Culturally-determined differences in vitamin A and iron deficiency between girls and boys in Machakos and Makueni Counties, Kenya

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LIST OF ABBREVIATIONS

24HR:	24 Hour recall
AEZ:	Agro-Ecological Zone
AGP:	Serum α-1-acid glycoprotein
ASAL:	Arid and Semi Arid Land
CIFSRF:	Canadian International Food Security Research Fund
CPHR:	Center for Public Health Research
CRP:	C - reactive protein
DDS:	Dietary Diversity Score
DFATD:	Department of Foreign Affairs, Trade and Development
ELISA:	Enzyme Linked Immunosorbent Assay
FFQ:	Food Frequency Questionnaire
FG:	Farmer Group
HB:	Hemoglobin
HDDS:	Household Dietary Diversity Score
HPLC:	High Performance Liquid Chromatography
IDA:	Iron Deficiency anemia
IDDS:	Individual Dietary Diversity Score
IDRC:	International Development Research Centre
INREF:	Innovation of Resilient Farming Systems and Food Security
IVACG:	International Vitamin A Consultation Group
KARI:	Kenya Agricultural Research Institute
KARLO:	Kenya Agricultural and Livestock Research Organization
KCDF:	Kenya Community Development Foundation
KDHS:	Kenya Demographic Health Survey

KEMRI: Kenya Medical Research Institute

LM: Low midlands

NGO: Non Government Organizations

NFFA: National Food Fortification Alliance

NMCC: National Micronutrient Control Council

RBC: Red Blood Cell

RDA: Recommended Daily Intake

VAD: Vitamin A Deficiency

WDDS: Women Dietary Diversity Score

WHO: World Health Organization

Z-score: Standardized scores/variables for population with normal distribution

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Special thanks go to my family for their prayers and encouragement, not forgetting appreciating my late father's contributions and supportive role up till the time God allowed him to.

Last but not least, I thank the Almighty Farther for giving me the opportunity, strength and wisdom to get through to this point.

PREFACE AND CONTRIBUTION OF AUTHORS

This study is a part of a bigger project entitled "Innovation of Resilient Farming Systems and Food Security in Semi-arid Midlands of Kenya (INREF)" aimed at increasing agricultural production through introduction of gender responsive technologies and innovations with a focus on agriculture, women empowerment and nutrition status. The overall project is a collaboration of several institutions; Kenya Agricultural Research Institute (KARI currently KARLO), Kenya Medical Research Institute-Center for Public Health Research (KEMRI-CPHR), FreshCo seed company and McGill University- Faculty of Agriculture and Environmental Science.

The analysis of Retinol Binding Protein (RBP), C-reactive protein (CRP) and α-1-acid glycoprotein (AGP) using Enzyme Linked Immunosorbent Assay (ELISA) was done in 'VitMin Lab' laboratory in Willstätt, Germany conducted by Dr. Juergen Erhardt PhD.

The author of this thesis had several roles in the study including:- Household listing for sample selection, community sensitization for the project, procurement and distribution of supplies for field work, organization of training of field work personnel, clinician and nutritionist in the field, data entry and data analysis.

ABSTRACT

Although malnutrition and micronutrient deficiency command global interest, the effect of gender favoritism on the nutrition status of infants and young children has not been extensively studied. In most developing countries, the nutritional standing of infants and young children is influenced by social cultural and traditional feeding practices with a gender bias in favour of the male child contributing to differences in prevalence of malnutrition between boys and girls related to disparities in levels of micronutrient intake. The study examines relationships and determinants of vitamin A and iron in infants and young children (6 to 36 months) of Machakos and Makueni Counties in Kenya, with a focus on variations and differences of micronutrient levels and dietary diversity score between the boys and girl as influenced by culture and taboos.

Data collected included: anthropometry, C-reactive protein, α-1-acid glycoprotein, retinol binding protein (RBP), hemoglobin, dietary intake, culturally prohibited foods and mother's demographic and economic characteristics. Pearson and Fisher's exact tests were used to determine correlations and relationships with a confidence interval of 95% applied. Data for 277 children were analyzed after adjustment for inflammation using CRP and AGP. Prevalence of anemia was 35.3% with a mean (standard deviation) of 11.4(1.4) g/dL. Prevalence of vitamin A deficiency (VAD) was 42.6% with a mean of 0.94µmol/L. 35.7% of the children were stunted with a mean of -1.5(±1.3). DDS showed that 76.6% of the children had a low DDS (≤ 3 food groups). No significant difference was observed ($p > 0.05$) in prevalence of anemia, VAD and low DDS between male and female children. A few locations had cultural/traditional forbidden foods like raw animal blood, meat from stomach of goat, meat, honey and fats. Relationship between anemic and VAD children was significant (p=0.03), with an odds ratio of (OR=1.59; 95% CI = 1.17, 2.16. A significant difference (p=0.01) was also observed between low education of child's mother/caregiver and child's DDS.

Tradition/cultural practices that prohibit consumption of certain foods does lead to low dietary diversity score causing micronutrient (iron and vitamin A) deficiency which reflects on the poor nutrition status of the IYC. However, the "Action Plan 2012-2017" put in place by the Kenyan Government's Ministry to improve nutrition status reduces the bias in micronutrient deficiencies between boys and girls by wiping out myths centered around feeding practices.

RÉSUMÉ

Bien que la malnutrition et la carence des micronutriments sont des sujets importants dans la discussion globale, l'effet de la discrimination entre les sexes sur la nutrition des nourrissons et jeunes enfants n'a pas été largement étudié. Dans la plupart des pays en développement, l'état nutritionnel des nourrissons et jeunes enfants est influencé par les normes d'alimentation sociale, culturelle et traditionnelle qui ont un favoritisme pour l'enfant male. Ceci cause des différences dans la prévalence de la malnutrition entre les garçons et les filles qui sont ensuite relié à des disparités dans les niveaux d'apports de micronutriments. Le but de cette étude est d'examiner les relations et déterminants de la vitamine A et le fer dans les nourrissons et jeunes enfants (6 à 36 mois) venant des régions de Machakos et Makueni au Kenya, avec un accent sur les variations et différences des niveaux de micronutriments et les scores de diversité alimentaire entre garçons et filles étant influencé par la culture et les tabous.

Les données recueillis comprenaient : l'anthropométrie, la protéine C réactive (CRP), l'alpha-1-glycoprotéine acide (AGP), la protéine de liaison du rétinol (RBP), l'hémoglobine, l'apport nutritionnelle, les aliments culturellement interdits, la démographique de la mère and les caractéristiques économiques. Le Test du X^2 et le Test exact de Fisher ont été utilisé pour déterminer les corrélations et liens avec un intervalle de confiance de 95%. Des données de 277 enfants ont été analysées après des ajustements pour l'inflammation à l'aide de CRP et AGP. La prévalence de l'anémie était à 35.3% avec une moyenne (l'écart type) de 11.4 (1.4) g/dL. La prévalence de la carence en vitamine A (VAD) était 42.6% avec une moyenne de 0.94 µmol/L. 35.7 % des enfants était en retard de croissance avec une moyenne de -1.5 (±1.3). Les scores de diversité alimentaire (DDS) étaient faibles pour 76.6 % des enfants (3 groupes alimentaires). Aucune différence significative ($p > 0.05$) n'a été observée dans la prévalence de l'anémie, la carence en Vitamine A et des DDS faibles entre des enfants mâle et femelle. Quelques emplacements interdisaient des aliments comme le sang cru d'animale, la viande de l'estomac de mouton, la viande, le miel et les matières grasses pour des raisons culturelles et/ou traditionnelles. Les relations entre les enfants anémique et en carence de Vitamine A était significatif ($p = 0.03$), avec un odds ratio (rapport des chances) de 1.59; 95% CI = 1.17, 2.16. Une différence significatif ($p = 0.01$) était aussi observé entre un faible niveau d'éducation de la mère/soignant et le DDS de l'enfant.

Les pratiques traditionnelles et culturelles qui interdissent la consommation de certains aliments mènent à des faibles scores de diversité alimentaires. Cela cause une carence de micronutriments (Vitamine A et fer) qui souligne le mauvais état nutritionnel des nourrissons et jeunes enfants. « Action Plan 2012-2017 » est une solution mise en place par le ministère du gouvernement pour améliorer cet état nutritionnel en effaçant les mythes de pratiques d'alimentation. Cette solution pourra ainsi progressivement éliminer les disparités de carence de micronutriments qui existe entre les garçons et les filles.

INTRODUCTION

Among a number of factors can lead to food insecurity, harsh climatic conditions deter ample food supply, hence making food commodities unaffordable and unavailable (1). Machakos and Makueni Counties are some of the areas in Kenya prone to harsh climate, with low rainfall between 500-800 mm in a year, high evaporation rate and seasonal rivers (2). This area is considered arid and semi-arid and the water scarcity leads to low farm produce (population relies on subsistence farming for household consumption and income generating activity). This ultimately affects the dietary intake of the local population (2).

As well in this area traditional and cultural influences on feeding practices affect the utilization aspect of food insecurity. The practices that forbid a certain group of people from eating certain foods, affect their dietary intakes and this affects their micronutrient intake leading to malnutrition (3). Among the major micronutrients that are of concern deficiency in iron and vitamin A in an individual, especially an infant or young child (IYC), can lead to morbidity and irreversible effects if not attended to (4).

Infants and young children are vulnerable to micronutrient deficiencies as they are not fully developed. Their full development and functionality of their immune systems largely rely on their micronutrient intake. If IYC are forbidden to eat certain foods that are major sources of vitamin A or iron because of traditions/ cultural beliefs, they suffer from vitamin A deficiency and anemia respectively, leading to their development being impaired in one way or another (5).

Different communities have different traditions/ cultural practices that influence their feeding practices. Some of these tradition/cultural practice have a gender bias in favor of the boy child (6). This means that the girl child is forbidden from consuming certain foods due to cultural reasons, which leads to girl child having a lower dietary intake than the boy child in certain food groups. If this is the case then nutrition status for the boys and girls are not the same (7).

To show that the tradition/ cultural beliefs leads to difference in dietary intake between boys and girls, a full nutrition assessment on the IYC should be carried out including:- micronutrient analysis (vitamin A and iron), dietary intake (24 hour recall and food frequency questionnaire),

anthropometric assessment and culturally forbidden foods (8). Nutrition assessment data for girls is compared to that of boys to determine if the difference is significant (7).

To be able to determine and show effectively that tradition, taboos and cultural influences affect micronutrient intake, information on dietary intake (24 hour recall and food frequency questionnaire) and foods that were culturally prohibited to the girl child should be recorded (6). This information is used to see what the dietary diversity score of the IYC are and if the information on culturally forbidden foods is reflected in the dietary intake.

The analysis of both vitamin A and iron should be assessed and compared to dietary intake information so as to determine a relationship and also establish the extent traditionally prohibited foods affect vitamin A and iron status.

LITERATURE REVIEW

Food insecurity is the inaccessibility, unaffordability and unavailability of food; it can either be chronic or transitory (1). In Eastern Kenya, a region generally considered semi arid, food insecurity is transitory as it occurs during seasons in which there is low rainfall or no rainfall at all (2). Other than rainfall/precipitation patterns, there are numerous other factors that exacerbate the precarious food insecurity situation in the region, from political down to household level (9, 10).

With food insecurity, comes cases of nutrition insecurity, which according to Bohle *et al*, may be defined as an unsatisfactory nutrition status of an individual (1). ***Malnutrition*** can be described as when the nutrient intake and requirements of an individual are not balanced resulting in low levels of proteins, energy and micronutrients that lead to adverse effects (11). In infants and young children, some of the effects include child morbidity as well as mortality in approximately one-third of children less than 5 years of age (10). According to the 2008 Kenya Demographic Health Survey (KDHS) carried out on children younger than 5 years of age, the prevalence of malnutrition in Kenya was high. In Eastern province, the survey reported that 40% of infants and young children were stunted, 7.0% wasted and 19.9% underweight (12). The recent KDHS study carried out in 2014 indicated that the nutrition indicators improved across the board with Eastern province having 38.3% of the children stunted, 5.6% wasted and 14.4% being underweight.

Micronutrients are nutrients that our bodies require in small amounts but cannot synthesize. In infants and young children, deficiencies in these nutrients, which are acquired from plant and animal sources, increase the risk of adverse outcomes such as irreversible damage if not addressed adequately/sufficiently and in good time (4). Over and above malnutrition, food insecurity instigates micronutrient deficiencies, which in turn can result in long term or even fatal effects in affected individuals (13).

To tackle the issue of food insecurity within Eastern Kenya, where communities predominantly enjoy starch based diets, many interventional programmes have been launched by different organizations, community and non-governmental organizations (14). The bulk of these programmes endeavor to introduce agricultural interventions which aim to increase crop productivity and improve nutritional status through the introduction of drought resistant varieties

or varieties of fortified seeds in addition to other relevant interventions such as agricultural extension, as well as through distribution of micronutrient sprinkles or supplements. The aim of food based agricultural interventions is to bolster food production and increase dietary intake with the key outcome of improving nutrition status (15). The effectiveness of these agricultural interventions is assessed through the use of indices and markers that monitor agricultural productivity and nutrition status that include biochemical and anthropometric assessments (16).

Intracultural feeding practice

The term intracultural refers to behaviors practiced within a particular community while intercultural is applied to those being practiced among several different communities and that can be borrowed/ adopted from other communities. In this case the particular behavior in focus is eating/ feeding practices. Studies have shown variations in micronutrient levels between boys and girls of young age (7).These variations can be attributed to different intracultural feeding practices and social norms. Kenya has diverse cultural practices that are upheld in most rural communities and this influences eating habits at communal level (17). Some practices centered on feeding are biased against the female child thus connecting gender bias to prevalence of nutrition deficiency.

Gender inequality in terms of nutritional status can be attributed to a number of factors, some of which can be traced as far back as the maternal mother's nutritional status; poverty can have cascading effects on the health of the fetus through to childhood, ultimately impacting on the community as a whole (6). As some see it, the girl child is disadvantaged from birth as shown in a study by Osman *et al* 2003 conducted in Bangladesh, India which reported the girl child being treated unequally in terms of nutrition intake from neonatal period up to childhood. The study exposed a gender gap in which 54.2% of girls were found to be severely malnourished compared to 45.8% of boys (18, 19).

In many cultures, females (including girls) are expected to consume less, and grow smaller to keep their bodies fit to do household chores and more attractive. This is an ingrained cultural bias experienced in South Asia, Africa and parts of Mexico (20); it depends largely on social and economic context of the household and/or the community (21). For instance, in some African

communities it is believed that animal proteins, especially if obtained from chicken, may lead to infertility if consumed by female members of those communities (3). It is also observed in households which are food insecure, that the female child is more likely to experience food insecurity than the male child (22).

In Northern Kenya a study on prevalence of iron deficiency showed that girls were 2.4 times more likely to be affected than boys (5). Cultural practices in that region dictate that the boys are fed "hard" foods such as blood which is iron-rich, while the girls are fed "soft" foods such as maize meal porridge (uji). It is the community's belief that the boy child will benefit more from "hard" foods (5).

A study carried out by Ndiku *et al* 2010 on children less than 5 years of age in Mwingi and Makueni in Kenya, showed that the prevalence of poor nutrition was higher in girls than boys. Boys were getting a higher energy intake from consuming more grains, while the girls' had a lower energy intake from consuming less. This consequently resulted in an increase in the girls' susceptibility to infections (7).

Conflicting papers

Contrary to the literature in support of the theory that girls are more malnourished, there are other studies that report prevalence in malnutrition is higher in boys than in girls. One paper attributes it to evolution, explaining that natural selection in a bid to ensure reproductive success, favors the female child due to their maternal ability. This causes male children to be more susceptible to environmental stress in their early life than the female child (23).

From a dietary intake point of view, the fact that boys are more energetic than girls and run around more, if they are fed the same amount of food as girls their high physical activity is sure to dispense a lot of energy and not put on weight as much as the girls; hence, this can be indicated through the z-score depicting boys to be more malnourished than the girls (24).

Data from Kenya Demographic Health Survey from 2008-09 (KDHS) reported that in children under the age of five years in Eastern province of Kenya, boys were more malnourished than

girls. 33.1% of stunted children were girls and 37.3% were boys. In wasting, 7.4% were boys and 5.6% girls; while in underweight 16.4% were boys and 15.5% were girls (12).

Nutrition assessment

Nutrition assessment involves assessing several aspects including anthropometric indices, biochemical assessments and dietary intake. These assessments give a complete picture of the nutrition status of an individual and population under study (8).

I. Anthropometric assessment

Anthropometric measurements are the easiest, quickest and most accurate method of determining body size, if executed accurately. Anthropometric measurements are applied in combination with Body Mass Index (BMI) in epidemiological studies to determine changes after nutrition intervention as well as under-nutrition or obesity (25).

Anthropometric measurements include weight, height, length, skin folds and circumferences of waist, head and arm. They are non-invasive and measurements can be taken in health facilities or in the fields using portable instruments. Choice of anthropometric measurement depends on the aim of assessment, equipment, funds available, respondent being measured and skills of the observer taking the measurement.

Weight is measured using weighing scales and can depict if an individual is suffering from underweight by having low weight for their age (WAZ). WAZ is a sensitive indicator for wasting in children. Weight measurements combined with height/length data can be used to determine wasting. Wasting is where an individual has low weight for his/her height (WHZ) as a result of acute shortage of food or infections and diseases (44, 45).

Height is measured using a portable headboard or a stadiometer. In children under the age of 2 years, length is measured where the child lies down on a height board facing up (**Appendix 2.2**). Length and height measurements are used to determine growth and from this stunting. If a child has inadequate nutrient intake, it results in slow skeletal growth and ultimately the child's height/length is low for their age. Low height for age is called stunting and depicted as (HAZ) (45).

BMI is calculated as weight in kilograms (kg) divided by height^2 in meters squared (m^2). BMI is used for screening underweight (<18 kg/m^2), underweight (18-24.9 kg/m^2) and overweight (≥25 kg/m^2). This is usually done for adults and not infants and young children (26).

II. Biochemical assessment

This is considered objective in assessing nutritional status because it chemically measures the nutrient components in the body. Biochemical assessments can only be done in laboratories using standard operating procedures. Some of the analyses include retinol binding proteins, hemoglobin, malaria and response proteins e.g. CRP and AGP which act corrective indicators (27). Depletion of nutrients especially vitamins occurs in two stages: i) depletion of nutrients in body stores is characterized by a decrease of nutrient in urine, but blood levels typically remain unchanged; and ii) decrease in nutrient concentration in blood and tissue (28).

Iron and Hemoglobin

Iron is a micronutrient essential to several metabolic processes including carrying oxygen from lungs to the rest of the body with hemoglobin cell as its carrier/transporter. There is a strong positive correlation between iron and hemoglobin, thereby suggesting that if iron levels in the body drop, so will the amount of viable hemoglobin cells that require iron attached to the red blood cell for function, eventually this results in low oxygen levels in the body (29).

Hemoglobin is a vital component in blood whose functional effectiveness can be distorted by a range of factors including infections; deficiencies of micronutrients such as vitamin A, B12 and iron; infectious diseases; biological variation; and race (25). 70% of iron present in the human body is contained in hemoglobin, where it is essential for its biochemical function. Hemoglobin is the prosthetic protein of the heme molecule and in this form it is also called iron protoporphyrin IX (30).

