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Effectiveness of food baskets in reducing micronutrients deficiency among pregnant Maasai women in Ngorongoro, Tanzania

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EFFECTIVENESS OF FOOD BASKETS IN REDUCING MICRONUTRIENTS DEFICIENCY AMONG PREGNANT MAASAI WOMEN IN NGORONGORO, TANZANIA

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A Dissertation Submitted in Partial Fulfillment of the requirements for the Degree of Master's in Life Sciences of the Nelson Mandela African Institution of Science and Technology

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ABSTRACT

Micronutrients are comprised of vitamin and mineral nutrients needed during pregnancy for fetus growth, development, maturation and reducing/preventing maternal complications. In the Ngorongoro Conservation Area (NCA) micronutrient rich foods (vegetables and fruits) are lacking due to restrictions on cultivation and unavailability of vegetables and fruits in the local markets. Therefore, the current study introduced a food basket intervention and assessed its effectiveness in addressing anemia, vitamin A and iron deficiencies among pregnant Maasai women within the NCA. The quasi-experimental study included Misigiyo ward as a control group (provide education only) and Olbalbal ward an intervention group (provided food baskets and education). The study assessed hemoglobin, serum ferritin, and retinol levels during baseline and follow-up together with knowledge, attitudes towards micronutrient intake, and local dietary practices. Hemoglobin, serum ferritin, and retinol were quantitatively (duplicate) measured with Hemocue ™, Maglumi 800 ™ and vitamin A Elisa respectively. This study recruited 140 participants from both wards and found 78% of the participants had good knowledge on dietary iron, while less than a quarter (24.3%) had good knowledge on vitamin A. Moreover, 94% of the participants reported consuming African nightshade (as a wild vegetable in the rainy seasons) together with stiff porridge. Furthermore, there was a statistically significant increase in serum retinol ($p<0.001$) in the intervention group compared to the control group while there was no statistical significance difference in hemoglobin and serum ferritin before and after food basket intervention. The baseline serum retinol was positively associated with the follow-up serum retinol levels while baseline serum ferritin and hemoglobin were negatively associated. The food basket intervention holds promise in reducing micronutrients deficiency, especially in communities where micronutrient rich foods are scarce.

DECLARATION

I, Naelijwa Hanson Mshanga do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

Signature: .... Date: ....

Naelijwa H. Mshanga

The above declaration is confirmed

Signature: ……………………………………… Date:……………………

Dr. Haikael Martin

Signature:…………………………………… Date: ……………………

Prof. Pammla Petrucka

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CERTIFICATION

The undersigned certify that they have read the dissertation titled "Effectiveness of Food Baskets in Reducing Micronutrients Deficiency among Pregnant Maasai Women in Ngorongoro, Tanzania" and recommend for examination in fulfillment for the requirements for the degree of Master's in Life Sciences of The Nelson Mandela African Institution of Science and Technology.

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Prof. Pammla Petrucka

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DEDICATION

With great joy I dedicate this work to my husband, Yonaz Reuben for his unconditional love and support during this period of my study and beyond.

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LIST OF ABBREVIATIONS AND SYMBOLS

CREATES	Centre for Research, Agricultural, Advancement, Teaching Excellence and Sustainability in Food and Nutritional Security
FAO	Food and Agriculture Organization
ID	Iron Deficiency
IDA	Iron Deficiency Anemia
LMIC	Low and Middle-Income Countries
NCA	Ngorongoro Conservation Area
NCAA	Ngorongoro Conservation Area Authority
NMRI	National Medical Research Institute
RE	Retinol Equivalent
TBA	Traditional Birth Attendants
TDHS-MIS	Tanzania Demographic Health Survey- Malaria Indicator Survey
TDHS	Tanzania Demographic Health Survey
WFP	World Food Program
WHO	World Health Organization
mg	Milligrams
ng/mL	Nano gram/milliliters
µmol/L	Micromole/liter

CHAPTER ONE

INTRODUCTION

1.1 Background information

Micronutrients are comprised of minerals and vitamins needed in small amounts for body growth and development. They play a major role in improving health of the fetus and pregnant mothers. Adequate intake of micronutrients during pregnancy can prevent birth of babies with neural tube defects, iron deficiency anemia, low birth weight, and reduce complications in pregnant mothers like stillbirths, miscarriage, and death due to hemorrhage.

The World Health Organization (2001) reported an estimated 2 billion people are afflicted with multiple micronutrient deficiencies worldwide. Pregnant women are disproportionately represented as they have increased nutrition needs. According to Gernand *et al.* (2016), micronutrient deficiency in pregnant women can cause immediate, short-term, or long-term effects for their offspring, such as neural tube defects, anemic child, low birth weight babies, growth retardation, and preterm babies. This study focuses on Vitamin A and iron which are micronutrients of significant public health concern.

Vitamin A is a fat-soluble vitamin. It plays a major role in cell division, growth, and maturation (fetal organ and skeletons), upkeep of the immune system to fight against infections, development of vision in the fetus, maintenance of eye health and prevention of night blindness (Downie *et al.*, 2005). The prevalence of night blindness (a consequence of vitamin A deficiency) among pregnant women is at approximately 8 million worldwide (WHO, 2009). In low- and middle-income countries (LMIC), 15% of pregnant women have gross vitamin A deficiency, while 8% of pregnant women have vitamin A deficiency at a sufficient level to cause night blindness.

Iron is a mineral naturally found in foods. It plays a major role in formation of hemoglobin that aids in transportation of oxygen throughout the body (Abbaspour *et al*., 2014). When there is a chronic lack of iron in the diet, iron-deficient anemia can result causing maternal mortality and morbidity. Maternal mortality can be caused by increased blood loss during delivery, pre-eclampsia, and miscarriage (Ogundipe *et al.,* 2012). Iron deficient mothers are at risk of delivering low birth weight babies, preterm, and/or iron deficient babies (Khalafallah and Denis, 2012). Prevalence of prenatal iron deficiency anemia is 15–20% worldwide and increased to as high as 35-75% in developing countries (Black *et al.*, 2013). In

Tanzania, 45% of women of reproductive age (15-49) are anemic (Tanzania Demographic Health Survey - Malaria Indicator Survey (TDHS-MIS), 2016).

Micronutrient deficiency in LMIC often relates to lack of knowledge regarding nutrient intake (Muthayya *et al*., 2013). Poor quality and quantity of food consumed by a pregnant mother can also contribute to the poor health, growth, and development of the fetus (King, 2000). As reported by Torheim *et al*. (2015), micronutrient deficiency among pregnant women can be due to cultural beliefs, poor eating habits, and food insecurity (leading to poor dietary intake). Empirical laboratory screening to detect micronutrient deficiency in pregnancy is limited in LMICs due to high cost or low availability of performing biochemical tests. The result is that women do not know their micronutrient status early enough for any intervention that could result in a healthier pregnancy or pregnancy outcome. This is a major public health concern for pregnant women.

Lennox *et al.* (2017) and Martin *et al.* (2014) have documented that, in pastoral societies, it is common for pregnant women to refrain from eating food rich in protein (such as milk, meat, and beans) in fear of delivering a big baby, which may jeopardize the mother's life. Such behaviors have potentially major implications on the micronutrient status of pregnant women in these settings. The NCA, including the villages of Olbalbal and Misigiyo, are home to many of Tanzania's Maasai people. Due to the sensitive nature of the ecosystem in this protected geographic area, there are laws restricting the cultivation of foods (such as per the *Ngorongoro Act* of 1957). According to Goodman (2002), despite government provision of food rations, food security remains a pervasive concern in these areas.

Pregnant Maasai women are known to experience high burdens of micro- and macro-nutrient deficiency and anemia (Taraiya, 2004). Micronutrient deficiency in Maasai pregnant women is likely to be partly attributable by these restrictions. Therefore, the food basket was used to supply the vegetables and fruits cultivated from Karatu District to Ngorongoro District. The food basket consists of different foods from local farmers of which, each farmer specializes cultivating certain food and later combine each produce from all the farmers in one food basket (WFP, 2018). The purpose of the food basket is to supplement the diet of these pregnant women to improve their micronutrient intake.

1.2 Problem statement

Micronutrient deficiency is a major public health problem that often affects pregnant mothers, women of reproductive age, and their newborn infants. According to the TDHS-MIS (2016), only 21% of Tanzania pregnant women consume micronutrient enriched foods and/or iron tablets or syrup during first 90 days of pregnancy.

Maasai are pastoralists who primarily depend on cattle for milk and food. Due to global environmental changes the Maasai have shifted to intake of cereals-based meals due to lack of pastures for their flocks (McCabe *et al.*, 2011). The Maasai diet do not usually contain micronutrient rich foods (vegetables and fruits). As shown in a study conducted in Samburu, an average of 49% of the energy needs in the Maasai community comes from maize, followed by sugar (13%) and milk (11%). This pattern clearly demonstrates a high probability of inadequacies for iron as well as vitamins A, B_{12}, and C (Iannotti and Lesorgol, 2014).

The diets of Maasai women, in general, and, specifically for those living in conservation areas, are affected by their living circumstances. Their inability to cultivate, grazing constraints for their animals, and inadequate access to local markets with fresh vegetables are all factors limiting their food diversity. As a result, they walk long distance searching for fruits and vegetables or simply forego the effort as they cannot afford these essential food stuffs (Lennox *et al.*, 2017).

Moreover, during pregnancy, as in many cultures, there are food taboos and/or restrictions for Maasai women. Many of these forbidden items are protein foods (good sources of iron) and carbohydrates, in fear of a challenging delivery of large babies (Lennox *et al.*, 2017). A previous study reported that 29% of Masaai women were anemic and 100% of participants were found to be deficient in vitamins A and C (Martin *et al.*, 2014). Dietary intake for iron, folate, and iodine were found to be below the Recommended Dietary Intake (RDI) for Maasai women participants (Martin *et al.*, 2014).

1.3 Research objectives

1.3.1 Main objective

The main objective of this study was to determine the effectiveness of nutritious food basket in reducing vitamin A and iron deficiencies among pregnant Maasai women of Ngorongoro Conservation Area in Tanzania.

1.3.2 Specific objectives

This study includes the following specific objectives:

(i) To explore the knowledge and attitudes towards micronutrient dietary intake in pregnant Maasai women of NCA.

(ii) To determine the level of vitamin A, Ferritin and Hemoglobin before and after food basket supply and nutrition education provided for pregnant Maasai women of NCA.

(iii) To assess frequency dietary micronutrient intake of pregnant Maasai women in NCA.

1.3.3 Research questions

(i) What are the usual (non-intervention) practices of pregnant Maasai women with regards to micronutrient intake?

(ii) To what extent can food basket provision reduce Vitamin A and iron deficiency in pregnant Maasai women?

(iii) To what extent are pregnant Maasai women knowledgeable about dietary micronutrient?

1.4 Significance of the study

The significance of the study, which highlights the early third of the first thousand days of life, is threefold. Firstly, the study provided a comprehensive profile of vitamin A, hemoglobin, and ferritin status of the at-risk population. Secondly, the study demonstrated an innovative micronutrient enhancement approach to improving the health of mother-baby dyads within the target communities. Finally, this study is also significant in the potential for knowledge translation and uptake in the area of micronutrients and maternal child health within a unique pastoralist population especially to the pastoral pregnant women.

CHAPTER TWO

LITERATURE REVIEW

2.1 Prevalence of maternal micronutrient deficiency

Pregnant women and women of childbearing age are high-risk groups for vitamin A deficiency in developing countries. The global prevalence of vitamin A deficiency among pregnant women stands at 15% (Christian *et al*., 2000). The 2010 TDHS found that 37% of women of reproductive age are vitamin A deficient (after adjusting for infection). Supplementation and dietary diversification can help reduce the prevalence of Vitamin A deficiency (WHO, 2009).

Recent national data from Tanzania found the prevalence of anemia during pregnancy to be 58%. About 60% of pregnant women from rural Tanzania were found to have reduced iron stores and anemia due to nutrients deficiency and infections (Ogundipe *et al.*, 2012). In Arusha Region, where the target district of Ngorongoro is located, reported anemia prevalence is 57% (TDHS-MIS, 2016), although this does not necessarily reflect the inter-regional variances.

Anemia among women of reproductive age is a public health priority (TDHS-MIS, 2016). Studies in the United Republic of Tanzania have revealed severe vitamin and mineral deficiency concerns such as iron, vitamin A and folic acid in women (Vestel *et al.*, 2010). Furthermore, the majority of pregnant women have higher chance of becoming anemic (53%) than women who are breastfeeding (39%) or other women of reproductive age (39%) (WHO, 2011).

2.2 Pregnancy outcomes of micronutrient deficient women

Micronutrient deficiencies in pregnancy can lead to numerous shorter-term adverse outcomes, but their effects on long-term health and later chronic diseases of the children of such pregnancies are largely unknown (Eckhardt, 2006). Vitamin A deficiency during pregnancy can lead to fetal wastage, although high doses of vitamin A in early pregnancy can lead to vitamin A toxicity (Azais-Braesco and Pasca, 2000). Vitamin A deficiency is a public health concern in pregnant women as it was estimated that 19 million pregnant women are vitamin A deficient, with the majority of them found within the African context and other developing countries (Hamdy *et al.*, 2013).

About 1.62 billion people are affected by anemia with the majority of them being women and young children. Iron deficiency anemia (IDA) can lead to a decrease in oxygen carrying capacity as one of the most common pregnancy-related complications (Stevens *et al.*, 2013). Deficiency of iron and folic acid during gestation period can lead to complications during pregnancy, such as postpartum hemorrhage, and maternal mortality. Furthermore, maternal iron deficiency can lead to an increase of premature/stillbirth babies, low birth weight babies, and anemic offspring (Darnton-Hill and Mkparu, 2015).

