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*Full Length Research*

# Impact of school garden on dietary diversity and micronutrient level of pre-school children in Makueni County –Kenya

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**ABSTRACT:** Pre-school children are more vulnerable to malnutrition. This study sought to assess the effect of school gardens intervention in improving serum zinc, iron, and retinol levels of pre-school children in the early childhood center through diet diversity in Mulala ward, Makueni County, Kenya. A between-group quasi-experimental design study on a sample of 63 children was adopted. The intervention early childhood centres were giving vegetables and animal proteins to children from the school garden as part of the ten o'clock snack of porridge and lunchtime meal of maize and beans for six months while the control early childhood centres had the usual ten o'clock porridge and lunchtime maize and beans meal. Questionnaires were used to collect end line data on demographic, socio-economic, feeding practices, and diet diversity. Blood samples were also collected from the children and blood tests for zinc, iron, and retinol done. Blood tests for serum zinc and iron were analyzed by flame atomic absorption spectrophotometry, serum retinol was assessed by High-Pressure Liquid Chromatography. The mean dietary diversity score of the control and intervention groups was found to be significantly different at post-intervention (p-value = <0.001). A significant and positive correlation between the levels of serum hemoglobin, retinol, zinc and dietary diversity was observed among the intervention population (P-value =0.045, n= 31 R=0.363), (P-value =0.033, n= 31 R=0.384), and **(**P-value =0.048, n= 31 R=0.358). The study concludes that the use of a variety of green leafy vegetables and small animals in diets of young children; can improve both dietary diversity and micronutrient levels.

**Keywords:** Dietary diversity score, interventions, serum level, small animals, vegetables.

**Abbreviation: AAS,** Atomic Absorption Spectrophotometry; **ASALs,** Arid and Semi-Arid (ASALs); **Fe,** Iron; HGSF, home-grown school feeding Programme; **HPLC,** High-Pressure Liquid Chromatography; **Hb,** Hemoglobin; **SD,** Standard Deviation; **SPSS,** Statistical Package for Social Science; **Zn,** Zinc.

## INTRODUCTION

Good nutrition and physical condition of the children are prerequisites for intellectual and learning ability. The double burden of malnutrition is presently persistent in developing countries (Kimani-Murage et al., 2014; WHO, 2014). Under-nutrition contributes to almost half (48%) of all the <5 deaths today (UNICEF, 2014). Kenya has made great improvements in the reduction of stunting prevalence to 26% in 2014, from 35 percent in 2008 (KNBS, 2015; KNBS and ICF Macro 2010).

Households with low incomes are normally limited in food selection resulting in nutritionally inadequate diets that most of the time deficient in vital micronutrients. Provision of a modest lunch at school is believed to enhance enrollment, improve nutritional status as well as the performance rate of participating children (Lawson, 2012). The universal access to basic education due to the

introduction of free primary education has enabled many children to have an opportunity to attend school therefore most children from a mainly poor background who could not be influenced through the school system can now be reached (Jaluo, 2015).

The school feeding program was established so that children, especially girls in a household with low socio-economic status could have an opportunity to join a school (Jomaa et al., 2011). But the concept of tapping school feeding programs as a channel to develop agriculture in low-income households has also gained momentum. The justification of the use of locally-produced food for school feeding programmes is based on the fact, that, it can provide a reliable, regular market and source of income for smallholder farmers (Sumberg and Sabates-Wheeler 2011; Machocho, 2012). Moreover, the appropriateness of the school food to the children will be guaranteed due to local production, this would also result in low cost of running the programme and its sustainability (Lawson, 2012). An example of a cost-effective school feeding programme where foods for the school meals are sourced from local farmers is Home Grown School Feeding (HGSF) (Ministry of Education, Science and Technology, Ministry of Health, Ministry of Agriculture, Livestock & Fisheries, 2016).

Children in the pre-schooling stage are faced by a host of challenges which include: lack of quality parental care, being fed on foods with low nutritional value and high-energy content, low or no animal protein source foods intake, low vegetables and fruits intake and in some cases none at all, which can result to sub-clinical micronutrient deficiency (Della Lucia et al., 2016). A baseline survey carried out in Makueni County by Child Fund, a Non-Governmental organization in partnership with Otago and Kenyatta Universities revealed that the food intake of the pre-school children was based mainly on carbohydrates consisting of unrefined maize porridge and maize kernel and beans, but little or no meat consumption. Biochemical data indicated multiple micronutrient deficiencies including iron, zinc and vitamin A along with a high prevalence of infections. Growth faltering, particularly stunting among the sampled children was documented (Houghton et al., 2019).

The home-grown school feeding Programme (HGSF) was introduced and is being implemented in the Arid and Semi-Arid (ASALs) (Ministry of Education, Science and Technology, Ministry of Health, Ministry of Agriculture, Livestock & Fisheries, 2016). However, the allocation of the school budget for this programme has its limitation; therefore, most schools provide only maize and beans as school food, which cannot supply essential micronutrients that are needed by pre-school children for them to be healthy and grow well. There was therefore need to supplement these foods and ensure children get adequate micronutrients. Since supplementation and food fortification may not be sustainable, it would be of great necessity to introduce food-based strategies to supply some of the food items that can supply these micro- nutrients without increasing the cost of making them available.

