Cloud Publications
International Journal of Advanced Nutritional and Health Science
2016, Volume 4, Issue 1, pp. 155-173, Article ID Med-280
ISSN 2348-5140

Research Article **Open Access**

Quality Nutrition Education and Its Impact on Haemoglobin Levels of School Pupils of Muranga County, Kenya

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Publication Date: 22 February 2016

Article Link: http://medical.cloud-journals.com/index.php/IJANHS/article/view/Med-280

Abstract Anaemia can dramatically affect school children with adverse impact on their cognitive development and school performance. Nutrition education has not been given the priority it deserves in primary schools due to the busy school curriculum although it is concerned with changing an individual's behavior. It is in this light that this study was designed. The main objective of this study was to evaluate the effects of three main nutrition education facilitators on nutrition knowledge among primary schools children in Gatanga Sub-County. The facilitators used were researcher, 5 pupil peer educators and an agriculture staff in nutrition education classes using the FAO curriculum chart. A baseline survey was conducted in 12 randomly selected schools for class six pupils' households. Questionnaires for pupils and an interview schedule for caregivers were used to collect data, with pre and post-tests. Demographics and socio-economic factors, food production hygienic practices, dietary intake and biochemical data were obtained. The intervention schools were Mabanda, Kigio and Kirwara (experimental) and Gakurari (control school). Baseline data were analyzed by use of Statistical Package for Social Sciences (SPSS) version 17 and Nutri-Survey software using both descriptive and inferential statistics. The data were coded to search for emerging themes and gaps identified. On average, the mean mark in nutrition knowledge at baseline was 30.05%. In the post-tests all experimental schools significantly improved in nutrition knowledge with the highest school scoring an average of 52% and lowest 40%. A total of 31.4 % pupils at baseline and 21.4% after interventions were found to be anaemic after altitude adjustments at a calculated factor 0.5 for Gatanga altitude (2237m ASL). Improvement in the adoption and use of the projects that enhance nutrition and health significantly occurred in the experimental schools as opposed to the control school. Pupils' haemoglobin status were not significantly different ($p>0.05$) between the experimental and control schools at baseline. However, notable differences in haemoglobin levels occurred in the experimental schools after the interventions. The relationship between nutrition knowledge and nutrient intake was positive and there was a significant relationship between nutrition knowledge and haemoglobin levels at $p<0.05$ ($r=0.253$, $p=0.025$). Anaemia was found to be a significant problem and therefore the need for a comprehensive intervention strategy by all stakeholders. The study findings would contribute towards operationalization of the Kenyan National School Health Policy and Guidelines, the National Food Security and Nutrition Policy in prevention and control of IDA by enhancing nutrition education.
Keywords *Agriculture Extension Staff Anaemia; Haemoglobin Levels; Peer Educator*

1. Introduction

Iron is a micronutrient that is required in the tissues of the body for basic cellular functions and is critically important in the muscle, brain and red blood cells. Iron is a component in many proteins including enzymes and haemoglobin, the latter being important for the transport of oxygen to tissues throughout the body. Although there are many health surveys which have been done on the general population the adverse effects of iron deficiency anemia on school children has been somehow neglected and it becomes difficult to lay strategies of interventions [8]. About 1.8 million of Kenyan children are malnourished and affected by anaemia [15]. Iron deficiency anaemia affects all age groups whereby it affects 21% school girls in Western Kenya [34]. Iron deficiency anemia is characterized by low levels of haemoglobin in combination with abnormal levels of other iron indicators such as transferrin saturation (i.e. iron stores). IDA can lead to weakness, poor physical growth, increased morbidity, impaired cognitive performance and delayed psychomotor development. In particular, iron deficiencies early in life are thought to potentially inhibit the function of neurotransmitters, thus compromising brain function [6]. Impaired gastrointestinal function, altered patterns of hormone and metabolism and reduced DNA replication and repairs have also been noted as other consequences of iron deficiency anaemia [23]. Anaemia is simple to measure and has been used as a marker of iron deficiency severe enough to affect tissue functions. However, iron deficiency is not the sole cause of anaemia in most populations. Even in an individual, anaemia may be caused by multiple factors such as food access and health status [18].

Iron deficiency may, however occur throughout the lifespan where diets mainly consist staple foods and little of animal products. The cause is a one-sided diet based mainly on grains. These contain phytates, substances which bind the nutrient iron from plant sources as insoluble salts [4]. In Kenyan households, studies have been undertaken and diets are mainly cereal-based with tubers and a variety of vegetables and fruits when available. White maize, sorghum and millet are high in phytate and fiber, which inhibit the absorption of micronutrients such as zinc and iron. Communities growing cash crops such as coffee have little land for food crops. Although households may own cattle, goats and poultry, these are not commonly consumed but sold in order to earn income. In addition, products of these animals are sold to earn income [7]. There are multiple sources of dietary iron including heme and non-heme iron, contamination iron and fortification iron. Heme iron is usually of animal origin and of high bio-availability with sources including meat, fish and blood products. Dietary intake of heme iron is negligible in developing countries while iron status and health status (infection, mal-absorption) are the host factors influencing iron absorption [39]. Iron deficiency could also be due to inadequate folic acid, riboflavin, copper, vitamin A, & B_{12} and zinc intake [54]. Micronutrients such as vitamin A, zinc and iron interact with each other to promote appetite which leads to increased food intake and intake of other macro-nutrients and micro-nutrients [38].

According to [18] a study in Egypt, it was revealed that teachers perceived that the unhealthy feeding habits of the school children especially lack of breakfast, affected the interaction between the school children and the teachers. Food security coupled with nutrition education is an important factor that should be considered and addressed in tackling malnutrition [30]. In Kenya, school feeding programs have not been implemented in high potential areas with success [28]. The aim of this study was to offer nutrition education to primary school pupils and assess the iron status after consumption of iron rich foods.

