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Serum zinc levels of school children on a corn-soy blend feeding trial in primary schools in Suba district, Kenya

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ABSTRACT

Objective: Micronutrient deficiencies are among the top ten leading causes of death in Sub Saharan Africa. In Suba district of Kenya, the problem is compounded by high poverty levels and a high prevalence of HIV and AIDS. This study determined the effect of corn soy fortified complementary food on serum zinc levels among primary school pupils in Suba district.

Methodology and results: An experimental study was conducted with children in two schools (Mbita and Sindo) being fed with corn soy blend for three months. Children in a third school (Ong'ayo primary) were the control and were not fed with the corn-soy blend. Blood samples at baseline were drawn from 156 school children aged 6 to 9 years from the 3 schools (Mbita 55, Sindo 52 and Ong'ayo 49) through systematic sampling while blood samples at follow up were drawn from 138 children (Mbita 49, Sindo 46 and Ong'ayo 43). Assessments of serum zinc were done before and after three months of feeding. SPSS and Nutri-survey software packages were used to analyze data into descriptive and inferential statistics. At baseline, nearly all (95.7%) of the pupils were found to be deficient, with low serum zinc (<10.7µm/l). There was a significant reduction (p=0.0421) in the number of zinc deficient cases to 70.2% after feeding for 3 months on corn soy blend with the mean serum zinc having improved from 8.4 to 10.2 µm/l (p=0.002). Although not significantly different, girls had higher serum zinc levels than boys before feeding trials while the opposite was observed after the feeding trials.

Conclusion and potential application of findings: The fortified complementary food significantly improved serum zinc levels and reduced the level of absenteeism from school. Parents are therefore encouraged to introduce and ensure families consume more of corn-soy blended foods at home. It would also be valuable for schools with feeding programmes to introduce corn-soy blends or products as part of school meals. The findings can also be used by policy makers to promote production and consumption of soya beans. Authors recommend a similar study be conducted in a different area among the same age group and results compared to validate the findings of this study.

Key words: Micronutrient deficiency, serum zinc, school children, corn-soy blend

INTRODUCTION

Suba district has borne the brunt of HIV and AIDS with approximately 41% of the total population being infected with the virus according to 2005 data, though the prevalence dropped to 31% by 2006 (MOH/NASCOP, 2006). Studies show that HIV and AIDS can reduce household food security rendering children more vulnerable to malnutrition and infections (UNAIDS/UNICEF/USAID, 2004).

A situational analysis on the nutritional status of children under five years and school going children in Suba District (Ohiokpehai *et al*., 2007) showed that the effects of HIV and AIDS infections adversely affected school children with associated malnutrition characterized by stunting, wasting and being underweight. The impact was worsened by the irregular availability of food in the household coupled with inadequate or inappropriate complimentary feeding, considering that the district has high poverty levels (GoK, 2005).

Studies have shown that there exists a relationship between Protein-Energy Malnutrition (PEM), which is usually linked to lack of food and specific micronutrient deficiencies especially those of Vitamin A, Zinc, Iron and Iodine. These deficiencies are associated with consumption of foods that are poor in micronutrients and/or are not fortified. PEM as reflected by stunting, wasting and underweight levels could be taken as an indicator of micronutrient deficiencies (WHO, 2002; WFP/UNICEF, 2006.) Although micronutrient deficiencies are less visible, they constitute a devastating form of malnutrition whose consequences can be crippling or fatal, hence these conditions have been referred to as 'hidden hunger'. These deficiencies are prevalent among population groups who are already experiencing insufficient quantity and quality of food and often in areas that are overburdened by HIV and AIDS.

The World Health Organization (WHO, 2002) prevalence data for micronutrient deficiencies indicates that approximately 4 million women and young children are Vitamin A deficient, almost 7 million school children are iodine deficient and 7 million women of childbearing age are anemic. Deficiencies of one or more micronutrients usually mean there are also deficiencies of other micronutrients such as zinc (WHO, 2002; WFP/CDC, 2005; IZA, 2008). This is because the origin of these deficiencies, a deficient diet, means that other micronutrients are also not present in sufficient amounts (WFP/CDC, 2005).