2.3 Foods rich in vitamin A (provitamin A) and iron

Vegetables and fruits, such as spinach and pumpkin seeds, have the valuable potential of addressing micronutrient malnutrition (Nandi and Bhattacharjee, 2005). As reported by Traoré *et al.* (2012), homegrown vegetables and fruits (high in micronutrients) and staple foods such as cereals and legumes enhance bioavailability of micronutrients when they are consumed together. According to Arimond *et al.* (2010), foods, such as nutrient-dense grains (e.g., sorghum), dark green leafy vegetables, nutrient-rich fruits, and liver, were shown to meet micronutrient needs of women of reproductive age in urban Burkina Faso.

2.4 Knowledge and attitude among pregnant mothers of pastoral societies regarding micronutrient dietary intake

Poor attendance at maternal clinics can lead to lack of health and nutrition education, thus contributing to low consumption of fruits and vegetables, as demonstrated in one Maasai community in Kenya (Chege and Kuria, 2017). Furthermore, some of the knowledge comes from cultural practices, which may contribute to nutrition deficiency. For example, Southern Ethiopian pregnant women are prohibited from consuming vegetables believing that the newborn baby will have a bad smell (Zepro, 2015).

As reported by Tarayia (2004), traditional midwifes, mothers, and other siblings advise pregnant women on food choices during pregnancy in many LMIC. Kratli and Dyer (2009) explained that the likelihood of pastoral women to be educated is low compared to men, as most marry when they are relatively young. This leads to low literacy levels, which may limit their understanding of the implications of micronutrient intake during pregnancy.

2.5 Dietary micronutrient intake of pastoral pregnant women

In the Gabra society of Kenya, pregnant women became micronutrient deficient due to poor dietary intake and dietary diversity caused by food insecurity (Adongo *et al.*, 2013). The level of year-round access and consumption of vegetables varies based on affordability, distance to the market place, and insufficient market supplies. Pregnant Maasai women tend to consume vegetables during the rainy season as they naturally grow and are more abundant (Lennox *et al.,* 2017). Furthermore, they are restricted to consume carbohydrate, protein, and fat foods in order to have an easy delivery with a low weight baby (Martin *et al.,* 2014a).

2.6 Prevention of micronutrient deficiency by food-based approaches

Food-based approaches are described as preventive, comprehensive strategies that use food (i.e., whole, refined forms, processed, fortified or a combination) to overcome micronutrient deficiency (Thompson and Amoroso, 2011). Nandi and Bhattacharjee (2005) reported that a consistent supply of vegetables and fruits could help to address micronutrient malnutrition.

According to Aphane *et al.* (2003), micronutrient deficiency can be decreased and controlled, especially in poor communities, through sustainable approaches such as facilitating people to increase consumption of vegetables, legumes, and fruits. Vegetables tend to be easier to grow, may be more impervious to pests and diseases, and are quite customary to local taste. Education must be provided, especially to vulnerable groups, on the importance of micronutrient dietary intake.

Improving dietary intake of micronutrient foods can diminish micronutrient deficiency. Improving dietary intake can be achieved by increase food production that will later ensure consumption of micronutrient rich foods. This approach is the most sustainable method, which will improve micronutrient levels of population (Beal *et al.,* 2017).

2.7 Cut-off point for detection of anemia, vitamin A and iron deficiency

The cut off points for detecting maternal anemia as suggested by WHO is <7.0 g/dl for severe anemia, 7.0-9.9 g/dl for moderate anemia, 10-10.9 g/dl for mild anemia and <11 g/dl for all anemia while >11 g/dl was termed as non-anemic (WHO, 2009). Furthermore, iron deficiency is being classified as a ferritin level of less than 12 ng/mL while, vitamin A deficiency is detected with a serum retinol level of less than 1 mcg/L (Abbassi-Ghanavati *et al*., 2009).

2.8 Micronutrients interaction

Vegetables have different micronutrients (vitamins and minerals) which may positively or negatively affect micronutrient absorption and bioavailability. For instance, calcium tends to compete with iron during absorption, and later diminish iron absorption hence reducing iron bioavailability (Lönnerdal, 2010). On the other hand, zinc is used in the formation of an enzyme which breaks provitamin A to retinol and increase the availability of retinol from plant food. Moreover, vitamin A plays a crucial role in hemopoiesis, which later increases the hemoglobin levels while vitamin C helps in converting Fe^{3+} to Fe^{2+} for easy absorption in the body (Sandstrom *et al.*, 2001).

2.9 Provitamin A and its conversion to retinol

Plants provides vitamin A in form of provitamin A which must be broken down into a form that is easily absorbed such as retinol. After consumption of provitamin A, β,β carotene 15, 15'-monooxygenase enzymes found in the liver and small intestine, is responsible for the breaking down of provitamin A to two units of retinol in the body. Consequently, the WHO came up with the conversion factor of 12:1 (keeping all other factors constant i.e gastrointestinal diseases which affects absorptions) to be used when calculating the retinol, a plant could provide (DeBruyne *et al*., 2013).

2.10 Overall micronutrient

Although, food-based approaches are being suggested as sustainable interventions for reducing micronutrient deficiency and ensures agriculture sustainability (Thomposon, 2007), little is known on its effectiveness in reducing micronutrients deficiency especially to pregnant women. The following sections provides the evidence on the usefulness of food basket in reducing micronutrient deficiencies as implemented to pregnant women.

CHAPTER THREE

METHODOLOGY

3.1 General overview

This chapter presents the description of the study area, study design, sampling techniques, data source, sample size and location, data/laboratory analysis, and analytical tools used in the study.

3.1.1 Parent study

The Maasai Agri-Health Cooperative program is one of the programs offered by Green Hope Organization. The aim of this program is to develop a model which address both Tradition Birth Attendants' (TBAs) needs and maternal malnutrition by involving TBAs in farming activities (vegetable gardens). Farming activities were done at Karatu district thereafter, the vegetables were transported to the NCA and given to the pregnant women who are under TBA care. Ten TBAs, each responsible to attend three pregnant women who were the beneficiaries of the free food baskets. The student researcher and TBAs put different vegetables in baskets and gave 4/5 baskets to each pregnant woman attending the Antenatal Clinics (ANC). The goal of this research was to determine the effectiveness of vegetables supplied to pregnant women in reducing micronutrient deficiency. The project is still ongoing since it aims to ensure sustainable availability of vegetables in the Ngorongoro Conservation Area (NCA).

3.1.2 Food basket content

Enhanced food baskets contained different types of vegetables (Table 1). These vegetables were cultivated at Karatu District and transported to Olbalbal ward. However, due to the limited time for research the oranges, onions, and carrots were bought at Karatu market and transported with other vegetables to NCA. The content of food basket (type of vegetables and fruits) were selected based on the local participants' preference and existing levels of micronutrient malnutrition (based on the baseline results of our study reported in Fig. 4-6).

Table 1: Micronutrients content of vegetables present in food basket.

Vegetable	Botanical names	Fe (mg)	Vit A	RE	Vit C	Zn (mg)
Sweet potato (20 leaves)	*Ipomoea batatas (L)*	152	5340	455	436	12
Amaranth (12 leaves)	*Amaranthus*	157.2	2052	171	534	7.2
Pumpkin (12 leaves)	*Curcurbita pepo (L)*	78	4992	416	294	19.2
Onion (20)	*Allium cepa (shallote)*	4	0	0	148	4
Orange (10)	*Citrus aurantium*	1	80	6.6	530	1
Pumpkin (three)	*Cucurbita*	2.4	603	50.25	15	0.6
Carrots (10 pc)	*Daucus carota*	3	8410	700.8	59	2
Spinach (12 leaves)	*Spinacia oleracea*	32.4	9828	819	120	9.6
Chinese cabbage (12 leaves)	*Brassica rapa (bok choy)*	3.6	1440	120	300	2.4
Saro (12 leaves)	*n.a*	151.2	22.92	1.91	241.2	7.2
African nightshade (12 leaves)	*Solonumnigrum*	190.8	47.64	3.97	20	3.4
WHO **RDI** during pregnancy.	*n.a*	31-61	-	600	50	20

Sources: Lyimo *et al.* (2003), Weinberger and Msuya (2004), Lukmanji *et al*. (2008), WHO (2012), Kamga *et al.* (2013) and Mamboleo *et al.* (2018).

3.2 Description of study location

The current study was conducted in NCA which is one of the three divisions that comprise Ngorongoro district. Ngorongoro district is one among the seven districts in Arusha region.

3.2.1 Study area

NCA, covering 14 036 square kilometers, is a unique protected area where conservation of natural resources (animal, vegetation) is integrated with human development. NCA is located 180 km west of Arusha in the crater highlands area of Tanzania. The conservation area is administered by the Ngorongoro Conservation Area Authority (NCAA), an arm of the Tanzanian government, and its boundaries follow the boundaries of the Ngorongoro division of the Arusha Region.

Ngorongoro district has 28 wards and two private hospitals. Each ward has one dispensary (all Government except 3 private dispensaries) that offers Antenatal Clinics (ACNs) as well as mobile clinics in remote communities. It was estimated that 90% of pregnant women attended Antenatal Clinics; however, only 7% deliver in those clinics (Magoma *et al.*, 2011). This study was done specifically at Misigiyo and Olbabal wards that are among the wards in

Ngorongoro District, therefore having strict laws restricting all planting and growing practices, even for food consumption. Misigiyo is about 10km from NCAA gate while Olbalbal is 42 km from NCAA gate.

Therefore, all foods consumed are either imported from outside the region with the exception of milk, blood of the cows the Maasai raise, the meat and milk of their goats. The wards were purposively selected based on their geographical location such as Misigiyo is located far from Olbabal ward and having similar characteristics with the Olbalbal ward while, Olbalbal ward was selected as an intervention since the project was principally implemented in Olbalbal ward. To assess the effectiveness of the project implemented in Olbalbal ward, the Olbalbal group was categorized as an intervention group and Misigiyo as the control group. Thus, the intervention group received the food basket and nutrition education while the control group received nutrition education only.

3.2.2 Population and ethnicity

Ngorongoro district has a population of 174 278 of which 91 668 are female with 46 750 being women of reproductive age (National Bureau of Statistics, 2012). Misigiyo is a new Ward formed from Ngorongoro Ward. Currently there is no population data for Misigiyo Ward but in Ngorongoro Ward the total population is 12 586, of which 5871 are men and 6715 are female. In Olbalbal Ward the total population is reported to be 8969, with 4119 males and 4850 females (National Bureau of Statistics, 2012). Pregnant Maasai women from Olbalbal and Misigiyo Wards were involved in this study. The majority (98%) of NCA population are the Maasai while the remaining 2% consist of Hadzabe and Dagoota also known as Barabaig (Swanson, 2007).

3.3 Study design

The study comprised of three designs such as, quasi-experimental (pre-post), cross-sectional (questionnaire) and qualitative (focus group discussion [FGD]) designs.

3.3.1 Quasi-experimental study

Quasi-experimental design classifies individual in treatment and comparison groups, but all participants have similarities in overall baseline characteristics. The experimental group receives a treatment/intervention (Fig. 1) while, the comparison group, often called the control group, represents the outcomes of non-intervention. A selection criterion in quasi experimental is based on self-selection rather than randomization (Levy and Ellis, 2011); in this case, the selection criterion is based on geographic location.

Having small sample size can make it difficult to randomize subjects by locations (White and Sabarwal, 2014). According to Shadish *et al*. (2002), using quasi-experimental design can lead to difficulties in controlling confounding variables and misleading conclusions that the effect is caused by an intervention while it could be due to chance. Furthermore, providing free food baskets to only some members in a tight-knit community could lead to dissention amongst neighbors, which could have harmful social effects.

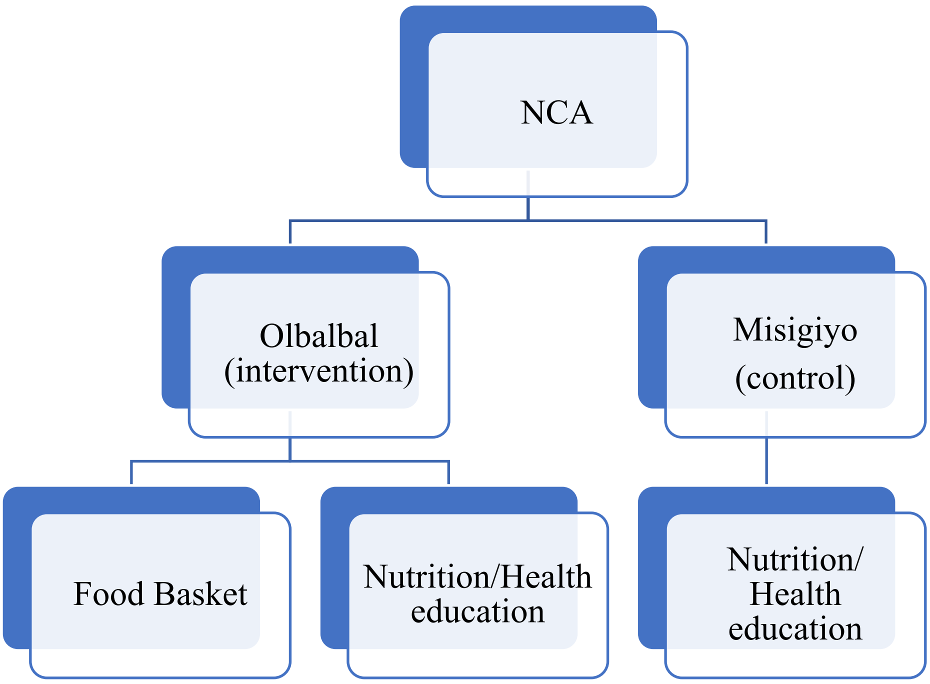

Figure 1: Study design and the division of intervention/s in each ward

Food baskets, as well as nutrition and health education, were provided to pregnant women living in Olbalbal Ward, the experimental group. The same nutrition and health education, but no food baskets, was given to the pregnant women in the comparison group, the Misigiyo Ward. The reason for providing education to both groups is ethical. According to Harris *et al.* (2006), the strength of using quasi-experimental design is that we do not need to randomize subjects who are all in need of intervention.