2. Nutrition Knowledge, Attitude and Practices of School Children

2.1. Nutrition Knowledge

Improving nutrition brings greatest benefits to the poor and the most vulnerable especially school going children. According to a Food and Agriculture Organization report [10], it is important to incorporate nutrition education into the curriculum of primary education which considers priority nutrition issues affecting children and their families in the country [13]. Children are eager to learn, are role models for their peers and schools can stimulate and support children to develop skills and knowledge to face daily challenges now and in the future [16].

Knowledge is necessary for practice of good nutrition in the school environment and households. Without adequate nutrition, health and hygienic education, school nutrition programme seem to be less effective [46]. Poor health and stunting continue to occur during the school years which can be reversed by appropriate nutrition interventions. This was revealed by a study undertaken in Zambia on children 6-15 years [14].

2.2. Agronomic and Small Livestock Production Practices

Poorer households have less land, produced less food; have less food storage and little purchasing power [7]. Intervention measures that promote green leafy vegetable production and small livestock production should be embraced to enhance consumption of micronutrient rich foods. School-based gardening programmes can be an excellent means of introducing new ideas about gardening and a useful channel for reaching others in the community and hence promoting consumption of the vegetables and other iron rich foods [13]. Gardening also promotes agriculture as a dignified and important vocation, increases the knowledge and use of best practices in farming and increases the quantity and quality of available food. Unfortunately, young people often have a poor opinion of agricultural work. Moreover, agriculture is not taught as a school subject in primary schools in Kenya and many students do not take it seriously since they consider it a financially and morally impoverishing vocation. Hence the importance of introducing it to the young primary school pupils when their habits are being formed. This study sought to use three nutrition education facilitators to address iron deficiency anaemia among school children in the coffee growing area of Gatanga Sub-County, Muranga County.

A study in Nepal in which pupils aged 10-14 years and their teachers were trained on agriculture, the study showed much appreciation of the great importance and dignity of agricultural activities. A school agricultural programme provided the resources to establish a model farm on each school's grounds; participants carried out the work, from tilling and digging of compost pits to final harvest. Students also passed knowledge along to their farming families [29].

2.3. Iron Status, Nutrition Knowledge, Attitudes and Practices

Some strategies for the prevention and control of micronutrient deficiencies are; food-based strategies and dietary diversification, combined with nutrition education. Nutrition education by all stakeholders can greatly improve the nutritional status of populations [44]. Food-based strategies are an essential component of a long-term global strategy for the control of micronutrient malnutrition. Nutrition education engages in establishing existing levels of nutrition knowledge, attitudes and practices. In a study [3] it was found out that nutrition education can improve knowledge of healthy nutrition and lifestyle choices. Focused nutritional education using available resources and correcting current dietary habits in a vulnerable group of adolescent girls resulted in dietary changes and practises that ultimately improved iron intake. In another study [24] they reported that nutrition education did have a positive effect on the iron status possibly by improving the dietary iron intake. The study also concluded that long-term community-based approaches involving dietary education emphasizing optimum feeding schedules and adequate diets for children may possibly reduce the risk of anaemia and raise iron status. Food beliefs, preferences and habits in Kenyan families have been passed from generation to generation hence has become a custom or tradition which influences food choices. School-based approaches accord the children the excellent chance to practically participate in the Nutrition Education programme, food selection, preparation and consumption as well as understanding why good nutrition is important [19]. Nutrition education and promoting good nutrition practices in schools are known to have a significant effect in fostering healthy eating habits [33].

2.4. Nutrition Education, Iron Rich Food Consumption and Iron Status Outcomes

The pressures from population growth and poverty contribute to severe malnutrition and continue to affect nearly half of the world's population. Also alarming is that an 18 percent rise in the number of malnourished children is projected for Africa by 2020. Over 2 billion people suffer from malnutrition in their diets, including protein-calorie deficiencies and micronutrient malnutrition like iron deficiency anaemia. Such malnutrition prevents much of the world's population from reaching their full potential - mentally, physically or financially [15]. Dietary intervention may be a safer and more feasible solution to address iron deficiency anaemia in the long run compared to other strategies like supplementation. This intervention requires nutrition education to improve knowledge and practices that support healthy outcomes. Integrated rural nutrition projects and nutrition education have a significant impact on knowledge and attitudes leading to long-term beneficial health effects than activities that only aim at increasing food availability. Nutrition education is therefore a viable, sustainable solution in resource limited setting [23]. In their study [24] in a population group in India, where, the iron and nutritional status was highly compromised, nutrition education intervention was effective, as it improved the dietary iron intake and prevented the children from suffering the sharp decline in iron status noted in the control group.

2.5. Food Sources

Children require iron for their expanding red cell mass and growing body tissue. In addition, iron is needed in increased amounts by girls as they begin to menstruate. Children have lower total energy requirements and therefore eat less and thus at a greater risk of developing iron deficiency, especially if their dietary iron is of low bio-availability [53]. The best food sources of easily absorbed iron are animal products which provide heme iron. Vegetables, fruits, grains and supplements provide non-heme iron which is of low bio-availability.

Food sources of high bioavailability iron include liver, lean red meat (especially beef), poultry, fish, iron fortified cereals, dried fruits and dark leafy green vegetables. Reasonable amounts of iron are also found in lamb and pork. Non-heme iron is found in whole grains such as wheat, millet, oats and brown rice; legumes (beans, *dolicos lablab*, soybeans and peas); dried fruits (prunes, raisins, and apricots); vegetables (broccoli, spinach, kale, beetroots, collards) [57]. Meat, fish, poultry, ascorbic acid (vitamin C) and organic acids are all thought to enhance non-heme iron absorption [40]. Tea, coffee, phytates (storage form of phosphate and minerals) and calcium hinder the absorption of non-heme iron and may contribute to the overall lower bioavailability of non-heme iron compared with heme iron [41].