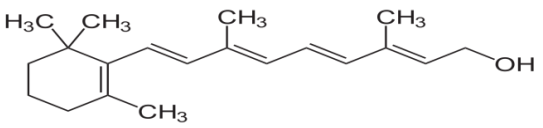
Iron deficiency anemia (IDA) is a condition common in infants, young children and pregnant women. The criterion for diagnosing anemia is having hemoglobin levels lower than 11g/dL. Infants and young children are at high risk as they require iron to support their rapid growth. Furthermore, iron deficiency can be carried from the neonatal stage into childhood (19). Effects of IDA in infants and young children include growth retardation, poor neurodevelopment and

low immunity (31). To assess iron deficiency anemia, analyses of the structure and content of hemoglobin present in whole blood is widely carried out (25).

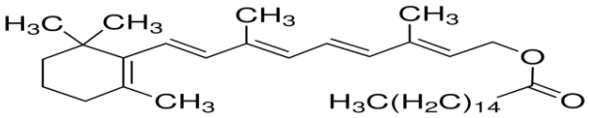
Food sources of iron include liver, red meat, kidney and some green leafy vegetable with high iron content. Chicken and fish have medium iron content while milk and milk products have iron content with low bioavailability (25). Low levels of iron status can be due to a combination of reasons including low dietary intake, or poor bioavailability of iron in the diet and excessive losses (25). The heme form of iron obtained from animal sources has high bioavailability whereas the non-heme form of iron available in plants and milk have low absorption and require ascorbic acid to increase their bioavailability (5, 32). Although milk, milk products and plants iron content with poor bioavailability, these are the main food items offered to infants and young (33) children in Eastern Kenya. While in developed countries most foods are fortified with iron, in developing countries this seldom occurs thus, the prevalence of IAD is quite high (31). For this reason it is recommended that infants and young children residing in developing countries be administered with iron supplements

Vitamin A

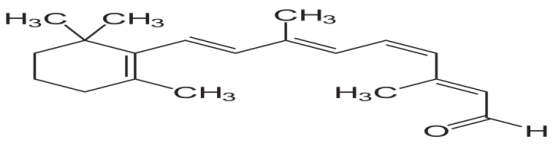
Vitamin A is an important micronutrient necessary for the growth and well-being of an individual; it is especially critical in children. It plays a number of major roles, including; bone growth, immune system, vision related functions and differentiation of epithelial cells (25). As no animal is capable of carrying out *de novo* synthesis of vitamin A, it is exclusively obtained from diet. Sources of preformed vitamin A include egg yolks, butter fat, liver and fish liver. Sources of pro-vitamin A, on the other hand, include most orange and yellow fruits, tubers and dark green leafy vegetables (25). Vitamin A has several forms: retinol, retinal, retinoic acid among others as shown in **Figure 1** (25, 34). We also consume beta-carotene, which is essentially the structure of two retinol molecules. This nutrient is also found in fruits and vegetables that are yellow, orange and red in color, and so makes these a good source of pro-vitamin A (35).



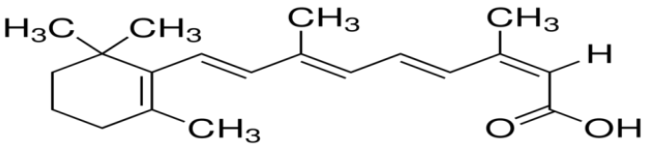
All trans retinol



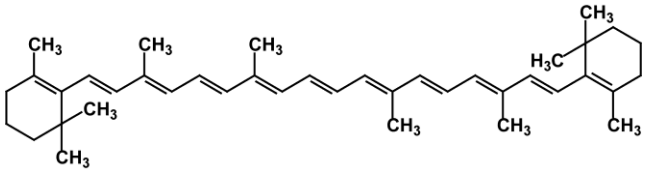
Retinyl palmitate



11-cis retinal



13- cis retinoic acid



Beta carotene

Figure 1: Various forms of retinoid and beta carotene (34)

The International Vitamin A Consultation Group (IVACG) defined vitamin A deficiency as "any health and physiological consequence attributed to vitamin A deficiency irrespective of whether there is any clinical evidence of deficiency" (36). Severe vitamin A deficiency (VAD) can be indicated by night blindness, growth retardation, diarrhea and a suppressed immune system (11). Vitamin A deficiency is endemic in Africa, Eastern Asia and parts of the Middle East and Latin America. However, if vitamin A is administered in very high levels it can have adverse effects. As it is a lipid-soluble vitamin, its excretion through urine is minimal so consumption above the recommended daily allowance (RDA) can cause toxicity (37). Some toxic effects related to its excessive (> 6mg/ 20,000 IU) intake include hypervitaminosis A (38), skeletal pain, hepatic inflammation, desquamation and fissuring of the lips (39-42).

There are two known biochemical markers that can be used to determine VAD: serum retinol and retinol binding protein (RBP). Serum retinol is analyzed using high performance liquid chromatography (HPLC) analysis, while retinol binding protein (RBP) is analyzed using the sandwich enzyme linked immunosorbent assay technique (ELISA) technique (43, 44).

Serum retinol levels in infants and young children are affected by several factors including race, age, sex, intake of a low fat diet, infections and other nutrient deficiencies which co-occur such as deficiency in zinc. Most vitamin A is stored as retinyl esters in the liver, meaning testing of liver ester provides the best index to measure vitamin levels. However, doing liver biopsies is impractical for a big survey. In addition, vitamin A is not evenly distributed in the liver (35). For this reason, serum retinol concentration is used as an indicator. It represents 1% of the body's total reserve, which is useful in detecting severe depletion or excess concentrations of vitamin A (25). The cut-off for retinol according to WHO and IVACG is < 0.70µmol/L (20µg/dl) (45).

Retinol binding protein (RBP) is a biomarker that can be used as a proxy/surrogate indicator to determine serum vitamin A deficiency (44). It has its advantages as it is a much simpler process and more stable than serum retinol. Serum RBP correlates well with serum retinol and can therefore be used to determine Vitamin A deficiency (45). As vitamin A status of an individual decrease, the serum retinol and RBP decrease as well as. In essence RBP levels are affected by factors that affect retinol levels simply because RBP are transport vessels for the serum retinol and are released from the liver as *holo*-RBP to bind to the serum retinol on the one binding site; the ratio of RBP to serum retinol is approximately 1:1. (45,46). Several factors affect RBP status including organ disease especially of the liver which may affect the production of *holo*-RBP, lack of proteins, and infections, among others (45).

RBP is analyzed using the sandwich ELISA, which is rather inexpensive as it does not require an expensive machine or a lot of reagents (47). Using RBP as a proxy for vitamin A can be very economical especially in this day and age where vitamin A deficiency is being studied extensively (46). A standard cut-off for RBP has not been established but rather a cut-off is established based on prior research according to a particular population and country. In this investigation the cut-off for RBP for the study population is <0.87 µmol/L. This cut-off was arrived at from a previous National Micronutrient Survey undertaken in 2011 which used a large

sample size to analyze the RBP for the Kenyan population. The same approach was used in Uganda during the Uganda Demographic Health Survey in 2011, where they used RBP of the population to come up with the cut-off (0.825µmol/L) that is reflective of the national population for children (6-59 months) and eventually determine VAD prevalence (43).

Protein response markers

C-reactive protein

C-reactive protein is an acute- phase protein that responds to infections, inflammations or tissue damage. Produced by hepatocytes, the protein is used as an indicator of presence of infection (48). The levels of C-reactive proteins are elevated (> 5mg/L) from the onset of an infection and therefore, can be used to detect infections at an early stage (49, 50).

Since CRP levels rapidly increase in events of infections, trauma and inflammations and reduce just as rapidly when the problems are resolved, measuring its levels in an individual can be used to determine if the individual is sick or not (50). Some micronutrients levels are affected by infections and in this case the CRP levels will be useful in determining if the individual is infected or not, which in turn determines if the micronutrient levels measured are as close to the true value as possible or are altered. It is an important corrective indicator in the measurement and interpretation of micronutrients concentration (43).

Serum α-1-acid glycoprotein (AGP)

AGP is an inflammatory marker for chronic infections i.e. infections that have been in the system for a length of time which may affect the level of retinol in the system. When there is an infection, the levels of AGP like CRP are elevated (>1mg/L) (49). Therefore, it is a useful indicator to rule out if an individual has a chronic infection that may result to the alteration of some of their micronutrients concentration.

III. Dietary assessment

Dietary assessment involves measurement of nutrient/food intake at household, national or individual level and linking it to health outcomes. Reasons for conducting dietary assessment vary from nutrition surveillance, screening or epidemiological research (51). Data collection methods of dietary assessment vary depending on the purpose for data collection, available resources, study population and burden imposed on respondent. Individual dietary assessment tools are used as they are more intensive in terms of information collected from the individual about their nutritional intake (52). Information from diet assessment can be used to determine the dietary diversity score (DDS).

A DDS is categorized depending on the number of food groups consumed by an individual to produce an Individual dietary diversity score (IDDS) that has 6-7 food groups or by a household for a Household Diversity Score (HDDS) that has 8-12 food groups (example shown in **Table 1** below).

Food grouping for Household dietary diversity Score		
Group	**Food**	**Inclusive**
1	Cereals	
2	White tubers and roots	
3	Vegetables	Vitamin A rich vegetables and tubers, dark leafy vegetables
4	Fruits	All vitamin A rich fruits
5	Meat	all organ meat (offal)
6	Eggs	
7	Fish and Seafood	
8	Legumes, nuts and seeds	
9	Milk and milk products	
10	Oils and fats	
11	Sweets	
12	Spices, condiments and beverages	

Table 1: Foods categorized into food groups for HDDS

A recent addition based on a FAO report in 2013 is Women Dietary Diversity Score (WDDS); this is basically an IDDS but tailored specifically for women of reproductive age and includes 9 food groups as shown in **Table 2** below (32).

Food grouping for Women dietary diversity Score		
Group	**Food**	**Inclusive**
1	Starch	all cereals and white root tubers
2	Dark green vegetable	
3	Vitamin A rich vegetables and fruits	all fruits and vegetables rich in Vitamin A
4	Vegetables and fruits	all other fruits and vegetables not rich in vitamin A
5	Organ meat	
6	Meat and fish	all meat and fish
7	Eggs	
8	Legumes, nuts and seeds	
9	Milk and milk products	

Table 2: Foods categorized into groups for WWDS

Food groups are formed by grouping together foods which have the same characteristics (53). An IDDS consists of 6-7 food groups. The score is ranked as low if one consumes 3 or less food groups, medium if 4-5 food groups are consumed and lastly high if the individual consumes more than 6 food groups (32, 54).

24 hour recall (24HR) determines the food or nutrient intake in the individual's last 24 hours. It can assess the habitual diet at the population level and gives information that can be used for group assessments for interventions that may be carried out in that population (32). Data from repeat 24 hour recall questionnaires is used to determine the quality and nutrition adequacy of an individual (32).

IDDS can be determined using 24 hour recall with low scores reflecting diet quality and ultimately nutrition status, especially if the foods in the minimal food groups being consumed are of low bioavailability (54).

Food frequency questionnaire (FFQ) contains a list of foods and respondent provides information regarding how frequently they consumed food items enlisted. If the questionnaire contains portion sizes the FFQ is termed as semi-quantitative. FFQ should be designed to encompass a list of common foods and methods of preparation that are common in the particular community under assessment (52).

IV. Focus group discussions (FGD)

Focus group discussions (FGD) are essentially discussion groups comprising of people from similar background, gender or education; sharing opinions, information and ideas in regards to a particular topic that affects all of them in one aspect or another. In some cases, some information can be shared in these groups to give more insight that would otherwise be inaccessible or not fully understandable with questionnaires administered face to face (55).

JUSTIFICATION

Nutritional status is an important indicator of the state of health and well being of a person. Some nutritional components affect the growth of a child causing reversible, irreversible or fatal effects. Children are potentially delicate and need to be nourished for their healthy growth; malnutrition at this stage of their lives is the major course of mortality especially in developing countries (56). Since infants and young children aged between 6-36 months are vulnerable to malnutrition (11), their nutrition status is a reflection of that of the household and the community and offers a unique perspective on the public health situation of a region.

Almost a third of the world's child mortality is associated with micronutrient deficiency (10). The nutrition status of infants and young children is particularly important as children at this stage affected in any way by a micronutrient deficiency, may suffer long term defects, if the situation is not correctly identified and addressed.

In the semi-arid areas of developing countries, malnutrition associated with food insecurity is rampant, especially to infants and young children (57). It exacerbates the degree of infection from parasites further leading to the deterioration of health in infants and young children (58). Information on prevalence of malnutrition can be used in the determination of appropriate nutritional care, intervention or surveillance needed by the community in order to focus on most vulnerable group and alleviate the situation (59).

Children aged 6-36 months are assumed to be physiologically similar and if they are treated and fed in the same manner their nutrition status can be evaluated against common standards. A difference in nutrition status suggests a difference in dietary intake and feeding practices between boys and girls (7). Kenya being a diverse country, there are different feeding practices within each community which tend to be gender biased (17). This reflects a difference in the sexes in terms of dietary intakes, micronutrient level and ultimately the unfavored gender being more vulnerable and at a higher risk of malnutrition (7).

OBJECTIVES

Main objective:

To investigate the relationship and determinants of vitamin A and iron in infants and young children of Makueni and Machakos counties.

Specific objective

1. To assess the effect of mothers/caregiver's demographic characteristics and economic status on the nutritional status of their IYC.
2. To investigate the differences in anthropometric indicators between boys and girls.
3. To investigate differences in iron deficiency anemia (IDA) and vitamin A deficiency (VAD) between boys and girls.
4. To determine the dietary diversity score between boys and girls in Machakos and Makueni Counties.
5. To assess the relationship between Dietary Diversity Score (DDS) and micronutrient (vitamin A and Iron).
6. To understand cultural influences, taboos and feeding practices on gender differences in nutrition indicators.

HYPOTHESIS

- Prevalence of malnutrition is higher in girls than in boys due to cultural /traditional practices that are in favor of the boy.

METHODOLOGY

Study design and study sites

Although the INREF project in which this study is a part of was longitudinal with an initial baseline survey and a follow up of an end line as the final assessment, the design of this study is cross-sectional but. The study took place in Eastern Province of Kenya in Makueni and Machakos counties. The area lies between latitudes 1˚35′S and 3˚S and longitudes 37˚10′E and 38˚30′E, with an altitude of 600-1200m above sea level. The temperatures in the area average around 20.2˚C-24˚C, with a high evaporation rate. Agro-Ecological zones within which the Counties are classified are Low Midlands 4 (LM4) and Lower Midlands 5 (LM5) (2, 9).

Sample selection

The study target was a household with a child between the ages of 6-36 months and a mother/caregiver (woman) of childbearing age between the ages of 15-46 years. The mother and baby pairs chosen were living and eating in that household. Households were chosen using stratified sampling techniques. The first step involved compiling a list of farmers who were involved in farmer groups (FG) by the District agricultural officers from both counties and contacting them. The famers were then categorized into two groups; one group included farmers participating in the INREF project and was coded as "Treatment arm", while the second group included farmers who were not participating in the INREF project and was coded "Control arm". For this particular study, the segregation of treatment and control arm was not applicable, as it did not involve any intervention; however the INREF project involved introducing, and hence required the control and treatment segregation of the farmer groups.

The second step involved determining which households from the contacted farmers had the mother and baby pair who fit the criteria fit for the study. Lastly, the list of eligible participant was compiled forming a sampling frame from which candidates were randomly selected. In total 72 FG's from 109 villages were enlisted with the treatment arm having 47 FG's from 69 villages and the control arm having 25 FG's from 40 villages. 324 household from both counties were sampled and 277 selected for the study. Information on sample selection is summarized in **Figure 2 below.**

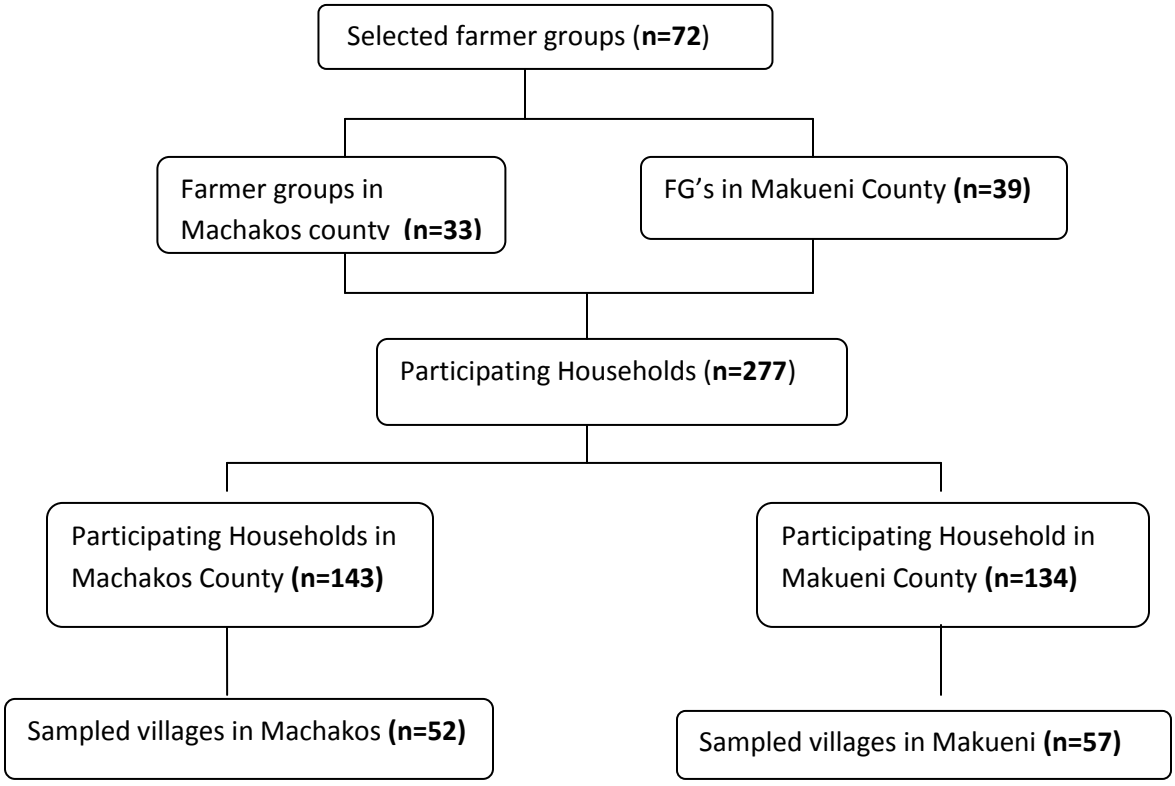


Figure 2: Sampling in Machakos and Makueni Counties

Sample size calculation

The approach taken to calculate for sample size is the calculation for a relative risk. This formula shown in **Figure 3** below (unequal variance asymptotic formula) puts into account the event rate which is determined from previous studies of the same study (60).

$$n = \frac{\left[z1-\alpha\sqrt{2p(1-p)} + z1-\beta\sqrt{p1(1-p1)} + p2(1-p2)\right]\text{^}2}{(p1+p2)/2}$$

Figure 3: Formula for sample size calculation (61)

Where P is = $(\underline{P_1+P_2})/2$

P1 = prevalence of underweight in eastern Province = 25.2%

P2 = Expected prevalence after intervention=15.2%

P= (25.2+15.2)/2=40.4/2=20.2%

Za=1.645

$Z_{ß}$=0.842

n= {1.645$\sqrt{2*0.202\ (0.798) + 0.842\sqrt{(0.252*0.748+0.152*0.848)\}^{\ 2}/(0.1)^2}$

= 252

With an assumption of a 20% refusal and attrition of 10%, 379 pairs of mother/caregivers and babies were to be selected from the study population. This highly depended on how the study was to be implemented.