A school garden can act as a good complement where there is a shortage in some of the supplies like vegetables and animal source foods for the pre-school children (WFP, 2013, WFP, 2016). In similar studies, the implementation of school gardens has demonstrated a positive effect on nutrition education and the academic performance of children (Gitau et al., 2015). School gardens may affect diversifying diets and blood biomarkers, but there is a scarcity of data on its effectiveness. This study assessed the effectiveness of a school garden in improving the micronutrient level of pre-school children through diet diversity in Makueni County, Kenya.

## Description of School meal for pre-school children

Approximately 20% of children daily food is consumed at school in Kenya, the menu is in most cases boiled maize and beans offered at lunchtime and maize porridge given as a mid-morning snack at ten o'clock. School-based interventions of fruits and vegetables have been reported to have had some positive effects on children's dietary habits. Meals consumed at school have been beneficial in supplying the much-needed nutrients; they can be used to introduce new foods and they can be used to prevent hunger and malnutrition and also form the basis for nutrition education; School meals, have been shown to improve the enrolment of children especially for girls, reduced absenteeism and improved nutritional status (Jomaa et al., 2011).

The implementation of feeding programmes in schools especially in ASAL areas has enabled many children to have an opportunity of having a hot meal every school day even when there is no food at home due to frequent droughts, this is encouraging but most children are affected by sub-clinical micro-nutrient deficiencies which has a great impact on the children even though it is not easily noticed.

## Dietary diversity of pre-school children

There is an increasing bulk of evidence that shows dietary diversity, nutritional adequacy and health outcomes among the rural poor, particularly women and children have a high correlation. Among poor populations especially in developing countries lack of dietary diversity is a severe problem because their diets are mainly based on starchy staples. The plant-based diets are normally low in protein and most of the micronutrients, and those which have maybe low in bioavailability (M'Kaibi et al., 2016).

The South Africa food-based dietary guidelines suggest that children aged three to five years should enjoy a diversity of foods; Starchy foods should be made part of most meals; these foods can be eaten every day, lean chicken or lean meat or fish or eggs; plenty of vegetables and fruit should be eaten every day; regular eating of dry beans, split peas, lentils, and soya is encouraged;

consumption of milk or yogurt should be every day; feed children regularly on small meals and healthy snacks; salt and foods high in salt and sugar and food and drinks high in sugar should be eaten sparingly; fats should be used sparingly. Use vegetable oils instead of hard fats; clean, safe water should be taken a lot; wash of hands should be with soap and clean water before preparing or eating food (Vorster et al., 2013).

In Kenya according to healthy diets and physical activity guidelines for Kenya (Ministry of health, 2017), the following is suggested: Feed the child 2-4 meals and 1-2 healthy snacks in between meals. Give at least 1½-2 bowls of 250 ml of food per meal every day. Include at least one food from each food group (animal source, staple, legumes, and seeds, vitamin A-rich fruits, and vegetables). If no fatty foods are included in the meal, putting a little fat or oil in the meal adds energy and helps to absorb vitamin A. Give nutritious snacks such as ripe banana, mango, boiled egg, sweet potatoes, or milk in between meals. Avoid sugary foods and sweets. Increase the nutrient density of foods by adding oilseeds (e.g. groundnuts, soybeans), as these will provide extra energy and are good for growth. Give plenty of clean water to drink. Give 2-3 cups of milk per day. Use iodized salt for family meals sparingly. Maintain good hygiene practices, make mealtimes a relaxed and happy time for the child; encourage but do not force the child to eat.

Increasing the number of individual foods in the diet does not have a greater effect on nutrient adequacy like increasing the number of food groups. This is because the essential nutrients needed to meet the nutritional requirements of a person are not all obtained in a single food item but from a diet comprised of several food groups (FAO, 2008; Matla et al., 2008; Kennedy et al., 2009, Arimond et al., 2010; Kennedy et al., 2013). From the cross-sectional survey that was conducted in Makueni County among the ECD children, it showed that the diets of the preschool children were mainly based on carbohydrates with little or no consumption of animal products (Houghton et al., 2019).

Most scholarly work suggests promising results of school gardening programmes and the potential of changing children's self-efficacy and motivation to taste unusual fruit and vegetables provided there is an interactive environment (Schreinemachers et al., 2017). The use of school garden produce in school lunch programs has been proposed as a way of improving the quality of food served for school lunch and a way to moderate the school lunch cost (Kammar et al., 2017).

**Serum levels of retinol, ferritin, and zinc among pre-school children**

Micronutrients comprise minute amounts of vitamins and minerals needed by the body, the micronutrients help in regulating growth activity and development; operation of the immune system, and the reproductive system (Swaminathan, 2012). When the body of a person or a child has insufficient amounts of a vitamin or mineral due to inadequate dietary intake and/or insufficient absorption and/or sub-optimal use of the vitamin or mineral therefore micronutrient deficiency occurs (UNICEF 2009; WHO, 2009). Iron deficiency anemia, iodine deficiency disorders, and blindness are health outcomes relating to micronutrient deficiencies (Black et al., 2008).