2.6. Food Guide Pyramid for Meal Planning and RDA

The food guide pyramid is an excellent tool to help make healthy food choices. It assists in selection of foods in order to provide the body with nutrients needed and at the same time the right amounts of calories to maintain a healthy weight. The food guide pyramid is used for food servings and meal plans. The food guide will assist one to organize foods according to the energy and nutrients that they supply, so that the prepared meals are balanced and nutritious. The food guide illustrates how foods should be selected and indicates the foods that should be eaten more (at the base of the food guide), moderately and generously (center) and in small amounts (at the top of the food guide). The food guide also recommends consumption of a minimum of 8 glasses of clean safe water per person per day. It serves as a general guide that lets one choose a healthy diet that is right for them with adequate macronutrients and micronutrients [32; 50]. Figure 1 shows a food guide pyramid.

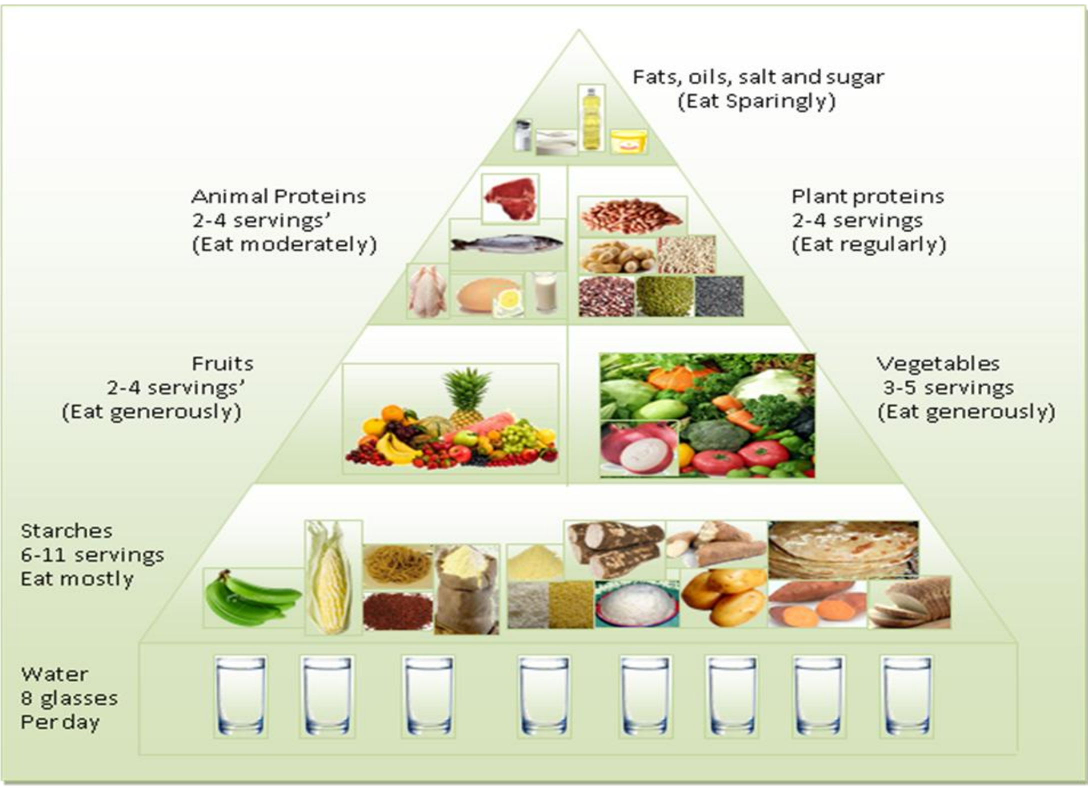

Figure 1: *The Food Guide Pyramid, Source: MOPHS 2012*

The Recommended Dietary Allowance for Iron is, 8-13 mg for 10-18 years old pre-adolescent and adolescent children both girls and boys [48]. An average school lunch must contain at least 3mg of iron in primary schools [56]. A modification of culturally acceptable foods to include iron-rich foods may provide a sustainable approach to controlling and preventing iron deficiency in the population of school aged children [9].

2.7. Effect of Different Nutrition Education Strategies in Addressing Iron Deficiency Anaemia

Schools are the natural development zone for nutrition education. They are one of the main social contexts in which lifestyles are developed. Children of school-going interact with their environment at home, their communities this influences their eating habits [13]. The primary goal of nutrition education should be to help young people adopt eating behaviours that promote health and reduce risk for disease. Behaviourally based education encourages specific healthy eating behaviours for example eating more fruits and vegetables. Learners or target audience from different cultural groups have different health concerns, eating patterns, food preferences and food-related habits and attitudes. These differences need to be considered by teachers and facilitators when designing lesson plans or discussing food choices.

Learners are more likely to adopt healthy eating behaviours when they learn about these behaviours through fun, participatory activities rather than through lectures [35]. Food-based approaches to addressing malnutrition should include educational input. School-garden interventions are most effective when combined with promotional and educational interventions. Strategies combining information, education and communication are needed, and these should be combined with community mobilization and agricultural inputs. School-based nutrition education can improve dietary practices that affect a young person's health, growth and intellectual development [2]. For effective coverage of agricultural extension work in the farms and schools agricultural extension workers fully assist the school pupils in the already formed clubs. The projects they promote include agriculture, health and nutrition that promote healthy eating, growth and income generation for schools and households. Therefore, embracing any strategy in nutrition education content delivery would go a long way in addressing malnutrition issues

The research was designed to include Peer and Agriculture staff in-order to compare their effectiveness in content delivery to the learners. Peer education is a flexible social strategy within a prevention and early intervention delivery system. It usually focuses on children and youth among others to reach high-risk populations. It is a process in which trained supervisors develop and support a group of suitable people to educate, strengthen and support their peers to contend with the health threats and decisions they face (trainer -of -trainer approach). Peer educators create a safe place for candid and genuine examination of attitudes, choices and situations. Through their role as educators they become informal influences, helpers and advocates for systemic change [20]. Peers can influence each other positively for better nutrition [55]. This can be achieved by having both formal and informal teachings amongst themselves [47]. Where resources are limited and large numbers have to be reached, peer education can have a multiplier effect [55]. Therefore the researcher designed the three strategies of researcher, peer and agriculture staff in-order to compare their effectiveness in nutrition education content delivery to the learners.