Zinc deficiency has of late been gathering more attention from researchers and development organizations. It is estimated that some form of zinc deficiency affects about one-third of the world's population, with estimates ranging from 4 to 73% across sub regions in Sub Saharan Africa (WFP/CDC, 2005). This condition is responsible for 4% of deaths and disability-adjusted life years among children under five years old (Black *et al*. 2008). Worldwide, it is estimated that zinc deficiency is responsible for approximately 16% of infections of the lower respiratory tract, 18% of malaria and 10% of diarrheal diseases (IZiNCG, 2004). In 2002, about 1.4% of deaths worldwide were attributed to zinc deficiency (WFP/CDC, 2005). Although severe zinc deficiency is rare, mild-to moderate zinc deficiency is quite common throughout the world (WHO, 2002).

According to the International Zinc Association and The World Health Report (2002), lack of zinc is the fifth leading cause of diseases such as diarrhea and pneumonia in children, which can lead to high mortality rates. Early deficiency may lead to impaired cognitive function, behavioral problems and memory impairment. Further, as the child grows older, skin problems become more frequent while gastrointestinal problems, anorexia and mood changes reduce (IZiNCG, 2004). Due to Zn deficiency school-aged children experience hair loss, growth retardation, inflammation of the eyelids and conjunctiva and other recurrent infections. These problems can be prevented through zinc supplementation and fortification. A study by John Hopkins University (2007) found zinc supplementation to reduce mortality in older children.

The recommended dietary requirement for children between 4-8 years old is 4-5 mg per day (IZiNCG, 2004; Brown *et al*., 2004). WHO (2002) attributes zinc deficiency largely to inadequate intake or absorption from the diet, the latter occurring due to presence of inhibitors such as phytates and fibre, which are high in foods of plant origin. Animal products are the best sources of zinc, but they are unaffordable to many.

Serum and plasma zinc concentrations are the most widely used biochemical markers of zinc status. This study was carried out using serum zinc as a marker and school children as the target population. The study was necessitated by high levels of macronutrient deficiency observed during a previous study (Ohiokpehai *et al*., 2007), high prevalence of HIV and AIDS in the study area (NASCOP, 2004), and lack of a diversified diet. The objective was to assess the effect of corn-soy blend, a fortified complementary food, on serum zinc levels of children aged 6-9 years.

MATERIALS AND METHODS

Study location: Suba district is one of the twelve districts in Nyanza Province, located on the southwestern part of Kenya a long L. Victoria. The district borders Bondo to the North across the lake, Homa bay to the east, Migori to the south and lake Victoria to the west. It is located between the longitudes 34'E and 34'20 ''E and latitudes 0'20''S and 0'52'' S. The district covers an area of 1,056km² exclusive of water surface. It comprises 16 islands, the biggest being Mfangano and Rusinga. The water mass covers an area of 1190km^2. The project covered Mbita Division, Township Sub-division where Mbita primary school is located and Central Division where Sindo and Ong'ayo primary schools are situated in Kaksingri and Sumba Sub-divisions, respectively. According to the 1999 population and housing census, the district had a total population of 174,524 people with an annual growth rate of 2.9%. The household size was 4.7 with 35% of the population being between 6-15 years (Ohiokpehai *et al*., 2007). In 2005, the HIV prevalence was 41% of the population in reproductive age group, which dropped to 31% in 2006 (MOH/NASCOP 2006). The district is also characterized by rampant poverty with a poverty index of 64%, food insecurity and poor infrastructure (GoK, 2002). The inhabitants of this district mainly depend on cereals such as maize and sorghum as their staple diet while fish is their main source of protein. Vegetables and fruits are hardly available in the area forcing the traders to import from the neighboring Kisii District.