Selection criteria

Inclusion criteria:

I. Infants and young children within the ages of 6-36 months.
II. Mothers/Caregivers and baby pairs who have consented to participating in the study.
III. Mother/ caregiver (female) child bearing age 15-46 years.

Exclusion criteria*:*

I. Infants and young children outside the range of 6-36 months.
II. Infants and young children with terminal illnesses or mental disorders.
III. Mothers and caregivers outside the age bracket or pregnant.
IV. Infants and young children whose guardians have not consented to participate in the study.

METHODS

Preparation for data collection

For all data collection, two teams were formed and trained to collect all the data needed for the survey from the sampled households. The training and team formation was organized and carried out in KEMRI-CPHR facilities. Facilitators for the training sessions included research officers from KEMRI-CPHR as well as co-investigators taking part in the overall INREF project including me. The training session started from 21st to 24th May 2012.

A team comprised of: 1 nurse and 1 clinician (collect blood samples, anthropometric data and clinical information), 1 enumerator (household questionnaire), 1 nutritionist (24Hour recall, FFQ and FGD), 2 cluster laboratory technicians (separation, cover and storage of biological samples in a medical facility in field site), 1 team leader (clarifies respondent's consent, coordinates the team, guardian of data) and 1 driver (transport department). It was the duty and responsibility of the field and cluster laboratory teams to ensure maintenance of cold chain of the biological sample until they reach the central laboratory (KEMRI-CPHR) from the field site to be stored to await analysis. Data was collected over 26 days from 26th May to 20th June 2012.

Standard Operating Procedures (SOPs)

In order to achieve a nutrition assessment for the study participants, data collected included anthropometry, biochemical data, dietary intake and demographic data for the mothers/caregivers of the children. Indicators which were assessed to determine the nutritional status of the infants and young children included low RBP count to determine VAD, low hemoglobin count to determine anemia, low Z-scores to determine wasting, stunting and underweight and low dietary diversity score to determine nutrient adequacy as well as diet quality.

1. **Labeling**

   Labeling is quite an important part of a study as it assures that biological samples and data collected and analyzed are not mixed or confused resulting in an error in the final results. Labels were given in code; this assures the anonymity and confidentiality of the participant as well as maintaining a non biased analysis of all the data. Codes assigned to a study

participant should be the same all through their data, so as to link the biochemical and anthropometry or any other field being analyzed easily.

Respondents were assigned a code distinguishing them with regards to household, treatment or control group and area/village. The label was appended on the questionnaires for lab anthropometry and blood sampling. The labels also linked to their 24 hour recall and food frequency questionnaire.

2. Demographic and economic characteristics

A household questionnaire containing questions pertaining to the mother's/caretaker demographic characteristics was administered by an enumerator in my team. The questions included the mother's education, age and income.

3. Anthropometry assessment

In this study the measurements taken included; height and weight following the anthropometric measurement guide by Food And Technical Assistant (FANTA) (62, 63). These data was used to calculate the Z-scores for stunting, wasting and underweight as well as BMI for the mother/caregiver which was calculated as weight/height^2 (kg/m^2).

Weight was measured using a Seca 881 U scale which is powered exclusively by batteries. 120,000 weighing operations can be performed with one set of batteries. The scale used four type AA 1.5 V batteries that are easily replaceable. Weight was collected using two methods:

1. Child stepped on the scale alone.
2. Babies and very small children were weighed while being held in the arms of a mother/caregiver. This second method of weighing is called 'tared weighing' and for this purpose the scale has a "mother-and-baby function".

The scale was placed on a hard, level surface (wood, concrete or firm earth), in the shade, or indoors so as to avoid errors. The child was told to remove shoes and stand upright on the scale

and the measurements confirmed and recorded in the laboratory anthropometry form. For the second method (tared method); the "Seca scale was switched to "mother-and-baby" function. Mother/caregiver was asked to step on the scale without shoes and stand still and the "mother-and-baby" key pressed. The baby was handed to mother/caregiver and the weight displayed and recorded

Height and *length* were taken using a height board .The wooden height board was procured from UNICEF and can be used to measure infant's length, child's height and the mother/caregiver's height as well as it has a maximum of 200cm. Height measurements was recorded to the nearest 0.1 centimeters and taken by following strict rules to ensure correct values were recorded. Some of the rules adhered to included; placing the height board on a flat surface and against a wall or tree so as to avoid leaning. Child was requested to remove shoes and unbraid hair so as not to give extra height measurement in final reading. The child was instructed to put feet flat together and look straight ahead, ensuring the back of the head, shoulder blades and buttocks touch the board. The height board's head piece was moved down slowly so as to avoid hitting and causing injury to the child. Measurements were recorded and verified by both measurer and assistant. This is illustrated in **Appendix 2.1** (63).

Length was also recorded to the nearest 0.1 centimeter. The board in this case was placed on a hard flat ground or a table. Child was lowered gently on the board with the assistance of the mother and the measurer. The mother was positioned on the side of the head to hold the child's face and keep it calm, while measurer slowly slid the mobile part of the board towards child's heels until the feet were perpendicular to the board and called out the measurements which were recorded and verified. More details can be found in **Appendix 2.2** (63).

4. Biochemical assessment

Blood collection

A clinician drew a total volume of 2.5ml of blood from the respondent. 1.5 ml of this was drawn into a heparin tube and the remaining 1 ml in an EDTA tube. The blood in the heparin tube was centrifuged to obtain plasma for analysis of retinol binding protein, AGP and CRP.

Blood in the EDTA tube was used to test hemoglobin levels for anemia determination using Hemocue 301. In the cases of collapse of the vain, blood was drawn from a finger prick to a microtainer. **(Appendix 1.0)**

Hemoglobin

Hemoglobin was measured by a clinician using the HemoCue 301(Hb-301) to determine anemia (Hb < 11g/dL). Venous blood coagulated with EDTA was used for the measurement as it is the best for this (25). In cases of vein collapse or refusal of venous blood collection, capillary blood from finger or heel stick was used to do the test. Capillary blood can also accurately be used to adequately determine prevalence of anemia in population (64). Results by HemoCue instrument are as accurate as results from a standard laboratory assay, provided sample collection is done in a standardized manner (65). Additional and detailed information can be read in **Appendix 3.1.**

Analysis of vitamin A and protein response markers (CRP and AGP)

One of the micronutrient analyzed in this study is vitamin A which was done by measuring its proxy, retinol binding protein (RBP) using the sandwich ELISA technique in Germany. Levels of RBP < 0.87µmol/L was considered vitamin A deficient. The response proteins if are elevated indicate an infection. The cut-off for CRP (> 5mg/L) indicates an acute infection and AGP (> 1g/L) indicates a chronic infection. These response proteins are used together as corrective indicators and have four diagnosis categories for infection as shown in **Table 3** below.

CRP (mg/L)	AGP (g/L)	**Infection diagnosis**
≥5	<1	Incubation
≥5	≥1	Early convalescence
<5	≥1	Late convalescence
<5	<1	Healthy

Table 3: Infections categories as determined by CRP and AGP levels

Serum samples for this analysis were covered by aluminum foil and stored in liquid nitrogen for transportation to the central laboratory where they were stored in a -80ºC freezer. The serum samples for RBP, CRP and AGP analysis were then put in a styrophorm box filled with dry ice ($CO_2^{(S)}$) and sealed for shipment to VitMin Lab laboratory in Willstätt, Germany where the analysis was conducted by Dr. Juergen Erhardt PhD. All the analysis for RBP, CRP and AGP used the Enzyme Linked Immunosorbent Assay (ELISA) method.

Diluted serum and standard samples were added to the wells containing a buffer (pH 7.2) and antibodies of respective analytes (anti-RBP, anti-AGP and anti-CRP). The ELlSA plates are incubated at room temperature for 1 hour. A color development step follows, where a solution of hydrogen peroxide mixed with 3,3´,5,5´-tetramethylbenzidine dihydrochloride (TMB) , is added to each well of the ELISA plate causing a reaction that forms a blue or yellow color. The intensity of the color is measured in a spectrophotometer at wavelength 450 nm with the reference wavelength set at 650 nm. High color intensity translates to a high concentration of the analyte being tested. Detailed description can be found in **Appendix 4.0.**

Axillary (armpit) temperature was taken by a digital thermometer to determine presence of fever as it would be one of the obvious symptoms in case of an infection.

The tip of the thermometer was placed at the center of the armpit (child's arm should tuck snugly against their body). The thermometer was left in the arm until the beep went off, thereafter, removed, read and the reading recorded. Normal temperature should be between 36.4˚C and 36.9˚C in the morning and afternoon respectively, but a temperature of above 38˚C is considered as a fever and the respondent was referred by the team nurse to the nearest hospital for examination (66).

5. Dietary assessment

To determine household consumption patterns and nutrient intake, a food frequency questionnaire (FFQ) and a 24 HR questionnaire were administered to the child's mother/caretaker by the team's nutritionist. This was used to determine the habitual intake of the family. The sample questionnaires are found in **Appendix 6.**

24 hour recall collects the quality and nutrition adequacy by focusing on micronutrient intake while the FFQ collects the frequency and diversity of foods consumed in the household. The data collected from these questionnaires (24 HR and FFQ) were analyzed to calculate a Dietary Diversity Score (DDS), in terms of food groups which were formed by combining a number of food types from the questionnaires to form one food group with similar characteristics e.g. all types of meat are grouped as one as illustrated in **Table 4** below.

In scoring, an individual is considered to have a low IDDS if they consume ≤ 3 food groups, medium IDDS if they consume 4-5 food groups and a high IDDS if they consume ≥ 6 food groups.

Food grouping for Individual dietary diversity Score (IDDS)		
Group	**Food**	**Inclusive**
1	Dairy products	Milk products, yogurt, cheese
2	staple starches	Grains, roots, tubers, bread, potatoes
3	Vitamin A rich foods	yellow/orange pumpkin, carrots, ripe yellow/orange fruits
4	other vegetables and fruits	Other fruits and vegetables
5	Meats	Meats, poultry, fish, seafood's and organ meats (liver, gizzards, offal's)
6	Eggs	
7	Pulses, legumes	Pulses, legumes/nuts

Table 4: Foods categorized in food groups for IDDS

Focus group discussions were conducted using a Knowledge Attitude and Practices (KAPS) questionnaire that included questions related to foods that were culturally/traditionally prohibited. FGD's were used to collect and record foods that are taboo or have cultural implications and also get information as to why they were prohibited/taboo. A sample of the questionnaire can be found in **Appendix 6.3**. 18 FGDs comprising of 9 women FGDs and men FGD's were formed in 7 divisions. The FGDs were categorized by gender to allow the participants to feel comfortable. A nutritionist from the team and an enumerator conversant with local mother tongue (Kamba); asked the questions and translated them into the national (Swahili) or local mother tongue (Kamba) if one could not understand. The discussions were recorded using both writing and a recorder, to avoid missing any information in the discussion. The information was transcribed and translated to English.

DATA MANAGEMENT

Data collected through household questionnaires, 24 hour recall, food frequency questionnaire and anthropometric assessment data were double entered in a database designed with Microsoft Access software. Back-up was done regularly to avoid any loss or tampering with back-up files were stored in flash drives. Data cleaning and validation were performed to achieve clean datasets that were exported into Statistical Packages for Social Sciences (SPSS) for analysis version 17.0.

Data analysis

Descriptive analyses were run for continuous variables (mean, standard error and standard deviation) and categorical variables (demographic characteristics, and some nutrition variables e.g. dietary intake). Using Shapiro-Wilk test the distribution of the study variables for the population was found to be normally distributed.

Before analyzing for RBP and Hemoglobin distribution, the raw data was adjusted for inflammation (CRP and AGP) using a logistic regression model. Four categories of infection were formed (Incubation, early convalescence, late convalescence and healthy). Each group was multiplied by the ratio of the mean of healthy group and one infected group. Nutrition data was categorized and grouped for further analysis (43).

Independent Student's *t*-test was used to compare mean differences of between boys and girls for continuous variables, while the difference in categorical variables (VAD, IDA, DDS and stunting) between boys and girls were analyzed using Chi-square and Fisher's exact test. Bivariate analysis was used to determine the risk probability (Odds Ratio) of being VAD, anemic and having low DDS. A regression model was used to assess interactions between demographic characteristics of mother and nutrition status of the IYC. Relationships and associations were tested using Pearson test and Fisher's exact test and a confidence Interval of 95% with a marginal error (alpha) of 0.05 was applied to determine the strength of the relationship.

ETHICAL CONSIDERATION

The proposed study was examined by the National Scientific and Ethics Committee of KEMRI and McGill's Research Ethics Board III (REB III), in accordance with their protocols. The process considered the interests of participants and aimed to protect their privacy, dignity and integrity. Those found to be ill were referred to the nearest medical care facility immediately for treatment and follow up.

Information on the research study and protocol were thoroughly explained to the local administration, research respondents and their guardians for clarifications. Oral and written consent were obtained from guardians of the respondents. Participation was entirely voluntary and withdrawal from the study at any time did not jeopardize respondent's treatment at any health facility.

RESULTS

1. Demographic characteristics of sample population

Child and mother/caregiver pairs were interviewed from 277 households. Infants and young children had a mean age (standard deviation) of 21.16 (8.61) months. As depicted in **Table 5** below, the children were categorized by both gender and age (months). The population had a 50 to 50 ratio in terms of gender, with 139 girls and 138 boys. The 6-23 months age group comprised 57.4% of the total number of children, with the second category of children between 24-36 months having 42.6% of the children. Within the larger category (6-23 months) male children were slightly more than the females. The opposite was true in the second age category; a higher percentage of girls results in the overall population having an almost equal distribution in terms of gender.

Characteristics	Total (n=277)	Female (n=139)	Male (n=138)
Age: Mean (SD) months	21.16 (8.61)		
6-23 months %	57.4	27.8	29.6
24-36 months %	42.6	23.8	18.8
Mean (SE) 6-23months	15.0(0.4)		
Mean(SE) 24-36 months	29.5(0.3)		
Weight: mean(SE)Kg	10.23(0.12)		
Height: Mean(SE)Cm	78.8(0.46)		

Table 5: Infants and young children categorized in both gender and age

The 277 women respondents had a mean age (standard deviation) of 29.45(0.391). The women were also categorized in two categories: category 1 (15-30 years) comprised 63.9% and category 2 (31-49 years) 36.1%. A large percentage (81.2%) of the women had an education below primary school This number is higher than the national number of 76.8% reported by KDHS 2008 and the most recent KDHS 2014 that reported that 57.3% of women have primary education to no education at all (12, 67). 14% of the women are single (separated, divorced, widowed or never married). The percentage (86%) of married women in this study is higher than the national level reported by KDHS 2014 which is 59% (67). This information is summarized in **Table 6** below.

Characteristics of mother/Caregiver	
Total number of women	n=277
Age category	
15-30 years (%)	63.9
31-49 years (%)	36.1
Mean (SD) years	29.4(0.39)
Education	
< Primary (%)	81.2
> Primary (%)	18.8
Monthly income (KSh.)	
<5000 (%)	64.8
5001-9999 (%)	20.7
>10000 (%)	14.5
Marital status	
Never married (%)	9.6
Married (%)	86
Separated, widowed, divorced (%)	4.4
BMI (Kg/m^2)	**%**
Underweight (<18.5 kg/m^2)	14.4
Normal (18.5-24.9 kg/m^2)	67.9
Overweight (≥25.0 kg/m^2)	17.7

Table 6: Demographic characteristics of mothers/caregivers

2. Dietary diversity score (DDS)

The number of the 277 children who had all their data available for individual dietary score was 145. From 145, 76.6% (n=111) of the children had a low DDS. The dietary diversity scores for children categorized for both gender and age groups. The percentage of boys who had a low dietary score (80.8%) was not significantly different (p = 0.13) from the girls (71.6%) as shown on **Table 7** below. In age category, a significant number (88 out of 145) of the children with low DDS were in the 6-23 months, showing a statistical significance after a Pearson chi-square test (p = 0.023).

	low DDS	Medium-high DDS	*p* - value
Total (n=145)	76.6 (n=111)	23.4 (n=34)	
Males % (n=78)	80.8 (n=63)	19.2 (n=15)	0.13
Female% (n=67)	71.6 (n=48)	28.4 (n=19)	
6-23 months% (n=88)	77.3 (n=68)	22.7 (n=20)	0.023
24-36 months% (n=57)	75.4 (n=43)	24.6 (n=14)	

Table 7: Individual Dietary Diversity score categorized in both gender and age group

To understand what food groups the IYC were consuming, information from 24 hour recall as well as FFQ were grouped into the major food groups used to determine IDDS and HDDS respectively and categorized by gender as shown on **Figure 4** and **5**.

The graph below **(Figure 4)** shows information from 24HR recall grouped into seven major food groups. It shows that most of the children had consumed 4-5 food groups. Overall, the consumption of animal source of iron and vitamin A was low. The graph shows that the pulses and nuts were consumed more than the meat and eggs by the female child, although this was not statistically significant ($p > 0.05$). According to the findings consumption of vitamin A rich fruits and vegetables was equal in both genders.

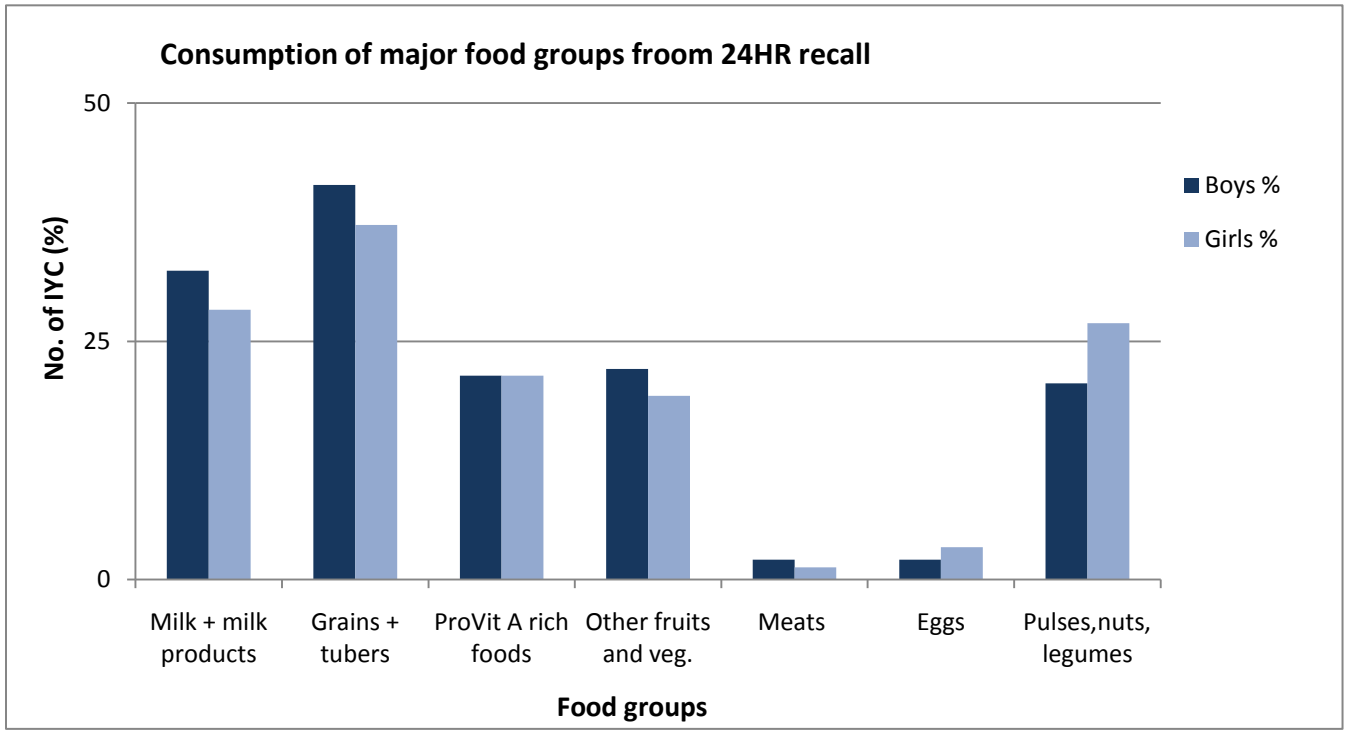


Figure 4: Consumption of major food groups by IYC from 24 HR recall categorized by gender

Figure 5 below shows a monthly household dietary consumption of infants and young children in the 6-36 month category. The foods have been grouped according to the major food groups from the household dietary diversity score. The graph shows the monthly consumption, an expansion of the 24HR recall questionnaire and also gives more details of what the household consumes. It shows that no children consumed any fish and notes that only boys (1%) and no girls consumed organ meat and yogurt. More males than female children consumed 11 food groups out of the 18. Similar to consumption pattern from 24 HR recall, vitamin A rich foods were equally consumed by both genders in the household.

