
Total	**167**	**100**
Monthly expenditure(TZS)		
Less than 39,000	127	76.0
40,000-59,000	31	18.6
60000-99000	7	4.2
> 100000	2	1.2
Total	**167**	**100**

4.2 Haemoglobin (Hb) Status of Children Aged 2 to 5 years in Morogoro (R) District

Table 3 shows that, at a baseline majority (65.5 %, n=167) of the children had iron deficiency anaemia but few (37.3%, n= 95) had mild iron deficiency anaemia, about 25.9 percent (n=66) had moderate iron deficiency anaemia while very few (2.5%, n=6) of the children had severe anaemia.

Table 3: Hb status of children aged 2 to 5 years in Morogoro (R) district

HB test results	No. of children	Percent
Normal iron status (> 11 g/dl)	88	34.5
Mild anaemia (10 - 10.9 g/dl)	66	25.9
Moderate anaemia (7 - 9.9 g/dl)	95	37.3
Severe anaemia (< 7.0 g/dl)	6	2.5
Total	255	100

4.3 Perception of Benefits and Side Effects of Mothers/Caregivers towards Feeding Micronutrients Powder to their Children

Table 4 shows the perceived benefits and side effects of MNP on child health. The benefits of micronutrients powder were classified into two categories namely, changes observed in child behaviours and changes in child health. Positive effects reported by mothers/caregivers on behaviours included an increase in appetite (68.9%, n=115), children became more active (23.4%, n= 39), and children became more energetic (15.6%, n=26). One of mothers in the field reported that, her children liked the taste of micronutrients powder making them eat more food. Due to an increase in appetite, they gained more weight.

In terms of child health, there was an increase in haemoglobin (67.1%, n=112), an increase in body weight (53.9%, n=90), reduction of disease episodes (16.9%, n=28), and decrease in diarrhoea episodes (3% n=5).

Table 4: Mothers/caregivers' perceived benefits and side effects of micronutrients powder

Benefits of micronutrients	**Respondents n=167**	**Percent**
Changes observed in behaviours of child		
➢ Increase in appetite	115	68.9
➢ Child became more active	39	23.4
➢ Child became more energetic	26	15.6
Observed changes in child health		
➢ Less diseases	28	16.8
➢ Increase body weight	90	53.9
➢ Increase in blood Hb	112	67.1
Side effects of MNP		
➢ Diarrhoea	5	3.0

4.4 Effectiveness of Micronutrients Powder in Rehabilitating Iron Deficiency among Children Aged 2 to 5 years

4.4.1 Comparison of haemoglobin concentration after intervention

Table 5 shows that, there was a significant increase in haemoglobin concentration in all doses ($p < 0.05$). Haemoglobin increased by11.10±1.53 g/dl at the first month and 12.48±2.32 g/dl at the second month of intervention for those who used dose one. Haemoglobin increased by 10.34 ± 1.39g/dl in the first month and 11.86 ± 1.64 g/dl in the second month for subjects who received dose 2 while haemoglobin increased by 9.73 ± 1.39g/dl in the first month and 10.07 ± 1.32 in the second month of intervention for those who received dose 3. Overall, there was higher ($p < 0.05$) improvement of haemoglobin concentration in the second month compared to the first month, which had significant improvement of haemoglobin concentration ($p < 0.05$)

Table 5: Change of haemoglobin concentrations (Mean ± SD) g/dl after intervention

Duration	Treatment groups Dose 1 Mean ± SD	Dose 2 Mean ± SD	Dose 3 Mean ± SD	P-value
Baseline	9.48±0.99	9.14±1.22	9.53±1.11	0.947
1st month	11.10±1.53	10.34±1.39	9.73±1.39	0.006
2nd month	12.48±2.32	11.86±1.64	10.07±1.32	0.000

Key: Dose 1: Received one sachet of 1g daily for 60 days
Dose 2: Received one sachet of supplement in alternate days for 60 days
Dose 3: Received one sachet of supplement per week for 60 days

4.4.2 Comparison of decrease in number of anaemic children in all three Doses at Baseline, mid-line and end-line of intervention

Results in Table 6 show that, the number of anaemic children who received the first dose decreased from 100 percent (n=56) at baseline to 44.6 percent (n=25) at the first month and to 32.1 percent (n=18) at the second month of intervention. The number of anaemic children who received the second dose decreased from 100 percent (n=55) at baseline to 61.8 percent (n=34) at the first month and to 25.5 percent (n=14) at the second month of intervention. The number of anaemia children who received dose 3 decreased from 100 percent (n=56) at the baseline to 83.9 percent (n=47) at the first month and to 76.8 percent (n=43) at the second month of intervention. Anaemic children decreased during the period of intervention. A decrease in anaemia for children receiving dose 3 was slightly lower than those receiving dose 2 and dose 1. There was significant difference in the number of anaemic children in all the three dosages ($p = 0.000$).