3. Methodology

The study targeted pupils in upper primary class 6 and their parents who in our view were appropriate change agents in the community. The study population was chosen because at class six they would be able to grasp nutrition knowledge and practice it at their homes. The pupils at this stage were not under any pressure of external examinations like those in class eight. It was important for them to understand the importance of iron as a micro-nutrient as they enter puberty. This study was designed to assess and address the gap in nutrition knowledge using three facilitators.

3.1. Baseline Study

Baseline study was undertaken in-order to have a general overview of the study area and get the schools that met the required criteria for intervention. The intervention schools acted as a representative sample for the primary schools in the study area. Questionnaires were administered to class six pupils in 12 baseline schools. The structured interview schedule was administered to caregivers of the sampled households (those who prepared meals for the children). The researcher gathered socio-demographic and health data, dietary practices based on a 24-hour dietary recall, seven day food frequency using a questionnaire (FFQ for pupils from sixty seven [67] households in the 12 baseline survey schools from the caregivers. Focus group discussion at baseline was done in two schools with the teaching staff to assess the general need for a nutrition education study in the schools. The researcher convened parent meetings at each intervention school to inform them about the study discuss child health issues and obtain a written informed consent for their children’s participation in the study.

3.2. Pretests Done Before Interventions

Pre-tests questionnaires on nutrition knowledge were administered before embarking on the interventions to all the 154 study pupils in the experimental schools and the control school. This was done in March 2012 and interventions started immediately in the same month. For nutrition knowledge, each pupil in class six in the experimental and control schools did a pre- test (pre and post-test questionnaire) which was marked and marks recorded for each pupil to test the effect of the intervention on nutrition knowledge. Other nutrition education topics included food production mainly iron rich foods, selection of a balanced diet from locally available foods and recipe modifications and various projects at household level after the assessment. The assessment of iron status of the study pupils was done to 89 pupils at baseline and 79 at end-line. The procedures were done by a laboratory technician from Kirwara Sub-District hospital (level 4) on the first week of April 2012.

The purpose of the study and the procedures for blood sample collection for haemoglobin levels were explained to the head teacher, senior teacher, class teacher and the children in class six whose parents had signed the informed consent forms. Random sampling of boys and girls was done to come up with the sample required, from the 154 pupils' enrolled from both experimental schools and control school at baseline for the intervention. Information about name, sex, age and sample numbers were recorded. The sample size for both boys and girls were similar since none of the girls reported to have started menarche. The gender specific sample size was determined based on discussions with the laboratory technician who suggested a greater sample size for females than males if they had menarche since there is an established higher prevalence of anaemia in menstruating females. Pubertal status was assessed by the status quo method: Female pupils were asked whether they had experienced menarche before the blood samples were taken and the males' nocturnal emissions. None of them said they had menarche or emissions in both the pre-tests and post- tests.

Venous blood sample was drawn with a sterile disposable needle and syringe from the sampled pupils asceptically from antecubital veins of the arm and 2ml of blood was alliquotted into BD vacutainer tubes with K_2E anti-coagulant (EDTA-sequestrene) after disinfections with methylated spirit swap and drying of skin. The tubes were then packed in a cooler box at 20^0C for maximum 6 hours before being transported to Kirwara Sub-district hospital (level 4). Full blood count was analyzed using haematology analyser (Celltac) - Model MEK 6410K within 15 hours. A safety box and incineration container for used syringe and needles plus the used swaps was provided to carry the waste. The children were categorized as having iron deficiency anaemia when found with Hb <12g/dl for girls and <13g/dl for boys of the specified ages based on WHO standards.

The researcher had identified what was to be taught (content) in nutrition knowledge. Facilitators for each experimental school were identified and the notes offered by the researcher (same notes were used in all the facilitations). From the notes, the researcher had identified, the topics covered were relevant fitting with psychological development of class six pupils by carefully considering existing dietary needs, local foods, nutritional practices and the children's perceptions. From age 11-13 children learn about food supply and that plants are the basis of food chain (food production). It was therefore important to use different parties or strategies in carrying healthy messages to children and also evaluate their effectiveness in the delivery of the contents. Nutrition education was taught using the three facilitators of the researcher, agricultural officer and peer educators. Among other things the effectiveness of each facilitators was to be evaluated. At each visit, facilitators determined whether each child from the baseline roster was present, absent, had left school or had transferred to another school. Lesson plans showing the lesson organization and presentation were also made with guideline from the classroom curriculum chart and Class 5 and 6 Science books [13; 1; 51]. The pupils' were taught using visual aids where necessary. Real objects like, foodstuffs, vegetable seeds and seedlings, rabbits and fireless cookers were used. The effectiveness of each facilitator in delivery of nutrition education messages was measured during the study. The lessons took 30-35 minutes each for 10 weeks in March to May 2012. This took place in the evenings, weekends and during the holidays to avoid interfering with the school teaching programme. Charts and notes were validated by teachers and pre-tested as needed. Specific micro-nutrient rich foods by the facilitating team were used for demonstrations in the school gardens, including beetroots, Blacknightshade (*Solanum scabrum*) or *Managu*, *Amaranthus bitum* (*terere*) slenderleaf (*Crotalaria ochroleucia*) or *mitoo*, jute mallow (*Corchorus olitorius*) or *mrend*a, capsicum, kales, spinach, onion and cowpeas (-*Vigna unguiculata*) or *kunde* in local names.