3.3.2 Cross-sectional study

A cross-sectional design used a validated FAO KAP questionnaire (Appendix1) with structured questions as a tool to assess knowledge, attitude and frequency dietary micronutrients intake among NCA pregnant women.

3.3.3 Qualitative study

Qualitative methods, such as FGD (Appendix 2) were utilized in exploring people's knowledge, attitudes, and experiences of micronutrient-rich dietary intake during pregnancy. FGD method is particularly useful for exploring people's knowledge and experiences which can be used to examine, not only what people think, but how and why they think that way (Nyumba *et al.,* 2018).

3.4 Sample size calculation

Sample size was calculated from the standard formula for epidemiological studies [$n = [z^2 * P * (1-P)]/d^2$]; where n is the total number of the sample, d is the absolute precision (5), confidence interval (CI= 95%), Z is standard normal distribution (Z=1.96), and P is the proportion of maternal iron deficiency in Tanzania (p= 90%) (Makola *et al.,* 2003).

$$N = \frac{(1.96)^2 * 90\% * (100-90\%)}{(5\%)^2} \qquad N=138 \text{ total sample}$$

3.5 Sampling technique

3.5.1 Participants recruitment

At the beginning of the study in the intervention group, the TBAs announced the presence of this study during religious gatherings, village meetings, markets, and to their neighbors. All interested participants were instructed to contact any TBA who would then take the participant to the clinic for recruitment process. There were no mobile clinics at the intervention area due to presence of markets which resulted in participants to relying on public transport to reach the clinic. At the control group, announcements were made at the church gatherings by the health personnel and all village leaders made announcements in each household and interested participants were instructed to attend the clinic as well as mobile clinics for recruitment due to lack of markets in this community.

Upon recruitment, standard measurements, such as last normal menstruation calculations and positive results for pregnancy testing, were used to confirm pregnancy, while fundal height measurement was used to estimate pregnancy age in weeks. Thereafter, pregnant women below 12 weeks of pregnancy (to allow follow-up) were recruited to the study, while pregnant women who were above twelve weeks of pregnancy and experiencing maternal complications were excluded from the study (Fig. 2).

In the cross-section study, all Maasai pregnant women from one week to thirty-six weeks of pregnancy were invited to participate in the questionnaire. The qualitative study through FGD were important for the study participants who participated in the questionnaire and wanted to contribute more on their opinions regarding micronutrients through group discussions. The questionnaire and FGD were conducted at the clinic and mobile clinics in both wards.

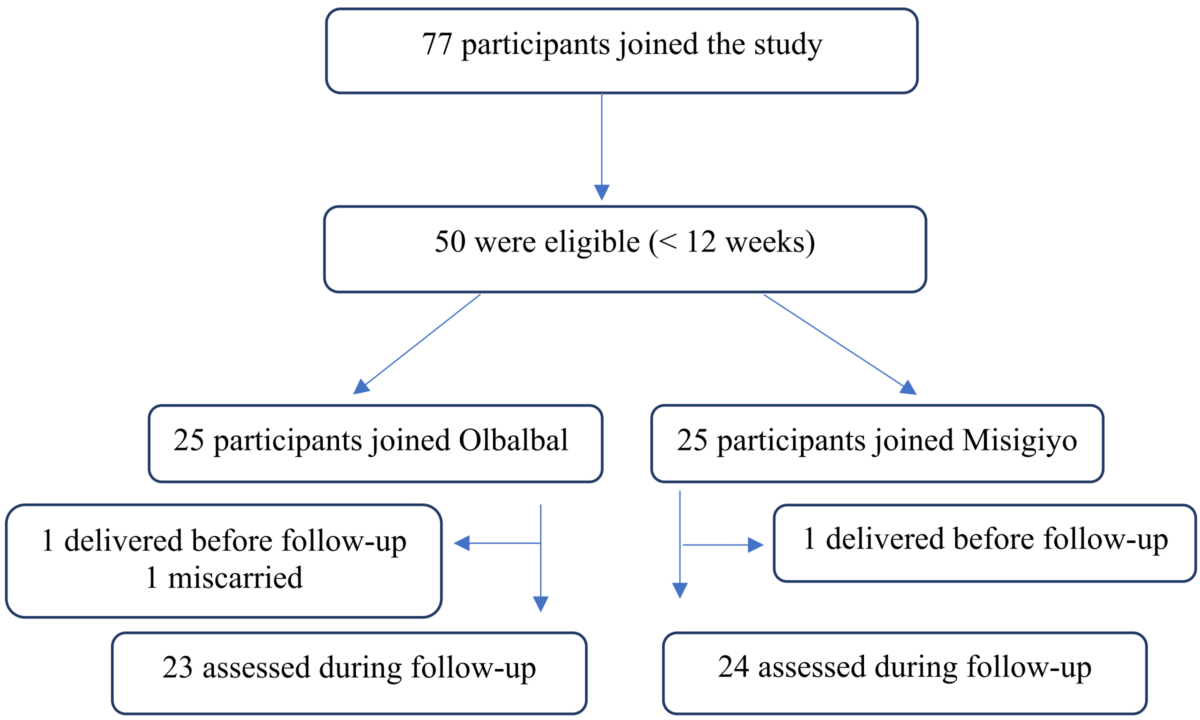

Figure 2: Distribution of study participants and loss to follow-up

3.5.2 Participants follow-up (quasi experimental study)

During the study period, each TBA was responsible to attend 2 to 3 participants based on their residential proximity. During food basket collection, participants were advised to consume the food frequently and instructed on how to cook and store food to preserve the nutrients. TBAs and the researcher filled the baskets with the selected vegetables and fruits and each TBA distributed the food baskets to the pregnant women they were attending. For those who were not able to visit the clinic on each occasion, the TBAs supplied the food basket to their homestead.

After food basket supply, the TBAs made unscheduled home visits (approximately three times per week) to evaluate compliance on dietary intake of vegetables and fruits supplied in the food basket and to encourage the participants to continue attending their ANC appointments to access the next food supplies. Attendance at ANC clinic was not a prerequisite for them to receive the food basket but rather a convenient way of meeting the study participants due to their dispersed settlements.

3.6 Materials and methods

3.6.1 Study procedures

(i) Cross-sectional research method

The questionnaire was comprised of a combination of multiple choice and open-ended questions translated into the Swahili language. Participants were grouped into three categories: participants who can read and write in Swahili (n=20), participants who knew Swahili but do not know how to read and write (n=40), and participants who knew Maa language but could not read and write (n=80).

Participants who knew how to read and write in Swahili filled the questionnaires by themselves, while the researcher read the questions and wrote answers for participants who did not know how to read and write but understood Swahili. A nurse who knew both Swahili and Maa read and wrote answers for those who understood Maa but cannot read and write. In this quantitative arm of the study, the questionnaire had five parts which included socio-demographic information, general micronutrient knowledge, specific knowledge on iron as well as vitamin A, and frequency of dietary intake of micronutrient rich foods. Dietary practices were assessed by using a food frequency questionnaire which had the following scale: never, seldom (less than once a month); 1-3 times per month; 1-2 times per week; 3-4 times per week; and daily. Participants, who voluntarily consented to participate in this phase of the study, took about 45 minutes to complete the questionnaires.

(ii) Quasi experimental study

Ferritin, vitamin A (blood serum), and hemoglobin levels were measured at baseline (pre-test) and after six months (post-test) in both control and treatment group for 47 participants. The biochemical measurements served as a proxy for overall nutrition changes over the course of the nutrition and health education, and the food basket intervention in the experimental group.

(iii) Qualitative research methods

Thirty-two participants among those who participated in the questionnaire consented to participate in the FGDs. Focus Group Discussion participants were selected based on their age, gravidity (number of pregnancies) and parity (number of deliveries) and grouped into one to four focus groups each comprised of eight participants. The student researcher provided the interview guide (Appendix 2) to the research assistance at the beginning of the focus group discussion.

(iv) Nutrition education

Nutrition education was provided by the nutritionist to the intervention and control group. The lessons were explained by use of real vegetable and fruit in Swahili language and translated into Maa by a research assistant (a Maasai experienced in translating research tools in Maa language). In the intervention group, participants were placed into two groups (each containing 12 or 13 participants) whereas, one group attend the nutrition education class and the other collect the food basket and attending their ANC clinics then reversing roles. The nutrition education was divided into three parts: (a) role of vegetables and fruits in our body and during pregnancy; (b) good preparation, cooking and storage methods for vegetables and fruits; and (c) foods that hinder/ affect absorption of certain micronutrients from vegetables and fruits (e.g. tea and iron; zinc and iron). Moreover, the same lessons from part 1 and 3 were given to the control group.

To preserve the vegetables and fruits, where there is no fridge, the participants who reported having clay pots (large and small) in their households were advised to put the smaller pot in the larger pot then put sand in the space between the two pots. Furthermore, they were instructed to keep the sand moist by adding water (daily) then, put the vegetables (packed in plastic bags) in the small pot and cover both pots with a wet sack to keep it cool. For those who did not have clay pots, they were advised to sprinkle the vegetables with water and put them in plastic bag. With the clay method the green leafy vegetables stayed for 4-6 days while the use of plastic bags preserved them for 3-4 days. The storage lessons were adopted from Technical Centre for Agriculture and Rural Cooperation (The ACP-EU Technical Centre for Agricultural and Rural Cooperation, 2007).

(v) Food basket intervention

Traditional Birth Attendants (TBAs) were responsible for the distribution of the food basket as part of the project and as influencers of pregnant women on the consumption of vegetables and fruits. The food basket contained vegetables and fruits, which were cultivated in Karatu district (a nearby district) and transported to Olbalbal ward (intervention group). The food basket contents and micronutrient contributions are shown in Table 1. The food basket contents were selected based on the participants' preferences, existing micronutrient deficiencies identified during baseline testing, plus nutritional quality and quantity of the available vegetables and fruits. The nutritional content of the vegetables and fruits in the food basket was obtained from previous studies (Lyimo *et al.,* 2003; Lukmanji *et al.*, 2008; Kamga *et al.,* 2013; Mamboleo *et al.,* 2018).

One food basket contained the core elements of one bunch (each equivalent to 300 g) of sweet potato leaves, amaranth, pumpkin leaves, onions, oranges, carrots and pumpkins. Dependent on availability, Chinese cabbage was added once in a while, spinach and saro were also given to the participants as these were the highly preferred vegetables in the community, thought it was difficult to obtain them on a weekly basis.

Due to the dispersed settlement patterns in these two communities, the food baskets were provided twice per month, on market days as there was reliable public transport which enabled the target population to go to the market, visit the ante-natal clinic, and collect their food baskets. More importantly, the study was conducted during rainy season (from March to August) and made the participants to continue consuming wild vegetable (African nightshade) as shown in food frequency data. The food baskets were provided for a period of six months.

3.6.2 Data collection and laboratory analysis

(i) Structured questionnaire

The validated FAO 2014 (KAP) questionnaire with structured questions (Appendix1) was administered to 35 participants per day by ten trained researchers and two nurses who knew both Swahili and Maa languages. A standardized questionnaire was used to assess frequency intake, knowledge, and attitude towards micronutrient-rich dietary intake.

(ii) Focus group discussions

The researcher provided a guide for discussions. The FGDs were moderated by a person who knew both Swahili and Maa language and an experienced note taker noted down all the discussions and recorded the conversation at the same time. Participants, in all FGDs, chose to use the Maa language and the scripts were later translated to Kiswahili language; thereafter, the researcher translated the scripts to English language. Immediately after each FGD, both the moderator and the note taker expanded the notes and summarized key issues raised before conducting the next session.

(iii) Blood collection and transportation

A qualified and experienced nurse collected blood samples from each participant during baseline and follow-up in the study. A 5 ml syringe was used to draw blood from the median cubital vein. A few drops were used for hemoglobin analysis by HemoCue™ machine and the remaining blood was stored in a vacutainer tube and left to clot for 30 mins. Afterward, the blood was centrifuged at a spin rate of 1100-1300 rpm for 15 minutes. The serum was pipetted from the clotted blood and stored in a 2ml Eppendorf tube. Then, the serum was transported in a liquid nitrogen jar to the laboratory where they were stored frozen at −40°C until analysis (Garcia-Casal *et al*., 2018).

(iv) Laboratory analysis (serum retinol and ferritin)

Calibration graphs were generated using standards and the quality control test were done before laboratory analysis of samples. The quality control test was done to the known concentration (standards) to find out if the technique was able to identify the known concentration and assure us to identify the unknown concentration (samples). The reagents used were comprised of conjugate, substrate, and stock solution. The conjugate played an important role in supporting the binding of ferritin/vitamin A to the antigenic side attached into the testing wells. Thereafter, applying of the substrate helps in creating the color of the formed complex between analyte and the antigen. Lastly, addition of stock solution assists in stopping and stabilizing the color developed in order to read from the machine.

Figure 3: Laboratory analysis of serum retinol and ferritin

Ferritin blood serum was quantitatively analyzed in duplicate by Maglumi 800 machine which is made from Snibe Co., Limited in Indonesia (using Chemo luminescence immunoassay system) and Vitamin A by the Human Reader machine made in Germany (using Vitamin A Elisa kit) consecutively at Safe Focus Laboratory (Fig. 3). Serum ferritin is an iron store which releases its iron when there is iron depletion (Kumar *et al.,* 2016); therefore, low levels of serum ferritin confirm iron deficiency. The analysis of serum retinol by enzyme-linked immunosorbent assay and serum ferritin by chemo luminescence immunoassay was based on Yalow and Benson (1960) and Woodhead and Weeks (1985) techniques respectively.