In dose 1, 55.4 percent (n=31) of the children recovered from anaemia in the first month, and 67.9 percent (n=38) recovered in the second month. In dose 2 (38.2 percent) recovered in the first month while 74.5 percent (n=41) recovered in the second month. Lastly, in dose 3, 16.1 percent, (n=9) of the children recovered from anaemia in the first month while 23.2 percent (n=13) recovered in the second month. There was a significant difference in the number of recovered children in all the three dosages (p = 0.000). The recovery rate of children who received doses 1 and 2 was higher than that of children receiving dose three. This indicated that, micronutrients powder was more effective in reducing iron deficiency anaemia among children when taken more frequently.

Table 6: Comparison of decrease in number of anaemic children in all three doses at Baseline, mid-line and end-line period of intervention

Intervention period	Prevalence of anaemia	Dose 1 %	Dose 2 %	Dose 3 %	P-value
0 month	HB (< 11 g/dl)	100	100	100	
1st month	HB (< 11 g/dl)	44.6	61.8	83.9	0.000
2nd month	HB (< 11 g/dl)	32.1	25.5	76.8	0.000
	Recovered children from anaemia at 1st month	55.4	38.2	16.1	0.000
	Recovered children from anaemia at 2nd month	67.9	74.5	23.2	0.000

Key: Dose 1: Received one sachet of 1g daily for 60 days
Dose 2: Received one sachet of supplement in alternate days for 60 days
Dose 3: Received one sachet of supplement per week for a total of 60 days

4.5 Dietary Diversity of Children

Foods consumed by the study children were classified into seven food groups (Table 7) according to WHO (2010) guidance. Results in Table 7 show that, most (100%, n=167) of the children consumed cereals, roots and tubers while 97.6 percent (n=163) consumed other fruits and vegetables. The least consumed food groups were vitamin A rich fruits and vegetables, which were consumed by 46.1 percent (n=77), legumes, nuts, and seeds that were consumed by 36.5 percent (n=61), meat and fish consumed by 16.2 percent (n=27) and eggs that were consumed by 4.2 percent (n= 7). Non-consumed food group was milk and milk products.

Table 7: Individual dietary diversity score for children aged 2-5 years

Food groups	Respondents	Percent
Cereals, roots and tubers	167	100
Vitamin A rich fruits and vegetables	77	46.1
Other fruits and vegetables	163	97.6
Meat and fish	27	16.2
Eggs	7	4.2
Legumes, nuts and seeds	61	36.5
Milk and milk products	0	0.0

4.5.1 Comparison of individual dietary diversity score (IDDS) for children and increased haemoglobin concentration after intervention

Results in Table 8 show a comparison of individual dietary diversity score and increased haemoglobin concentration after intervention. Iron deficiency anaemia group who had low diversity (≤ 4 groups) were 93.3 percent, (n = 70), medium diversity (5-6 groups) were 6.7 percent (n=5) and high dietary diversity (≥ 7 groups) were none.

Most (90.2%, n=83) of the children who were in the normal group had a low dietary diversity (≤ 4 groups), 8.7 percent (n=8) had medium diversity while1.1 percent (n=1) had high dietary diversity. There was no significant difference between dietary diversity score groups and the haemoglobin concentrations (p= 0.588).