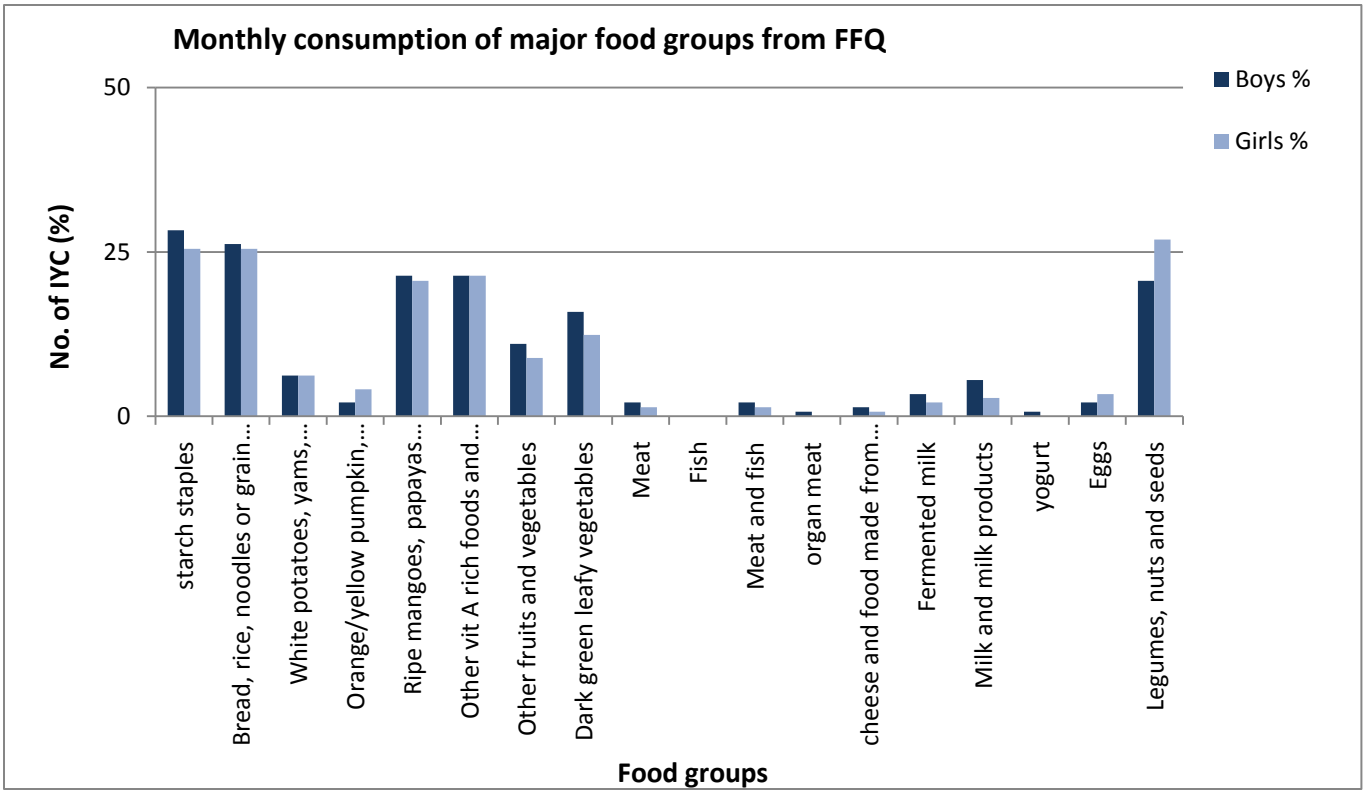


Figure 5: Monthly consumption of major food groups by IYC from FFQ categorized by gender

3. Biochemical indicators

Table 8 summarizes the biochemical indices tested for the population. There was no significant difference in biochemical indicators between males and females ($p > 0.05$). A higher percentage (25.6%) of children in 6-23 months age category suffered from anemia than the 24-36 months category (9.7%), with a significant difference ($p = 0.007$). Difference in vitamin A deficiency between the two age categories was not significant ($p > 0.05$).

A low count of malaria almost none was found in the population, with only two children (male) out of the whole population were diagnosed with the malaria parasite. Just like Malaria, fever in the population was low, with only seven children having temperatures >38ºC.

Summary of biochemical indicators							
		Categorized in gender			Categorized in age		
Indicator	**Total**	**males**	**females**	***p*-value**	**6-23 mo**	**24-36mo**	***p*-value**
IDA (%) (n=258)	35.3	20.9	14.4	0.43	25.6	9.7	0.007*
VAD (%) (n=190)	42.6	17.9	24.7	0.2	22.1	20.5	0.58
Fever (count)	7	4	3	-	6	1	-
Malaria +ve (count)	2	2	0	-	2	0	-

Table 8: Biochemical indicators categorized by gender and age

A. Iron deficiency anemia (IDA)

Out of the 277 children, 258 of them had their Hb count tested. **Table 9** gives a summary of results in iron deficiency anemia. With hemoglobin levels below 11.0 g/dL 35.3% of the children were classified as suffering from iron deficiency anemia (IDA) with a mean (standard deviation) of 11.4(1.4). In terms of gender 28.9% (n=37) of the females were anemic as compared to the 41.5% (n=54) of the males who were anemic. Though percentage and count show more boys were anemic than the girls, there was no significant difference (p = 0.428). The 6-23 months age category had a significantly higher percentage of IDA children than the 24-36 month category (p= 0.007).

Characteristics	***n*=258**	**%**	**Mean (SD)g/dL**	***p*-value (Pearson χ^2)**
Total anemic IYC	91	35.3	11.4(1.4)	
Based on sex				0.428
Female (n=128)	37	28.9	11.6(1.2)	
Male (n=130)	54	41.5	11.1(1.5)	
Based on age category				0.007*
6-23 months % (n=112)	66	58.9	10.2(3.4)	
24-36 months % (n=146)	25	17.1	11.2(2.8)	

*****Significant difference observed

Table 9: Anemia in IYC categorized in both sex and age group

B. Vitamin A deficiency (VAD)

190 out of 277 children had their RBP levels tested and analyzed. With levels of RBP below the cut-off point (< 0.87µmol/L, 42.6% (n=81) of the children were identified as vitamin A deficient (VAD). Out of the males 40.0% (n=34) were classified as VAD and in female category 44.8% (n=47) females. The mean was 0.94 and a standard deviation of 0.29. The difference between VAD in boys and girls was not significant after analysis using Fisher's exact with 95% CI (p = 0.287). In doing a risk assessment the probability of a boy being vitamin A deficient was lower (OR= 0.778; 95% CI) than the girl child (OR=1.222; CI 95%). **Table 10** summarizes VAD in IYC.

Characteristics	*n*=190	%	Mean (SD)µmol/L	*p* -value (Fisher's exact)
Total VAD in IYC	81	42.6	0.94(0.29)	
Based on sex				0.197
Female (n=105)	47	44.8	0.95(0.31)	
Male (n=85)	34	40.0	0.94(0.28)	
Based on age category				0.58
6-23 months (n=100)	42	42.0	0.93(0.27)	
24-36 months (n=90)	39	43.3	0.95(0.33)	

Table 10: VAD in infants and young children categorized by gender and age

4. Anthropometric indices

Stunting (HAZ): The mean and mean standard error of (HAZ) Z-scores for the children is -1.5(1.3). The overall percentage of children being stunted was 35.7% (n=51). Out of the 77 boys 28 (36.4%) were stunted and out of the 68 girls, 24 of them were stunted. However, there was no significant difference in the means for stunting between boys and girls (p = 0.45). When categorized by age group, the 6-23 months category had more children stunted (n=30) than the 24-36 months category with (n=22), although based on the Fisher's-test, there was no significant difference between the two age groups ($p > 0.05$).

Wasting (WHZ): The overall percentage of wasting was 4.81%, with only 7 children having a WHZ Z-score < -2SD; (4 males and 3 females). The mean and standard deviation Z-scores for the children was 0.02(1.1). From the children who were wasted; four were from 6-23 month age category and three from 24-36 month category. An analysis to determine if there was a significant difference in wasting between gender and age group was not carried out as the sample size was too small (n = 7). There was no significant difference between boys and girls (p = 0.547)

Underweight (WAZ): The mean and standard deviation WAZ Z-scores for the children was -0.8(1.1) with overall percentage underweight was 11.5% (n = 32). Among the male children, 19.2% (n=17) were underweight and among the female children 25.4% (n=15) were underweight. However, the number (n=16) of underweight children was equal in both age categories.

The table below (**Table 11**) summarizes the anthropometric nutrition indicators.

Nutrition status of IYC	*n*	%	Mean (SD)	*p*- value (Fisher's exact)
HAZ (stunting)				
Total	52	35.7	-1.5(1.3)	0.445
Females (n=68)	24	35.3		
Males (n=77)	28	36.4		
Categorized by age grp.				0.311
6-23 months (n=89)	30	33.7		
24-36 months (n=56)	22	39.3		
WAZ (Underweight)				
Total	32	11.5	-0.8(1.1)	0.475
Females (n=67)	17	25.4		
Males (n=78)	15	19.2		
Categorized by age grp.				0.557
6-23 months (n=88)	16	18.1		
24-36 months (n=57)	16	28.1		
WHZ (Wasting)				
Total	7	4.8	0.02(1.1)	0.547
Females(n=68)	3	4.4		
Males (n=77)	4	5.2		
Categorized by age grp.				-
6-23 months (n=89)	4	4.5		
24-36 months (n=56)	3	5.4		

Table 11: Nutrition status of IYC of Machakos and Makueni

5. Associations of IYC nutrition status

Dietary diversity score

As dietary intake impacts and is impacted by several factors it is associated with the overall health and nutrition status of an individual. This section examines the nutrition status of the IYC as it is affected by DDS.

Table 12 below gives a summary of the number of deficient IYC who had low DDS compared to the IYC who were normal (not stunted, anemic or vitamin A deficient) but still had low DDS. The analysis conducted determined that 69 out of 91 children (62.2%) who were anemic had a low DDS compared to the 42 children who were not anemic but had a low DDS. This indicated that there is higher probability of children with low DDS becoming anemic (p = 0.029). A risk assessment conducted showed children with low IDDS having a higher probability to become anemic (OR=1.385; 95% CI = 0.995, 1.927).

As regards vitamin A deficiency in relation to DDS, 57 out of 81 children with VAD had low DDS; that is 51.3% of the VAD children, compared to the 54 children without VAD but had low DDS the difference however was not significant as the *p*-value was 0.222 using the Fisher's exact test.

Out of the 52 stunted children 41 of them had low DDS compared to the children who were not stunted but had low DDS (63.1%). However, majority of the children were not stunted (n=93) hence, the significant p-value of 0.035.

Indicators	**Group with low DDS (n=111) (%)**	***P*-value (Fisher's)**
Anemic (n=91)	62.2 (n=69)	0.029*
Non-anemic (n=54)	37.8 (n=42)	
VAD (n=81)	51.3 (n=57)	0.222
Non-VAD (n=64)	48.6 (n=54)	
Stunted (n=52)	36.9 (n=41)	0.035
Non-stunted (n=93)	63.1 (n=70)	

*Significant difference observed

Table 12 : Relationship between IDDS and nutrition indicators

Relationships/associations of Mother/caregiver's demographic characteristics to IYC nutrition indices

Some characteristics of a child's mother/caregiver can directly or indirectly influence/affect nutrition status of the child. **Table 13** below shows the relationship/association of mother's/caregiver's characteristics with the nutrition indices of their children. A higher percentage of the children with low nutrition indicators had mothers/caregivers who had low education, income and belonged to women in the younger age category of 15-30 years.

	Percentage of nutrition indices of IYC					
	VAD	**IDA**	**Low DDS**	**Stunting**	**Wasting**	**Underweight**
Sample size "*n*"	n=190	n=258	n=145	n=277	n=277	n=277
Education						
< primary	81.5	78.9	84.6	84.8	57.1	81.3
> Primary	18.5	21.1	15.4	15.2	42.9	18.7
p-value (Fisher's exact/ Pearson χ^2)	0.55	0.28	0.01*	0.17	0.13	0.60
Monthly income (KSh)						
<5000	67.1	74.6	61.8	62.9	57.1	58.1
5001-9999	20.7	18.2	20.1	18	28.6	25.8
>10000	12.2	7.2	18.1	19.1	14.3	15.5
p-value (Pearson χ^2)	0.35	0.04*	0.03*	0.70	0.995	0.81
Marital status						
Never married	9.9	11.2	10.3	10	28.6	15.6
Married	87.6	85.0	86.2	84.4	71.4	84.4
Separated, widowed, divorced	2.5	3.8	3.5	5.6	0	0
P-value (Pearson χ^2)	0.78	0.33	0.13	0.44	0.53	0.56
Age category						
15-30 years	64.2	70.9	64.4	54.8	71.4	59.4
31-49 years	35.8	29.1	35.6	45.2	28.6	40.6
p-value (Fisher's)	0.35	0.029*	0.43	0.019*	0.51	0.35
BMI						
Underweight	15.9	11.8	12.9	13.3	0	6.3
Normal	69.5	75.5	66.7	63.3	100	78.1
Overweight	14.6	12.7	79.6	23.4	0	15.6
p-value (Pearson χ^2)	0.48	0.08	0.12	0.274	0.174	0.3

Table 13: Percentage of malnutrition indicators of IYC categorized by mother/caregivers demographic characteristics (*****Significant difference observed)

Other factors associated with nutrition status of IYC

Anemia: Some other factors associated with anemia apart from mother's demographic characteristics and income include; whether the child had previously been diagnosed to be anemic and whether or not the child had/is taking iron supplements as shown in **Table 14**. Analysis of how certain aspects like being previously diagnosed with anemia can significantly contribute to a child having a recurrence, although the results was not significant ($p > 0.05$). The same analysis was applied to determine if the IYC frequency of taking iron supplements had an impact in child being anemic; again the results showed no significance.

			Anemic %
previously anemic IYC	**Count**	**%**	**(n=277)**
No	269	97.5	96.4
Yes	6	2.2	3.6
Don't know	2	0.4	0
Total	277	100	100
linear by linear association $p = 0.433$			
Iron supplements taken in the last 7 days			***n*=7**
1 time	7	38.9	85.7
2 times	6	33.3	14.3
3 times	4	22.2	0
Don't know	1	5.6	0
Total	18	100	100
linear by linear association $p = 0.806$			

Table 14: Association of anemia with iron supplement intake and previous anemia diagnosis

An analysis to investigate a relationship between being anemic and VAD as well as stunting conducted using Fisher's exact test showed no significance ($p = 0.29$); only 8.6% (n=93) of the children who were stunted were also anemic. However, there is a strong relationship ($p = 0.003$) between anemia and VAD as shown in **Table 15** below.

VAD		IDA		Total
		anemic	normal	
VAD	Count	42	45	87
	% within VAD	56.8%	35.7%	43.5%
Normal	Count	32	81	113
	% within VAD	43.2%	64.3%	56.5%
Total	Count	74	126	200
	% within VAD	100%	100%	100%
Fisher's exact test (p = 0.003)				

Table 15: Relationship between VAD and anemia

Vitamin A deficiency

Stunting: 44.8% of stunted children had low RBP levels (< 0.87µmol/L) The Vitamin A deficient children had a higher risk (OR=1.05; 95% CI=0.72, 1.54) of being stunted than the ones not VAD (OR= 0.97; 95% CI=0.78, 1.21). This showed that children were at a higher risk of being stunted if they had VAD than if they had adequate vitamin A levels, however p = 0.46 hence no significance.

Some factors that can affect Vitamin A levels in IYC could also include supplement intake as shown in **Table 16** below. The number of children who had taken a vitamin A supplement was 125 (86.2%) and the mean and standard error was 1.9(0.6), a linear by linear association between vitamin A supplement and VAD showed no significant difference ($p > 0.05$).

Ever taken Vitamin A supplement			VAD%
	Count	%	(n=110)
No	19	13.1	8.9
Yes	125	86.2	89.9
Don't know	1	0.7	1.3
Total	145	100	100
Mean (SE)	1.97(0.6)		
Linear by linear association of VAD and supplement intake (p = 0.24)			

Table 16: Association of vitamin A supplement intake and VAD in IYC

Vitamin A supplement intake was categorized by both sex and age. It shows that almost equal percentage of female (40.0%) and male (46.2%) children have taken the vitamin A supplement, which showed no significant difference. By age, the 6-23 month age category had a higher count (n=82) than the 24-36 age category (n = 63), but like for sex, there was no statistical significance. This is summarized in the **Table 17** below.

	Categorized by gender		**Categorized by age**	
Ever taken Vitamin A supplement	Males (n=138)	Females (n=139)	6-23 months (n=159)	24-36months (n=118)
No (%)	6.9	6.2	7.6	5.5
Yes (%)	46.2	40	53.1	33.1
Don't know (%)	0.7	0	0	0.7
Total (%)	53.8	46.2	60.7	39.3
Chi-square test (χ^2)	p =0.65		p = 0.36	

Table 17: Vitamin A supplement intake categorized by both gender and age group

From the analysis conducted, the underlying factor associated with malnutrition in the children was mother's education. The most direct influential factor was low dietary diversity score. This showed a pattern flowing from education to VAD, low education leads to low income and hence a low DDS which affect vitamin A intake.

6. Cultural influence-FGD

Focus group discussions were conducted in ten locations and separated in terms of women and men. Findings from the focus group discussions showed that 6 focus groups in 3 locations had various traditions and cultural practices centered on feeding practices. Some of the foods were prohibited for females from girl child to adult woman e.g. "*kathiliko*" (meat from goat stomach), while some were specifically forbidden at the child stage e.g. meat. This information is illustrated in **Table 18** below.

	Focus group location	Group prohibited	Type of food	Belief
1	Kathonzewni c-men	Women and children	"*Kathiliko*" meat from goat stomach.	Woman grows a lot of anger
		Pregnant woman	Honey and fats	Infant grows large causing birth difficulties
2	Makindu-women	Pregnant women	animal heads, liver and eggs	Infant grows large causing birth difficulties
3	Masii-men	Women and children	raw animal blood	For men only to cure low libido
4	Kathonzewni -men	Children	"*Ua*" a traditional vegetable at flowering stage	Causes dizziness to children
5	Kathonzweni-T-women	Children	"*githeri*"-maize and beans	Causes children to have big bellies as they swallow them whole
6	Makindu-men	Children	Meat	delay in speaking and stammering

Table 18: Culturally prohibited foods in different areas of Makueni and Machakos

DISCUSSION

Overall no significant difference ($p > 0.05$) in nutrition indicators between the boys and the girls of the population under study was observed.