3.6.3 Statistical analysis

(i) Quantitative research analysis

Collected data from the questionnaire and laboratory analysis were analyzed using the Statistical Package for Social Science (SPSS) ™ Version 25 and Graph Pad Prism ™ Version 7. Descriptive analysis, such as frequency distribution and measures of central tendency, were used to assess socio-demographic data, general micronutrient knowledge, knowledge on dietary iron and vitamin A, symptoms of iron and vitamin A deficiency, as well as consequences of iron deficiency/anemia. The significant difference was detected at a p-value of <0.05.

The Chi square test was used to compare the categorical variables such as vitamin A deficiency (<1 mcg/dl), anemia status (hemoglobin <11 g/dl) and iron depletion status (ferritin <7 ng/ml) between groups (control and intervention). Dependent *t* test was computed to determine changes in the continuous variables such as serum retinol, ferritin, and hemoglobin concentration that occurred within control and intervention group. Further, independent *t* test was used to determine the changes in serum retinol, ferritin, and hemoglobin between the groups from baseline and after intervention. Lastly, stepwise multiple regression analysis was done to identify factors associated with serum retinol increase at the end of the study.

(ii) Qualitative research analysis

The recorded voice-note, which was in Maa language, was transcribed and translated into Swahili language by the experienced Maasai research assistant and later to English by a researcher (Principal Investigator). The researcher analyzed the transcripts using inductive thematic content analysis which involves, reading the scripts several times to identify similar as well as differing issues emerged in the scripts and make short phrases that sum up what have been narrated (Kawulich, 2004; Burnard *et al*., 2008). Thereafter, codes were generated from phrases having similar content across all FGDs and sorted into themes. Verbatim quotes from the script were chosen and presented in the result section.

3.7 Ethics and consents

Ethical clearance from National Institute for Medical Research (NIMR/HQ/R. 8a/Vol. 1X/2708) (Appendix 3) was obtained along with a permit from NCA Authority. The ethical committee approved a written consent, parental/guardian assent forms (for minor participants) and the use of verbal consent for the case of illiteracy. After explanation to the study participants, those willing to participate signed informed consent forms. For the participants who did not know how to read and write, consent was provided orally in Maa with an impartial (non-research associated) witness to acknowledge the individual's verbal consent, thumb print signature was used.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

4.1.1 Social demographic characteristics of the study participants

Data was collected from questionnaire, FGDs and quasi-experimental study. The questionnaire was administered to 140 participants from which 32 joined FGDs (Table 2). Due to the budget constraints and loss to follow up, a total of 97 pregnant women (50 pre and 47 post-test) from each group (treatment and control) participated in follow up study (Fig. 2).

Table 2: The number of expected and obtained participants in questionnaire and FGD's

Type of Data collection tool	Total expected	Total obtained
Questionnaire	138	140
Focus group discussions	40	32

(i) Social demographic characteristics of the cross-sectional study participants

Half of the participants fall into the age range of 25-29 years while a few of them were in the age range of 15-20 years. Near two thirds of the participants chose their mother-in-law (65%) as their closest supporter during pregnancy, whilst, nearly all of the participants were married (97%) (Table 3).

Table 3: Socio-demographic characteristics of cross-sectional study participants (n=140)

Variable	Categories	n	Percent (%)
Wards	Olbalabal	70	50
	Misigiyo	70	50
Age	15-20	19	13.6
	21-24	30	21.4
	25-29	70	50
	≥ 30	21	15
Nearest female supporter	Mother-in-law	91	65
	Co- wife	17	22.1
	Mother	32	12.9
Marital status	Single	4	2.9
	Married	136	97.1
Education Status	Illiterate	97	69.3
	Primary	31	22.1
	Secondary	12	8.6
Occupation	Pastoralist	140	100

(ii) Social demographic characteristics of the quasi-experimental study participants

Half of the pregnant women who joined experimental study came from Misigiyo ward and near to half came from Olbalbal ward. Above one third of participants were in the age of 25-29 years (35%) and 72% selected their mother–in-law as their nearest female supporter while almost all of the participants were married during study period (Table 4). Furthermore, almost half of the participants were in their first to third pregnancy during data collection, while 41% of the participants had experienced one to three deliveries in their entire life.

Table 4: Socio-demographic characteristics of quasi-experimental study participants.

Variable	Total (n)	Percent (%)
Wards		
Olbalbal	48	49.5
Misigiyo	49	50.5
Age		
15-20	19	19.5
21-24	25	25.7
25-29	34	35.2
≥ 30	19	19.6
Nearest female supporter		
Mother in law	70	72.2
Co-wife	17	17.5
Mother	10	10.3
Marital status		
Single	5	5.2
Married	92	94.8
Education Status		
No formal education	69	71.2
Primary	20	20.6
Secondary	8	8.2
Gravidity		
0	0	0
1-3	45	46.4
4-6	32	33
≥7	20	20.6
Parity		
0	10	10.3
1-3	40	41.2
4-6	29	30
≥7	18	18.5
Occupation		
Pastoralist	92	94.8
Business women	5	5.2

(iii) Social demographic characteristics of the qualitative study participants

The majority of the participants (n=13) in the qualitative arm of the study were in the age group of 21-24 while half of them did not have formal education (Table 5).

Table 5: Socio-demographic characteristics of qualitative study participants (n=32)

Focus group type	Total number	Age category	Education
Pregnant women (>1 gravida)- Olbalbal Group 1	8	(21-24)-2 (25-29)-5 (≥ 30)-1	Illiterate:3 Primary school:5
Pregnant women (first gravida)-Olbalbal Group 2	8	(15-20)-4 (21-24)-4	Illiterate:4 Primary school:2 Secondary school:2
Pregnant women (>1 gravida)-Misigiyo Group 1	8	(21-24)-3 (25-29)-5	Illiterate:5 Primary school:3
Pregnant women (first gravida)- Misigiyo Group 2	8	(15-20)-3 (21-24)-4 (25-29)-1	Illiterate:4 Primary school:3 Secondary school:1

4.1.2 Micronutrients knowledge and attitude

Findings from this part are both presented as quantitative (questionnaire) and qualitative data. The themes which emerged from FGDs are presented in Table 10 (Appendix 4).

(i) Participants' knowledge on fruits and vegetable consumption during pregnancy

The majority of pregnant women had good knowledge (86.4%) of the importance of eating fruits and vegetables during pregnancy (Table 6). Over one third of participants revealed that adequate dietary intake of fruits and vegetables can provide energy to the mother (39.3%), and increase fetal growth (37.9%), whereas a few indicated that these items would improve health (5.0%), produce heat (1.4%), and increase blood volume (5.0%) during pregnancy. One FGD participant mentioned that fruits and vegetables as foods treat anemia although she did not know about vitamins *"I know that fruits and vegetables treat anemia, but I don't know what vitamins are, their source and the role they play inside the body"* [Misigiyo-1st Group-P7]. However, the majority of participants believed that eating vegetables increases blood during pregnancy as stated in the narrative *"Dietary intake of vegetables increases blood during pregnancy"* [Olbalbal-1st and 2nd Groups-Many]**.**

Table 6: Micronutrient knowledge among pregnant women

Variable	Good (%)	Moderate (%)	Poor (%)
General Micronutrients Knowledge			
Importance of micronutrients dietary intake during pregnancy	86.4	0	13.6
Foods rich in micronutrients	78.3	0	21.7
Knowledge on Iron/Anemia			
General knowledge on iron	75.7	20	4.3
Foods rich in iron	77.05	16.05	6.9
Symptoms of anemia	78.1	15.9	6
Consequences of anemia	77.8	14.2	8
Knowledge on Vitamin A/Deficiency			
General knowledge on vitamin A	0	0	100
Foods rich in vitamin A	24.3	0	75.7
Symptoms of vitamin A deficiency	0	15	85
Consequences of vitamin A deficiency	0	0	100

Most of the participants (77.9 %) had good knowledge of iron and iron deficiency anemia but poor knowledge of vitamin A and vitamin A deficiency (24.3%) (Table 6). The few participants who knew about vitamins and the effect of vitamin deficiency had attended secondary school. One such FGD participant mentioned that her biology teacher taught her *"that vegetables have vitamins such as Vitamin A and C which helps someone to have good eye sight during pregnancy"* [Olbalbal-2nd Group-P4].

(ii) Participants' knowledge on symptoms and consequences of anemia during pregnancy

More than half of participants said swollen legs (57.1%) is a symptom of anemia and nearly one third recognized maternal and/or infant death (30.7%) as the worst result of iron deficiency anemia during pregnancy (Table 6). The following quote from the FGD participants clarifies more on symptoms and consequences of anemia during pregnancy which was reported by the majority of participants *"I came to realize that the swollen legs I had during my last pregnancy was due to low blood count"* [Olbalbal and Misigiyo-2nd Groups-Many]. Focus group discussion participants associated failure to push the baby and anemia as stated by one woman *"Pregnant women can get complications during delivery due to lack of energy to push the baby caused by low blood count"* [Olbalbal-1st Group-P6]. Furthermore, the consequences of anemia were mentioned by a few as reflected in the following statement: *"If you have low blood count you can start feeling dizzy, have swollen legs and become weak"* [Misigiyo-1st Group-P3].

(iii) Health outcomes of cultural dietary restrictions during pregnancy

The majority of women across all FGDs knew the health outcomes of cultural dietary restrictions. They expressed their different experiences on health outcomes after reduced dietary intake during pregnancy as described that: *"After food restriction during pregnancy, I deliver(ed) a low birth weight baby with poor health"* [Olbalbal-1st Group-P7]. While other participants reported they failed to push during delivery: *"Due to low dietary intake and food restrictions during my first pregnancy, I failed to push the baby since I had no energy to do so"* [Misigiyo-2nd Group-P8].

(iv) Source of nutrition knowledge during pregnancy

More than half of the participants mentioned TBAs (56%) while 11.9% of the participants indicated nurses were the primary source of nutrition information. Few of them chose schools (0.7%) and radios/televisions (1.4%) as places where they get nutrition and health information. This pattern was further confirmed during the FGD whereby the majority of pregnant women mentioned TBAs as their informants. *"I was advised by a traditional birth attendant on dietary intake during pregnancy"* [Misigiyo-1st Group-P2] while a few mentioned nurses, and teachers as their sources of nutrition information; *"I was advised to take vegetables, beans and fruits by a nurse"* [Misigiyo-2nd Group-P1]. Few of the study participants were educated about anemia when they are in school as reported that: *"I learned about anemia and health issues during pregnancy when I was in school*" [Olbalbal-2nd Group-P4].

Results presented in Table 6 show that, nearly all of the respondents had general knowledge of the importance of dietary intake of micronutrient during pregnancy. Besides, participants appeared to have good knowledge of dietary iron as well as symptoms and consequences of iron deficiency (78%) while the majority (85%) of participants had poor knowledge of vitamin A.

The majority of the participants attempted to respond correctly on the question said, *"it is important to consume micronutrients rich foods (Fruits/Vegetables) during pregnancy" (*86.4%). Three questions that respondents have the least knowledge on were *"the causes of vitamin A deficiency" (*0.3%), *"the consequences of vitamin A deficiency" (*0.4%) as well as *"night blindness as the symptoms of vitamin A deficiency" (*0.6%).

(v) Dietary intake increases during pregnancy

About three-quarters (73.6%) of participants agreed that it is extremely good to take a lot of food during pregnancy while 23.5% did not understand the statement and a few of them disagreed (2.9%). Marangoni *et al*. (2016) suggested that, dietary intake during pregnancy must increase to meet energy and other nutrient needs as pregnancy proceed therefore, the majority of the participants had a positive attitude on the increase of dietary intake.

(vi) Difficulties of increasing dietary intake during pregnancy

About two thirds of the participants felt it was difficult to eat a lot of food during pregnancy (69.3%); however, only 20% said it is not difficult while few of them seem not to understand the above statement. Furthermore, the majority of the participants who said it is difficult to eat a lot of food during pregnancy give their reasons such as, unavailability of food (52.9%) in the NCA and cultural constraints (60.7%) that does not allow them to eat enough during pregnancy in fearing of delivery of a large baby. These findings were similar to the Lennox *et al*. (2017) study which reported low dietary intake during pregnancy to be associated with unavailability of food in the conservation area, cultural dietary restriction in fear of delivering a low birth weight babies, lack of nearby markets hence, walking a long distance searching for food of which some of them forgo the effort of searching.

(vii) Dietary intake of fruits and vegetables during pregnancy improves mother's health and pregnancy outcomes

Almost all of the participants agreed that dietary intake of fruits and vegetables improves mother's health (80.7%). As far as nutrition is concerned, dietary intake of fruits and vegetables during pregnancy increase the minerals and vitamins status, which helps fetus development, growth, maturation as well as improves mother's health (WHO, 2001). Therefore, the majority of participants had a positive attitude on fruits and vegetable intake.

(viii) Dietary intake of fruits and vegetables increase during pregnancy compared to non-pregnancy

As shown in Table 7, about 61.4% of the participants felt that, it is good to increase dietary intake of fruits and vegetables during pregnancy compared to non- pregnancy. Participants had a positive attitude towards consumption of fruits and vegetables during pregnancy. Literature shows that the need for dietary intake of vitamins (A, C, B_{12}, B_9, B_2 etc.) and minerals (iron, zinc, iodine, magnesium etc.) increase during pregnancy compared to non-pregnancy to support infant growth and maturation (Williamson, 2006).