Suba district has a population of 172 primary schools with an enrollment rate of 94% boys (18,099) and 85% girls (16,366) as reported in the District Development Plan (GoK, 2002). From a survey conducted in April 2006 (Ohiokpehai *et al*., 2007), it was realized that Mbita Division had 51 primary schools with a total of 1,396 orphans while Central Division had 877 orphans. There were 5,072 orphans in the primary schools in the district. Despite this number of vulnerable school children, there was no school feeding programme in Suba District. Further, the baseline survey showed that the population of school children aged between 6-9 years in the three schools was 494 pupils.

Experimental protocol: A pre-test post-test control research design was employed with an experimental and control group made up of school children aged 6-9 years old. Three study schools were purposively selected due to the high HIV and AIDS burden in Suba district. Other factors such as accessibility to the schools and homogeneity of the schools were considered in order to reduce confounding factors. A systematic sampling frame based on age and vulnerability status of the pupils was developed with the help of the class teachers and used to identify orphans and vulnerable children in the three schools. A total of 55, 52 and 49 pupils from Mbita, Sindo and Ong'ayo primary schools, respectively, were sampled for the study out of the entire population at baseline but these numbers dropped to 49, 46 and 43 respectively, after three months of intervention. This was occasioned by transfers to other schools and some pupils refused to give consent to have their blood samples taken at follow-up due to fear of pain. The sample population size was above the minimum according to Mugenda and Mugenda (1999), of 30 experimental subjects and 30 controls for studies of this nature. In this study, however, an additional number of pupils were taken to counter drop out effects.

All pupils in the pre-primary sections from Mbita and Sindo primary schools (experimental schools) were fed on porridge made from corn-soy blend that was produced locally by Nutro EPZ food manufacturing company for three months. The porridge (precooked and roasted) was given daily during the mid-morning break at school. It was prepared by making a paste from corn soy flour and some cold water, then adding it into boiling water, then stirring for five to ten minutes until it was cooked using the consistency and aroma of the porridge to determine cookability. Each of the study children received 100 grams corn-soy blend in form of porridge per day for a period of three months with a take-home ration for the weekends. The study children took home 500 grams of corn soy blend which was prepared for the index child and four other family members. This was to ensure that the index child got his/her share of the fortified complementary food on Saturdays and Sundays and for the continuity of the feeding trial.

According to FAO/WHO (1985), 100g of soybean per day in combination with a cereal would provide most of the daily protein requirement of 40g per day. In this regard, the ratio of carbohydrate i.e. corn to soybean was 3:1. The fortified complementary food provided 5.0 mg of zinc per 100g. According to IZiNCG (2004) and Brown *et al*. (2004), children of this age group (6-10 years) require about 5 mg of zinc daily from the diet. In addition, each child received 5g oil, which was added to the corn soy blend to give approximately 364 kilocalories and 12-14 % protein from the complementary food per day. The pupils did not receive any other food but relied on their normal household diets for further nutritional nourishment. Pupils from Ong'ayo primary school who served as the controls did not receive the fortified complementary food.

Nutrition and Health education was also offered to all the pupils in the study schools and their guardians by the researchers in order to raise their awareness regarding the intervention and increase their knowledge and understanding. The impact of this education, however, was not measured. The pupils (in pre-primary section which included the study pupils) were also supplemented with vitamin A to reduce the risk of vitamin A deficiency and de-wormed.

At baseline, blood samples were collected from 55, 52 and 49 children in Mbita, Sindo and Ong'ayo primary schools, respectively. After 3 months feeding blood was collected from 49, 46 and 43 children in the same primary schools, respectively. The lower number of subjects at the end of the study is due to the fact that there were drop outs in the course of the study and others who consented to give blood samples at baseline but were not willing to do so at follow up, possibly due to unpleasant previous experiences of needle pricks and the sight of blood. During analysis at the Kenya Medical Research Institute (KEMRI), results showed that some blood samples were spoilt during transportation.