The school gardening activities (establishment) included conventional and multistory gardens in the school at the plots allocated by the head-teacher. Cookery of the iron rich locally available foods was taught in all the experimental schools to class six pupils in about one hour of practical classroom setting. The sustainability projects meant to reduce micronutrient deficiencies, thus multistory gardens, conventional gardens, rabbit and poultry projects were promoted at pupils' households. Improved cookers (*jiko kisasa)* and fireless cookers were also promoted for nutrient and fuel conservation. The lessons that took 30-35 minutes also included the nutritive value of food, the balanced diet, the food guide pyramid, deficiency diseases, health and sanitation, hygiene and food safety, cooking methods and selection of balanced meals from locally available foods and recipe improvement. More emphasis was laid on the importance of iron rich foods and how to grow and eat them. The pupils' responses and teachers' responses on Likert items were analyzed at 3 point and 5 point scales respectively. Two continuous assessment examinations validated by teachers and the post-test were done by the pupils during the study. An end-term survey was undertaken to assess the impact of the intervention to the pupils' households. The dietary intake on 24hr dietary recall (taken twice and averaged), seven day food frequency and technologies adopted were assessed at the household level for the follow-up pupils. A focus group discussion was conducted at the end-term of the study in one school with some teaching staff to evaluate the effectiveness of the study. The post-tests and final home follow-up were done in July-August 2012.

3.3. Data Management

In Phase 1, biochemical results were keyed in the laboratory information system and copies of results kept in manual and an electronic laboratory notebook. These results were to be compared with post-tests of the experimental and control school class six pupils who consented to be included in the biochemical data collection. In phase two, the questionnaires were ordered numerically and edited before data entry. Averaged dietary data from the 24 hour dietary recall were entered into a modified version of Nutri-survey computer nutritional assessment package for quantitative calculations. The resulting data from socio-demographics and economic characteristics, health and sanitation, nutrition knowledge, attitude and practice among others were transferred to Statistical Package for Social Sciences (SPSS version 17) for comparison and contrasting between the independent variables.

3.4. Logistical and Ethical Considerations

A letter to get clearance to carry out research was obtained from the Kenyatta University Board of postgraduate and the Deputy Vice Chancellor (Academics). Research permit was obtained from the National Council for Science and Technology. Administrative permission was also granted at Sub-County and Municipality level and by the schools management committees. Ethical clearance for biochemical data collection was sought from Kenyatta University Ethics Review Committee and also approved by Medical Officer of Health Thika, the Sub-county Public Health Officer and Kirwara Sub-county Hospital (Level 4). Head teachers, pupils and parents were informed about the aim of the study, its procedures and then written consents were obtained from the head teachers and parents.

4. Results

4.1. Nutrition Knowledge across the Experimental Schools after Interventions

The primary outcome was nutrition knowledge while iron status was considered as secondary outcome resulting from the intervention. Post-tests showed a significant difference with experimental schools under three facilitators performing significantly better than the control school (Figure 1). The peer facilitated school performed best with (51.52+24.79) marks, followed by the researcher facilitated school (48.39+22.23) and the agriculture staff (39.29+9.87). The pre-test post- test improvement in the control school (31.21+12.74) was however not significant ($p>0.05$) as compared to the performance of the experimental school. The hypothesis that there is no significant difference between nutritional knowledge in the experimental schools across the three nutrition education facilitations compared to the control schools in the coffee growing area of Gatanga Sub-County is therefore rejected at p< 0.05 (Figure 1). The hypothesis is rejected because T-test revealed differences in nutrition knowledge before and after the interventions at p<0.05. The results shown in Figure 1 are the performance in nutrition knowledge before and after interventions across all the intervention schools.

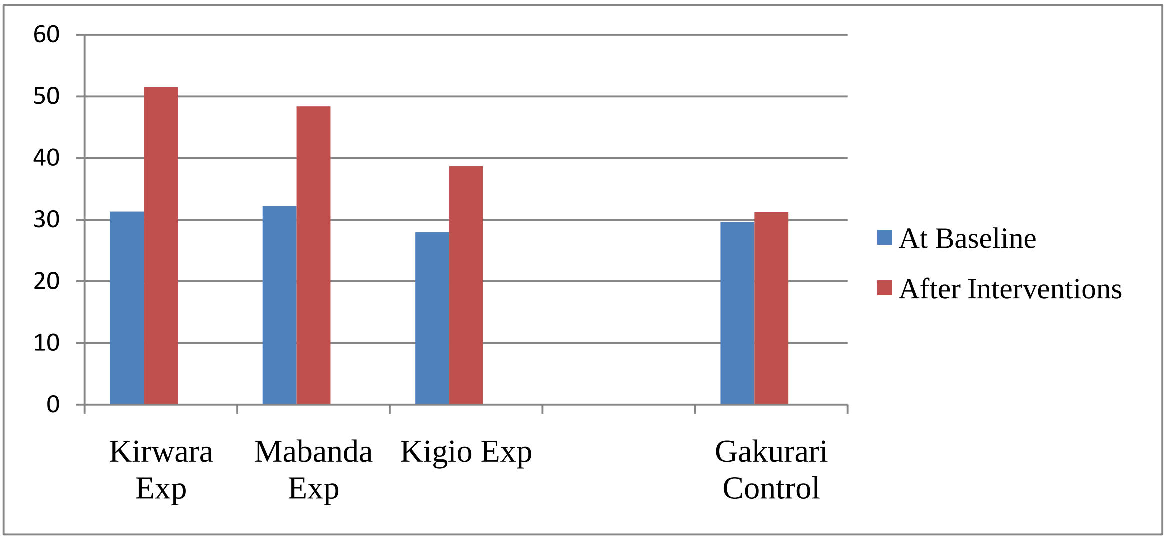

Figure 1: *Nutrition Knowledge Before and After Interventions*

The results show the improvement attained in experimental schools compared to the control school after the interventions. The improvements in the experimental schools were significantly different compared to the control school.

4.2. The 24hr Dietary Intake After interventions

Dietary intakes increased significantly after the interventions in the experimental schools as compared to the control school (Table 1). T –test was computed on food consumption and iron status and food consumption patterns and iron status were not significantly different (p>0.05) between the experimental and control schools at baseline. Notable differences occurred in the experimental schools after the interventions in the intake of some nutrients. Consumption of all nutrients increased and was statistically significant at p<0.05 except for Vitamin E, Calcium (Ca), iron (Fe) and Magnesium (Mg). Based on the results the hypothesis that there is no significant relationship between nutrition knowledge and the consumption of iron rich foods in the experimental schools (Kirwara, Kigio, Mabanda) across the three nutrition education strategies and the control school (Gakurari) of Gatanga Sub-county at p<0.05 is rejected. Table 1 shows the 24hr dietary intakes at post intervention.