The differences in the **anthropometric indicators** between boys and girls were not statistically significant ($p > 0.05$). Based on anthropometric indices underweight for both sexes were equal. Wasting is a predictor of child mortality as it is often caused by severe acute food shortage or diseases and infections. This population had a low to none serious rates of infections and almost most of them were still breastfeeding (94.2%) and weaning; hence, the low prevalence in wasting (68).

Overall the anthropometric indices indicate that for the study population nutrition status has improved since the KDHS study of (2008-09) on children under five years in Eastern Province as well as from what was reported from Ndiku *et al* 2011 study (7, 12). Prevalence of stunting, wasting and underweight has decreased to 35.7%, 4.8% and 11.5% from 44%, 3% and 23.5%, respectively, as reported in the Ndiku *et al* 2011 study (7). The prevalence in the current study are similar to findings from the most recent KDHS for the year 2014 which reported the prevalence of stunting, wasting and underweight in Eastern province as 30.1%, 4.% and 11% respectively (67). The cut-off used in determining the prevalence of all three anthropometric indices is (< -2 SD) which is moderate and in accordance with the WHO guidelines (68). Low DDS, has a strong impact on anthropometric indices as 80.6% of the children who were stunted had a low dietary diversity score. This was the same for underweight and wasting; 5 out of the 7 children who were wasted had a low DDS, and 13 out of the 16 who were underweight also had a low DDS. This shows there is a relationship between dietary diversity and anthropometry (13, 53).

The study population evidently had a low **socio-economic status** judging from income of the mother's and caregivers. 64.8% of the women had a low monthly income (< 5000 KSh/64 CAD). The low income in the area is linked to the low education of the women in this region as 81.2% had education of primary level and below, which is equivalent to $\leq 8^{th}$ grade in the GCSE system. It is alarming that a high number of the women had a low education as most (63.9%) of

the women in the study were in the age category of 15 – 30 years, meaning that a large number of the low educated were young women (69).

After analysis, some associations were found between the mother's demographic characteristics and the IYC's nutrition indicators as summarized on **Table 13.** One of the demographic characters that stood out was education of mother/caregiver and DDS with a *p*-value of 0.01 as seen on **Table 13**. The odds ratio was 1.277 (95% CI = 1.019, 1.600), showing that the children who had mothers/caregivers with low education were at a higher risk of having low DDS that the children with mothers/caregivers with a higher education.

Income and anemia showed a statistically significant (p = 0.04) relationship; children with mother/caregiver with low income were at a higher risk of being anemic than the children with mother/caregiver's with higher income. Low income likely explains a low DDS (p = 0.03) that leads to a high risk in being anemic as the mother/caregiver does not have enough money to buy food that would encompass dietary diversity, thus foods considered expensive but rich in heme-iron may not be purchased. This leads to low intake in such foods as shown in the FFQ monthly consumption graph **(Figure 6)** and contributes to the high prevalence of IDA**.**

Low education is commonly associated with poor nutrition status of the household occupants as it relates to low income paying jobs and poverty, which all translates to poor dietary diversity that is evident in nutrition status of children and the mothers themselves (57).

Dietary diversity score is used to show quality of diet; here it shows that the overall diet quality of this population is rather low with 76.6% eating 3 food groups and less; an ideal dietary diversity score will have 6 food groups and more, while a medium score has a range of 4-5 food groups (32). This is an indication of status of food insecurity in Machakos and Makueni counties, largely attributable to the region's harsh climate as well as low income of the children's mother/caregiver as they do not have enough money to buy food that will contribute to the dietary diversity of the child.

The child DDS comprised seven food groups since it is an individual dietary score (54), while a household DDS has 12-16 food groups. DDS can be used to determine the diversity of a diet in regards to the number or rather variety of food groups an individual consumes in a given period of time and frequency of consumption (32).

The DDS was not significantly different ($p = 0.19$) in terms of sex; but in terms of the two age categories significance was observed ($p = 0.023$); 46.9% of the population with low DDS were in the of 6-23 months age category. This however, can be explained by the fact that most (60.7%) of the IYC still breastfeeding are in this age category and breastfeeding is not counted as a food group. The infants are also weaning on only soft foods (porridge) which contributes to their low DDS (54).

To better understand what types of food groups from the populations where low DDS was being consumed, information from 24 HR recall was grouped into the 7 major food groups for IDDS and a graph **(Figure 4)** categorized by gender used to clearly put this into perspective. This strategy was used to look at information from the FFQ and show the monthly consumption of the population (**Figure 5**); in this case the food were grouped into the 18 major food groups used to calculate the HDDS according to FAO guidelines (32).

Twenty-four hour (24HR) recall and FFQ showed that the population generally had poor intake of meat, which clearly contributes the high prevalence of IDA and VAD. The poor intake of iron and vitamin A from animal sources has contributed largely to deficiency in the two micronutrients. Poor consumption of meats can also be attributed to the climate in the area under study as well. With this region being situated in arid and semi-arid land (ASAL) rearing of animals for human consumption is constrained due to insufficient water and pasture for grazing. Scarcity of meat product makes them more costly and unavailable to most of the local population. Both climate and the low socio-economic status of the mothers and caregivers explains the low consumption of meat product. Most of the food crops that do well under this type of climate include starch, grains, legumes and seasonal fruits and traditional vegetables, which are reflected in the FFQ and 24HR.

Information from the 24HR and FFQ also showed that both boys and girls had an equal level intake of vitamin A rich foods, which also contributed to the non-significance ($p > 0.05$) in difference of VAD between boys and girls in the study population. It is also important to note that only boys, but no girls, consumed any organ meat (liver, kidney, heart), which is an

indication that few areas still uphold the cultural traditions that women and children are not allowed to eat such foods as observed from information from FGDs **(Table 18)** (14).

The prevalence of **VAD** was 42.6% (n =190) in the population. This high prevalence is largely due to the poor nutrient intake of the population, from which a large percentage (70.4%) has a low DDS (food groups ≤ 3). On close scrutiny of their daily and monthly consumption from 24HR **(Figure 4)** and FFQ **(Figure 5)** respectively, intake of animal sources of vitamin A is low to minimal. Meat and organ meat have high content of preformed vitamin A, which contribute to increasing levels of RBP (42). Consumption of orange/yellow pumpkin, squash, carrot which are rich in both retinol and beta-carotene was low; less than 10% of the population consumed this over a monthly period as depicted on **Figure 5**.

No significant differences was observed in VAD between boys and girls (p = 0.197). From 24 HRs **(Figure 4)** vitamin A rich fruits were equally consumed by both boys and girls, which would contribute to the non-significance of VAD between the boys and girls; as well as the vitamin A supplement intake was not significantly different between the girls (40%) and boys (46.2%).

A strong correlation between IDA and VAD was observed after a Fisher's exact test (p = 0.03) with an odds ratio of (OR=1.59; 95% CI = 1.17, 2.16). This shows that children who were anemic were at a higher risk of being vitamin A deficient than the children who were not anemic; it shows a positive correlation of vitamin A and iron (70).

Prevalence of **IDA** in the population was 35.3%, which is high compared to the nationwide study conducted by Ngesa *et al* in 2014 that depicted a prevalence of 30.9% of children ≤ 36 months and 28.8% prevalence in children between 6 months and 14 years (71). This might be influenced by the population's DDS. There is a higher intake in food groups which have non-heme iron (milk, vegetables) and have low bioavailability of iron, and quite low intake in foods rich in heme iron (meat ,organ meat). This high dietary intake of foods rich in non-heme iron other than foods rich in the heme-iron contributed to the low levels of hemoglobin in the population (5, 32). This is because foods rich in non-heme iron do not essentially contribute to the iron group that is attached in the prophyrin ring to make functional hemoglobin; consequently this does not

increase the number of viable red blood cells, leading to a low red blood cell count termed as anemia.

There was no significant difference in IDA between boys and girls but when categorized in age group, IDA in the 6-23 month category was significantly higher (p = 0.007) than in 24-36 month category (T**able 9)** likely a result of the low DDS this age category has compared to the 24-36 month age group. Low DDS has been linked to IDA and shown to have a strong relationship (p = 0.029) by Fisher's exact test as shown on **Table 12 (53).** This relationship showed that IYC who had a low DDS were at a higher risk of being anemic than the IYC who had a medium to high DDS (OR=1.385; 95% CI = 0.995, 1.927) agreeing with findings of Swindale *et al (53).*

Ironically, the level of education of the mother did not have any effect on whether or not a child received micronutrient supplement since children with mothers who had a primary level education had a higher percentage of receiving these supplements; this is likely a major contributor to the non significance of micronutrient deficiency between boy and girl child. This improvement is largely due to the fact that healthcare facilities have improved and increased in numbers in the region making them accessible to mothers with low level education and to able of information during pre/post-natal visits (14, 72).

This is an effort by the Kenyan government's Ministry of Health Action plan that is targeted to improve the nutritional status of vulnerable group by impacting several strategies that include; improving and availing health facilities and hence, nutrition information. Another major objective and strategy according to the Action Plan for 2012-2017 that has had an impact on availability of micronutrient supplements to all the mothers/caregivers regardless of education level is; the aim to prevent and reduce micronutrient deficiency in both children under five years and women of reproductive age, by providing micronutrient supplementation through dietary diversification, fortification and micronutrient tablets and syrups. The micronutrient supplementation is coordinated by the National Food Fortification Alliance and National Micronutrient Control Council (73).

From the **focus group discussions**, most of the areas seemed to have had and heard of the foods which were culturally prohibited to the girl child and adult woman as well as pregnant women; in some cases, some foods were prohibited to both the girl child and adult woman. From the 18

FGD's only 6 reported that they had foods that were culturally prohibited, the other 12 FGD's do not uphold or practice these traditions. That the majority of the FGDs indicated that the cultural traditions were no longer being upheld can explain why there were no significant differences in nutrition indicators between the boys and the girls.

Qualitative data from the FGDs summarized in **Table 18**, revealed that meat as well as organ meats were forbidden yet these are high sources of heme-iron as well as preformed vitamin A (5, 42). This information is clearly reflected in the 24 HR and FFQ and eventually translated into the micronutrient deficiencies which explain the high prevalence of both IDA and VAD. These few areas still upholding cultural beliefs that are biased, still have an impact overall, as it lowers the DDS which in turn causes a decrease in both macro and micronutrient intake which is eventually reflected in the nutrition status of the affected group (7, 13, 17).

Due to information gained from education in school, health facilities or different nutrition organizations that launch nutrition programs in the Eastern region of Kenya these traditions are slowly being faced out; this was clear from the number of FGDs that still uphold these traditions/culture (14, 57, 72). These findings highlight the positive impact of one of the objectives by the Kenya Ministry of Health and Sanitation through its "Action plan" to improve Knowledge Attitude and Practices of the local population through nutrition education that has been geared to wipe away the beliefs and myths around feeding practices (73).

Challenges and limitations

While conducting the study, some challenges during field and lab analysis were faced, as well as some limitations noted that affected the study in one way or another.

One of the limitations was *sample size* which contributed to the non-significance of most of the data. The data available for the analysis was for a smaller sample size than the expected as some respondents had missing data due to: - child's collapsed veins, refusal of respondents to have their children's blood collected, hemolyzed blood samples that could not be analyzed and missing information during answering of questionnaires.

Unreported micronutrient intakes, which would influence the levels of micronutrient status and eventually prevalence of malnutrition, represents a limitation of this study.

One major challenge was the *terrain* in some parts of the area under study, which had impassable roads and deep valleys faced in reaching a household; this sometimes necessitated long walks and the carrying equipment to the households.

Expected application of results

Results from the study can be used as baseline data for current or future studies similar to or touching on this topic. This data can be used in policy planning by decision makers to improve or introduce different interventions in the area that better target the most affected; as well as to judge the success of current or previously implemented interventions or strategies e.g. "Action Plan". This information can also be used to educate the respondents on how to change or what to include in their diet so as to increase micronutrient intake and eventually increase nutritional status of the vulnerable groups.

CONCLUSION

Tradition/cultural practices that prohibit consumption of certain foods does lead to low dietary diversity score causing micronutrient (iron and vitamin A) deficiency which reflects on the poor nutrition status of the IYC.

However contrary to Ndiku *et al* 2011 study, nutrition status between boys and girls does not have a significant difference ($p > 0.05$) (7). This means that the feeding patterns for both genders are not as different and strongly influenced by traditions, culture and beliefs, judging from the small number of FGD's that reported to be practicing the traditions. This is as a result of knowledge and information being widespread in the area through education and health facilities as well as through nutrition programmes that are implemented by several non-government organizations (NGO) partnering with government institutions that visit the area often as it is considered a focus of food insecurity. The main program is the "Action Plan" of the Ministry of Health and Sanitation, which seeks to provide micronutrient supplements, fortification and dietary diversification to the local population. The Action Plan's objective for Knowledge Attitude and Practice (KAPS) has also contributed in slowly wiping out the beliefs and myths centered around feeding practices and hence, contributing to the non-significance of nutrition indicators between boys and girls (57,73).

It is my **recommendation** that further research be done with ample sample size to better understand social/cultural influence on nutrition status, as this study contradicted both the Ndiku *et al* 2011 study that showed more girls than boys were malnourished and the KDHS 2004 that showed the opposite that it was more boys than girl who were malnourished (7, 12). As well, implementation of this study in other Counties and Provinces especially areas that are considered food secure and so do not get much attention, could investigate where cultural/tradition beliefs may still affect IYC nutrition status.

Community development programmes by organizations like the Kenya Community Development Foundation (KCDF) that encourage and fund groups that come together to improve themselves and their community, e.g. women forming chicken farms, basket weaving or tailoring, can also benefit the community through increase in incomes, thus enabling dietary diversity and eventually improving nutrition status.

REFERENCES

1. Bohle HG. Food Security. In: Editors-in-Chief: Neil JS, Paul BB, editors. International Encyclopedia of the Social & Behavioral Sciences. Oxford: Pergamon; 2001. p. 5728-30.

2. Jaetzold R, Schmidt H. Farm Management Handbook of Kenya. Nairobi: Ministry of Agriculture; 1982.

3. Messer E. Intra-household allocation of food and health care: Current findings and understandings—Introduction. Social Science & Medicine. 1997;44(11):1675-84.

4. Bhutta ZA, Salam RA, Das JK. Meeting the challenges of micronutrient malnutrition in the developing world. British Medical Bulletin. 2013;106(1):7-17.

5. Shell-Duncan B, McDade T. Cultural and environmental barriers to adequate iron intake among northern Kenyan schoolchildren. Food and Nutrition Bulletin. 2005;26(1):39-48.

6. Osmani S, Sen A. The hidden penalties of gender inequality: fetal origins of ill-health. Economics and Human Biology. 2003;1(1):105-21.

7. Ndiku M, Jaceldo Siegl K, Singh P, Sabaté J. Gender inequality in food intake and nutritional status of children under 5 years old in rural Eastern Kenya. European Journal of Clinical Nutrition. 2011;65(1):26-31.

8. Caballero B. Nutritional Assessment | Clinical Examination. In: Editor-in-Chief: Benjamin C, editor. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 2005. p. 329-31.

9. Ifejika Speranza C, Kiteme B, Wiesmann U. Droughts and famines: The underlying factors and the causal links among agro-pastoral households in semi-arid Makueni district, Kenya. Global Environmental Change. 2008;18(1):220-33.

10. Bhutta Z, Salam R, Das J. Meeting the challenges of micronutrient malnutrition in the developing world. British Medical Bulletin. 2013;106(1):7-17.

11. Kapil U, Bhavna A. Adverse effects of poor micronutrient status during childhood and adolescence. Nutrition Reviews. 2002;60(5):S84-90.

12. Masibo P, Makoka D. Trends and determinants of undernutrition among young Kenyan children: Kenya Demographic and Health Survey; 1993, 1998, 2003 and 2008-2009. Public Health Nutrition. 2012;15(9):1715-27.

13. Acham H, Oldewage-Theron W, Egal AA. Dietary diversity, micronutrient intake and their variation among black women in informal settlements in South Africa: a crosssectional study. International Journal of Nutrition Metabolism. 2012;4:24-39.

14. Macharia C, Kogi-Makau W, Muroki N. A comparative study on the nutritional status of children (6-59 months) in a world vision project area and a non-project area in Kathonzweni Division, Makueni District, Kenya. African Journal of Food Agriculture and Nutritional Development (AJFAND): Volume. 2005;5(1).
15. Masset E, Haddad L, Cornelius A, Isaza Castro J. Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review. BMJ British Medical Journal. 2012;344(7843):d8222-d.
16. Berti P, Krasevec J, FitzGerald S. A review of the effectiveness of agriculture interventions in improving nutrition outcomes. Public Health Nutrition. 2004;7(5):599-609.
17. Oniang'o RK. Contemporary African food habits and their nutritional and health implications. Asia Pacific Journal of Clinical Nutrition. 2003;12(3):331-6.
18. Dey I. Gender inequality in nutritional status among under five children in a village in Hooghly District, West Bengal. Indian Journal of Public Health. 2008;52(4):218-20.
19. Choudhury KK, Rasheed S, Bhuiya A, Hanifi MA. Gender inequality and severe malnutrition among children in a remote rural area of Bangladesh. Journal of Health, Population and Nutrition. 2000;18(3):123-30.
20. Allen LH. The nutrition CRSP: what is marginal malnutrition, and does it affect human function? Nutrition Reviews. 1993;51(9):255-67.
21. Pal S. An Analysis of Childhood malnutrition in rural India: Role of gender, income and other household characteristics. World Development. 1999;27(7):1151-71.
22. Hadley C, Lindstrom D, Tessema F, Belachew T. Gender bias in the food insecurity experience of Ethiopian adolescents. Social Science and Medicine (1982). 2008;66(2):427-38.
23. Wells JCK, Wells JCK. Natural selection and sex differences in morbidity and mortality in early life. Journal of Theoretical Biology. 2000;202(1):65-76.
24. Wamani H, Åstrøm A, Peterson S, Tumwine J, Tylleskär T. Boys are more stunted than girls in Sub-Saharan Africa: a meta-analysis of 16 demographic and health surveys. BioMed Central Pediatrics. 2007;7(1):17.
25. Gibson RS. Principles of nutritional assessment. New York: Oxford University Press; 2005.
26. Eaton–Evans J. Nutritional assessment | Anthropometry. In: Editor-in-Chief: Benjamin C, editor. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 2005. p. 311-8.

27. Fidanza F. Nutritional status | Biochemical Assessment. In: Editor-in-Chief: Benjamin C, editor. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 1998. p. 1364-73.
28. Fidanza F. Nutritional assessment | Biochemical Indices. In: Editor-in-Chief: Benjamin C, editor. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 2005. p. 318-29.
29. Crawley J. Reducing the burden of anemia in infants and young children in malaria-endemic countries of Africa: From evidence to action. The American Journal of Tropical Medicine and Hygiene. 2004;71(2 suppl):25-34.
30. Nagababu E, Rifkind J. Heme degradation by reactive oxygen species. Antioxidants & Redox Signalling. 2004;6(6):967-78.
31. Domellöf M. Iron requirements in infancy. Annals of Nutrition & Metabolism. 2011;59(1):59-63.
32. Kennedy G, Ballard T, Dop MC. Guidelines for measuring household and individual dietary diversity: Food and Agriculture Organization of the United Nations; 2013.
33. Ndemwa P. Relationship of the availability of micronutrient powder with iron status and hemoglobin among women and children in the Kakuma refugee camp, Kenya. Food and Nutrition Bulletin. 2011;32(3):286-91.
34. Blomhoff R, Blomhoff HK. Overview of retinoid metabolism and function. Journal of Neurobiology. 2006;66(7):606-30.
35. Olson JA, Gunning D, Tilton R. The distribution of vitamin A in human liver. The American Journal of Clinical Nutrition. 1979;32(12):2500-7.
36. Sommer A. Assessment and control of vitamin A deficiency: The annecy accords. The Journal of Nutrition. 2002;132(9 Suppl.):2845S-50S.
37. Duerbeck N, Dowling D. Vitamin A. Obstetrical and Gynecological Survey. 2012;67(2):122-8.
38. Rothman KJ, Moore LL, Singer MR, Nguyen U-SDT, Mannino S, Milunsky A. teratogenicity of high vitamin A intake. The New England Journal of Medicine. 1995;333(21):1369-73.
39. Lind T, Lind PM, Jacobson A, Hu L, Sundqvist A, Risteli J, et al. High dietary intake of retinol leads to bone marrow hypoxia and diaphyseal endosteal mineralization in rats. Bone. 2011;48(3):496-506.