Table 7: Respondents attitudes on dietary iron intake

	Questions	Percent of Respondents (%)		
		Extremely Good	**Not sure**	**Not at all**
a)	Nutritionally is it good to eat a lot of food during pregnancy?	73.6	23.6	2.9
b)	How difficult is it for you to eat more food during pregnancy?	69.3	10.7	20
c)	It is good to eat fruits and vegetables during pregnancy for child's and mother's health.	80.7	18.6	0.7
d)	Is it good to increase dietary intake of fruits and vegetables during pregnancy compared to non-pregnancy.	61.4	38.6	0
e)	How good is it to prepare food rich in vitamin A and Iron such as carrots, green vegetables, liver, pumpkinse.t.c	56.8	43.2	0

(ix) Preparation of vitamin A and iron rich foods

More than half of the participants thought it is easy to prepare vitamin A and iron rich foods (56.8%). Vegetables and/or fruits are rich in iron and vitamin A. Food preparation may have an influence on dietary choices when consumers have a limited time to prepare foods and made them opt to prepare the foods having minimal preparation such as fruits and vegetables (Caswell and Yaktine, 2013). Hence, the participants may have a positive attitude based on their busy schedule, as pregnant women graze animals and do a lot of activities in the second and third trimisters to lose weight.

4.1.3 Hemoglobin, serum retinol and ferritin levels during baseline and follow-up

(i) Hemoglobin and anemia

During baseline, study participants had a mean hemoglobin level of 12 and 11 g/dl in the intervention and control group respectively, showing no statistical difference of the hemoglobin levels between the groups ($p=0.74$) (Fig. 4). There was no significant difference in the level of hemoglobin after six months between the intervention and control group ($p=0.06$). Moreover, 76.2% of the participants were anemic during baseline with no significant difference between the groups ($p=0.27$); however, there was a significant decrease in the proportion of anemic women in the intervention group ($p<0.02$) compared to the control group at follow-up.

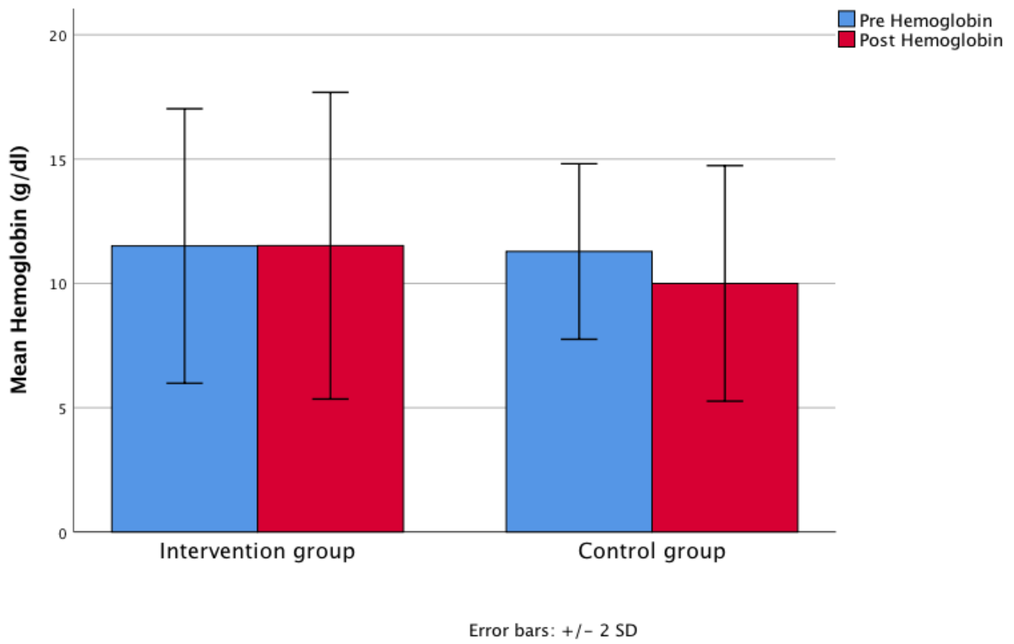

Figure 4: Pre and post hemoglobin

(ii) Serum ferritin and iron deficiency

At the beginning of the study, participants across both groups had a mean ferritin of <7 ng/ml. However, after the food basket intervention, the ferritin levels were seen to slightly increase in the intervention group and further decrease in the control group (Fig. 5) while there was no statistical difference of pre- and post-intervention ferritin (p=0.10). Although there was no significant difference in the proportion of iron deficient women in both groups (p=0.44) at the beginning and end of the study, the control group had a higher prevalence of iron deficient women than the intervention group at the end of the study.

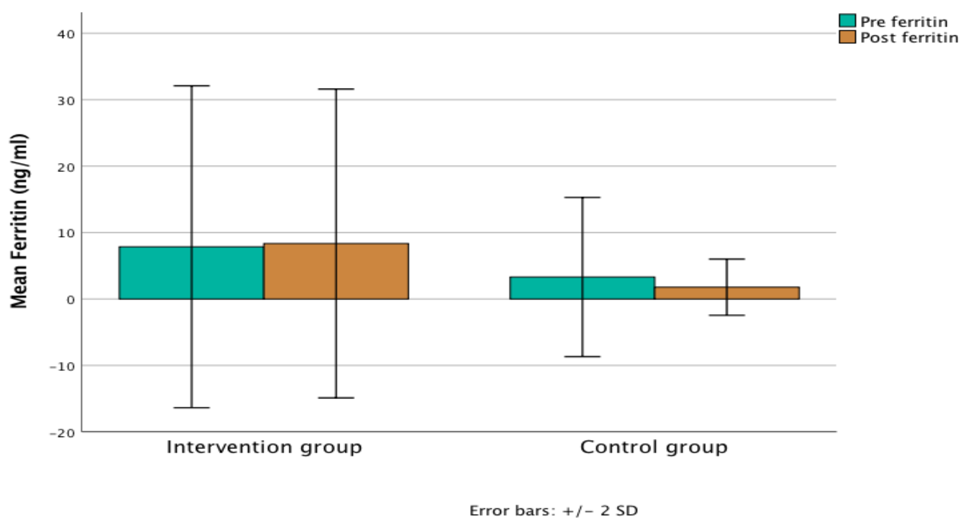

Figure 5: Pre and post serum ferritin

(iii) Serum retinol and vitamin A deficiency

Both groups had a serum retinol of less than 0.70 µmol/L during baseline and the difference was statistically insignificant between the groups (p=0.32). After six months of the food basket intervention, there was a significant increase of serum retinol of 20 µmol/L in the intervention group (p<0.001), while an insignificant increase of 3 µmol/L in the control group (p=0.07) (Fig. 6). All study participants were vitamin A deficient and there was no statistically significant difference between the two groups at baseline (p=0.28). Both groups experienced a decrease in the proportion of vitamin A deficient women over the course of the study, but the control group remained with a higher proportion of vitamin A deficient women after six months (Fig. 7-8).

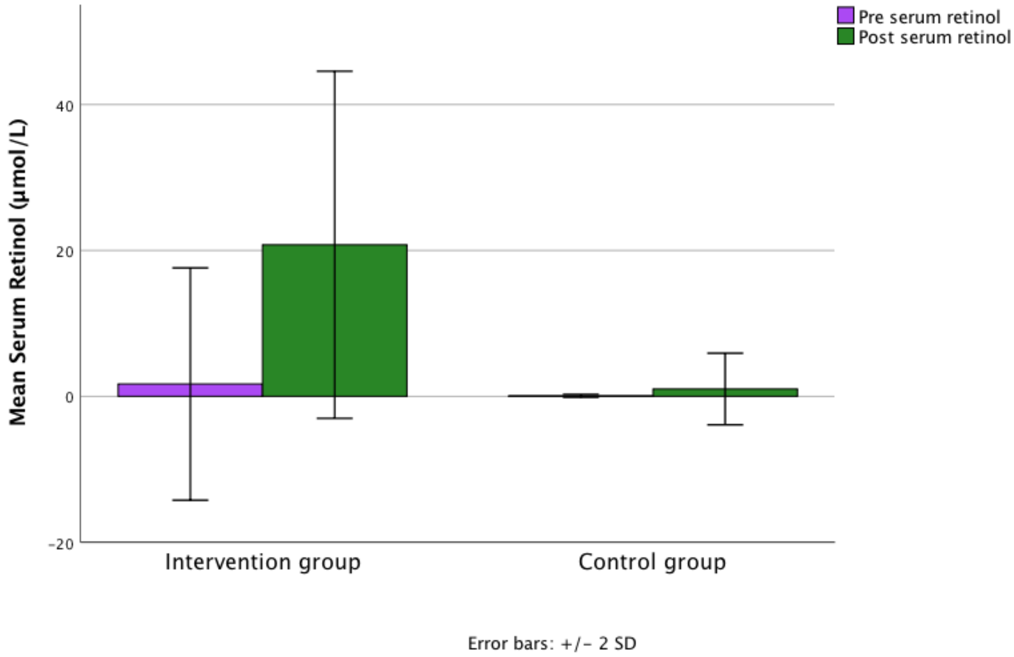

Figure 6: Pre and post serum retinol

A stepwise multivariable analysis was performed to calculate the contributions made by the geographic location (ward), baseline hemoglobin, serum ferritin, and serum retinol changes. The findings showed at baseline vitamin A status of the participants was positively associated with the increase of serum retinol during follow-up. Conversely, wards, baseline hemoglobin, and serum ferritin were negatively associated with serum retinol levels (Table 8). In addition, independent variables were able to predict 69% of the serum retinol changes.

Table 8: Factors predict the vitamin A changes during baseline and follow-up

	β^2		P Value	Confidence Interval
Constant	49.18	8.31	0.000	32.40 to 65.95
Wards	-19.78	2.330	0.000	-24.49 to -15.08
Pre-hemoglobin	-.15	0.62	0.805	-1.41 to 1.10
Pre-ferritin	-.21	0.15	0.166	-.52 to 0.09
Pre-vitamin A	.578	0.21	0.009	0.15 to 1.007

R=0.83 **R^2**= 0.69 **adjusted R^2** =0.65

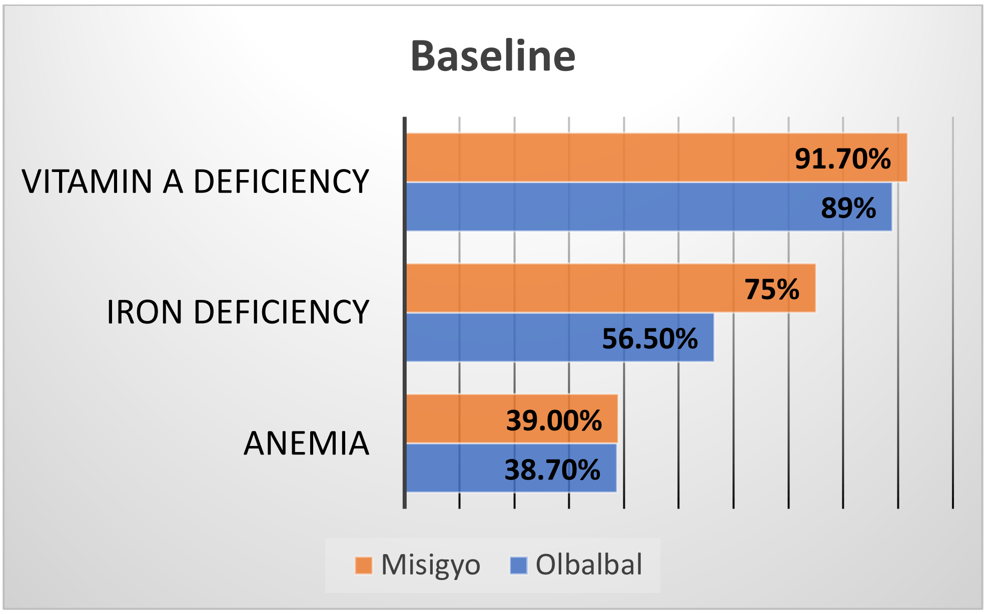

Figure 7: Proportion of vitamin A, iron deficient and anemic pregnant women during baseline.

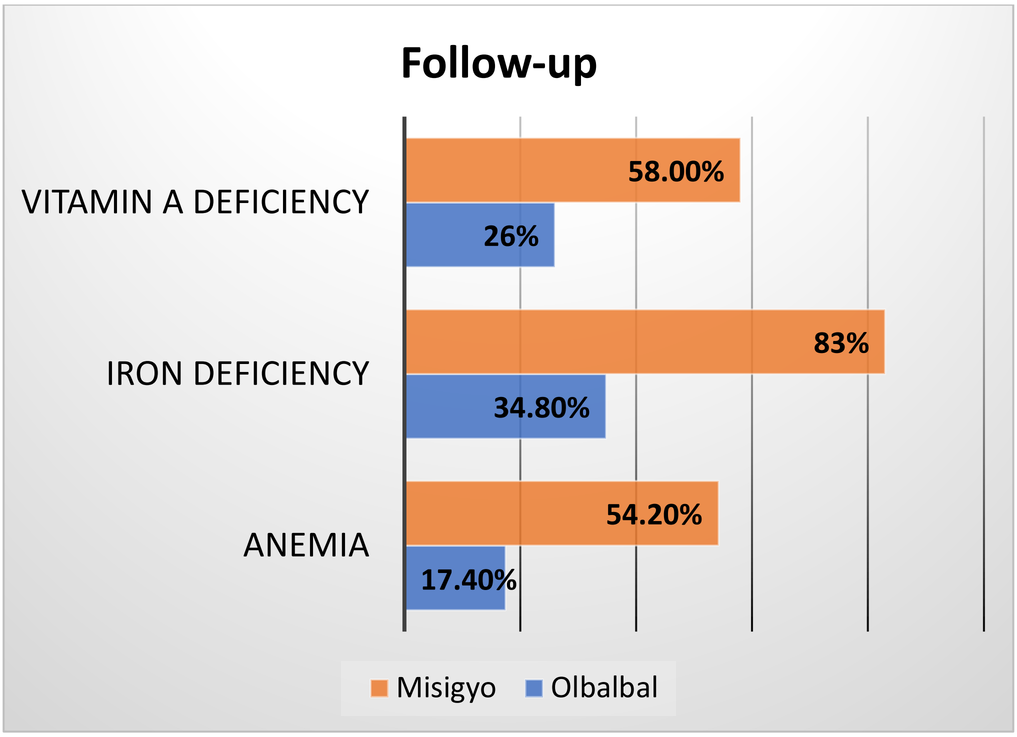

Figure 8: Proportion of vitamin A, iron deficient and anemic pregnant women during follow up.