Table 1: *The 24 hr Dietary Recall Nutrient Intake after Interventions*

Nutrient	**Control School**	**Experimental Schools (n=43)**			
	Control[0]	Peer facilitated[1]	Researcher facilitated[2]	Agriculture Staff facilitated[3]	p value
Energy (Kcal)	1125+34[a]	1554 +30[b]	1662+28[b]	1627+24[b]	p<0.001
Protein (g)	32.8 +3.0[a]	42.3+9.2[b]	45.9+12.0[b]	46.4+9.8[b]	P<0.05
CHO (g)	315+21[a]	305+23[a]	402+27[a]	465+17[a]	P=0.146

Vit. A (ug)	259+48^{a}	488+41^{b}	502+45^{b}	576+30^{b}	P<0.05
Carot. (mg)	554+46^{ab}	249+35^{a}	244+39^{a}	1230+33^{b}	P<0.05
Vit. E (mg)	0.72+0.62^{a}	1.28+1.07^{a}	0.75+0.33^{a}	0.71+0.62^{a}	P=0.181
Vit. B_1(mg)	0.93+0.19^{a}	2.26+3.35^{a}	3.5+7.4^{a}	1.28+0.28^{a}	P=0.416
Fol.acid (ug)	71+19^{a}	179+10^{b}	141+42^{b}	128+44^{b}	P<0.05
Vit. C (mg)	44.4+19.4^{a}	65.2+17.1^{a}	76.0+19.6^{b}	81.2+18.4^{b}	P<0.05
Ca (mg)	248+22^{ab}	228+26^{a}	268+21^{ab}	306+25^{b}	P=0.129
Mg (mg)	398+19^{a}	425+11^{a}	373+10^{a}	358+13^{a}	p=0.670
Zinc (mg)	1.3+0.5^{a}	3.4+2.4^{b}	2.8+1.4^{b}	2.6+1.2^{b}	P<0.05
Iron (mg)	10.2+1.7^{a}	11.0+2.3^{a}	11.7+3.6^{a}	11.5+2.6^{a}	P=0.368

NB: Means in the same row with the same letter are not significantly different.
[0=]**Control school:** Gakurari**, Experimental Schools**: [1=]Kirwara, [2=]Mabanda, [3=] Kigio

4.3. Haemoglobin Levels after the Interventions

After the intervention, the haemoglobin levels were compared at pre and post intervention to establish if there was any change (Table 2). Pupils' haemoglobin status were not significantly different (p>0.05) between the experimental and control schools at baseline but, notable differences occurred in the experimental schools after the interventions. In the peer facilitated school (Kirwara) the mean Hb levels were 12.8g/dl before interventions and after the interventions the mean levels improved to 13.41g/dl. For researcher facilitated school (Mabanda) the mean levels improved from 14.26 g/dl to 14.50g/dl, and the agricultural officer facilitated school (Kigio) the levels improved from 13.50g/dl to 13.83g/dl. For the control school the Hb levels decreased from 13.70g/dl to 13.33g/dl. There was a statistically significant difference between the pre-test and post-test mean Hb values (p= 0.038). Table 2 shows changes in mean haemoglobin levels of pupils at post intervention.

Table 2: *Mean Haemoglobin Levels Before and After Intervention*

	Mean Hb levels g/dl (+) SD		
Schools	Before	After	p- value (t-test)
Control[0]	13.8+0.9	13.3+0.7	0.038
Peer facilitated[1]	12.8+0.9	13.4+1.0	0.002
Researcher facilitated[2]	14.2+1.2	14.5+0.7	0.268
Agriculture staff facilitated[3]	13.6+0.8	13.8+0.8	0.075

[0=]**Control school:** Gakurari**, Experimental Schools**: [1=]Kirwara, [2=]Mabanda, [3=] Kigio

There was a statistically significant difference in the Hb levels before and after the interventions in the peer facilitated school at p= 0.002. Notable improvement occurred in the other two schools but was not significantly different at p=0.268 in the researcher facilitated school and p=0.075 in the agriculture staff facilitated school. The results rejected the hypothesis that there is no significant difference between iron status in the experimental schools across the three nutrition education facilitations compared to the control schools in the coffee growing area of Gatanga Sub-County at p<0.05. The hypothesis is rejected because t-test revealed significant differences in iron status before and after the interventions at p<0.05.

4.4. Effect of Nutrition Education facilitation on Nutrition Knowledge and Practices

The study partly aimed to translate the knowledge transferred through the three facilitators into practices that promote good nutrition and health for pupils and their households. Experimental schools grew vegetables at school in the school gardens. During the study period, the researcher facilitated school did best in vegetable production (12kgs) followed by peer facilitated (10.5kgs) and agriculture staff (8.0kgs).

4.5. Presence of Multi-Storey Gardens in Pupils' Households

Training and use of demonstrations to children on food production showed increase in the crop yields and the variety of foods grown at their households. This improves nutrition and combats chronic hunger. Follow up on the pupils to their households revealed that twelve households in the peer facilitated and researcher facilitated schools had adopted growing of vegetables using the gunny bags since land sizes are very small in this area and such technologies were easily adopted (Plates 1 and 2)

Plate 1: A Sack (Multi-storey) Garden at School growing kales

Plate 2: A Pupil with a Sack Garden at Home growing kales

The researcher and peer facilitated school did significantly better than the agricultural staff facilitated school at $p<0.05$. The control school improved but not statistically significant at $p>0.05$. Peer and Researcher facilitated schools showed improved adoption in food production with peer and researcher facilitated schools showing a statistically significant different improvement at $p<0.05$. Knowledge gained from school gardens was transferred to the community by the experimental pupils. There was an evident improvement in the introduction of new varieties of foods such as cowpea leaves, kales, jute mallow (*mlenda*), beetroot, capsicum, amaranth and black nightshade in the experimental schools. The establishment of gardens with a variety of vegetables was significantly different in the experimental schools households than in the control school. Children from two experimental groups in the peer facilitated and researcher facilitated schools were more likely to have consumed several of the individual micronutrient-rich foods.