About 5 ml of blood was drawn from the arm of each child by qualified laboratory technicians and put in tubes covered with aluminium foil. The universal precautions recommended by WHO for the safety of technicians and the subject when drawing blood samples were followed (WFP/CDC, 2005). The samples were wrapped in foil paper to protect retinol from destruction by light then transported to the Suba district hospital laboratory where they were then centrifuged at 3,000 rpm for 10 min and clear serum samples separated into sterile cryovials. The samples were then flushed with white spot Nitrogen gas and stored in liquid Nitrogen at -70 °C and transported to KEMRI laboratories in Nairobi for analysis. To determine the zinc values, Atomic Absorption Spectroscopy (AAS) as described by Smith *et al*. (1979) was used. Briefly, zinc stock solutions were prepared. The blank was made by adding 10 ml of the sodium stock solution into a volumetric flask through a pipette to make up 100 ml. The sample was then prepared by adding 2.25 ml of de-ionized water into polythene test tubes. The serum sample was vortexed for at least 1 minute. Using a micropipette, 250 µl of the serum was pipette into 2.25 ml of the de-ionized water and vortexed for 1 minute. The blank was aspirated followed by the standards and upon satisfaction with the standard curve; the standards were read as samples. The samples were then aspirated and read directly from the screen. The results in microgram/100 mls were multiplied by 10 since the sample was diluted in the ratio 1:9. Low plasma zinc level was considered to be < 10.7 µm/l (King, 1990). Further, Nutrition status Z-scores were calculated using height, weight, and age values to obtain standardized z-scores for height-for-age (HAZ), weight-for-height (WHZ), and weight-for-age (WAZ) based on the National Center for Health Statistics (NCHS, 1983) standard. These indicators represent stunting, wasting and underweight, respectively.

Ethical clearance for the study was sought from the Ministry of Health, Suba District and signed informed consent obtained from the parents/guardians and their children (pupils) before commencement of the feeding trial and during drawing of blood at baseline and at three months.

Data analysis: Nutri-survey and SPSS computer software packages were used to analyze data using descriptive and inferential statistics. T-tests were used to compare mean differences in control and experimental subjects before and after the corn soy blend feeding trial. Chi-square tests were used to test for relationships and significances between variables.

RESULTS

Assessment of Zinc status: Low serum zinc levels are used as an indicator of poor zinc status. Low plasma zinc level was considered to be < 10.7µm/l (King, 1990; IZiNCG, 2004) while serum zinc with levels 12-18µm/l is considered to be the normal range (Thompson, 1991; Brown *et al*., 1998; Wood, 2000). This current study adopted serum zinc of 10.7 µm/l to be the borderline. Before the intervention, nearly all the children in all three schools (95.7%) had low serum zinc of less than 10.7µm/l (Table 1) with a mean of 8.41µm/l (Table 2). There was a significant improvement (P<0.05) after the intervention in all schools with the number of those with low serum zinc reducing from 95.7% at baseline to 70.2% (P=0.0421) after the intervention. Similarly, the mean serum zinc improved from 8.41 at baseline to 10.2 (P=0.002) at follow-up, which is slightly lower than the normal levels of 10.7. The difference between the means was also significant. The results show that the children in the control school, Ong'ayo primary, also attained a significant decrease in prevalence of zinc deficiency after the intervention (Table 1). This is possibly because of the Vitamin A supplementation that was given to both experimental and control schools at baseline. Studies have shown that there exists a relationship between zinc and other micronutrient deficiency (John Hopkins University Bloomberg School of Public Health, 2007). Studies done by Solomons (2001) also showed positive interactions between zinc and Vitamin A.

Table 1: Prevalence of Zinc deficiency among school children in three schools in Suba district of Kenya, assessed before and after feeding pupils on supplemental corn-soy meal.