40. Hayman R, Dalziel S. Acute vitamin A toxicity: A report of three paediatric cases. Journal of Paediatrics and Child Health. 2012;48(3):E98-E100.
41. Russell RM. The vitamin A spectrum: From deficiency to toxicity. The American Journal of Clinical Nutrition. 2000;71(4):878-84.
42. Olson JA. Recommended Dietary Intakes (RDI) of vitamin A in humans. The American Journal of Clinical Nutrition. 1987;45(4):704-16.
43. Survey Uganda Demographic Health Survey UDHS-addendum chapter 11. 2011.
44. Baeten JM, Richardson BA, Bankson DD, Wener MH, Kreiss JK, Lavreys L. Use of serum retinol-binding protein for prediction of vitamin A deficiency: effects of HIV-1 infection, protein malnutrition, and the acute phase response. The American Journal of Clinical Nutrition. 2004;79(2):218-25.
45. de Pee S, Dary O. Biochemical indicators of vitamin a deficiency: Serum retinol and serum retinol binding protein. The Journal of Nutrition. 2002;132(9):2895S-901S.
46. Gamble MV, Ramakrishnan R, Palafox NA, Briand K, Berglund L, Blaner WS. Retinol binding protein as a surrogate measure for serum retinol: studies in vitamin A–deficient children from the Republic of the Marshall Islands. The American Journal of Clinical Nutrition. 2001;73(3):594-601.
47. Erhardt JG, Estes JE, Pfeiffer CM, Biesalski HK, Craft NE. Combined measurement of ferritin, soluble transferrin receptor, retinol binding protein, and C-reactive protein by an inexpensive, sensitive, and simple sandwich enzyme-linked immunosorbent assay technique. The Journal of Nutrition. 2004;134(11):3127-32.
48. Sato A, Nakashima H, Kinoshita M, Nakashima M, Ogawa Y, Shono S, et al. The effect of synthetic C-reactive protein on the in vitro immune response of human peripheral blood mononuclear cells (PBMCs) stimulated with bacterial reagents. Inflammation. 2013;36(4):781-92.
49. Engle-Stone R, Haskell MJ, Ndjebayi AO, Nankap M, Erhardt JG, Gimou M-M, et al. Plasma retinol-binding protein predicts plasma retinol concentration in both infected and uninfected Cameroonian women and children. The Journal of Nutrition. 2011;141(12):2233-41.
50. Du Clos TW. Function of C-reactive protein. Annals of Medicine (Helsinki). 2000;32(4):274-8.

51. Tucker KL. Dietary surveys. In: Editor-in-Chief: Benjamin C. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 2005. p. 27-32.
52. Welch AA. Dietary intake measurement | Methodology. In: Editor-in-Chief: Benjamin C. Encyclopedia of Human Nutrition (Second Edition). Oxford: Elsevier; 2005. p. 7-16.
53. Swindale A, Bilinsky P. Household dietary diversity score (HDDS) for measurement of household food access: indicator guide. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development. 2006.
54. Organization WH. Indicators for assessing infant and young child feeding practices: part 1: definitions: conclusions of a consensus meeting held 6-8 November 2007 in Washington DC, USA. World Health Organization 2008.
55. Wong LP. Focus group discussion: a tool for health and medical research. Singapore Medical Journal. 2008;49(3):256-60.
56. Bloss E, Wainaina F, Bailey RC. Prevalence and Predictors of Underweight, Stunting, and Wasting among children aged 5 and under in Western Kenya. Journal of Tropical Pediatrics. 2004;50(5):260-70.
57. Macharia C, Kogi-Makau W, Muroki N. Dietary intake, feeding and care practices of children in Kathonzweni Division, Makueni District, Kenya. East African Medical Journal. 2004;81(8):402-7.
58. Breman JG, Alilio MS, Mills A, Caulfield LE, Richard SA, Black RE. Undernutrition as an underlying cause of malaria morbidity and mortality in children less than five years old. The American Journal of Tropical Medicine and Hygine. 2004; 71(Suppl 2); 55-63.
59. Ngare DK. Prevalence of malnutrltion in Kenya. The East African Medical Journal. 1999;76(7):376-80.
60. Pobiruchin M, Kieser M. Sample Size calculation and blinded sample size recalculation in clinical trials where the treatment effect is measured by the relative risk. Communications in Statistics-Simulation and Computation. 2013;42(7):1643-53.
61. Sahai H, Khurshid A. Formulae and tables for the determination of sample sizes and power in clinical trials for testing differences in proportions for the two-sample design: a review. Statistics in Medicine. 1996;15(1):1-21.
62. Cogill B. Anthropometric indicators measurement guide. Food and Nutrition Technical Assistance Project: Revised edition 2003.

63. Bruce C. Anthropometric indicators measurement guide. Washington DC:, Academy for Educational Development. 2001.
64. Burger S, Pierre-Louis J. A procedure to estimate the accuracy and reliability of HemoCue measurements of survey workers. Washington: International Life Sciences Institute. 2003.
65. von Schenck H, Falkensson M, Lundberg B. Evaluation of "HemoCue," a new device for determining hemoglobin. Clinical Chemistry. 1986;32(3):526-9.
66. Whittaker C. Paediatric fever. Professional Nursing Today. 2011;15(5):17-21.
67. Kenya National Bureau of Statistics; Minstry of Health, National Aids Control Council, Kenya Medical Research Institute, National Council for Population and Development. Kenya Demographic Health Survey 2014.
68. Organization WH. Global database on child growth and malnutrition. Geneva: World Health Organization. 1997.
69. Mulongo G. Inequality in accessing higher education in Kenya; Implications for economic development and well-being. International Journal of Humanities and Social Science. 2013;3(16).
70. Majía LA, Hodges RE, Arroyave G, Viteri F, Torún B. Vitamin A deficiency and anemia in Central American children. The American Journal of Clinical Nutrition. 1977;30(7):1175-84.
71. Ngesa O, Mwambi H. Prevalence and risk factors of anaemia among children aged between 6 months and 14 years in Kenya. Public Library of Science (PLoS ONE). 2014;9(11):e113756.
72. Maingi C. World Vision Kenya Silver Jubilee Brochure. World Vision Kenya Communication Department Nairobi. 1999:3-10.
73. Kenya Minstry of Public Health and Sanitation . National Nutrition Action Plan 2012-2017. 2012.

APPENDICES

Appendix 1: Protocol for collection, labeling and storage of data and samples

1.1: Data collection and labeling

A unique coded number will be assigned to each respondent consenting to sample collection. At the time of the sample collection, the coded label with each respondent's ID will be affixed to the questionnaires (lab anthropometry, 24hour recall and food frequency questionnaires), Microtainer/Vacutainer.

1.2: Blood collection

1. Place all collection materials on top of a disposable pad. Once the patient is present, open the lancet, alcohol swabs, gauze, bandage, and other items. Have all items ready for blood collection.
2. Put on powder-free gloves. Turn patient's hand upward. Massage patient's hand and lower part of the finger to increase blood flow.
3. Scrub the patient's middle finger or ring finger with an alcohol swab. Dry with gauze.
4. Hold the finger in an upward position and lance the palm side surface of the finger (between the nail and the finger pad) with the proper-size lancet (child). Press firmly on the finger when making the puncture. Doing so will help you to obtain the amount of blood you need.
5. Apply slight pressure to start blood flow. Wipe away the first drop of blood on a gauze pad and discard pad in appropriate biohazard container.
6. Keep the finger in a downward position and gently massage it to maintain blood flow. An effective way to do this is to apply pressure to the nail for three seconds, release for three seconds, and repeat continuously while collecting the blood. Hold the Microtainer® at an angle of 30 degrees below the collection site and use the scoop on the Microtainer® to guide the drops into the vial. Do not scrape the skin. Fill the Microtainer® to the 350 - 500 µL level.
7. Cap the Microtainer® and gently invert it 10 times to prevent clots from forming.
8. Apply a sterile adhesive bandage over the puncture site.
9. Label the Microtainer® with the preprinted label provided, and use a permanent marker to add the blood collection date to the label (if a date or date range is not already printed). If the label contains a barcode, the barcode needs to be vertical like a ladder when placed on the

vial. If the barcode is not vertical, the laboratory will not be able to read the label with the barcode reader. Place the label from left to right starting from the cap end and leave the graduated numbers on the tube visible.

10. Properly discard all used materials according to the biological waste disposal laws of the country in which the survey is taking place.

Additional tips:

- If the patient's hands are cold, it is helpful if they rub their hands together. The mother can help warm their child's hands prior to testing to stimulate blood flow to the capillaries.
- When applying pressure to stimulate blood flow, it is helpful to apply pressure and then relax pressure momentarily to allow blood to flow into the capillary bed.
- Perform puncture with respondent's hand held at or below heart level.
- Hold the patient's hand in a downward fashion to allow gravity to assist with blood droplet formation.

Appendix 2: Protocols for anthropometric measurement

2.1: Measuring a Child's Height (see illustration on **figure 6**)

(1) **Measurer or assistant:** Place the measuring board on a hard flat surface against a wall, table, tree, staircase, etc. Make sure the board is stable.

(2) **Measurer or assistant:** Ask the mother to remove the child's shoes and unbraid any hair that would interfere with the height measurement. Ask her to walk the child to the board and to kneel in front of the child (if she is not the assistant).

(3) **Assistant:** Place the questionnaire and pen on the ground (Arrow 1). Kneel with both knees on the right side of the child (Arrow 2).

(4) **Measurer:** Kneel on your right knee only, for maximum mobility, on the child's left side (Arrow 3).

(5) **Assistant:** Place the child's feet flat and together in the centre of and against the back and base of the board. Place you right hand just above the child's ankles on the shins (Arrow 4), your left hand on the child's knees (Arrow 5), and push against the board. Make sure the child's legs are straight and the heels and calves are against the board (Arrows 6 and 7). Tell the measurer when you have completed positioning the feet and legs.

(6) **Measurer:** Tell the child to look straight ahead at the mother if she is in front of the child. Make sure the child's line of sight is level with the ground (Arrow 8). Place your open left hand on the child's chin. Gradually close your hand (Arrow 9). Do not pinch the jaw. Do not cover the child's mouth or ears. Make sure the shoulders are level (Arrow 10), the hands are at the child's side (Arrow 11), and the head, shoulder blades and buttocks are against the board (Arrows 12, 13 and 14). With your right hand, lower the headpiece on top of the child's head. Make sure you push through the child's hair (Arrow 15).

(7) **Measurer and assistant:** Check the child's position (Arrow 1-15). Repeat any steps as necessary.

(8) **Measurer:** When the child's position is correct, read and call out the measurement to the nearest 0.1 centimetre. Remove the headpiece from the child's head, your left hand from the child's chin and support the child during the recording.

(9) **Assistant:** Immediately record the measurement and show it to the measurer. Alternatively, the assistant could call out the measurement and have the measurer confirm by repeating back.

NOTE: If the assistant is untrained, the measurer records the height.

(10) **Measurer:** Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to cancel and correct any errors.

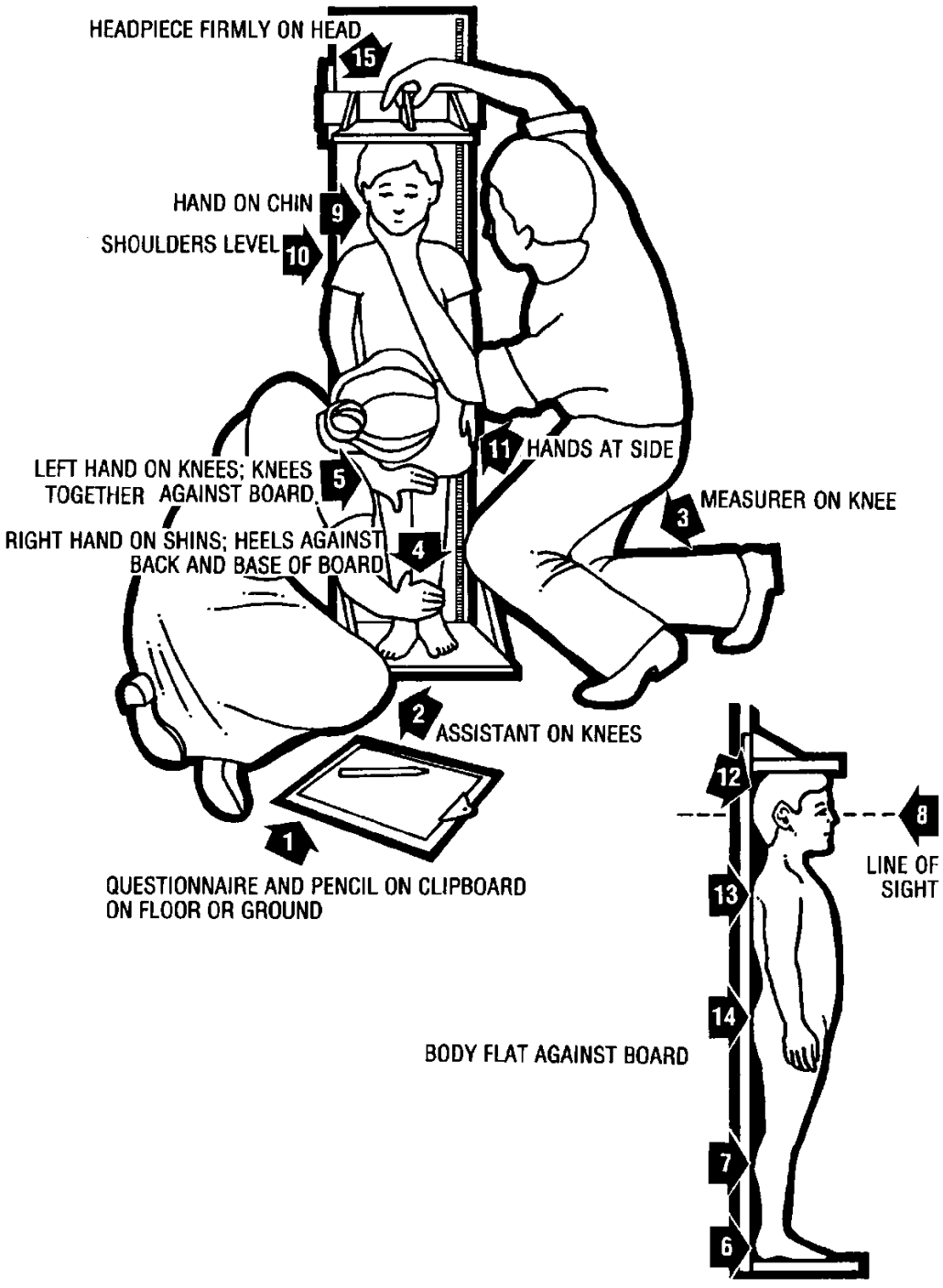


Figure 6: Illustration on measuring child's height (63)

2.2: Measuring a Child's Length (See illustration on **figure 7**)

(1) **Measurer or assistant:** Place the measuring board on a hard flat surface, such as the ground, floor or a steady table.

(2) **Assistant:** Place the questionnaire and pen on the ground, floor or table (Arrow 1). Kneel with both knees behind the base of the board, if it is on the ground or floor (Arrow 2).

(3) **Measurer:** Kneel on the right side of the child so that you can hold the foot-piece with your right hand (Arrow 3).

(4) **Measurer and assistant:** With the mother's help, lay the child on the board by doing the following:

Assistant: Support the back of the child's head with your hands and gradually lower the child onto the board.

Measurer: Support the child at the trunk of the body.

(5) **Measurer or assistant:** If she is not the assistant, ask the mother to kneel on the opposite side of the board facing the measurer to help keep the child calm.

(6) **Assistant:** Cup your hands over the child's ears (Arrow 4). With your arms comfortably straight (Arrow 5), place the child's head against the base of the board so that the child is looking straight up. The child's line of sight should be perpendicular to the ground (Arrow 6). Your head should be straight over the child's head. Look directly into the child's eyes.

(7) **Measurer:** Make sure the child is lying flat and in the centre of the board (Arrow 7). Place your left hand on the child's shins (above the ankles) or on the knees (Arrow 8). Press them firmly against the board. With your right hand, place the foot-piece firmly against the child's heels (Arrow 9).

(8) **Measurer and assistant:** Check the child's position (Arrows 1-9). Repeat any steps as necessary.

(9) **Measurer:** When the child's position is correct, read and call out the measurement to the nearest 0.1 centimetre. Remove the foot-piece, release your left hand from the child's shins or knees and support the child during the recording.

(10) **Assistant:** Immediately release the child's head, record the measurement and show it to the measurer. Alternatively, the assistant could call out the measurement and have the measurer confirm by repeating back.

NOTE: If the assistant is untrained, the measurer records the length on the questionnaire.

(11) **Measurer:** Check the recorded measurement on the questionnaire for accuracy and legibility. Instruct the assistant to cancel and correct any errors.