The leading cause of anemia is iron deficiencies (World Health Organization, 2015). Iron is important in oxidation and reduction reactions. It has an oxygen-carrying compounds component e.g. hemoglobin and myoglobin (Abbaspour et al., 2014). Iron deficiency anemia is a common situation with low social status. The nutritional causes of iron deficiency anemia include diets with little bioavailable iron, poor absorption of most dietary iron, and the presence of dietary factors that inhibit iron absorption (Bhandari and Banjara, 2014). Iron deficiency anemia lowers immunity to illness and children's capability to learn and their physical stamina. It slows mental and motor growth and decreases work performance (Houghton et al., 2019). In the world, the most common nutritional disorder is iron deficiency (Kiige, 2004), it results from the consumption of a diet with a low level of iron especially animal protein, which mostly occurs in poor people (Black et al., 2008).

The outcomes of deficiencies of zinc in children include: stunted cognitive growth and faltered immune system that results in late physical maturation (Roohani et al., 2013). Zinc is particularly important for the correct functioning of the immune system, growth and development, and the antioxidant system, it is found virtually in every tissue in the body (Das and Das, 2012). The deficiency of zinc contributes to an increased occurrence and severity of common infections such as pneumonia and diarrhea. Diarrhea is linked to increased loss of zinc in feces. Zinc has often subtle rather than dramatic clinical features unlike other micronutrients of public health importance (Wieringa et al., 2015).

Throughout the developing world Vitamin A deficiency is a third micronutrient deficiency that results in a considerable health burden (Laughon, 2014). Vitamin A deficiencies can result in stunted mental physical childhood development and night blindness (Wu et al., 2014). Vitamin A is transported by retinol-binding protein (RBP) which is synthesized by zinc. Hence zinc deficiency may limit the body from mobilizing vitamin A stores from the liver and transport it to the body tissues. Ebele et al. (2010) reported that Vitamin A deficiency contributes to malnutrition in children. The incidences of the micronutrient deficiencies have steered to a widespread occurrence of their symptoms and thus a need for reduction of micronutrient deficiencies especially in children (Rao et al., 2016).

## Addressing micronutrient deficiency

Food-based strategies have largely been recommended to improve the dietary intake of people at risk such as young children and mothers due to their sustainability and wide coverage. Production of vegetables and fruit locally, in the school garden or within the community, can increase the number of fruits and vegetables included in the school meal (Laurie et al., 2017). School and home gardens in arid and semi-arid areas can contribute intensely to the nutritional and economic well-being of households by decreasing the intensity and extent of seasonal food shortages (Greiner, 2013).

The conclusion drawn from a review of agricultural interventions was that home gardening interventions had positively impacted agricultural foods production and consumption of protein and micronutrients rich foods (Masset et al., 2012). A study carried out by Jones et al. (2014) on-farm production diversity, found that there was a strong association between farm production diversity with consumption of legumes and vegetables. Nutritional problems resulting from food insecurity and inadequate micronutrient intake can be alleviated by dietary diversification, which has been widely recommended (Kennedy, 2009). Diets of children from developing countries have been classified using the likelihood of consumption of foods from at least four food group having been associated with a high likelihood of a child consuming at least one animal-source food and at least one serving of fruit or vegetable, in addition to a staple food (Saakaa and Galaab, 2017).

Food-based strategies directed by family members like home and school farming can alleviate food insecurity better than those depending on the government, and may even reduce levels of morbidity and growth retardation in young children (Greiner, 2013). Schools are suitable settings to carry out health-promoting strategies targeting children (FAO, IFAD &WFP, 2015; WHES, 2016) because of the constant, concentrated contact with children (UNICEF, WHO &WB, 2016) and the opportunity to reach most children in the local environment (Ruel et al., 2017). Implementation of school gardens is one approach that can contribute to health behavior change of children.

## METHODOLOGY

A between-group quasi-experimental research design was adopted for this study (Gibson, 2005). The study was conducted in Makueni County, Kenya in Mulala ward. The target population was of children (36 to 48 months) who were attending the Early Childhood Development (ECD) centre in Mulala ward. Inclusion criteria was all children aged 36 to 48 months attending ECD centres sponsored by Child-Fund in the four sub-wards and those whose parents consented while exclusion criteria was all the children in the same age category who were not attending Early Childhood Centres sponsored by Child Fund and those whose parents did not consent.

The County, Sub-County and the ward were purposively sampled because of high levels of poverty at 73% and stunting, wasting and underweight among the under-five children currently standing at 25.1, 2.1 and 10.2% respectively according to the district poverty reduction strategy paper (KDHS, 2014). Four sub-wards; Maatha, Kwakakulu, Tutini and Emali were selected using simple random sampling. Numbers were given to the eight sub-wards and then the four sub-wards were computer-generated without replacement. Simple random sampling (the above process) was used to select one school from each sub-ward therefore four schools were selected from the sub-ward. Two control ECD were Kwakaleli and Tutini and the two intervention ECD were Mulala and Emali. Children in the study were selected using simple random sampling, the list was computer-generated (Kothari, 2004). A sample size formula determination for two independent samples with a two-sided test of 5% was used (Chan, 2003).

$$m \text{ (size per group)} = 2c/\delta 2 + 1$$

where $\delta = |\mu 2 - \mu 1|/\delta$ is the standardized effect size.

a) Anticipated values of the population = 35%
b) Level of significance= 95%
c) Power of the test = 80%

The sample was 72 due to attrition but the drop out from the study reduced the sample to 63, which is 32 for the control ECDs and 31 for the Intervention ECDs. According to Gall et al. (1997) for comparative studies, a sample of 30 subjects per group is considered adequate. The study children comprised of both male and female, more female children were enrolled in the control group (18) where as in the intervention group more male children were enrolled in the study (20)

## Intervention phase

School farms for the intervention ECDs were prepared two months to the start of the intervention phase for the production of kales, amaranth, spinach, and black-night shade leaves as vegetables. Gunny bags technology was used to grow vegetables as the intervention schools had a challenge with water supply. Construction of poultry houses was also done for rearing chicken for egg and meat production. The produce from the school gardens was used for school meals. Technical support for the initiation and management of the school gardens was sought from the Ministry of Agriculture extension officers.