Table 8: Comparison of individual dietary diversity score (IDDS) and haemoglobin concentrations after intervention

IDDS	Hb conc. (after intervention)				P-value
	Anaemic		Normal Hb		
Categories	n	%	n	%	
Low (≤4 groups)	70	93.3	83	90.2	0.588
Medium (5-6 groups)	5	6.7	8	8.7	
High DDS (≥7groups)	0	0	1	1.1	

4. 6 Preparation of Foods or Drinks to be Fortified with MNP

In the first month of intervention, all (100 %, n=167) mothers/caregivers in each group reported to have mixed the MNP with maize porridge and in the second month 89.8 percent, (n=150) reported to have mixed MNP with maize porridge while (10.2 percent, (n=17) mixed MNP with Banana pap. Majority (69.5%, n=116) of mothers/caregivers reported to have added MNP in the hot food, 24.6% (n=41) mixed MNP after cooking the food, 3.0 percent (n=5) added MNP before cooking the food while 3.0 percent, (n=5) added MNP in the cold food in the first month of intervention. In the second month, 70.7 percent, (n=118) of the caregivers/mothers reported to have added the MNP in the hot food, 27.5 percent (n=46) added MNP after cooking the food, 0.6 percent (n=1) added MNP before cooking while 1.2 percent (n=2) added MNP in the cold cooked foods (Table 9).

Table 9: Food preparation and use of micronutrients powder

Period of intervention	Food	Respondents	Percent
1st month	Porridge	167	100
	Total	**167**	**100**
2nd month	Porridge	150	89.8
	Milk	0	0.0
	Black tea	0	0.0
	Water	0	0.0
	Banana pap	17	10.2
	Total	**167**	**100**
When do you add the MNP to the food			
1st month	Before cooking	5	3.0
	After cooking	41	24.6
	In hot food	116	69.5
	In cold food	5	3.0
	Total	**167**	**100**
2nd month	Before cooking	1	0.6
	After cooking	46	27.5
	In hot food	118	70.7
	In cold food	2	1.2
	Total	**167**	**100**

4.7 Effects of Micronutrients Powder on the Anthropometric Measurements of the Children

Results in Table 10 show the effects of micronutrients powder on the anthropometric measurements. Among 167 participating children at baseline, 3.6 percent (n=6) had moderate wasting and none had severe wasting. After intervention, 1.2 percent (n=2) had moderate wasting while none had severe wasting. There was significant difference (p= 0.000) in the prevalence of wasting before and after intervention. Among 167 participating children at baseline, 28.7 percent (n=48) had moderate stunting while 6 percent (n=10) had severe stunting. After intervention, 23.4 percent (n=39) had moderate stunting while 3.6 percent (n=6) had severe stunting. There was significant improvement (p= 0.000) in the prevalence of wasting before and after intervention.

At baseline, out of 167 participating children, 10.3 percent (n=17) had moderate underweight while 0.6 percent (n=1) had severe underweight. After intervention, 4.8

percent (n=8) while none of the children had severe underweight. There was significant difference (p= 0.000) in the prevalence of underweight before and after intervention.

Table 10: Effect of micronutrients powder on the anthropometric measurements

	Baseline		After intervention		
Categories	**Respondents**	**Percent**	**Respondents**	**Percent**	**P-value**
Weight for height					
Normal ($\geq {}^{-}2 \leq {}^{+}1$)	161	96.4	159	95.2	
Overweight($> {}^{+}2 \leq {}^{+}3$)	0	0.0	6	3.6	
Obese ($> {}^{+}3$)	0	0.0	0	0.0	0.000
Moderately wasted($\geq {}^{-}3 < {}^{-}2$)	6	3.6	2	1.2	
Severely wasted($< {}^{-}3$)	0	0.0	0	0.0	
Total	**167**	**100**	**167**	**100**	
Height for Age (HAZ)					
Normal($\geq {}^{-}2 \leq {}^{+}3$)	109	65.3	122	73.1	
Moderately stunted($\geq {}^{-}3 < {}^{-}2$)	48	28.7	39	23.4	0.000
Severely stunted($< {}^{-}3$)	10	6.0	6	3.6	
Total	**167**	**100**	**167**	**100**	
Weight for Age					
Normal($\geq {}^{-}2 \leq {}^{+}1$)	149	89.2	159	95.2	
Moderately underweight ($\geq {}^{-}3 < {}^{-}2$)	17	10.2	8	4.8	0.000
Severely underweight($< {}^{-}3$)	1	0.6	0	0.0	
Total	**167**	**100**	**167**	**100**	

4.8 Monitoring Compliance for Intake of Micronutrients Powder

4.8.1 Compliance based on the count of empty MNP sachets

Results in Table 11 show that, in the first month children who received dose one were given 30 sachets of MNP per month. About 89.3 percent, (n=50) of the children consumed 30 sachets, 10.7 percent (n=6) consumed 16-29 sachets, while none of the children, consumed ≤15 sachets. In the second month, 83.9 percent (n=47) of the children consumed 30 sachets, 16.1 percent (n=9) consumed 16-29 sachets while none of the children consumed ≤15 sachets.