Effectiveness of the Different Nutrition Education facilitations Amongst the Study Pupils at Pre and Post-test

The different nutrition education strategies had different impact on the study pupils. Table 3 shows effect of different nutrition education facilitations on the study pupils at pre and post-test.

Table 3: *Performance of Nutrition Education Facilitations Before and After Interventions*

Variable	Strategy used in schools	P value(t-test)
Nutrition knowledge	Control	0.337
	Peer facilitated	0.000
	Researcher facilitated	0.000
	Agriculture staff facilitated	0.000
Haemoglobin levels	Control	0.038
	Peer facilitated	0.002
	Researcher facilitated	0.268
	Agriculture staff facilitated	0.075
Multi-storey gardens	Control	0.324
	Peer facilitated	0.001
	Researcher facilitated	0.044
	Agriculture facilitated	0.323

Performance in all the nutrition education strategies showed improvement in all the selected variables. Most of the selected variables showed a significant difference at p<0.05.

4.6. Relationship of Nutrition Knowledge and Selected Nutrient Intakes after Interventions

Nutrition interventions are known to help in management of all kinds of malnutrition amongst the populations. Table 4.6 shows correlation and p values post interventions.

Table 4: *Correlation and p values post Interventions*

Nutrition knowledge and:	r	p value
Protein intake	0.218	0.080
CHO intake	0.667	0.000
Kcal intake	0.661	0.001
Vitamin A intake	0.217	0.036
Vitamin C intake	0.272	0.068
Zinc intake	0.037	0.261
Folic acid intake	0.230	0.057
Iron intake	0.349	0.007
Haemoglobin levels	0.253	0.025 (p<0.05)

Bivariate correlations (r) explain the relationship between nutrition knowledge and selected nutrients at post-test. The Kcal, Carbohydrate, Vitamin A, folic acid and iron intake relationships were statistically significant except for protein, zinc, folic acid and vitamin C (Table 4). There were significant positive correlations between nutrition knowledge and hemoglobin levels (Table 4). The pupils in the experimental schools improved their nutrition knowledge, iron rich food intake which could have positively influenced their hemoglobin levels (Table 4). The hypothesis that there is no significant relationship between nutrition knowledge and the iron status in the experimental schools compared to the control school (Gakurari) in the coffee growing area of Gatanga Sub-County at (r= 0.253, P=0.025) p<0.05 is rejected. The results show that the interventions in nutrition knowledge had an effect on the levels of haemoglobin levels. The school gardens would be used as a simple and cost effective means to improve nutrition education. Children learn by doing therefore an effort was made to continue training them and involving them in food production, record keeping, sales and utilization by involving the NGO. Linear regression for post-test nutrition knowledge had a positive trend and the haemoglobin levels were increasing. Nutrition knowledge scores increased the haemoglobin levels. The results show that the interventions in nutrition knowledge had an effect on the levels of haemoglobin levels.

5. Discussion

5.1. Pupils' Nutrition Knowledge at Pre-test

The pre-intervention tests showed that pupils lacked adequate nutrition knowledge (an average of 30.05%) and identified the need to increase effort on nutrition education in Gatanga Sub-County. Interventions on nutrition education to improve knowledge and practice that support healthy eating to address iron deficiency are required in any given population [23]. School gardens and other resources that could have been used as teaching aids for nutrition education were not actively used in the study area. Consistent with the findings, nutrition practices in the area before the intervention were poor since the learners could not practice what they did not know. This is comparable to a study undertaken in Machakos County whereby most pupils scored an average of 35% at pre-test in nutrition knowledge [30].

5.2. Pupils' Haemoglobin Levels at Pre-test

In the current study almost 1/3 of the total pupils were found to be anaemic after altitude adjustments at a calculated factor 0.5 for Gatanga altitude (2237m ASL). The findings compared well with [5] report that in rural public schools in Delhi anaemia was 23% among boys and, 15.3% among girls. This also compares with a study done in Turkey, [26] whereby 12.6% of pupils' in two primary schools were anaemic. In the current study, it was revealed that iron deficiency in a population may be masked by altitude induced polycythaemia as increased prevalence of anaemia after altitude adjustment amongst the population stood at 31.4%. The results are in agreement with [5] in a study undertaken in Chandigarh India where 25.4% rural pupils (age 12-18years) sampled from two rural schools were anaemic. A similar study in Ouagadougou, Burkina Faso revealed that 45.6% of primary school pupils of ages 13-14 years were anaemic. In a report on six African and two Asian countries, 40.2% of children aged 7-11 years and 54.4% of those aged 12-14 years were anaemic [8]. In their study [45] found iron deficiency anaemia prevalence of 31% among Tanzanian school going children.

5.3. Pupils' Dietary Intakes at Pre-test

This study showed a low intake of most nutrients except carbohydrates which were above RDA. The low mean intakes could have been influenced by the poor harvests, large family sizes and the level of inflation that affected food access during the study. In poor countries, diets tend to be deficient in multiple micro-nutrients and not only iron and folate, but deficiency in vitamin B_{12}, vitamin A as well as zinc contribute to iron deficiency anaemia [7]. Many factors influence dietary intake at individual and household levels. It has been documented in some studies that the bigger the land the more diversified crops and livestock breeds are grown and kept respectively meaning diversified diets and more nutrient intake. Research has shown that the higher the income, the better the dietary intakes and the bigger the household the higher the competition for various resources [37]. Low dietary iron intake is an attributed cause of iron deficiency and anaemia in many parts of the developing world. Food-based intervention should be one of the important strategies for reducing the magnitude of the problem of anaemia in school children and their communities [45].