The intervention involved the provision of a diversified diet which included, vegetables and an animal source protein to children every two school days in the interven-

tion ECD centre. Each child at the ECD centre received one boiled egg per one school day in a week. This was being served as part of a mid-morning snack together with a 360 ml cup of porridge. It was made from Unimix flour and oil fortified with Vitamin A, the porridge was thick and eaten with a spoon. One serving spoon (100 gms) of either Kales; amaranth leaves; spinach or black-night shade vegetables was served to the children to be eaten with the main meal of maize and beans that was provided for school lunch. The vegetables were prepared with oil and salt, the cooking method was improved to ensure that the children would get the nutrients available in the vegetables. The beans were soaked overnight and the water used for soaking the beans pour away. This was to ensure that the phytates that are found in the beans leach into the water and the children could be able to absorb iron from the beans. Fifty grams of minced chicken meat was served to the children for one school day with the main meal of maize and beans. The control ECD centre was fed on the usual foods that were being provided by the school, which was, maize porridge for ten O'clock snack and maize and beans meal for lunch. The children were having the break time snack of porridge and the lunch time meal in school. The vegetables, the chicken and the eggs were being grown and reared at the early childhood centre with the help of the parents and the teacher.

## Pre-testing of data collection tools

A pilot study on caregivers of children in the same age group was conducted in an adjacent ward (Ndundune) two weeks to the study. The pilot study was done on 10% of the targeted sample size to optimize the study procedures, pre-test study tools and provide information on other factors to aid in the planning of the main study.

## Data collection

### *Dietary intake by a multiple pass 24-hour recall*

The 24 hours dietary recall questionnaire (multiple-pass method with four steps) was used to collect information on the foods and drinks taken by the index child during the previous 24 hours. The quantity of food eaten by children, method of preparation and the frequency of meals and types of foods given were also collected. Participants (caregivers and ECD teachers) recalled the food and beverage intake for the children aged 36 to 48 months over the previous 24 hours. Portion sizes were estimated using salted replicas of staple foods, measuring cups, calibrated home utensils, play dough and water displacement to estimate volume consumed (Gibson and Ferguson, 1999). The information about the food and drinks recalled by the respondent were recorded into 9 standardized food groups form to measure dietary diversity (Kennedy et al., 2013).

### *Biochemical sample: Blood sample collection, handling, and storage*

Morning fasting peripheral venipuncture blood samples was taken from children. A topical local vasodilator anesthetic amethocaine (Ametop™) was applied to the venipuncture site to minimize any discomfort. 7 mls of blood was drawn into a trace-element-(TE)-free evacuated tube containing an anticoagulant (Becton Dickinson, Franklin Lakes, NJ, USA), marked, placed into a screw-cap plastic container, and placed in cooler boxes immediately with ice packs which were at 5° C, then they were moved to the laboratory. In the laboratory, hemoglobin concentrations were determined via HemoCue®Hb (HemoCue, Sweden) from an aliquot of the whole blood. The remaining blood was centrifuged and the plasma separated using TE-free techniques. Aliquots of plasma were stored in TE-free polyethylene vials and frozen at -20°C.

### *Hemoglobin measurements*

An aliquot of the whole blood was taken up by capillary action using the reagent filled microcuvette. The filled microcuvette was put into the Hemo Control photometer. The color emitted by the chemical reaction in the microcuvette was measured and the Hb value was displayed approximately after 5 seconds. The micro cuvettes were meant for singular use only and were disposed of after use as a possible infectious waste in agreement with the current regulations.

### *HPLC analysis for retinol in serum samples*

All extraction and HPLC procedures were performed under subdued light and samples protected from light by wrapping the glassware with aluminum foil. Extractions were completed the same day and extract injected into the HPLC column to reduce the exposure time of sample extracts. Material that was used including all glassware was thoroughly cleaned with soap and tap water, rinsed with distilled water and left to dry overnight. The glassware was rinsed 3 times with acetone and air blown to dry before being used for the preparations of solutions.

### *Retinol extraction*

Frozen samples were left to thaw for 20 minutes then 300-µl aliquots of serum were pipetted into serum vials using a micropipette and diluted with 300-µl double-distilled de-ionized water. The resulting mixture was then deproteinized by vortex mixing for 30 seconds with 600-µl ethanol containing BHT (0.0599 g/ml) as an antioxidant. Extraction was repeated twice with 2 ml hexane and the combined supernatant was evaporated under a stream of nitrogen at 30°C. The residue was dissolved in 70 µl ethyl