For dose two, children were given 15 sachet of MNP every month of the intervention. In the first month, 89.1 percent (n=49) of the children consumed 15 sachet, 9.1 percent (n=5) consumed 11-14 sachets while 1.8 percent (n=1) consumed ≤10 sachets. In the second month, 96.4 percent, (n=53) of the children consumed 15 sachets, 3.6 percent (n=2) consumed 11-14 sachets while none of the children consumed ≤10 sachets. Lastly, in dose 3 children were given 4 sachets of MNP every month of the intervention but in all the months all (100%, n=56) of the sachets were consumed.

Table 11: Compliance based on the count of empty MNP sachets

Period of intervention	Type of dose	No. of MNP sachets provided	No. of empty MNP sachet collected	Respondents	Percent
1st month	**Dose 1**	30	30	50	89.3
			16-29	6	10.7
			≤ 15	0	0.0
			Total	**56**	**100**
	Dose 2	15	15	49	89.1
			11-14	5	9.1
			≤10	1	1.8
			Total	**55**	**100**
	Dose 3	4	4	56	100
			Total	**56**	**100**
2nd month	**Dose 1**	30	30	47	83.9
			16-29	9	16.1
			≤15	0	0.0
			Total	**56**	**100**
	Dose 2	15	15	53	96.4
			11-14	2	3.6
			Total	55	100
	Dose 3	4	4	56	100
			Total	**56**	**100**

4.8.2 MNP compliance based on participants who shared sachets

During the intervention period, some mothers/caregivers reported that, their children shared the MNP with other children who were not included in the study. Results in Table 12 show the children who shared MNP sachets during the intervention period.

Table 12: Participants who shared MNP sachets during the intervention for all 3 doses

Intervention period	Respondents	Percent
1st month (n=167)	4	2.4
2nd month(n=167)	0	0.0

4.8.3 MNP compliance based on participants who lost/threw away the empty sachets

Table 13 shows the number of the participants who lost/threw away the empty MNP sachets in all three doses in the first month of intervention. In the last month, however, there was no any case of lost MNP sachets.

Table 13: Participants who lost/threw away the empty MNP sachets

Intervention period	Respondents	Percent
1st month (n=167)	1	0.6
2nd month(n=167)	0	0.0

CHAPTER FIVE

5.0 DISCUSSION

5.1 Socio-economic and Demographic Characteristics of the Respondents

5.1.1 Education status of mothers/caregivers

Majority (76%, n = 127,) of mothers/caregivers attended primary school and only few (8.4%, n=14) completed secondary schools and higher education levels. This finding implies that, most mothers/caregivers had low education level. According to NBS (2015) Morogoro region had 35.1percent of mothers/caregivers who attended primary school. Findings of these studies also showed that, education status of mothers/caregiver had relation to nutritional status of children; the higher the education level of the mothers the higher the nutritional status of the children. A study from central Tanzania reported that, mothers who had higher education had children with low prevalence of stunting than was the case with mothers with low education levels (Semali *et al.,* 2015).There is correlation between mothers/caregivers education level and nutrition status of children, the higher education level of mothers/caregivers the better nutrition status of children (Alderman *et al.,* 2017). In addition, children with mothers who had low education level were more likely to develop iron deficiency anaemia than mothers who had higher education (Choi *et al.,* 2011). Asmare *et al.* (2018) reported that, women who received even a minimal education provided appropriate care to their children, which was important to improve child growth and development.