4.1.4 Frequency of dietary intake

(i) General dietary practices during pregnancy

About 60% of the respondents did not consume barley during data collection as shown in Table 9, while 46% of the participants reported consuming liver more than three times a week and 91.4% did not consume milk. All of the study participants reported not consuming fish, chicken as well as pork during pregnancy. Nearly, all of the participants took African nightshade (94.3%) more than three times a week while all of them did not eat spider flower (100%) during pregnancy. Only 26.4% of the participants reported consuming oranges twice a week during data collection however, 94.3% did not have ripe bananas during the data collection week.

(ii) Foods mostly eaten during pregnancy

Almost all of the participants took maize (porridge) more than three times a week (87.9%) while, 26.4% of the participants preferred to take wheat (26.4%) during pregnancy (Table 9). One participant explained to have restricted her own dietary intake *"I drink porridge once in a day and do a lot of activities in order to reduce weight"* [Misigiyo-2nd Group-P3]. One woman stated the reason for reducing weight during pregnancy *"As a Maasai pregnant woman, I am not allowed to eat beans(legumes), meat, milk, rice in order to cut off weight* *and have an easy delivery"* [Olbalbal-1st Group-P1]. Furthermore, one participant explained what Maasai women eat during pregnancy in the narrative below: *"Pregnant women drink porridge, water or eat boiled maize without adding anything once in a day to survive"* [Misigiyo-1st Group-P3].

(iii) Dietary intake of fruits and vegetables

Nearly all of the participants (94.3%) reported consuming naturally grown African nightshade (mnavu) three times per week as one of the vegetables despite its foul odor; however, only 20% of the participants consumed oranges during pregnancy (Table 9). On the other hand, the majority of the study participants reported to consume vegetables during rainy season as narrated in the narrative thus; *"You have come in a rainy season, that's why you find us eating wild vegetables (wild African nightshade) as they grow during this season"* [Olbalbal and Misigiyo-1st Groups-Many]. Most importantly one participant reported not to consume vegetables as they smell bad as; *"I know it is important to take vegetables during pregnancy, but I don't consume them because they smell bad"* [Olbalbal-2nd Group-P5]

Table 9: Respondents dietary practices

Foods	Never	once	twice	3times	3-4 times	1 month ago
Cereals n (%)						
Maize	0(0)	1(0.7)	5(3.6)	11(7.9)	123(87.9)	0(0)
Wheat (breads e.t.c)	16(11.4)	17(12.1)	39(27.9)	31(22.1)	37(26.4)	0(0)
Porridge (Maize flour)	0(0)	0(0)	0(0)	69(49.3)	71(50.7)	0(0)
Rice	56(40)	8(5.7)	27(19.3)	9(6.4)	40(28.6)	0(0)
Barley	84(60)	27(19.3)	22(15.7)	6(4.3)	0(0)	0(0)
Cassava	19(13.6)	7(5)	25(17.9)	35(25)	52(37.1)	2(1.4)
Meat, Fish, Legumes, Chicken, Eggs and Nuts n (%)						
Beans (soybeans, kidney beans)	43(30.7)	33(23.6)	30(21.4)	11(7.9)	16(11.4)	7(5.0)
Cowpeas	65(46.4)	16(11.4)	41(29.3)	11(7.9)	6(4.3)	1(0.7)
Liver	5(3.6)	4(2.9)	16(11.4)	47(33.1)	64(45.7)	4(2.9)
Goat meat	40(28.6)	38(27.1)	34(24.3)	20(14.3)	8(5.7)	0(0)
Fish	140(100)	0(0)	0(0)	0(0)	0(0)	0(0)
Chicken	140(100)	0(0)	0(0)	0(0)	0(0)	0(0)
Pork	140(100)	0(0)	0(0)	0(0)	0(0)	0(0)
Cow's milk	128(91.4)	12(8.6)	0(0)	0(0)	0(0)	0(0)
Vegetables n (%)						
Amaranth	20(14.3)	17(12.1)	33(23.6)	39(27.9)	29(20.7)	2(1.4)
Spinach	48(34.3)	6(4.3)	35(25)	29(20.7)	22(15.7)	0(0)
African nightshade	7(5)	0(0)	1(0.7)	0(0)	132(94.3)	090)
Spider flower	140(100)	0(0)	0(0)	0(0)	0(0)	0(0)
Fruits n (%)						
Mangoes	125(89.3)	4(2.9)	3(2.1)	6(4.3)	2(1.4)	0(0)
Ripe bananas	132(94.3)	1(0.7)	291.4)	3(2.1)	2(1.4)	0(0)
Oranges	30(21.4)	18(12.9)	37(26.4)	26(18.6)	28(20.0)	1(0.7)

4.1.5 Feedback at the end of the study

During follow-up, the participants were invited to participate in the focus group discussion where 90% reported consuming each vegetable provided in the food basket. *"We appreciate and enjoyed the vegetables, actually, we consumed each vegetable in the food baskets"* [Olbalbal-1st and 2nd Group-Many]. However, around 10% of the participants revealed not to consume the sweet potatoes leaves and pumpkin leaves because they are not palatable, and they take long during cooking. *"I ate the vegetables in the food basket, but I don't like the sweet potatoes leaves and pumpkin leaves because they don't taste good and takes much time during preparation"* [Olbalbal1st and 2nd Groups-P3, P4, P7, P8, P24]. However, they continued suggesting collard greens and other vegetables to be included more in the food basket as quoted; *"we would wish to consume amaranth, African nightshade, collard greens and others supplied in the basket (except sweet potatoes and pumpkin leaves) because, they test good, takes few minutes during preparation and we are used to them"* [Olbalbal 1st and 2nd Groups-P3, P4, P7, P8, P24].

(i) Vegetable intake prevents different maternal complications

The study participants reported to have experienced reduced maternal complications compared to their past pregnancy/ies and they suggested that it may have been caused by dietary intake of vegetables as this was their first time consuming more vegetables during pregnancy as narrated by some of the study participants that: *"I always had headaches, swollen legs and fatigue in my past second and third trimester but in the current pregnancy the complications disappeared, I believe it may be caused by vegetables consumption"* [Olbalbal-1st and 2nd Groups-P1, P20, P13]

(ii) Importance of vegetables intake during pregnancy

At the end of the study, the participants expressed wishes in increasing vegetables consumption since it doesn't make them increase weight hence in line with their culture of food restriction to prevent big babies. Two participants reported explaining that *"It is good to consume vegetables during pregnancy since it improves health and does not increase our weight"* [Olbalbal-1st Group-P6 and P8].

4.2 Discussion

This section discusses findings from different analysis in the present study.

4.2.1 General overview

Micronutrient dietary intake plays a major role in improving maternal and child's health however, dietary intake can be influenced by nutrition knowledge. There is a direct link between nutrition knowledge and dietary intake as well as food choices (Spronk *et al*., 2014); moreover, nutrition and/or health knowledge can be highly attributed to level of education and/or cultural beliefs (Klevor *et al*., 2016). The present study found that, there was a significant increase in ferritin and vitamin A in the intervention group (Olbalbal ward) while there were no changes in vitamin A, ferritin and hemoglobin in control group (Misgiyo ward) during follow up. Furthermore, the participants had positive attitude towards micronutrients rich foods, they had knowledge especially on the importance of iron intake compared to vitamin A, yet they did not translate it into dietary practices.

4.2.2 Nutritional knowledge of the participants

The majority of the participants reported the importance of fruits and vegetables intake during pregnancy and associated dietary intake of vegetables and fruits with the increase of fetal growth and provision of energy to the pregnant mother. These findings were similar to Marangoni study who found dietary intake of iron rich foods such as green leafy vegetables play an important role in fetus growth and development (Marangoni *et al*., 2016). Furthermore, the provision of energy by dietary intake of fruits and vegetables was supported by Slavin and Lloyd (2012) who described the increase of energy after consumption of fruits and vegetables.

Surprisingly, participants from this pastoral community had knowledge of micronutrients, specifically Iron, however; those who had secondary education knew Vitamin A as found in green vegetables and fruits having red or orange color which helps in eye sight/improves vision and body immunity. This is a unique finding as most of the studies from this area did not suggest adequate micronutrient knowledge in a pastoralist society (Keverenge-ettyang *et al*., 2006; Martin *et al*., 2014; Chege *et al*., 2015; Harika and Faber, 2015; Mayanja *et al*., 2015).

Study participants identified the health consequences of food restrictions during pregnancy, such as delivery of low birth weight babies and/or difficulty during child birth (i. e., no urge to push). These are highly associated with low dietary intake. Similarly, a study done in Nepal depicted that low consumption of meat, beans, milk, green vegetables, and food taboos can lead to delivering low birth weight babies (Sharma *et al.*, 2015). Difficulties in pushing the baby during delivery as the reason for low dietary intake was in contrary to the Ozkan's study that reported the causes of no urge to push to be associated with the restriction to eat or drink fluids/foods a few hours before labour, bad position during delivery, full bladder, and the use of single pushing technique (spontaneous or coached) during delivery (Ozkan, 2017).

Furthermore, participants mentioned swollen legs and maternal/infant mortality as the symptoms and consequences of anemia during pregnancy. These findings were scientifically supported by Sabina who mentioned swollen legs as one of the symptoms of maternal chronic anemia/iron deficiency anemia (Klopovich, 1983). Additionally, Noronha and colleagues (2012) revealed that, anemia during pregnancy can lead to maternal and fetus mortality (Noronha *et al*., 2012).

4.2.3 Sources of nutrition knowledge during pregnancy

Most of the participants chose traditional birth attendants (local midwives) as their informants on nutrition/health information, such as intake of fruits with red color and green vegetables can increase body energy as well as reduce anemia. Present findings were similar to the studies done in Kenya which reported TBAs to be good advocates of nutrition to pregnant women by advising them to take fruits and vegetables for the aim of increasing blood and energy *(*Anono *et al.*, 2018; Reeve *et al*., 2016). Traditional birth attendants acquired knowledge and skills on health care, support and advice during and after pregnancy, through learned experience obtained from previous TBAs based on their traditions and customs of their society. Although, non-governmental and other training institutions that are present in different countries provides maternal nutrition trainings to TBAs (WHO, 2002).

4.2.4 Dietary practices

Dietary restriction of carbohydrate, protein and fat for the reason of having an easy delivery is still common in the Maasai community as findings from this study reported the majority of the study population did not consume cow's milk, fish, chicken and pork during pregnancy. Nutritionally it is known that, dietary intake of cow's milk, fish, pork and chicken provide the body with high to moderate amounts of calcium, omega-3-fatty acid, heme iron, and protein (Gao *et al*., 2013), which are highly needed during pregnancy and lactation. The reason for avoiding dietary intake of fish in a Maasai community was reported as, the cattle could get effects when they come in contact with fish blood (Kulindwa *et al*., 203). Furthermore, Maasai do not eat chicken as they regard them as animals from the forest and mistakenly used as food by other communities however, some of the Maasai women sell chicken eggs to earn an income (Renton, 2008). Apparently, there was no research explaining the reason for not eating pork meat in a Maasai society, more research should be done in this issue.

Nearly all of the study population reported consuming maize porridge once in a day. Currently, maize and maize porridge can be grouped together with other staple foods in a Maasai society since it has been reported by different studies as the frequently consumed food in rainy and dry seasons (Lennox *et al*., 2017; Martin *et al*., 2014a). Consuming one meal a day was similarly reported by Martin *et al*. (2014b) who showed most of the Maasai pregnant women reported consuming one meal per day. According to Tanzania food composition table, maize porridge with no milk and sugar have low amounts of minerals and vitamins compared to fruits and vegetables therefore, frequent dietary intake of maize porridge alone cannot increase the micronutrients status of Maasai pregnant women however, with maize fortification and improving dietary diversification, the micronutrients levels will increase (Tanzania Food Composition Tables, 2008).

Our study participants had good micronutrient knowledge, but they did not consume micronutrient rich foods other than African nightshade during the rainy season. Poor dietary micronutrient intake in this pastoralist society may be due to cultural dietary restrictions, prohibition to cultivate in conservation areas, lack of fresh vegetables and fruits in local markets, poor attributes of the foods (i. e., bad smell) and minimal availability of different vegetables in this area. These findings were in line with Zepro study that found low dietary intake of vegetables and fruits to the Ethiopian women to be associated with the bad smell reported by the participants (Zepro, 2015). Our findings are similar to previous studies done in Ngorongoro that found low dietary intake during pregnancy is associated with cultural restrictions and unavailability of fruits and vegetables (Martin *et al*., 2014a; Martin *et al*., 2014b). For those who consumed vegetables, African nightshade "mnavu" was commonly used. African nightshade is a wild vegetable (grows naturally during rainy season) and it is known to have high levels of potassium (K) and iron (Fe) (Burnard *et al*., 2008). According to the nutritional content of African nightshade, dietary intake may increase the level of Fe and K in pregnant women if prepared in a manner that preserves the nutrients.

4.2.5 Hemoglobin levels and anemia

According to the study setting and culture/traditions present in this community, Maasai pregnant women are not allowed to eat carbohydrate, fats, and protein foods (meat, milk, beans etc.) for the fear of delivering big babies (Lennox *et al*., 2017; Martin *et al*., 2014b). Furthermore, 90% of the pregnant women in this society attend antenatal clinics (Magoma *et al*., 2010) and are given iron supplements as recommended by World Health Organization (WHO, 2012); however, only 20% of the study participants reported consuming iron supplements. The study participants reported the reasons for low consumption of supplements to be associated with shortage of supplements in the health centers. Therefore, the preferable source of micronutrients to the Ngorongoro Conservation Area (NCA) pregnant women would be from vegetables and fruits due to their low contribution in weight increase and richness in different micronutrients, which are highly needed.