acetate and vortex- mixed for 10 seconds. The mixture was then diluted with 200 µl of the mobile phase and ultrasonically agitated for 10 seconds before injection in an HPLC column. The mobile phase for the isocratic elution of serum extracts for retinol analysis consisted of an aqueous binary mixture of acetonitrile: water in ratios of 85:15 (v: v). The fresh mobile phase when prepared was filtered and ultrasonically degassed for one hour before use. The sample extracts were checked for their UV-Vis maximum absorbance before injection into the column to avoid column overloading. The HPLC model L-6000 (Hitach instrument Inc Model L-6000) equipment was calibrated using freshly prepared working standards with the absorbance of retinol set at 325 nm. Five different standard solutions of increasing concentrations were injected into the HPLC column. Plotting peak area counts of the five standard solutions against the spectrophotometrically determined concentrations generated calibration curves for retinol. Retinol in samples was identified by comparing the retention time with that of the standard and from the extraction of retinol and a retinol (vitamin A) tablet. The chromatogram was integrated with the respective recorder/ software and peak area was used for quantification of all-*trans*-retinol and concentrations expressed in µmol/L. A volume of 20 µl of serum extract was injected into the HPLC column for isocratic elution and the mobile phase flow rate was 1.5 ml/min with 15 minutes run time.

### *Analysis of iron and zinc*

Analysis of Iron and zinc was done using Atomic Absorption Spectrophotometer (AAS). In the determination of the minerals, 300 µl aliquots of serum were pipetted into a digestion tube. Concentrated nitric acid (5 mls) was added to the sample and heated. Hydrogen peroxide (30%) was then added to the digestion mixture until it became clear. The clear solution was then topped up to 50 mls with a volumetric flask.

A working solution of 10 mls of 1000 ppm (stock solution) was put into 100 mls flask and topped up to the mark with distilled water. A calibration standard for iron was prepared by adding 0, 2, 4, 6 and 8 mls of the working standard solution into100 mls volumetric flask and topped up to the mark using distilled water. A plot of calibration graph of concentration (ppm) against the absorbance was made. From the calibration curve, the absorbencies of the samples were extrapolated to determine the content of iron in the samples. This procedure was repeated for zinc analysis. All these assays were performed at Kenyatta University Food and Nutrition Laboratory.

## Logistical and ethical considerations

The permission to conduct research was sought from Kenyatta University graduate school and a research permit sought from the National Commission for Science, Technology and Innovation. Ethical clearance was obtained from the Ethical Review Committee of Kenyatta University (PKU/453/1 556). Authority to conduct research was obtained from the Ministry of Health, County officials (Director of Education, Health, Agriculture, Early childhood development and the County commissioner) local administration, school heads and teachers and the communities informed about the interventions. The benefits of the study to the community in the short and long term were explained. Children found to have any nutrition or health-related problem were immediately referred to the nearest health facility for assistance. Blood samples were drawn by registered experienced phlebotomists and assisted by nurses from the health facility; this gave assurance of reduced risks. Informed and signed permission were sought from the caregivers before the study after explaining the purpose of the study without revealing the study hypotheses. The interviews were conducted in a place where the respondent found suitable and appropriate setting was used for taking measurements. No direct reference to the name of the respondent or contact information was published at the end of the study. The data collected from the respondent was treated with the utmost confidentiality.

## Data analysis

The field data (Socio-economic status, dietary practices, micronutrient intake) was cleaned, coded and analyzed using Statistical Package for the Social Sciences (SPSS) software version 20. Nutrient intakes were analyzed using Nutri-survey (Nutrisurvey2007.exe). Selected characteristics of the children, households, and their parents were presented as percentages (%) for categorical variables and means with standard deviation (SD) for continuous variables. Chi-square ($\chi 2$) was used to assess the associations between categorical variables.

### *Dietary data analysis*

The 24-hour dietary recall data were entered, computerized and analyzed using the Nutri-survey. In cases of multiple dishes, similar food items recorded in the Nutri-survey programme were used. Analyzed data were exported to Excel spreadsheets, where energy, macronutrients (carbohydrate, fat and protein), minerals [Iron (Fe) and zinc (Zn)], and vitamin A, were isolated before statistical analysis. The mean percentage contribution of energy, total carbohydrate, protein, fat and micronutrient (Fe, Zn and vitamin A) intakes provided by each food group at each dietary assessment measurement was calculated.

### *Analysis of retinol, iron and zinc*

The following interpretive criteria were used for the

**Table 1.** Dietary diversity of the study children.

| Food group consumed | | Baseline | | Post-intervention | |
|---|---|---|---|---|---|
| | | Control (N=32) | Intervention (N=31) | Control (N=32) | Intervention (N=31) |
| Grains and grain products | | 29 (90.6%) | 27 (87.1%) | 32 (100%) | 31 (100%) |
| Pumpkin, yellow yams, butternut, carrots, roots and tubers | | 4 (12.5%) | 5 (16.1) | 3 (9.4%) | 12 (38.7%) |
| Dark green leafy vegetables | | 23 (71.9%) | 16 (51.6%) | 25 (78.1%) | 23 (74.2%) |
| Ripe mango, pawpaw, guava | | 1 (3.1%) | 0 (0.0%) | 1 (3.1%) | 8 (25.8%) |
| Other fruits and vegetables | | 17 (53.1%) | 19 (61.3%) | 18 (56.2%) | 22 (71.0%) |
| Any meat, eggs | | 9 (28.1%) | 5 (16.1%) | 8 (25.0%) | 14 (45.2%) |
| Legumes | | 19 (59.4) | 18 (58.7%) | 20 (62.5%) | 25 (80.6%) |
| Foods made with red palm oil | | 9 (28.1%) | 14 (45.2%) | 8(25.0%) | 15 (48.4%) |
| Sour milk, cheese/yoghurt | | 17 (53.1%) | 22 (71.0 %) | 16 (50.0%) | 17 (54.8%) |
| Minimum DD | Met | 20 (62.5%) | 20 (62.5%) | 21 (65.6%) | 29 (93.5%) |
| | Unmet | 12 (37.5%) | 11 (35.5%) | 11 (34.4%) | 2 (6.5%) |

FAO, 2011.