5.1.2 Marital status of the mothers/caregivers

More than a half (66.5%, n= 111,) of mothers/caregivers were married and only few (18.0%, n=30) were single, 10.8 percent (n=18) were cohabitating 4.2 percent (n=7) were divorced, while 0.6 percent (n=1) were widowed. The proportion of married mothers (66.5%, n= 111) reported in this study was higher than the proportion (55.8%) reported in NBS (2015) in Morogoro region. The proportion of single mothers was also lower by 4.2 percent than that reported by NBS (2015), which was 4.7 percent. Findings in a study by Odencrants *et al.* (2013) showed that, participants who lived alone with their children had poor nutritional status than those who lived with their spouses. A study in Ethiopia reported that, marital status of the mother is associated with better child nutritional status (Woldemariam *et al.,* 2002).Also the study in Sub Saharan Africa reported, the marital status of mothers/caregivers has relation to a good nutrition status of children (Amadu *et al.,* 2021)

5.1.3 Household income and expenditure per month

Majority (76.0%, n=127) of mothers/caregivers who participated in the study had an income of 39000 TShs per month followed by, 18.6 percent (n=31) who has an income of 59,000 Tshs per month. According to global poverty index (2015) per day expenditure of 1.90 USD (4,390 TZS) is the basic minimum for a very poor person. Mothers at Kibungo Juu had low-income expenditure per month. Low household income could limit children's access to adequate dietary diversity and this could lead to increased number of undernourished children (Mohd *et al.,* 2015). A study by Galgamuwa *et al. (*2017) indicated a strong relationship between nutritional status of children and family income. Animal foods and animal food products such as milk help to increase iron status of children. However, this types of foods are expensive so if a household has small income it cannot afford the foods.

5.2 Haemoglobin (Hb) Status of Children Aged 2 to 5 Years in Morogoro (R) District

The proportion of children aged 2 - 5 years with haemoglobin concentration of <11g/dl was 65.5 percent. This was higher than the national average of 58 percent and slightly lower than the regional average of 65.7 percent (NBS, 2015). A recent study carried out in Mwanza and Arusha reported similar results of higher rate of children aged 2 – 5 years with low haemoglobin concentrations (<11g/dl) by 77.2 and 84.6 percent, respectively (Simbauranga et al., 2015) and Kejo *et al.*, 2018). Low haemoglobin concentration could be one of the factors for iron deficiency anaemia and this could be due to low intake of animal foods in Morogoro (R) District. Majority of people living in Morogoro Rural District were not pastoralists. Plant foods containing high levels of non-heme iron, are not readily absorbed in the gastrointestinal tract (Hurrell, 2010).

5.3 Perception of Benefits and Side Effects of Caregivers towards the Use of Micronutrients Powder to the Health of their Children

5.3.1 Benefits and side effects of Micronutrients powder to children

Majority of mothers/caregivers reported that, their children increased appetite for eating foods, gained weight, and became more active and more energetic. They had fewer episodes of diseases, and had an increase in blood haemoglobin. Similar findings were reported by Mosha *et al.* (2014) and Rehema (2018).

Few mothers/caregivers (3.0%, n=5) perceived negative side effects of diarrhoea in the first month of intervention. Elsewhere, Gera *et al.* (2002) reported that, 11 percent of the children who received micronutrients powders were at risk of contracting diarrhoea.

A study conducted in Arusha reported that, micronutrients powders helped children to reduce diarrhoea and other diseases (Kejo *et al.,* 2019).

5.4 Efficacy of Micronutrients Powder in Rehabilitating Iron Deficient Children Aged 2 to 5 Years

5.4.1 Comparison of haemoglobin concentrations after intervention

In this study, dose 1 (consumed one sachet per day) and dose 2 (consumed 1 sachet in alternated days) were found to be effective in improving haemoglobin concentration and address severe, mild, and moderate iron deficiency anaemia. Dose 3 (one sachet per week) was found not effective in improving haemoglobin concentration in the first month of intervention. Dose 3 could be good to children with mild iron deficiency anaemia but not for children with severe iron deficiency anaemia. Also dose 3 took more than one month to register improvement in haemoglobin concentration. The finding was similar to that reported in a study by Kejo (2019). Other studies revealed that, MNP had significant effect in improving haemoglobin concentrations and in reducing anaemia from severe to moderate levels through daily intake of sachets rather than once or twice intakes per week (Kounnavong *et al.*, 2011).

5.4.2 Comparison of decrease number of anaemia in all three doses from baseline to end- line

This study found that, doses one and two were better in reducing iron deficiency anaemia among children aged 2 to 5 years for 60 days than was the case with dose three. In the first month of intervention, dose one scored higher than dose two; while in the second month dose two scored higher than dose one. This was due to the delay by caregivers/mother of providing MNP in the second month after seeing higher improvement of health status against anaemia in the last month. Many children who received doses one and two recovered from iron deficiency anaemia rather quickly. Other studies also reported that, daily and alternate day's intakes of MNP scored higher in reducing anaemia (Kejo, 2019; Kounnavong *et al.*, 2011).