The present study found an increase of 0.01 g/dl hemoglobin after the food basket supply however, there was a statistically insignificant difference detected in the hemoglobin levels during baseline and follow-ups. This situation may explain the statistically insignificant increase of hemoglobin and ferritin after food basket supply which may be attributed by the supply of non-heme-rich vegetables and highly perishable vegetables (i.e., they cannot store for longer periods of time). Thompson explained that, vegetables have non heme-iron, which have a low absorption rate (5-10%) compared to the heme iron found in animal foods (25-40%) (Thompson, 2007).

Moreover, the NCA, which includes Misigiyo and Olbalbal wards, have a dispersed settlement which forced us to provide the food basket twice per-month (during the market days) at the clinic. This was the only reliable solution of getting all the study participants to collect the food basket due to the presence of public transports in the market days. Supplying of highly perishable vegetables twice per-month (on every 3rd and 16th each month) may have contributed to the minor increase of hemoglobin due to its short life span and increased loss of micronutrients before the next supply. Barrett (2010) explained that, green leafy vegetables are highly perishable and have a short life span of about 2-7 days therefore overstaying for more than one week might mean a loss in the number micronutrient and/or the vegetables may become spoiled.

A small increase of hemoglobin can be caused by an inability to meet the recommended 25 mg of vitamin C per-serving (Lynch and Cook,1980), since the vitamin C acts as a reducing agent for ferric iron (Fe^{3+}) found in non-heme to ferrous iron (Fe^{2+}), which is easily absorbed by the muscle cells (Teucher *et al*., 2004). The reason for this may be the short period of time of the study (6 months) which limited cultivation of the fruits rich in vitamin C (e.g. oranges) and forced us to rely on purchased fruits resulting in provision of moderate amounts of vitamin C due to market price fluctuations as well as seasonal availability of fruits.

On the other hand, the relatively small increase of hemoglobin was attributed to the minimal nutrition education provided to the study participants on good methods of cooking vegetables. Severi *et al.* (1997) suggested that education on good methods of cooking vegetables should be provided to consumers to prevent micronutrient loss. Some of the lessons taught were meant to preserve iron, for example, the liquid present after cooking the vegetables should not be discarded as iron dissolves in it.

In addition, the rise of hemoglobin in the intervention group may be related to the vitamin A rich foods supplied in the food basket. The role of vitamin A is to facilitate the use of iron for blood cells and platelets formation thus there will be an increase in hemoglobin levels (Cañete *et al*., 2017). These findings were similar to a randomized placebo control study done by Suharno that found a high increase in hemoglobin in the iron and vitamin A supplemented group compared to the single (vitamin A/iron) supplemented groups in pregnant women (Suharno *et al*., 1994).

Furthermore, there was a 13% decrease of anemia after intervention. The decrease of anemia was associated with the presence of folic acid rich vegetable (spinach) in the baskets since folic acid helps in metabolic utilization of iron therefore, there was an increase in hemoglobin which eventually reduce the proportion of anemic women. This is scientifically explained by Juarez-Vazquez (2012) who did a randomized clinical trial and reported a high increase of iron in the group supplemented with folate compared to the one supplemented with iron only (Juarez-vazquez *et al*., 2012).

4.2.6 Ferritin levels and iron deficiency

The present study found no significant difference in ferritin levels and iron deficiency at the end of the study between the groups however, there was a small increase of serum ferritin (0.49 ng/ml) found in the intervention group and decrease in the control group. Additionally, the proportion of iron deficient women decreases in the intervention group though there was no statistically significance difference seen in the proportion of iron deficient women at the end of the study between the groups. The small increase of serum ferritin and hemoglobin may be attributed to the hemo-dilution (increase of blood volume (approximately 1.5 liters) which occurs in the last trimester; hence, clinically reduce the amount of ferritin and hemoglobin (Chandra *et al*., 2012; Achebe and Gafter-gvili., 2016).

Furthermore, the minor increase of serum ferritin may be triggered by the increased use of ferritin (stored iron) in hemoglobin synthesis. These findings were similar to Milman's study (2006) which found a decrease in ferritin when hemoglobin increases; and associated it with the increased use of ferritin during hemoglobin formation. These results were in line with a study done by Makola *et al*. (2003) which found low ferritin levels after 8 weeks supply of dietary supplements in Tanzanian pregnant women. The increase of hemoglobin and ferritin in the intervention group may be attributed to the reduced consumption of calcium rich foods (i.e., milk) as one of their cultural restricted foods during pregnancy, since calcium tends to hinder absorption of iron in the body (Lynch, 2000). A study by Bivolarska *et al.* (2015) found a significant reduction in maternal serum ferritin with dietary intake of fish and cow's milk. At the end of the study there was a small mean increase of hemoglobin and serum ferritin in the intervention group and a decrease in the control group; however, due to a small sample size, the changes were statistically insignificant.

4.2.7 Serum vitamin A and vitamin A deficiency

Howson (1998) suggested that, dietary intake of plant foods (provitamin A) during pregnancy reduces vitamin A deficiency, provides different micronutrients compared to the single supplement, and prevents the risk of vitamin A toxicity (Howson *et al*., 1998). However, most food-based interventions focus on school children and leave out pregnant women who are also in need. The current study measures the effectiveness of provitamin A provided from the food basket in relation to maternal serum vitamin A. The plant food provides provitamin A which contain both alpha and beta carotene and are less absorbed (35-88%) compared to animal food, which offers a highly absorbed (70-90%) form, termed as preformed vitamin A (Tanumihardjo *et al.,* 2016).

There was a mean increase of 19 and 1.02 mcg/dl serum vitamin A in the intervention and control group respectively. The stepwise multivariate regression model indicates that the participants who had low serum vitamin A during baseline (89%) had a remarkable increase of serum vitamin A at the end of the intervention. Moreover, the reason for this shift may relate to Tanumihardjo *et al.* (2010) finding that, supplying of vitamin A rich foods to the deficient patients results in high cleavage rates of provitamin A, which contributes to the increased bio-efficacy of serum retinol.

The study participants reported to increase the small amount of fat when cooking green leafy vegetables, this practice may be associated with the increased serum vitamin A at the end of the study. The current findings are similar to the study done by Mulokozi that found a high increase in maternal serum vitamin A after frequency consumption of green leafy vegetables cooked with small amount of fat (Mulokozi *et al*., 2003). Additionally, a study done by Mills (2009) explained the use of fat during cooking to be associated with the increase of carotenoids intestinal absorption. Mills continued explaining that the moderate temperature used during cooking support the breaking of the plant matrix thus release the provitamin A which, in turn, increase its absorption in the body (Mills *et al*., 2009). Therefore, the method of cooking practiced by the participants could have contributed to an increase in serum vitamin A.

Furthermore, the high increase of serum vitamin A in the intervention group may also be associated with the zinc-rich vegetable supplied in the food basket (e.g spinach). The relationship between provitamin A absorption and dietary zinc intake was scientifically explained by Hess that, zinc acts as a cofactor of β,β-carotene 15-15'- dioxygenase 1 (BCO1) enzyme, which plays an important role in breaking down the provitamin A from plant foods to the form that is easily absorbed (retinol) in the body (Hess *et al*., 2005). The phenomenon above was proved by Dijkhuizen *et al*. (2004), who found a higher increase of maternal serum vitamin A in the zinc and beta-carotene supplemented group compared to the beta-carotene alone supplemented group.

More importantly, the increase in serum vitamin A in both groups could also be explained, in part, by the intake of deworming pills which were given to the study participants when attending to their ANCs clinics, for the purpose of preventing worm infection and increase absorption of Vitamin A. These results were in line with a Nigerian study which found low vitamin A in pregnant women having worm infection and an increase of vitamin A in those taking deworming tablets (Arinola *et al.*, 2015).

The recent study is the first to be conducted in Tanzania and indeed the first in almost the entire African continent to evaluate the effect of consumption of vegetables and fruits in the maternal serum vitamin A in a pastoral society. Most of the studies look at the prevalence of prenatal vitamin A deficiency and its related factors and found serum vitamin A to be positively associated with dietary intake of preformed vitamin A (animal), which was divergent with the current findings (Williams *et al*., 2008; Garcêz *et al*., 2016; Gebreselassie *et al.*, 2013).

Due to the scarcity of experimental studies assessing the effectiveness/role of fruits and vegetables in serum vitamin A, the current study uses dietary supplementation studies and/or studies outside Africa for comparisons. The significant increase of serum retinol may be associated with the dietary intake of vegetables and fruits present in the food basket. These findings were contrary to the findings of Mulokozi *et al*. (2003) who found no significant difference between vegetable intake and retinol status of Tanzanian pregnant women. The difference between the current and Mulokozi results may be attributed to the different study designs as the latter study assessed the participants' retinol level and related it to the vegetable intake while we experimentally measured the retinol levels of vegetable intake and non-vegetable intake participants for a period of time. Moreover, our results are in contrast to the Pee de study that found no increase in serum retinol to the Indonesian mothers after 12 weeks supply of green leafy vegetables (Pee de *et al.,* 1995).

Lastly, the nutrition/ health education provided during the course of the study might be associated with the increase in serum vitamin A in both groups. As suggested by Howson, providing nutrition education together with food interventions improves the dietary intake since the educated population would have acquired a certain knowledge (e.g. dietary intake of green leafy vegetables prevents night blindness) which trigger their dietary practices (Howson *et al.*,1998). The results were congruent to the Kidala quasi-experimental post-test study, that found a high increase of serum vitamin A in Tanzanian mothers who received nutrition education (Kidala *et al.*, 2000). Moreover, dietary intake of wild vegetables (i.e., African nightshade), as reported in frequency dietary intake in both wards may have contributed to the small increase of serum retinol in the control group.

4.2.8 Feedback at the end of the study

The study participants revealed not having swollen legs, headache and fatigue after dietary intake of vegetables. This can be explained by Klopovich (1983) thus, when a pregnant woman has anemia, she might have swollen legs and headache, but this can be corrected after dietary intake of different vegetables and/or iron supplements. Moreover, dietary intake of vegetables has been reported to small increase in weight since, vegetables provide less energy compared to carbohydrate, protein and fat (DeBruyne *et al.,* 2013), as reported by participants.

4.3 Study limitations

(i) The study failed to control consumption by the target participants, although the TBAs undertook intermittent visits to the participants to evaluate their dietary intake and advising them to continue using the vegetables and fruits.

(ii) The study failed to provide the food baskets everyday due to the dispersed settlement.

(iii) Although the study participants used traditional storage methods (i.e., clay pots), some of the green leafy vegetables could not make it to two weeks period due to lack cold storage in this community.

(iv) The majority of study participants joined the study during their 6^{th} to 12^{th} week of pregnancy, so this may have missed a crucial period where there is high need of micronutrients (such as folic acid is highly needed before conception and during the first trimester).

(v) Another limitation encountered was the communication barrier because the majority of participants could only understand Maa. Translation may cause loss of meaning in some cases.

(vi) An additional limitation was seen in the tool used in collecting food frequency. The Food Frequency Questionnaire takes account of foods eaten in a past month period which may be difficult for the participants to remember; therefore, an interviewer used probes and cues to improve accuracy of food data collected.

(vii) Lastly, data collection was done during the rainy season; this timing might have affected results due to differences in food intake (for example, during the rainy season wild vegetables like African nightshade is available for consumption).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Although dietary micronutrient intake is highly recommended during pregnancy, yet some of the societies have unavailability and inaccessibility of micronutrients rich foods as well as supplements in their Ante-natal clinics (ANCs). In addition, the study participants have good micronutrient knowledge especially in iron, but they do not translate the knowledge into dietary practices due to unavailability, inaccessibility, cultural restrictions, and conservation acts present in this community. Furthermore, Ngorongoro Conservation Area (NCA) health centers lack nutritionist, nurses and health personnel's and made the pregnant women to rely on TBAs for nutrition knowledge and other maternal health care. For this matter, TBAs must be trained on maternal nutrition and care to the pregnant women.

Overall, the evidence from this study indicates that food basket and nutrition education as interventions could be used together in reducing micronutrient deficiency in the developing countries especially to the pastoralist societies. As the current study revealed a significant reduction of maternal vitamin A deficiency after the food basket intervention, food-based approach can be considered in combating micronutrient deficiency, malnutrition related diseases and increase dietary practices and diversity in pastoralist communities.

5.2 Recommendations

Based on the conclusion above, the study provides recommendations below:

(i) The nutrition policy makers should formulate polices which emphasize increasing consumption of fruits and vegetables during pregnancy as this is the safest way of reducing vitamin A deficiency yet prevent toxicity.

(ii) In order to ensure year-round availability of fruits and vegetables in NCA, the Ministry of Agriculture should train the members of the community on how to dry the vegetables during the high seasons so that they can still have supplies the vegetables (dried) in the NCA even in low seasons.

(iii) The community/traditional/religious leaders (e.g Laigwanan, elders) should be trained by nutritionists and health professionals on the importance of vegetables/fruits intake among pregnant, lactating women, women of reproductive age as they are the most influential persons in the community. Therefore, winning them ensures knowledge transmission and uptake in the community.

(iv) Young girls should be encouraged to continue with secondary school education, while health and nutrition components should be taught to traditional birth attendants to improve maternal and child health.

Moreover, the study provides recommendations for future studies such as:

(i) Further studies on maternal micronutrients in pastoral societies should be done with a large sample size using mixed methods approaches and assess the micronutrients levels of the born babies.

(ii) Future studies should provide fewer perishable vegetables in order for them to stay longer.

(iii) In addition, vitamin B_9, vitamin B_{12}, zinc, serum carotenes (alpha and beta) can be biochemically measure as they are the crucial micronutrients needed during pregnancy.