5.4. Pupils' Nutrition Knowledge after Interventions

Post-tests showed a significant difference in nutrition knowledge with the experimental schools performing significantly better than the control school. The performance of the control school also improved in some nutrition knowledge aspects such as the knowledge of enhancers of iron uptake, food guide pyramid and iron rich green vegetables. This could have been contributed by the first sensitization during the pre-test assessment, which may have provoked the pupils thinking and understanding of the nutrition knowledge. The pre-test post-test improvement in the control schools was however not significant (p>0.05) as compared to the performance of the experimental schools. Findings in an integrated rural nutrition project in Kawambwa, Zambia indicated that nutrition education programs have a significant impact on knowledge and attitudes than activities that only aimed at increasing food availability [23]. The pre-intervention test had shown that without adequate training no sex would have an advantage over the other in nutrition knowledge. Significant improvement in nutrition knowledge and practice were observed in all the experimental schools under the different facilitators, while the control school improved but not significantly. In the study, the control school could have improved because the children were exposed to similar questions and discussions may have occurred after the first exposure meaning an improvement in the repetition (post-test).

Peer education can produce leaders in nutrition education who act as positive role models for other pupils. Peer education makes a conscious use of peer influence in a positive way (meaning in a way that contributes to everyone's well-being) [55]. It is well documented that peers have confidence with one another and this could have resulted into the good performance under the peer facilitation strategy. The other reason could probably because the class was fairly small with twenty seven pupils. The primary outcome was improved nutrition knowledge while the iron, worm status and practice were considered as secondary outcomes resulting from the positive effect of the intervention. Changes in practice after intervention demonstrate the effectiveness of the intervention programmes in improving nutrition both among school pupils and household members. Class participation and iron rich food consumption improved greatly. These findings are in agreement with a study done in India whereby there was improved nutrition knowledge after interventions [42]. Pupils in the experimental schools adopted new projects as compared to the control school. Nutrition education leads to general improvement in dietary patterns and other practices like better farming practices.

5.5. Pupils' Nutrition and Health Practices after Intervention

After the interventions, nutritional practices improved greatly at schools and the pupils' households. For example, in this study, consumption of traditional vegetables before the nutrition intervention was poor although almost every family had a small plot to grow the crops. After the intervention, growing of vegetables, consumption of cowpeas, amaranth and black nightshade increased. Increase in the hemoglobin levels was noted in the experimental schools compared to the control school. The results were in agreement with a study in Machakos primary schools whereby the pupils transferred nutrition knowledge to their community/households and improved various practices like consumption of various foods which in turn improved their nutritional status [30].

The findings of the intervention study leads to the conclusion that the food based approach using the three facilitators (Peer facilitated, Researcher facilitated and agricultural extension worker facilitated) could have some influence and hence effective to combat deficiencies and promote good health and well-being of the pupils. Gains made may be attributed to the interventions made, when comparison were made between the experimental schools and the control school. Similar findings are reported in a study done in Chennai district, India where by haemoglobin levels of school children who used micronutrient rich foods improved significantly. Sound nutrition knowledge imparted to the children and their households may also have helped to promote their home food intake [42]. The impact was the improved nutrition and haemoglobin levels. The School Health and Nutrition Policy emphasize the promotion of school gardens to enhance integration of nutrition interventions into routine school activities [34].

5.6. Relationship of Variables

In the current study, haemoglobin levels were low before the interventions but significantly improved in the experimental schools. The peer facilitated school had the best improvement in haemoglobin levels, followed by the agriculture facilitated and then the researcher facilitated school. It is well documented that nutrition knowledge, good dietary practices can reduce disease prevalence. The results in the current study are in agreement with a study undertaken in Tanzania on school children whereby there was a significant correlation between iron intake and serum ferritin at $p<0.05$. Food-based intervention was an important strategy for reducing the magnitude of the problem of anaemia in the school children [45].

Iron deficiency anemia is a serious health problem that affects school going children reducing pupils' school performance and productivity. Iron deficient children tend to exhibit irritability and a low level of engagement with an interest in their immediate environment. These traits inhibit the development of a child's active learning capacity and impinge upon school achievement. Poor performance in a variety of achievement tests by iron deficient children enrolled in school has been reported by several authors. Iron deficiency anaemia is the end stage of a relatively long process of deterioration in Hb levels. Hb levels are indicators of the final stage of IDA. In the current study it was observed that the Gatanga primary school going children were moderately anaemic at baseline but improvements were noted in the experimental schools after the interventions. The facilitations used to address iron deficiency anaemia through nutrition education and associated measures to increase dietary intake were effective measures which can be up-scaled to other locations with a similar population. Signs and symptoms of anaemia are non-specific and difficult to detect though simple laboratory tests can be used to diagnose and determine its severity. Nutrition knowledge offered to the pupils impacted positively as the results revealed. The experimental schools improved in all aspects of the intervention as compared to the control school. The experimental school pupils households adopted various practices and increased food production in vegetable growing and small livestock keeping.

6. Conclusion

At Baseline

From the pre-test assessment most pupils were not knowledgeable in most practices and confidence in nutrition knowledge was inadequate hence more knowledge was needed as indicated by the pupils performance at baseline. All schools scored very poorly in the pre-tests on nutrition knowledge at baseline study. Many pupils had an interest in learning more in nutrition as a subject. The baseline study revealed that the households had low consumption of animal products and high consumption of plant foods. There was minimum consumption of traditional vegetables which were generally overcooked. Few households consumed organ meat, eggs and red meat. The mean nutrient intakes were all below the RDAs for iron.

Effects of the Intervention

Nutrition knowledge given to the experimental schools improved their dietary intake and agronomic practices. The hemoglobin levels increased after the intervention in the experimental schools while it decreased in the control schools. All nutrition education facilitators showed some impact such that there was improved performance in all aspects with the peer facilitated school doing the best. Relationship between nutrition knowledge and iron rich food intake showed increased nutrient intake and iron status. There was an increased iron rich food intake and hence increased hemoglobin levels. These interventions provided an opportunity to link food security interventions and nutrition outcomes.

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