**Table 2.** Mean Dietary Diversity Score (DDS) of study groups at baseline and post-intervention.

| Group | Mean DDS | | P-value (paired t-test) |
|---|---|---|---|
| | Baseline | Post-intervention | |
| Control group (n=32) | 4.00 ± 1.368 | 4.09 ± 1.489 | 0.374 |
| Intervention group (n=31) | 3.97 ± 1.251 | 5.39 ± 1.202 | <0.001 |
| P value(t-test) | 0.923 | <0.001 | |

DDs – Dietary Diversity Score; Baseline p value= 0.923; Post-intervention p value= <0.001.

biomarkers to define the presence of anaemia and micronutrient deficiencies: Anaemia was defined as hemoglobin (Hb) <110 g/L for children < 5 years (WHO, 2015). Vitamin A deficiency was based on a retinol-binding protein <0.7 µmol/L, adjusted for the presence of inflammation. Zinc deficiency was defined as a plasma zinc level <9.9 µmol/L for fasting blood samples. Repeat measures of analysis of variance were used to compare the effects of group and time for nutrition status, body iron stores, serum zinc and serum retinol. Significance was determined at a 95% confidence interval, a P-value of 0.05. Data is presented using tables and graphs.

## RESULTS

### Dietary diversity for the study children

Dietary diversity for this study was analyzed using data from the 24 hours dietary recall questionnaires. A dietary diversity score (DDS) card with 9 food groups (FAO, 2011; Kennedy et al., 2013) was created and used to categorize food items from the 24 hours recall (Table 1).

Grain and grain products were the most widely consumed food group with over 85% consumption in both groups at baseline. Dark green vegetables, other fruits and vegetables as well as dairy products were consumed with over half of the study population in both sub-samples indicating that they consumed foods from these groups.

The mean dietary diversity score (DDS) of the control and intervention groups as analyzed by the independent t-test, was significantly different at post-intervention (p-value = <0.001) while at baseline it was not significantly different (p-value = 0.923) (Table 2).

### Effect of school garden on dietary diversity

The effect of school garden on the dietary diversity of the children in the study was measured by determining the dietary diversity score of the control schools and the intervention schools both before and after an intervention. From the findings, about 62.5% of the study children from both the intervention and the control group were able to meet their minimum dietary diversity requirement of the consumption of foods from four or more groups at baseline. This improved significantly at 93.5% for the intervention group while remaining almost the same (65.6%) for the control group at post-intervention (Table 1). A paired t-test was conducted between the baseline and

**Table 3.** Mean intakes of energy and selected nutrients at baseline and end line.

| Nutrient | RDAs | Study children/p-value | Baseline | post-intervention | P-value |
|---|---|---|---|---|---|
| | | Control | 412.93 ± 362.53 | 430.11 ± 219.48 | 0.124 |
| Energy (Kcal) | 610 | Intervention | 455.67 ± 209.49 | 629.72 ± 289.95 | 0.034 |
| | | P-value | 0.213 | 0.028 | |
| | | Control | 178.81 ± 78.766 | 182.45 ± 109.57 | 0.172 |
| Carbohydrates (g) | 130 | Intervention | 185.34 ± 74.80 | 241.07 ± 135.769 | 0.045 |
| | | P-value | 0.684 | 0.048 | |
| | | Control | 26.37±12.34 | 27.43 ± 11.34 | 0.783 |
| Protein (g) | 13 | Intervention | 25.74 ± 11.67 | 31.50 ± 22.82 | 0.040 |
| | | P-value | 0.563 | 0.039 | |
| | | Control | 19.48 ± 15.76 | 17.15 ± 11.22 | 0.589 |
| Vitamin C (mg) | 15 | Intervention | 20.91 ± 14.15 | 63.39 ± 51.85 | 0.024 |
| | | P-value | 0.867 | 0.002 | |
| | | Control | 227.95 ± 191.07 | 233.73 ± 160.09 | 0.128 |
| Vitamin A (µg) m | 300 | Intervention | 249.79 ± 359.12 | 590.48 ± 502.87 | 0.004 |
| | | P-value | 0.058 | 0.026 | |
| | | Control | 1.63 ± 1.94 | 1.70 ± 1.98 | 0.044 |
| B-carotene (µg) | | Intervention | 1.54 ± 1.93 | 2.926 ± 2.73 | 0.036 |
| | | P-value | 0.203 | 0.046 | |
| | | Control | 11.21 ± 9.47 | 11.48 ± 10.94 | 0.967 |
| Iron (mg) | 7.0 | Intervention | 11.08 ± 5.44 | 14.38 ± 9.88 | 0.030 |
| | | P value | 0.897 | 0.035 | |
| | | Control | 5.25 ± 4.80 | 5.49 ± 3.45 | 0.502 |
| Zinc (mg) | 3.0 | Intervention | 5.63 ± 3.06 | 7.65 ± 5.33 | 0.029 |
| | | P value | 0.673 | 0.042 | |

the post-intervention for both the control and the intervention DDs, it showed no significant difference between the control group at the two stages of data collection (p-value = 0.374) while a significant difference (p-value < 0.001) was established for the intervention groups (Table 2).