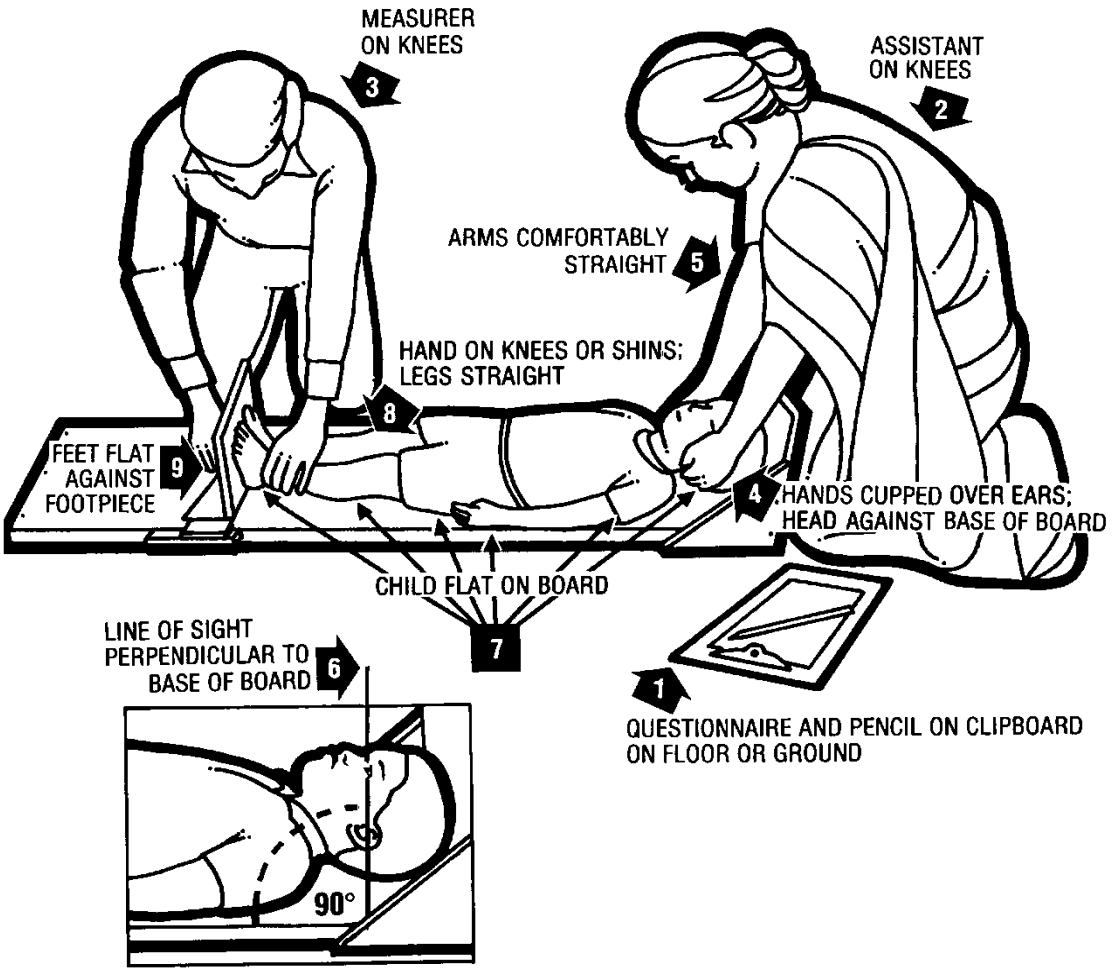


Figure 7: Illustration on measuring child's length (63)

2.3: Measuring a Child's Weight (62)

The Seca 881 U Electronic Scale

The Seca 881 U scale can be used in two ways:

3. Children can line up for weighing, stepping on the scale one after the other.
4. Babies and very small children can be weighed while being held in the arms of a mother or helper. This second method of weighing is called 'tared weighing' and for this purpose the scale has a "mother-and-baby function".

The Seca 881 U scale is powered exclusively by batteries. 120,000 weighing operations can be performed with one set of batteries. The scale uses four type AA 1.5 V batteries that are easily replaceable.

The scale switches off automatically;

- after 20 seconds in normal mode
- after 2 minutes, if the mother-and-baby function is switched on

Preparing the Seca 881 U Scale for use:

1. Place the scale on a hard, level surface (wood, concrete or firm earth). Soft or uneven surfaces may cause small errors in weighing.
2. Carefully turn over the scale so that the base is accessible. Open the battery compartment and insert the supplied batteries. To activate the power supply, push the switch located in the battery compartment in position "ON".
3. *The scale will not function correctly if it becomes too warm or too cold.* It is best to use the scale in the shade, or indoors. If the scale becomes hot and does not work correctly, place it in a cooler area and wait 15 minutes before using it again. If it becomes too cold, place it in a warmer area.
4. The scale must adjust to changes in temperature. If the scale is moved to a new site with a different temperature, wait for 15 minutes before using it again. STILL APPLIES?
5. Handle the scale carefully:
    - Do not drop or bump the scale.
    - Do not weigh loads totalling more than 150 kilograms.
    - Protect the scale from excess moisture or humidity.

- Do not use the scale at temperatures below 10º C or above 40º C.

Cleaning the scale: Wipe surfaces with a damp cloth. *Never put the scale into water.*

Storing the scale: Do not store the scale in direct sunlight or other hot places.

2.4: Weighing an infant or young child held by the mother or other person who can help (tared weighing)

The mother-and-baby key enables the body weight of infants and young children to be determined. The child is held in the arms of an adult.

- The scale is fitted with a vibration switch. Turn the scale on by gently stepping on the weighing platform.
- Wait until the display shows before stepping on the scale.
- Ask your helper to stand on the scale. Your helper's weight will appear on the display.

NOTE:

The person being weighed must stand still on the scale.

- With your helper standing still on the scale, press the mother-and-baby key. The display will read.
- The helper can now get off the scale to get the baby. Alternatively, the baby can be handed to her. If the helper gets off the scale to get the baby, the display will show ----
- After the helper steps back onto the scale and holds the baby, *only the weight of the baby will be displayed.*

Once the value is stable for about 3 seconds, the display is retained. This avoids the display jumping around as a result of the child's movements.

1. you press the mother-and-baby key again

2. the scale switches off automatically

Record the baby's weight.

Now the helper can hold the baby and get back on the scale. Only the baby's weight will show on the display.

1. Repeat steps 5 and 6 to weigh another baby.

The mother-and-baby function remains switched on until

3. you press the mother-and-baby key again

4. the scale switches off automatically

Remember: The scale switches off automatically 2 minutes after the last weighing in mother-and-baby mode, and 20 seconds after the last weighing in normal mode. If this happens, follow the instructions to turn it on again.

Taring weights

Important points

1. The weight of the person who will hold the child must be displayed (and then tared) before the child is given to her for weighing.
2. The same person whose weight is tared must also hold the child.
3. The tare can be de-activated by pressing the mother-and-baby key again or by waiting until the scale switches off automatically.

Appendix 3: Protocols for clinical assessment

3.1: Hemoglobin count using HemoCue (Hb-301) instrument

1. Hb-301 HemoCue instrument does not have a control cuvette or liquid controls. When the instrument is turned "ON", it automatically performs self-test.
2. Once the blood is collected in to the Microtainer or Vacutainer, label them appropriately.
3. Gently invert the Microtainer or Vacutainer about 10 times to prevent from forming clots. Fill the HemoCue cuvette by holding the Microtainer tube or Vacutainer in a horizontal position and carefully tapping the blood forward to the edge of the Microtainer or Vacutainer. Place the pointed tip of the HemoCue cuvette into the blood drop. The cuvette will fill automatically by capillary action. Never try to top off the cuvette after the initial filling.
4. Clean any excess blood from the cuvette using a lint-free wipe. Do not touch the open end of the cuvette with the wipe as this will suck out the blood. Inspect the cuvette for any air bubbles.
5. Place the cuvette in its holder and gently push the holder into the photometer. The results will be displayed in approximately 15-45 seconds.
6. Record the hemoglobin results. Dispose of the cuvette in the sharps container. Dispose all other materials in the biohazard bag.

1.2 Measuring temperature with digital thermometer

Axillary (armpit) temperature will be taken by a digital thermometer.

1. Place tip of the thermometer at the center of the armpit.
2. Child's arm should tuck snugly against their body.
3. Leave the thermometer in until the beep goes off.
4. Remove thermometer read and record reading.

Appendix 4.0: Protocols for biochemical analysis

4.1: Analysis of retinol binding protein (RBP), C-reactive protein (CRP) and Alpha-1-acid glycoprotein (AGP) using Sandwich Enzyme-Linked Immunosorbent Assay technique

Materials and reagents

- **Chemicals**: NaH_2PO_4, NaCl, citric acid, phosphoric acid, 3,3´,5,5´-tetramethylbenzidine dihydrochloride (TMB), 30% Hydrogen peroxidase (H_2O_2).
- **Antibodies:-**
  - Capture antibodies for RBP, CRP and AGP
  - Detection antibodies-anti-RBP, anti-CRP and Anti-AGP (horseradish peroxidases)
- Standards for curve calibration from serum control samples.
- Well plate

Procedure

1. Dilute antibodies in coating buffer (0.01 mol/L phosphate buffer, 0.15 mol/L NaCl, pH 7.2) in following concentrations:-
   a. Anti-RBP-0.82µg/well (1:1000)
   b. Anti-CRP-0.05 µg/well (1:20,000
   c. Anti-AGP-0.05 µg/well (1:20,000)
2. Add 100 µL of diluted antibody to well plates and cover with parafilm.
3. Incubate overnight in the refrigerator.
4. Invert and empty plates then pre-wash using buffer (0.01 mol/L phosphate buffer, pH 7.2, 0.5 mol/L NaCl, 0.1% Tween 20)
5. Repeat step 4 after 5 minutes and repeat step 4 and 5 twice.
6. Final rinse, tap plate on absorbent paper.
7. Add100 µL diluted serum and standard samples to the wells
8. To minimize biased readings, analyze duplicate samples but place the calibration standards in different positioned-wells on the plate.
9. Apply diluted serum to final reaction plate:-
   a. RBP: 25 µL D2 (1:6644 final dilution)
   b. CRP: 50 µLD2 (1:3322 final dilution)
   c. AGP: 50 µL D2 (1:3322 final dilution)
10. Incubate for 2 hours a room temperature and repeat step 4.
11. Add 100 µL of diluted antibodies coupled with Horseradish peroxidase.
12. Incubate for 1 hour at room temperature and repeat step 4.

Color reagent and plate development.

1. Add 1mg of 3,3´,5,5´-tetramethylbenzidine dihydrochloride (TMB) to 12ml 0.1mol/L citric acid phosphate buffer (pH 5.2).
2. Mix 2µl of 30% Hydrogen peroxide with 12ml TMB solution.

3. Add 100µl of the mixture above to each well.
4. Stop reaction after 5-10 minutes by adding 100µl of 1 mol/L phosphoric acid
5. Measure color (blue or yellow) intensity at wavelength 450 nm with the reference wavelength set at 650 nm.

Points to note

- Control samples are available commercially with provided values and Standard operating procedures for analytes. Follow procedure provided and use mean values of each analyte being tested to dilute samples for calibration curve.
- To prevent border effects while developing color, it is essential that the plate and the color reagent are both at room temperature

Appendix 5.0: Protocols for laboratory anthropometry form

ANTHROPOMETRY: WEIGHT AND HEIGHT MEASUREMENT FOR CHILDREN AGE 0-59MONTHS

CHECK COLUMN 10. RECORD THE LINE NUMBER AND AGE FOR ALL ELIGIBLE CHILDREN 0-5 YEARS IN QUESTION 502. IF MORE THAN SIX CHILDREN, USE ADDITIONAL QUESTIONNAIRE. A FINAL OUTCOME MUST BE RECORDED

P67	WEIGHT IN KILOGRAMS	KG. ☐☐.☐
P68	HEIGHT IN CENTIMETERS	CM ☐☐☐.☐
		MEASURED LYING DOWN OR STANDING UP?
P69	MUAC IN CENTIMETERS	CM ☐☐.☐
P70	RESULT OF WEIGHT AND HEIGHT MEASUREMENT	MEASURED…..……..1 NOT PRESENT..…….2 REFUSED..……..3 OTHER……..……...9
P71	Edema present?	NO…….....0 YES ……...……..1

CONSENT STATEMENT FOR BLOOD SAMPLE COLLECTION

Do you have any questions?

You can say yes to the test, or you can say no. It is up to you to decide.

Will you allow (NAME) to take the test?

P72	Was blood collected from respondent?	BLOOD TAKEN ……..1 NOT PRESENT……...2 REFUSED……3 OTHER……4
P73	HEMOGLOBIN RESUTS	g/dL □□.□
P74	MALARIA RESULTS	NO…….....0 YES ……...……..1
P75	SERUM VOLUME	Amount □□□.□
P76	Dried Blood Spot collected?	NO…….....0 YES ……...……..1

Appendix 6.0: Dietary assessment questionnaires

6.1: 24 Hour Recall (24HR) questionnaire

Mother/child 24 hour recall

List all the foods the respondent consumed during the last 24 hours giving a full description and key ingredients in the meal. Prompt for the preparation/cooking methods used to prepare if consumed at home

Before we talk about what your child ate yesterday, I'd like to ask you some introductory questions.

		Y	N		
118	Is your child currently breast feeding?	1	2		
119	Was your child sick yesterday? *(If "YES", please specify)*	1	2		
120	Cough……...	1	2		
121	Diarrhea……	1	2		
122	Fever…….	1	2		
123	Malaria……..	1	2		
124	Other _____ (SPECIFY)	1	2		
125	Was your child's appetite usual yesterday?	1	2	IF "NO", SPECIFY	
126	In the past day, has your child taken vitamin or mineral supplements? *(If "YES", please specify below.)*	1	2		
127	Iron……..	1	2	*IF "YES", SPECIFY DOSE, BRAND IF AVAILABLE.*	
128	Vitamin A……	1	2		
129	Zinc……...…….	1	2		
130	Other _____ (SPECIFY)	1	2		
131	In the past 6 months, has your child received a Vitamin A capsule?	1	2		

IDENTIFICATION (1)

100 INTERVIEWER: _____
(NAME)

_____
(ID)

101 DATE: ☐☐/☐☐/☐☐☐☐
102 DD / MM / YYYY

103 DAY OF THE WEEK: _____

TIME OF INTERVIEW: _____

104 PROVINCE*: _____ ☐

105 DISTRICT: _____

106 TOWN/VILLAGE: _____

* PROVINCE:

NAIROBI=1;	NYANZA=5;
CENTRAL=2;	R. VALLEY=6;
COAST=3;	WESTERN=7;
EASTERN=4;	NORTHEASTERN=8

107 NASSEP CLUSTER NUMBER: ☐☐☐☐

108 HOUSEHOLD NUMBER: ☐☐☐

RESPONDENT INFORMATION

109 NAME OF HOUSEHOLD HEAD:

_____
(FIRST & LAST)

110 SEX: 1 2
(M) (F)

111 BIRTH DATE: ☐☐/☐☐/☐☐☐☐
DD / MM / YYYY

114 RESULT**: _____

**RESULT CODES:
1 COMPLETED
2 NO HOUSEHOLD MEMBER HOME AT TIME OF VISIT
3 DWELLING VACANT
4 REFUSED
6 OTHER _____
(SPECIFY)

CHILD INFORMATION

112 SEX: 1 2
(M) (F)

113 BIRTH DATE: ☐☐/☐☐/☐☐☐☐
DD / MM / YYYY

115 SIGNATURE OF ☐☐ INTERVIEWER: ☐☐ ☐☐ ☐☐

_____

DATE: __ __ / __ __ / __ __ __ __

SUPERVISOR	FIELD EDITOR	OFFICE EDITOR	KEYED BY:
NAME:_____	NAME:_____		
DATE: _____	DATE: _____		

DD / MM / YYYY

117

RESPONDENT AGREES TO BE INTERVIEWED . . . 1 RESPONDENT DOES NOT AGREE TO BE INTERVIEWED . . . 2
→ END

16. Was yesterday a usual days pattern : 1 = yes 0 = No

17. If no please explain how it was different from your normal daily patterns

……

18. Indicate the day of the week the recall was done ……

Dietary Diversity Score Questions

WE ARE ALMOST DONE. THANK YOU SO MUCH FOR SPENDING THIS TIME WITH ME.

NOW I WOULD LIKE TO ASK YOU ABOUT LIQUIDS OR FOODS THAT **(CHILD NAME)** SINCE YESTERDAY, AT A TIME LIKE THIS. I AM INTERESTED IN WHETHER YOUR CHILD HAD THE ITEM I MENTION EVEN IF IT WAS COMBINED WITH OTHER FOODS.

	SINCE YESTERDAY, AT A TIME LIKE THIS, DID **(CHILD NAME)** DRINK/EAT THE FOLLOWING?		
P31	PLAIN WATER?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P32	JUICE OR JUICE DRINKS?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P33	SOUP?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P34	MILK SUCH AS TINNED, POWDERED, OR FRESH ANIMAL MILK?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	→**P36**
P35	HOW MANY TIMES DID **(CHILD NAME)** DRINK MILK:	NUMBER OF TIMES	

	(If 7 or more times record 7)	DRUNK MILK	
P36	INFANT FORMULA?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	**→ 38**
P37	HOW MANY TIMES DID**(CHILD NAME)** DRINK INFANT FORMULA? *(If 7 or more times record 7)*	NUMBER OF TIMES DRANK FORMULA ☐	
P38	TEA?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	**→40**
P39	HOW MANY TIME DID **(CHILD NAME)** DRINK TEA? *(If 7 or more times record 7)*	NUMBER OF TIMES DRANK TEA ☐	
P40	ANY OTHER LIQUID?	SPECIFY.....	
P41	YOGURT?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	**→ 43**
P42	HOW MANY TIMES DID **(CHILD NAME)** EAT YOGURT? *(If 7 or more times record 7)*	NUMBER OF TIMES EAT YOGURT ☐	
P43	ANY BRAND OF COMMERCIALY FORTIFIED BABY FOOD, E.G. CERELAC?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P44	BREAD, RICE, NOODLES, OR OTHER FOOD MADE FROM GRAINS?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P45	PUMPKIN, CARROT, SQUASH OR SWEET POTATOES THAT ARE YELLOW OR ORANGE INSIDE?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P46	WHITE POTATOES, WHITE YAMS, MANIOC, CASSAVA OR ANY	NO……... 0	

	OTHER FOOD MADE FROM ROOTS?	YES ……...……. 1 DON'T KNOW …….. 99	
P47	ANY DARK GREEN LEAFY VEGETABLES?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P48	RIPE MANGO, PAPAYAS, OR (INSERT ANY OTHER LOCALLY AVAILABLE VIT A RICH FRUITS) ?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P49	ANY OTHER FRUITS OR VEGETABLES?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P50	LIVER, KIDNEY, HEART AND OTHER ORGAN MEATS?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P51	ANY MEAT SUCH AS BEEF, PORK, LAMB, GOAT, CHICKEN OR DUCK?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P52	EGGS?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P53	FRESH OR DRIED FISH OR SHELL FISH?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P54	ANY FOOD MADE FROM BEANS, PEAS, LENTILS, OR NUTS?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P55	CHEESE OR OTHER FOOD MADE FROM MILK?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	
P56	ANY OTHER SOLID, SEMISOLID, OR SOFT FOOD?	NO……... 0 YES ……...……. 1 DON'T KNOW …….. 99	

Infant Feeding Practice Questions:

If the child is over three years (36 months) skip the questions on infant feeding practices

NOW I WOULD LIKE TO ASK YOU SOME ADDIITONAL INFORMATION ABOUT **(CHILD'S NAME)** FEEDING PRACTICES.