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APPENDICES

Appendix 1: FAO KAP Questionnaire for pregnant women

Questionnaire ID…………………, Village……………. Hamlet …………

Village leader name………………………………….

SECTION A: General Information

1. Which ward are you from?
2. How long have you lived in NCAA?
3. Who is your nearest female supporter? ………
4. And/or family member…………

SECTION B: **Socio-demographic characteristics**

5. Age of respondent (completed years): ……………….
6. Marital status:

   1. [] Single
   2. [] Married/cohabiting
   3. [] Divorced/separated
   4. [] Widowed

7. Occupation:

   1. [] Pastoralist
   2. [] Petty businesswoman
   3. [] Civil servant
   4. [] Student
   5. [] Unemployed
   6. [] Other (specify) ....

7. How many pregnancies have you had? …………, number of children…………

8. Name of nearest health facility………………….and the distance to the nearest health facility (hours)…………….

SECTION C: Knowledge/Awareness

Q1. Which foods do you eat mostly? (Circle the correct answers)	a) Fruits Vegetables b)Cereals(mazie,e.t.c) c)Meat andlegumes d)Meat products e) Mention…….	
Q2. Which foods do you think a pregnant woman is supposed to eat? (Circle the correct answers)	a) FruitsandVegetables b) Cereals(maize) c)Meat andlegumes d)Meat products e) Other ………..	
Q3. From your local foods, which ones are rich sources of vitamins and minerals? …………………		
Q4. Is it important to take vitamins and mineral rich foods during pregnancy? (Circle the correct answer)	a) Yes (b) No	If no, go to question 6
Q5. If yes in Question 4 what is the main reason?		
Q6. How should a pregnant woman eat in comparison with a non-pregnant woman to provide good nutrition to her unborn baby? (Put a tick in the correct answers) 1……………………………………….Eat more food (more energy) (Eat more at each meal (eat more food each day)/ Eat more frequently (eat more times each day))	1. () 2. () 3. ()	

2. Eat more protein-rich foods 3. Eat more iron-rich foods 4. Use iodized salt when preparing meals 5.Other 7. Have you heard about anemia?	4. () 5... a) Yes (b) No	
Q8. If Yes in Q7, where did you get information about anemia? (Put a tick in the correct answers) 1. Family members/relatives 2. Friends/peers 3. Health personnel/community health workers/Traditional Birth attendants. 4. Radio/television 5. At school 6. At meetings in the village/religious gatherings 7. Another place (specify) ………………………………………	Yes No [] [] [] [] [] [] [] [] [] [] [] [] [] []	
Q9. Have you come across anyone who was said to be having anemia (either in your village or at a health facility)?	1. [] Yes 2. [] No	If no, go to question 11
Q10. If YES in Q8, Q9, what do you understand by the term anemia: ……………………………………………		
Q11. Could you please tell me what are the reasons that make pregnant women become anemic: (Put a tick in the correct answers) 1. Inadequate intake of foods rich in specific nutrients like iron, folic acid and vitamin C 2. Diseases such as malaria and worm infestation. 3. Poverty 4. Bleeding as it occurs during menstruation, delivery and in accidents	Yes No [] [] [] [] [] [] [] [] [] []	

5. I don't know 6. Others (specify) …………………………………………………	[] []	
Q12. Could you please tell me the symptoms/sign of which an anemic pregnant/person can have? ………………………………………………………………		
Q13. Can you please tell me the effects of anemia/ low blood in pregnant women? ……………………………………………………………… Q14. Have you heard about vitamin A deficiency and/or night blindness? Q15. If Yes in Q14, from where did you get information about Vitamin A deficiency/ night blindness? (Put a tick in the correct answers) 1. Family members/relatives 2. Friends/peers 3. Health personnel/community health workers/Traditional Birth attendants. 4. Radio/television 5. At school 6. At meetings in the village/religious gatherings 7. Another place (specify) …………………………………………	a) Yes (b) No Yes No [] [ ] [ ][] [][] [][] [][] [][]	
Q16.Have you come across anyone who said to be having Vitamin A deficiency/night blindness? Q17. If YES in Q16, what do you understand by the term Vitamin A deficiency: (Put a tick in the correct answers) 1. Failure to see at mid night 2. Low immunity in the body 3. Reduced amount of iron in the blood 4. Reduction in the amount of blood in the body 5. I don't know/remember	a) Yes (b) No Yes No ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	If no, go to question 18

Q18. Could you please tell me what are the reasons that make pregnant women become Vitamin A deficiency: (Put a tick in the correct answers) 1. Inadequate intake of fruits and vegetables. 2. Diseases such as malaria and worm infestation. 3. Poor intake of food. 4. Poverty 6. I don't know 7. Others (specify) ………………………………………………	Yes No ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	
Q19.Could you please tell me the symptoms/sign of which a Vitamin A deficiency pregnant woman can have:(Put a tick in the correct answers) 1. Failure to see at night. 2. Increased sequences of diseases. 3. Preterm delivery. 4. Other symptoms (specify) …………………………………………………………………..	Yes No ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	
Q20. Can you please tell me the effects of Vitamin A or night blindness in pregnancy women? (Put a tick in the correct answers) 1. Can lead to anemia. 2. Poor pregnancy outcomes such as low birth weight, abortions, and premature babies 3. Increased susceptibility to infections because of decreased immunity 4. Increased maternal mortality 5. Other effects (mention) ………………………………………………………………	Yes No ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	

SECTION D: Prevention

Q1. Could you tell me some ways, which can be used to prevent and control anemia? (Put a tick in the correct answers) 1. Eat nutritious foods like meat, fish, liver, sardines (dagaa) and eggs 2. Use of iron supplements 3. Prevent from getting diseases such as malaria, parasitic infections, and schistosomiasis 4. Eat fruits like oranges, pawpaw's, baobab (ubuyu) and tamarind fruit (ukwaju)	Yes [] [] [] []	No [] [] [] []	

5. Eat vegetables like cassava leaves, sweet potato leaves, pumpkin leaves, spinach, amaranth 6. Other measures (specify) …………………………………………………………………	[] []	[] []	
Q2. According to your understanding, do you think different types of foods can help to prevent or treat anemia?	1. [] Yes	2. [] No	
Q3. If Yes in Q2, could you mention some foods that you think can prevent one from becoming anemic, or increase the level of blood in the body? (Put a tick in the correct answers) 1. Foods of animal origin: Meat, eggs, fish, kidneys and poultry 2. Foods of plant origin such as: Dark green leafy vegetables, pulses, maize and other cereals 3. Fruits like oranges, mangoes 4. Vegetables like amaranth, spinach, sweet potatoes leaves, pumpkin leaves. 4. Other foods (specify) ………………… 5. I don't know	Yes [] [] [] [] []	No [] [] [] [] []	
Q4. According to your understanding, do you think different types of foods can help to prevent or treat Vitamin A deficiency? (Put a tick in the correct answers) Q5. f yes in Q4, what kind of foods do you think can prevent and control Vitamin A/ night blindness? 1. Eat nutritious foods like meat, fish, liver, sardines (dagaa) and eggs 2. Eat fruits like oranges, pawpaws, baobab (ubuyu) and tamarind fruit (ukwaju) 3. Eat vegetables like cassava leaves, sweet potato leaves, pumpkin leaves, spinach, amaranth 4. Other measures (specify) …………………………………………………………………	Yes () No( ) Yes [] [] [] [] [] []	 No [] [] [] [] [] []	

SECTION E: Attitude about dietary micronutrient intake

I would like to ask a few questions about your opinion and ideas on diet needs. (Circle the response that is closest to how you feel)

1: How good do you think it is to eat more food during pregnancy?

1. Not good 2. You're not sure 3. Good

If not good: Can you tell me the reasons why it is not good? ....

2.How difficult is it for you to eat more food during pregnancy?

1. Not difficult 2. Ok 3. Difficult

If Difficult: Can you tell me the reasons why it is difficult? ....

3: It is good to take vegetables and fruits during pregnancy for the health of the unborn baby and mother.

1. Not good 2. You're not sure 3. Good

If not good: Can you tell me the reasons why it is not good?.....................................

4. During pregnancy, is it good to take more vegetables than before pregnancy?

1. Not good. 2. You're not sure 3. Good

If not good: Can you tell me the reasons why it is not good? ....

5.How good do you think it is to prepare meals with vitamin-A-rich foods such as carrots, green leafy vegetables, sweet potatoes or liver?

1. Not good 2. You're not sure 3. Good

If not good: Can you tell me the reasons why it is not good? ....

6.How good do you think it is to prepare meals with iron-rich foods (spinach, liver, meat)?

1. Not good 2. You're not sure 3. Good

If not good: Can you tell me the reasons why it is not good? ....

SECTION F: Practices on dietary micronutrient intake

Please keep a record of what you eat every day for a period of seven days. Just put a tick mark in the correct column about how many times over the last month you have eaten each item.

Food frequency questionnaire for 7 days						
List of foods	**Never**	**Once**	**Twice**	**3 Times**	**≥ 3 times**	**1month ago**
a) Main staples						
Maize						
Wheat,						
Sorghum or millet						
Other staples (mention)						
b) Legumes						
Cooked beans						
Soy beans						
Pigeon peas						
Other legumes (mention)						
c) Food of animal origin and its products						
Liver						
Goat meat						
Milk						
Fish						
Poultry						
Pig						
Another animal origin (mention)						
d) Vegetables and Fruits						
Amaranth						
Spinach						
Nightshade						
Oranges						
Spider flower						
Other vegetablesand fruits (mention)						
e) Vegetables from Food Basket						
•Spinach						
•Sweet potatoes leaves						
•Amaranth						
•Pumpkin						
•Pumpkin leaves						

Appendix 2: Focus group discussion-guide

1. What foods do you normally eat (before, during pregnancy)?

Probe: What do you want to be eating before and during pregnancy?

2. What do you understand by the term's vitamins and minerals in relation to food?

Probe: Can you give me a few examples of vitamins and minerals?

OR if no, interviewer to provide a few examples of vitamins and minerals.

Probe: Can you describe why we need vitamins and minerals?

3. Which foods do you think are most important during pregnancy?

Probe: Why do you think so?

Probe: If they don't mention vegetables, ask them what they think about vegetables

4a. Tell me what you know about anemia (describe the symptoms)?

Probe: Have any of you experienced these symptoms? And/or have you ever seen somebody having these symptoms?

Probe: How does anemia relate to food intake?

4b. Can you tell me the effects of anemia on pregnant women?

4c. Can you tell me any preventive measures for anemia?

Probe: Intake of vegetables?

5a. Tell me what you know about vitamin A deficiency and/or night blindness?

Probe: Have any of you experienced these symptoms? And/or have you ever seen somebody having these symptoms?

Probe: How does Vitamin A deficiency relate to food intake?

5b. Can you explain the effects of vitamin A deficiency during pregnancy?

5c. Can you tell me any preventive measures for vitamin A deficiency?

Probe: Intake of vegetables?

6. Which foods do you think are rich sources of Vitamin A,

Which foods do you think are rich sources of Iron?

7. Are pregnant women allowed to eat all kinds of foods?

If not, why?

Probe: Do you think these belief and attitudes are changing?

Probe: What are your personal opinions of these beliefs and attitudes?

Appendix 3: Ethical clearance

THE UNITED REPUBLIC OF TANZANIA

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NIMR/HQ/R.8a/Vol. IX/2708

01st March 2018

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Nelson Mandela African Institute of Science and Technology
C/o Dr. Haikaeli Martin
Nelson Mandela African Institute of Science and Technology
P. O. Box 447
Arusha

RE: ETHICAL CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Effectiveness of food baskets in reducing micronutrients deficiency among pregnant maasai women in Ngorongoro district (Mshanga N. *et al)* has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine as per NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Ngorongoro

Approval is valid for one year: 01st March 2018 to 28th February 2019.

Name: Prof. Yunus Daud Mgaya

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY DEVELOPMENT, GENDER, ELDERLY & CHILDREN

CC: RMO of Manyara
DMO/DED of Ngorongoro.

Appendix 4: Table of themes emerging during focus group discussion

Themes	Narrative	Respondent
1.Vegetables are essential to our body.	*"I know that fruits and vegetables treat anemia, but I don't know what vitamins are, their source and the role they play inside the body"*	Misigiyo-1st Group-P7
2.We know anemia/iron, not vitamin A.	*"I know that fruits and vegetables treat anemia, but I don't know what vitamins are, where are they found and the role they play inside the body"*	Olbalbaland Misigiyo-1st and 2nd Groups-Many
3. Vegetables are important, yet we don't consume.	*"I know it is important to take vegetables during pregnancy, but I don't consume them because they smell bad"*	Olbalbal-2nd Group-P5
	"I don't like to take vegetables however I do take it since I don't have any other option"	Olbalbal-1st Group-P3 and Misigiyo-2nd Group-P4.
4.TBA's and nurses are our nutrition informants.	*"I was advised by a traditional birth attendant on dietary intake during pregnancy"*	Misigiyo-1st Group-P2
	"nowadays, we are taking vegetables, fruits and beans after been advised by nurses when visiting ANC's"	Olbalbal- 2nd Group-P2, P5 and Misigiyo-1st Group-P1, P3.
5. I delivered a low birth weight baby due to	*After food restriction during*	

food restriction.	*pregnancy, I deliver(ed) a low birth weight baby with poor health"*	Olbalbal-1st Group-P7.
6. Cultural food restriction during pregnancy.	*"Pregnant women drink porridge, water or eat boiled maize without adding anything once in a day to survive"*	Misigiyo-1st Group-P3.
	"we are not allowed to eat beans because a pregnant woman will gain weight and become overweight hence get difficulties during delivery"	OlbalbalandMisigiyo-1stand2nd Groups-Many
7. Increase vegetables consumption during rainy season.	*"You have come in a rainy season, that's why you find us eating wild vegetables (wild African nightshade) as they grow during this season"*	OlbalbalandMisigiyo-1st Groups-Many