## Nutrient intake

Baseline data indicate that the children from both groups of the study sample had adequate intakes of nearly all the nutrients apart from energy and vitamin A (Table 3). The mean intake values were above their RDA values for all the nutrients except energy and vitamin A. However, children from the intervention group were able to meet their vitamin A and energy requirements after the intervention. The mean daily intakes of energy and vitamin A from the 24 hours recall were 629.72 ± 289.95 Kcal and 590.48 ± 502.87 µg respectively, as compared to those of the control group which was found to be at 430.11 ± 219.48 Kcal and 233.73 ± 160.09 µg, values below RDAs of 610 Kcal/day and 300 µg/day for children at their age.

Generally, the paired t-test result showed that the mean intakes of all the nutrients increased significantly for the intervention group after the intervention (p values <0.05) while the intakes of the nutrients in the control group were not significant (p values >0.05).

## Micronutrient serum status of the children

### *Serum Hb levels*

The mean serum levels of hemoglobin at baseline were observed to be 11.9406 ± 1.318 and 11.8355 ± 0.713 g/dl

**Table 4.** Serum micronutrient levels between control and intervention groups.

| Analyte | Mean serum retinol levels | | | | | |
|---|---|---|---|---|---|---|
| | Baseline | | | Post-intervention | | |
| | Control (N=32) | Intervention (N=31) | P value | Control (N=32) | Intervention (N=31) | P value |
| Serum retinol (µmoI/L | 0.219± 0.121 | 0.214 ± 0.136 | 0.873 | 0.340 ± 0.343 | 0.730 ± 0.473 | <0.001 |
| Serum zinc (µg/L) | 0.328 ± 0.068 | 0.342 ± 0.10 | 0.531 | 0.329 ± 0.073 | 0.375 ± 0.089 | 0.027 |
| Serum Iron (µmol/L | 0.313 ± 0.032 | 0.307 ± 0.351 | 0.435 | 0.305 ± 0.043 | 0.326 ± 0.037 | 0.037 |

**Table 5.** Serum micronutrient levels at baseline and post-intervention.

| Analyte | Mean serum retinol levels | | | | | |
|---|---|---|---|---|---|---|
| | Baseline | | | Post-intervention | | |
| | Control (N=32) | | | Intervention (N=31) | | |
| | Baseline | Post-Intervention | P-value | Baseline | Post-Intervention | P-value |
| Serum retinol (µmoI/L | 0.219± 0.121 | 0.340 ± 0.343 | 0.055 | 0.214 ± 0.136 | 0.730 ± 0.473 | <0.001 |
| Serum zinc (µg/L) | 0.328 ± 0.068 | 0.329 ± 0.073 | 0.909 | 0.342 ± 0.10 | 0.375 ± 0.089 | 0.019 |
| Serum Iron (µmol/L | 0.313 ± 0.032 | 0.305 ± 0.043 | 0.298 | 0.307 ± 0.035 | 0.375 ± 0.089 | <0.001 |

for control and intervention groups respectively while the values at post-intervention were found to be 11.9063 ± 1.094 and 12.4968 ± 1.203 g/dl for control and intervention group respectively.

Independent t-test showed that the mean Hb levels of both the intervention and control groups were significantly different at post-intervention (p-value = 0.046). Besides, a paired t-test conducted between baseline and post-intervention data revealed a significant difference in the intervention group at baseline and end-line (p =0.020).

### *Serum micronutrient levels*

Findings from the t-test revealed no significant differences in serum micronutrient levels between control and intervention groups at baseline (p-value > 0.05) for all the three micronutrient analytes (serum retinol, serum zinc and serum iron) (Table 4). However, a significant difference was observed in serum micronutrient levels between the two study groups at post-intervention (p-value > for all the three-micronutrient analyzed (serum retinol, serum zinc and serum iron) (Table 4).

The serum levels of all the three micronutrients (serum retinol, serum zinc and serum iron) between baseline and post-intervention for the control group respondents were not significantly different at p-value > 0.5, except the p-value of serum retinol which was (0.055), although it was insignificant, while the value for the intervention group between baseline and post-intervention were found to be significantly different in all the three micronutrient analyses (serum retinol, serum zinc and serum iron) (p-value < 0.05) (Table 5).

## Relationship between dietary diversity and serum micronutrient status

### *Dietary diversity and serum hemoglobin*

Correlation between dietary diversity and the serum hemoglobin levels of the intervention group after the intervention were conducted. This was done since significant changes in dietary diversity scores among the group were recorded. The findings revealed a significant and positive correlation between the levels of serum Hb and dietary diversity among the study children (P-value =0.045, n= 31 R=0.363) (Table 6). As the children's dietary diversity increased their serum hemoglobin values also increased.

### *Dietary diversity and serum retinol*

Table 7 shows a significant and positive correlation between the levels of serum retinol and dietary diversity among the study children (P-value =0.033, n= 31 R=0.384). As the children's dietary diversity increased their retinol levels also increased. This implies that improved dietary diversity resulted in improved retinol levels.