5.5 Dietary Diversity of Children Aged 2 to 5 Years in Morogoro (R) District

From the study findings, all children (100%, n=167) consumed starch foods (cereals, roots and tubers) followed 97.6 percent (n=163) of children who consumed fruits and vegetables. However, intake of eggs, milk, meat and fish was very low. This might be due to the fact that, these foods were not readily available in the area, as most farmers did not keep animals. One of the studies from developing country reported that, majority of children in developing countries consumed starch foods (cereals, roots, and tubers) and little amount of eggs, milk, meat, and fish, were consumed by less than 20 percent of the children (Rakotonirainy *et al.*, 2018). A study conducted in Tanzania revealed that, most (91%) households consumed grains, roots, and tubers, 65 percent consumed vitamin A containing fruits and vegetables and very few (7%) consumed eggs, meat (36%), fish (36%), milk (22%) and dairy products (22%), legumes and nuts (35%) and other vegetables (21%) (Khamis *et al.*, 2019).

5.5.1 Comparison of individual dietary diversity scores (IDDS) and haemoglobin levels after intervention

A comparison of individual dietary diversity scores (IDDS) for both normal (who improved after intervention period) and iron deficient children after the final month of intervention, indicated no significant difference (p=0.588). This implied that, the foods consumed had no effect in curing iron deficiency anaemia. The findings in this study indicated that, more than half of both anaemic and normal children did not meet the WHO (2011) recommendations. This study findings correlate with the findings of a study conducted in Tanzania which reported that, 74 percent of the children scored ≤ 4 and only 26 percent scored > 4 dietary diversity score (Khamis *et al.,* 2019). Studies from Ghana and Ethiopia reported that, low dietary diversity score was one of the factors associated with iron deficiency anaemia (Saaka and Galaa, 2017; Belachew and Tewabe, 2020).

5. 6 Preparation of Foods/Drinks Fortified with MNP

Majority of mothers/caregivers reported to have mixed MNP in semi-solid foods in the whole period of intervention, as recommended by WHO (2016). Adding MNP to a very hot food or before cooking can cause degradation of some of the vitamins such as vitamins C and B group.

5.7 Effects of Micronutrients Powder on the Anthropometric Measurements of Children

Micronutrients powder was noted to improve wasting from moderate (3.6%) to low (1.2%), which compared with the Tanzania National Nutrition Survey (2018). This study showed that, the moderately wasted children developed overweight after intervention. This might be due to an increase in food intake due to an increase in appetite. Also, this study showed that, after intervention, the weight for age measurement showed an improvement in anthropometric measurements for children receiving micronutrients powder than was the case with other anthropometric measurements of height for age, and weight for height. Other studies reported similar improvements in anthropometric measurements for children receiving micronutrients powder (Rehema, 2018). Other studies did not report significant improvements in the anthropometric measurements (Rah, 2011).

5.8 Monitoring Compliance for Intake of Micronutrients Powder

5.8.1 Compliance based on the count of empty MNP sachets

The counting of empty sachets was used as the method of monitoring the consumption of MNP during the intervention period. This was done every month. This method was also used by Kounnavong *et al.* (2011) and Rehema (2018). The study results revealed an increase in the number of empty sachets in the second month of intervention expect in dose one, which showed a decrease in the number of empty sachets.

5.8.2 MNP compliance based on participants who shared sachets

Few mothers/caregivers reported to have shared sachets with other children who were not included in the study. This happened to mothers who had sibling children. Other mothers reported of her child who was not included in the study wanting to eat MNP with her neighbour. In other studies, children who were above the eligible age in the household complained that, they were not given the MNP and demanded to be given the foods fortified with MNP (Kounnavong *et al.*, 2011).

5.8.3 MNP compliance based on participants who lost/threw away the empty sachets

Few mothers/caregivers (0.6%, n=1) reported to have lost two sachets in the first month of intervention; and these mothers were given two sachets for replacement.