P57	DID YOU EVER BREASTFEED **(CHILD NAME)**?	NO……... 0 YES ……...……. 1	**→P61**
P58	HOW LONG AFTER BIRTH DID YOU FIRST PUT **(CHILD NAME)** TO THE BREAST?	IMMEDIATELY AFTER BIRTH……...…… 0 WITHIN ONE HOUR…..... 1 AFTER 1 HOUR BUT WITHIN A DAY…….…… 2 AFTER ONE DAY…….…… 3 DON'T KNOW……..... 99	
P59	SINCE YESTERDAY, AT A TIME LIKE THIS, WAS **(CHILD NAME)** BREASTFED DURING THE DAY OR AT NIGHT?	NO……... 0 YES ……...……. 1	**→P61**
P60	SINCE YESTERDAY, AT A TIME LIKE THIS, HOW MANY TIMES DID **(CHILD NAME)** DRINK BREAST MILK DURING THE DAY OR AT NIGHT?	☐☐ NUMBER OF TIMES *f don't know, enter 99*) 99	
P61	SINCE YESTERDAY, AT A TIME LIKE THIS, DID **(CHILD NAME)** DRINK ANYTHING FROM A BOTTLE WITH A NIPPLE?	NO……... 0 YES ……...……. 1	
P62	SINCE YESTERDAY, AT A TIME LIKE THIS, DID **(CHILD NAME)** RECEIVE ANYTHING TO DRINK OTHER THAN BREAST MILK?	NO……... 0 YES ……...……. 1	**→P64**
P63	IF YES, WHAT WAS (**CHILD NAME)**GIVEN TO DRINK? *(Mark all that apply)*	MILK (OTHER THAN BREAST MILK)……. 0/1 PLAIN WATER…… 0/1 SUGAR OR GLUCOSE WATER……. 0/1 GRIPE WATER…… 0/1 SUGAR- SALT- WATER SOLUTION…… 0/1 FRUIT JUICE …….. 0/1 INFANT FORMULA……. 0/1 TEA/ INFUSIONS……. 0/1 HONEY ……. 0/1	

		OTHER ……. 0/1 0/1 SPECIFY.....	
P64	HOW OLD WAS **(CHILD NAME)** WHEN HE/ SHE WAS INTRODUCED TO SOLID, SEMI- SOLID OR SOFT SOLID FOOD (COMPLEMENTARY FEEDING) FOR THE FIRST TIME? EXAMPLE OF SOLID FOODS INCLUDE: MEAT, CHEESE, FISH SEMI SOLID FOODS INCLUDE RICE, LENTILS; SOFT SOLID FOODS INCLUDE BANANAS (*Verify the age in months complete)*	MONTHS (COMPLETE) ☐☐ NOT YET INTRODUCED… 0 DON'T KNOW……... 1	→**P67** →**P67**
P65	SINCE YESTERDAY, AT A TIME LIKE THIS, DID**(CHILD NAME)** RECEIVE SOLID, SEMI- SOLID OR SOFT SOLID FOOD?	NO……... 0 YES ……...……. 1	→**P67**
P66	HOW MANY TIMES DID YOU GIVE **(CHILD NAME)** SOLID, SEMI-SOLID OR SOFT SOLID YESTERDAY?	NUMBER OF TIMES ☐☐ *f don't know, enter 99*) 99	

6.2: Food Frequency Questionnaire (FFQ)

Indicate how many times the following foods are consumed by the patient in a week

Ask and indicate how many times per week/month the following foods consumed?

1. Never eaten 2 – rarely eaten 3 - Once a month, 4 - Once every 2 weeks, 5- 2-1 times a week, 6 - 6-3 times a week, 7 - Once daily, 8 - More than once daily

CEREALS	**Daily**	**Weekly**	**monthly**	**Occasional (2 or more months)**
Rice Grade 2				
Rice- Grade 1 - Pishori/Basmati				
Maize Grain - Loose				
Green maize				
Maize Flour - Loose				
Maize Flour - sifted				
Wheat grain				
Wheat Flour				
Millet grain – wimbi				
Millet Flour - Wimbi				
Sorghum grain				
Sorghum flour				
Other millet grain/flour				
Barley and other cereals				
COST OF MILLING				
Bread				
Cakes				
Biscuits ...				
Breakfast cereal/oats				
Wheat buns /Scones				
Pasta (spaghetti/macaroni)				
Roots and tubers				
Potatoes (Irish)				
Sweet potato				
Arrow roots				
Cassava				
Cassava flour				
Yams				
Crisps				

Cooking banana				
Pulses				
Beans				
Grams				
Black grams (Njahi)				
Peas				
Groundnut				
Cowpea				
Other pulses (specify)				
Vegetables				
onion / Leeks				
Cabbages				
Carrots				
Tomatoes				
Spinach				
Kale-Sukuma wiki				
Capsicums (Pilipili hoho)				
Cucumber				
French beans				
Lettuce				
Courgette				
Celery				
mushrooms				
Cauliflower				
Aubergines-Egg plant (Biringanya)				
Pumpkins				
Okra				
Coriander leaves (Dania)				
Other vegetables (specify: _____)				
Meat				
Beef - with bones				
Beef - without bones				

Minced meat				
Pork				
Mutton/Goat meat				
Chicken				
Camel meat				
Other Meats (specify)				
Other Animal products				
Offal's (liver, kidney, etc)-Matumbo				
Sausages				
Ham/Salami				
Corned beef				
Fish				
Fresh fish				
Frozen Fish Filets				
Dried/smoked fish				
Prawns /Other sea Foods				
Dairy products and eggs				
Milk - fresh unpacketed				
milk - fresh packeted				
milk - fresh flavoured packeted				
UHT- fresh flavoured Milk				
Milk - condensed/powder				
Baby milk - tinned				
Milk Sour - Mala				
Yogurt (clotted milk)				
Fresh cream				
Cheese				
Eggs				
Oils and Fats				
Butter				
Ghee from milk				
Margarine				

Cooking Fat				
Cooking oil				
Lard (from butcheries)				
Peanut butter				
Fruits				
Banana – ripe				
Oranges				
Pawpaws				
Avocado				
Mangoes				
Pineapples				
Passion fruits				
Pears				
Peaches				
Plums				
Apples				
Lemons				
Grape fruit				
Strawberries				
Melons				
Grapes				
Coconut				
Strawberries				
Other berries				
Sugar cane				
Other fruits (specify)				

6.3: Focus group discussion (FGD) questionnaire

Enhancing Household Nutritional and Health Outcomes through Innovation for Resilient Farming Systems and Food Security in the Semi-Arid Midlands of Kenya

Location…….. Date…….

Farmer group……YES/NO…… Women/men group……

Introduction

The main theme is to discuss about food and the community where we come from.

Questions

1. From the community you represents, which are the commonly consumed foods?
2. Are there specific foods set aside for the children under five years?
3. Reasons why these foods are for children
4. Are there foods not for children under five years? (Reason)
5. Are there special ways of preparing food for children under five years of age?
6. Could there be special foods set aside for women or culturally prohibited?
7. Reason why the food(s) is prohibited to girls or women?
8. If food(s) have ceased to be forbidden, why?
9. Is there any of these diseases that can be treated with nutrition?
10. Do you have adequate knowledge / information about nutrition and diseases?
11. Where was the nutrition information acquired from?

Vote of thanks

Appendix 7.0: Consent form

7.1: Informed consent form- English

Enhancing Household Nutritional and Health Outcomes through Innovation for Resilient Farming Systems and Food Security in the Semi-Arid Midlands of Kenya

PART A. INFORMATION SHEET

THE FIRST PART EXPLAINS THE REASONS FOR THE STUDY AND DESCRIBES THE STUDY. IT WILL BE READ ALOUD TO PARTICIPANTS. THE SECOND PART WILL BE READ TO THE PARTICIPANTS INDIVIDUALLY TO OBTAIN THEIR CONSENT.

Introduction

The Kenyan Medical Research Institute (KEMRI), Kenya Agricultural Institute (KARI) and Mc Gill University, Canada, are carrying out a study in your community to assess your nutrition and health of women of reproductive age (15-49 years) and children of 6-24 months. **The proposed KARI/McGill project focuses on development of gender responsive technologies and innovations to increase agricultural productivity, improve nutrition, and reduce post-harvest losses, support for on-farm research informed by sound social and gender analysis assess resilience of food systems to a changing climate;" and "developing underutilized species for the achievement of food, nutrition and income security." Kenya Agricultural Research Institute (KARI) has been undertaking alot of agricultural activites in your area for a while now. This time they haver introduced innovative technologies which they would like to find their impact on the health of the communities where these technologies have been introduced. KEMRI will therefore undertake these assessments. The findigs will inform future agricultural activities that can be undertaken within your community.**

Objectives of Study:

The general objective is to determine the nutritional impact of the proposed KARI project interventions to the study population with special reference to children **6 to 24 months and women of reproductive age (15-49 years).**

Participation in the study:

We are asking you to join this research study. Joining the study is completely voluntarily. Through your participation we shall be able find out the effects of the new technologies to the nutrition and health status of the population. The relevant government departments have allowed us to conduct this study. This information will be recorded into standard forms and will enable us provide information on nutrition and health in your community. There are no foreseeable risks of taking part in this study. Alternatively, if you choose not to participate in the study, we will not victimise you in any way.

What your participation will involve

1. If you decide to join the study we shall enroll you. Then our staff attached to the project will ask you a number of questions regarding your community, family and your health and that of your baby.

2. If you decide to join the study we shall organize to assess you and the child for various nutrition related parameters as well as infection.

Procedures

If you agree to participate in this study by signing at the end of this form, you will participate in the study. You will be asked questions about your past medical dietary, social and economic history, and participation in farming activities. A clinical and physical examination will be done by the study medical person for signs and symptoms of diseases related.

Confidentiality

All information you provide us throughout the study will remain confidential and will only be used to provide for the objective it is intended to. Only the study team will have access to this information and it will not be relayed to any other persons.

Risks and Benefits of the study

The study has no serious risks to subjects. However we shall require a small amount of blood from the participants, amounting to just over 1 teaspoonful in quantity. This process will involve injecting the participants with a small needle which may cause little pain and discomfort at the site of the needle prick. However, we shall take all the necessary care to make this discomfort, will stop in a short while within the same day, as minimal as possible. Other than this all other specimen and sample collection processes will not cause any harm to you and your family

members. The findings of this project will be used to improve the nutrition of all communities in the country.

Costs to you

There is no cost to you for participating in the study.

Withdrawal from the study:

You may withdraw from participating in this study at any time without giving the reason. It is only necessary that you inform us in case you make such a decision.

If there are any questions you have about the study, please feel free to ask them to the investigator prior to signing your consent form. You may contact Zipporah Bukania (0722 336292) or Dr Yeri Kombe (0734 257864) of Centre for Public Health Research in KEMRI, or the secretary National/KEMRI Ethical Review Committee (ERC) on Tel: 2722541/2713349

Participants' statement

I have read the information sheet concerning this study and I understand what will be required of me if I take part in the study. Any questions I have concerning this study have been answered.

Name_____Signed_____Date_____

7.2: Informed consent Form - Swahili

FOMU YA RIDHAA

Enhancing Household Nutritional and Health Outcomes through Innovation for Resilient Farming Systems and Food Security in the Semi-Arid Midlands of Kenya

SEHEMU A.

SEHEMU YA KWANZA INAELEZA KUHUSU UTAFITII HUU NA SABABU ZAKE. ITASOMWA KWA SAUTI KWA WASHIRIKI. SEHEMU YA PILI ITASOMWA KWA MSHIRIKI PEKEE

Mwanzo

Taasisi ya utafiti ya KEMRI na taasisi ya utafitii wa kilimo KARI (Kenya Agricultural Institute) pamoja na Chuo Kikuu cha Mc Gill, Canada wanachunguza jinsi wanawake wa umri wa kupata watoto (15-49) na watoto wa miezi 6 -24 wanavyo pata au tayarisha lishe na afya yao kwa jumla. Mapendekezo ya mradi wa KARI/Mc Gill unalenga maendeleo ya Teknolojia inayojali jinsia na ubunifu ili kuongeza uzalishaji wa kilimo, uboreshaji wa lishe na kupunguza hasara baada ya mavuno, kutakana na mabadiliko ya hali ya anga. Taasisi ya utafiti ya kilimo (KARI) imekuwa ikifanya shughuli yingi za kilimo katika eneo lenu kwa muda sasa. Wakati huu wamevumbua teknolojia ambayo wangependa kupata matokeo ya kiafya katika jamii ambazo wanatumia teknolojia hizi. Kwa hivyo KEMRI wata tathmini mradi huu. Matokeo ya utafiti huu itawajulisha njia bora ya ukulima itakayofaa jamii hii.

Malengo ya somo

Lengo la jumla ni kuonyesha matokeo ya lishe ya mapendekezo ya utekelezaji wa mradi KARI na idadi ya watu kusoma na kuzingatia zaidi watoto miezi 6 hadi 24 na wanawake wenye umri wa kuzaa (miaka 15-49).

Kuhusika kwako kutahusisha

1.Ukikubali kuwa mhusik akatika utafitii huu, watafitii wetu wata kuuliza maswali juu ya jamii yenu, familia yako na afya yako pamoja na ya mtoto wako.

2. Iwapo utakubali kuwa muhusika, tuta jianda kutathmini wewe na motto wako juu ya lishe na maambukizi yamaradhi.

Taratibu

Kama unakubali kushiriki katika utafiti huu kwa kuweka sahihi mwisho wa fomu hii, utakuwa mshiriki katika utafiti. utaulizwa maswali kuhusu historia yako ya zamani ya matibabu kijamii na kiuchumi, na ushiriki katika shughuli za kilimo. Watalamu wetu watakupima afya yako kwa ishara ya kupima dalili za magonjwa yanayo husiana na lishe duni. Uzito na urefu wa mwili pia utapimwa. Aidha, Pia, tutaitaji kuchukua 8 mls ya damu kwa ajili ya kuchunguza vigezo mbalimbali vya lishe. Timu ya utafiti pia itakuitaji utoe mkojo kwa utafiti zaidi.

Siri

Habari utakayo tupatia haita fichuliwa kwa yeyote, shirika letu lita weka majibu yenu kisiri na Habari hii itatumiwa kwa uchambuzi na utafiti pekee. Majina yawahusika hayata tajwa katika ripoti yoyote, kwa hivyo majibu hayataonekana kama yanahusiana na wenye kujibu.

Hatari naUmuhimu wa utafiti huu

Utafitii huu hauna madhara yoyote kwa wahusika. Lakini wahusika watahitajik akutolewa damu, kiwango cha vijiko viwili vidogo vya chai. Wahusika wata dungwa kwa sindano ndogo na watahisi uchungu kwa sehemu watakayo dungwa pekee. Bali nakutolewa damu, tafitii zinginezo hazito wadhuru wahusika au familia zao. Matokeo ya utafiti huu yata saidia katika kuimarisha malisho bora katika nchi nzima.

Malipo

Hautaijika kulipa chochote kwa kuhisika katika utafiti huu.

Kujiondoa katika utafiti huu

Una haki yakutojihusisha katika utafiti huu wakati wowote bila kujieleza. Lakini ni muhimu kwetu ukitueleza unapo wafikia wazo hili.

Ukiwana swali juu ya utafiti huu, tafadhali uliza kabla ya kukubali/kutia sahihi kuwa mhusika katika utafiti huu. Tafadhali wasiliana na Zipporah Bukania (0722 336 292) au Dr. Yeri Kombe (0734 257 864) wa Centre for Public Health Research iliyoko KEMRI au Katibu KEMRI Ethical Review Committee (ERC) kwa nambari hizi 020-272-2541, or 020-272-6781

Taarifa ya washiriki

I have read the information sheet concerning this study and I understand what will be required of me if I take part in the study. Any questions I have concerning this study have been answered.

Nimesoma maelezo juu ya utafiti huu.Ninaelewa jinsi nitakavyo husika katika utafiti huu. Nimepewa nafasi ya kuuliza maswali kuhusu utafiti huu na nimejibiwa, nikaridhika.

Jina_____ Sahihi_____ Tarehe _____

7.3: Informed consent form -Kamba

Kwailia uima wa mwii na Miile misyini Kwisila nzia nzau sya auimi nzia nzau sya uimi (food security) nthini wa nthi ila nyumu sya Kenya

PART A. INFORMATION SHEET

Kilungu kwa mbee kielesya kieleelo kya masoma aya na masomo mwene. Kikasomwa na wasya kwa onthe. Kilungu kya keli kikasomwa kwa wasya kwa ala me nthini wa masomo oka

Mwambililio

Kituo kya Kenyan Medical Research Institute (KEMRI), Kenya Agricultural Institute(KARI) vanwe na University ya Mc Gill, Canada, mena masomo nduani yenyu kumanya uima wa mwii wa iveti sya muika (miaka 15 -49) na syana ila syina ukuu wa mwei 6 – 24. Masomo aa mekunikila muno maendeeo ma (gender responsive technologies and innovations) al mekwongeleela ngetha ya miunda, kuseuvya miile (improved nutrition) na kuola wanangiko wa ngetha itina wa kuketha kutethheesya masomo ma miunda iulu wa uvandiliku wa nzeve na kukathiisya maliu al matumikaa kwa unini(underutilised species) twathiisye kumina nzaa na ukya. Kenya Agricultural Research Institute (KARI) nimethiitwe na maundu maingi ma uimi kisioni kyenyu kwevinda yu. Kwa yuyu nimekwambiiasyi umanyi (technology) mweu ula uungethiwa na mauseo nthini wa uima wa mii yenu. KEMRI makathima mauseo asu ma mwii. Matokeo mauma makamanyithya nzia nzau sya uimi ila kisio/ndua yenu itonya utumia kuendeea na mbee.

Kitumi kya masomo

Kitumi kinene kya masomo ni kumanya matokeo ma miile nyhini wa mwii(nutritional impact) ala mekumanana na mipango isu ya KARI kwa la me masomoni mekkite kithingiisyo kwi syana sya ukuu wa mwei 6 - 24 na iveti sya muika (miaka 15 – 49).

Kulika masomoni

Nuukulwa ulike masomoni. Kulika masomoni ni kwa ngenda ya mwene. Kwisila masomo aya

tukamanya useo wa nzia nzau sya uimi nthini wa uima wa mwii wa andu ma kisio kii. Mivea ya selikali nitwitilikilitie kwika masomo aya. Uvoo wonthe ukaandikwa nthini wa mathangu maseuvye ula witumanyithya iulu wa uima wa mwii wa ando ma kisio kii. Vai wathe kana uthuku kwaku ukaumana naku kwithya wi masomoni. Indi una walea kwendeewa ni masomo vai uthuku ukona na kwonewa nongi.

Masomo makenda ata kwaku

1. Weetikila kulika masomo aya tukakuandithya. Muthukumi witu akaukulya makulyo iulu wa ndua yenyu, musyi waku, na uima wa mwii waku ovamwe na kana kaku.
2. Weetikila kulika masomo aya ukathimwa vamwe na kana kaku ithimo ila syinanasya uima wa mwii.

Mitalatala ya ithimo

Ukakulya uvoo wa maliu ala maisawa kaingi nduani yenyu. Uvoo usu wa maliu ukatumiwa kuseuvya ivuku ya visa sya maliu. Visa isu ikatumiwa kuseuvya ivuku inene yila yitumiawa ni asomi angi kumanya uvoo wa miile yo maliu.

(Kimbithi)

Uvoo woonthe ula ukanengana nundu wa masomo aya ukekali na asomi meoka na ukatumika o iulu wa itumi sya masoma aya memoka. Vai mundu ungi ute umwe wa asomi ukavikiwa ni uvoo usu.

Uthuku na vaita wa masomo

Vai wathe kana uthuku kwa ala makasoma. Indi nukakulywa umie nthakame nini ianene na kasiki kala kanini. Umia wa nthakame isu ni kwa kutonywa na singano ula utonya utuma wiwa kawolo kanini nziani ya singano indi athukumi matata kusiia muno kwiwa wuoo. Vamwe na uu kawolo kakathela itina wa kavinda kanini o muthenya usu. Ateo thankame syindu ila ingi ukaumia iikethya na uthuku kana wathe kwaku kana andu ma musyi waku. Masomo aya makatetheesya kuseivya uima wa mwii wa andu on the ma nthi.

Ngarama kwaku

Vai ngalama ona yiva kwaku kwithiwa wi nthini wa masomo aya

Kuma masomoni

Nutonya kuma masomoni aya o ivinda yonthe uteunengana kitumi ona kimwe. Indi no useo kututavya wavikia kusoania kuma.

Ukethiwa wina makulyo iulu wa masomo, ithiwa wi muanie kukulya mbee wa kususya kana kwikia saii ithanguni yii. No ukunie Zipporah Bukania (0722 336292) kana Dr Yeri Kombe (0734 257864) ma KEMRI kana muandiki wa National/KEMRI Ethical Review Committee (ERC) kwa Tel: 2722541/2713349

Ukusi wa musomi

Ninasoma maelesyo aya iulu wa masomo na naelewa kila kikwendeka kuma kwakwa neetikila kulika masomoni. Makulyo on the ala nii namo iulu wa masomo ni masungiwa na nzia mbianiu.

Isyitwa _____Saii _____ Matuku_____