### *Dietary diversity and serum zinc*

As reported in Table 8, there was a significant and positive correlation between the serum zinc levels and dietary diversity among the study children **(**P-value =0.048, n= 31

**Table 6.** Correlation between dietary diversity and serum Hb levels.

| | | DDS post-intervention | Hb post-intervention |
|---|---|---|---|
| **DDS post-intervention** | Pearson Correlation | 1 | 0.363* |
| | Sig. (2-tailed) | | 0.045 |
| | N | 31 | 31 |
| **Hb post-intervention** | Pearson Correlation | 0.363* | 1 |
| | Sig. (2-tailed) | 0.045 | |
| | N | 31 | 31 |

*Correlation is significant at the 0.05 level (2-tailed).

**Table 7.** Correlation between dietary diversity and serum retinol.

| | | DDS end line | Retinol end line |
|---|---|---|---|
| **DDS end line** | Pearson Correlation | 1 | 0.384* |
| | Sig. (2-tailed) | | 0.033 |
| | N | 31 | 31 |
| **Retinol end line** | Pearson Correlation | 0.384* | 1 |
| | Sig. (2-tailed) | 0.033 | |
| | N | 31 | 31 |

*Correlation is significant at the 0.05 level (2-tailed).

**Table 8.** Correlations between dietary diversity and serum zinc.

| | | DDS post-intervention | Zinc post-intervention |
|---|---|---|---|
| **DDS post-intervention** | Pearson Correlation | 1 | 0.358* |
| | Sig. (2-tailed) | | 0.048 |
| | N | 31 | 31 |
| **zinc post-intervention** | Pearson Correlation | 0.358* | 1 |
| | Sig. (2-tailed) | 0.048 | |
| | N | 31 | 31 |

*Correlation is significant at the 0.05 level (2-tailed).

R=0.358) as established by the study. Serum zinc levels positively corresponded to improvement in dietary diversity.

The correlation was not significant among the control study group. This implies that higher dietary diversity among the study children is associated with better micronutrient status of the body, that is, better micronutrient intake.

### *Dietary diversity and serum iron*

The results indicate a positive but insignificant correlation between dietary diversity and serum Iron levels (P-value =0.055, n= 31 R=0.348) (Table 9). As the children's dietary diversity improved their status of serum Iron also improved albeit in statistically insignificant proportions.

## DISCUSSION

The improvement in the children's dietary diversity especially from the intervention group could be associated with the school garden, as the foods were readily available at no extra cost, while the volunteer parents made the preparation, cooking, and serving of the foods made it easy, thus not burdening the school or the cooks employed. This study agrees with several studies done in the Asian continent on nutrition-sensitive of agricultural interventions although not conducted in a school setting (Schreinemachers et al., 2015; Schreinemachers et al., 2016; Osei et al., 2017; Darrouzet-Nardi et al., 2016; Birdi and Shah, 2015; Murty et al., 2016; Pant et al., 2014.

Baseline data showed that both groups in the study had adequate intakes of nearly all the nutrients apart from energy and vitamin A. However, children from the interven-

**Table 9.** Correlation between dietary diversity **and** serum Iron levels.

| | | DDS post-intervention | Iron post-intervention |
|---|---|---|---|
| **DDS post-intervention** | Pearson Correlation | 1 | 0.348 |
| | Sig. (2-tailed) | | 0.055 |
| | N | 31 | 31 |
| **IRON post-intervention** | Pearson Correlation | 0.348 | 1 |
| | Sig. (2-tailed) | 0.055 | |
| | N | 31 | 31 |

tion group were able to attain their vitamin A and energy rations after the intervention as opposed to those in the control group. The findings agree with Kammar et al. (2017); Selepe and Hendriks (2014); Jomaa et al. (2011) and M'Kaibi et al. (2016). Therefore, school gardens and kitchen gardens should be encouraged in the population with under-five children as it enables the caregiver access a variety of foods for the children thus enhancing their nutrient intake.

The serum levels of all the three micronutrients between baseline and post-intervention for the control group respondents were not significantly different, while the values, for the intervention group, between baseline and post-intervention were found to be significantly different in all the three micronutrients. These findings agree with those of a study done by Kiige (2004) that showed that serum ferritin, serum retinol and serum zinc levels were positively associated with kitchen gardening, but not supported by the study carried out in Mozambique explaining positive correlation between DDS and vitamin A status (Korkalo et al., 2016). This indicates that the consumption of animal protein and vegetables by children in this study resulted in the uptake of the micronutrients, supporting the importance of school gardens and school meals.

## Conclusion

The study reported a substantial number of children from the intervention group who were able to meet their minimum dietary diversity requirement of the consumption of foods from four or more groups at post-intervention. The mean dietary diversity score (DDS) of the control and intervention groups was also significantly different at post-intervention (p-value = <0.001). There was also a correlation between levels of serum Hb and dietary diversity; levels of serum retinol and dietary diversity; serum zinc levels and dietary diversity; dietary diversity and serum iron levels which have a great effect on the child's development and growth. From the findings, much need to be done in terms of monitoring and evaluation of the intervention to ensure that any possible confounding factors like infections and household food security are controlled so that a stronger relationship between the variables can be concluded.

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## AVAILABILITY OF DATA AND MATERIALS

The data supporting the conclusions of this article are included in the manuscript. Additional data is available upon reasonable request.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

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