CHAPTER SIX

6. 0 CONCLUSIONS AND RECOMMENDATIONS

6. 1 Conclusion

Micronutrients powder is effective in reducing the prevalence of iron deficiency anaemia to under-five children. Using 60 days intervention period and consuming micronutrients sachets every day (dose 1) and after every other day (dose 2) is the best method in reducing iron deficiency anaemia. Eating one sachet per week (dose 3) is not effective against anaemia; however, it could be the best in reducing mild iron deficiency anaemia among under-five children. Micronutrients powder was also found to be effective in reducing wasting, underweight and stunting. Also micronutrients powder were found for increase appetite and weight.

6.2 Recommendations

Based on the findings of this study, the following recommendations were made:

Future researchers should be done using one sachet of micronutrients powder per week for children with mild anaemia and should be used for more than 60 days. Mothers/caregivers or households with low income should use dose 2 (alternate days) of micronutrients powder per week for 60 days in controlling iron deficiency anaemia. Children with low appetite of eating food can use micronutrients powder for improving appetite. Based on these findings we would like to recommend that, RCH clinics should emphasize to the mothers/caregivers to add micronutrients powder in the complementary foods for their children in order to reduce the problem of iron deficiency anaemia and other micronutrients deficiencies.

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APPENDIX

QUESTIONNAIRE FOR ASSESING EFFECTIVENESS OF MICRONUTRIENTS POWDER IN REHABILITATING ANAEMIC CHILDREN AGED 2 - 5 YEARS IN MOROGORO(R) DISTRICT

Section A: Socioeconomic and Demographic Information

1. Level of education

a) Informal education

b) Primary school

c) Secondary school

d) Diploma /Degree

2. What is your family average monthly expenditure (TZSs)?

a) Less than 39,000

b) 40,000-59,000

c) 60,000-99,000

d) Greater than 100,000

3. Marital status

a) Single

b) Married

c) Divorced

d) Widow

e) Cohabitated

4. Age of child…………..

5. Age of caregiver/Mother……………

6. Sex of the child F/M

Section B: Food Preparation

1. What food or drink do you use MNP with?

a) Porridge

b) Milk

c) Tea

d) Water

e) Others mention

2. When do you use MNP?

a) Before

b) After cooking

c) In the cooking pan

d) In hot food

e) In cold food

3. Do you always use the whole satchet? Yes/No

Section C: Compliance of use MNP

1. Number of empty satchets (Collect all empty satchet) ……..

2. Number of full satchets…….

3. Have you lost or thrown an empty satchet of MNP during the last 30 days?

a) Yes…….

b) No….

c) Am not sure….

4. Who eats MNP?

a) Under 6 months

b) Aged 2 to 5 years

c) Mother

d) Whole family

e) neighbours

5. Have you given MNP to children or persons other than your young child who was included in the study?

a) Yes

b) No

Section D: Perception of Caregivers/Mothers towards MNP

1. Is it important to provide MNP to children? Yes/No

2. Explain why……………………

3. Is there any side effects to child after using MNP? Yes/NO

4. If yes explain ………………………………….

5. Are there any changes you have noticed on your child because of using the MNP? Yes/ No

6. If yes explain ……………………………….

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Individual Dietary Diversity Questionnaire

Please describe the foods (meals and snacks) that you ate or drank yesterday during the day and night, whether at home or outside the home. Start with the first food or drink of the morning.

	Food group	**Example**	**Yes=1 No =0**
1	Starchy staples	Corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products) + *insert local foods e.g. ugali, nshima, porridge or pastes or other locally available grains.* white potatoes, white yams, white cassava, or other foods made from roots	
2	Other vitamin a rich fruits and vegetables2	pumpkin, carrots, squash, or sweet potatoes that are orange inside + *other locally available vitamin A rich vegetables (e.g. red sweet pepper), ripe mangoes, cantaloupe, apricots (fresh or dried), ripe papaya, dried peaches + other locally available vitamin A rich fruits*	
3	Other fruits and vegetables 3	other vegetables (e.g. tomato, onion, eggplant), including wild vegetables, other fruits, including wild fruits	
4	Meat and fish 4	Beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds. Fresh or dried fish or shellfish	
5	Eggs	chicken, duck, guinea fowl or any other egg	
6	Legumes , nuts and seeds	beans, peas, lentils, nuts, seeds or foods made from these	
7	Milk and milk products	milk, cheese, yogurt or other milk products	
	Did you eat anything (meal or snack) OUTSIDE the home yesterday		

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Source: FAO 2011. Guidelines for Measuring Household and Individual Dietary Diversity