School	Prevalence (%)		Chi-square test P<0.05
	Before	After	
Mbita			
N=54(before)	96.3	73.6	0.0491
N= 53 (after)	3.7	26.4	0.0121
Ong’ayo			
N=53 (before)	94.3	61.4	0.0432
N= 44 (after)	5.7	38.6	0.0111
Sindo			
N=47 (before)	95.7	75.7	0.0499
N=37 (after	4.3	24.3	0.0251
Total			
N=154(before)	95.4	70.2	0.0421
N=134(after)	4.6	29.8	0.0193

According to Ministry of Health, Kenya (2003) and IZiNCG (2004) zinc levels <10.7 = low while >10.7 is normal/ no deficiency.

Results (Table 1) show that the difference in Zn deficiency levels between the three schools at baseline were not significant (P>0.05), with a difference of less than two percentage points. After the feeding program, however, children in all the schools improved significantly. Ong’ayo primary school, which was the control, also showed some unexpected improvement, though not significant (P=0.449).

Mean serum zinc was also not significantly different (P>0.05) at baseline for all schools (Table 2) although Ong’ayo had a higher mean compared to the other schools. After feeding, children in Sindo primary school reported the highest mean serum, which was close to the normal cut off level of 10.7µm/l. From these mean levels, it can be argued that the situation from Sindo primary school was mild. The improvement in mean serum zinc among pupils from Ong’ayo primary (control school) was not significant (P>0.05) as compared to the other two experimental schools. The significant improvement in serum zinc in experimental schools shows that the feeding trial had an effect.

Table 2: Mean and median distribution of serum Zinc among the study schools (cut off for normal serum zinc taken at >10.7 (µm/l).

School	Mean (95%CI)			**T-test	Median	
	Before	After	Difference		Before	After
Mbita N=55(before) N= 49 (after)	7.25±0.7	9.743±1.2	+2.49	0.003.	7.46	9.18
Ong'ayo N=52 (before) N= 43 (after)	10.3±1.1	10.94±1.3	+0.6	0.449.	7.80	10.15
Sindo N=49 (before) N=43 (after	7.67±1.5	9.95±0.9	+2.29	0.001.	7.94	9.33
Total N=154(before) N=134(after)	8.41±0.9	10.2±1.1	+1.19	0.012.	7.73	9.56

Comparison of serum zinc by sex: An independent sample t-test procedure which is suitable for comparing means between experimental and control schools was used to establish whether significant differences existed between girls and boys before and after the feeding trial (Table 3). There were no differences in serum zinc means between boys and girls in Mbita and Sindo schools but in Ong'ayo primary school girls had a significantly higher mean (11.102±03 µm/l) before the feeding trial than the boys. Considering that the levels for low serum zinc were set at <10.7µm/l it can be concluded that boys from Ong'ayo primary school were at a higher risk of zinc deficiency than girls before the trial.

After the feeding period, there were no significant differences between schools. Although not significantly different, girls had higher serum zinc levels than boys before feeding trials while the opposite was observed after the feeding trials except for the control school (Ong'ayo primary). Boys from Ong'ayo primary, who at baseline reported significantly lower serum zinc than girls reported a higher mean than girls. There is however no known reason or explanation for this trend in both experimental and control schools.

Table 3: Mean serum zinc levels (by sex) at baseline and after feeding school children with corn-soy blend in Suba District, Kenya.

Serum Zinc (µm/l)	Experimental schools				Control		*T-tests
	Mbita Primary		Sindo Primary		Ong'ayo Primary		
	Before (55) (B26,G29)	After (49) (B26; G23)	Before (49) (B24, G25)	After (43) (B23, G20)	Before (52) (B24, G28)	After (46) (B22, G24)	
Total	7.27±0.5	9.741±1.3	7.62±1.5	9.97±0.7	**10.4±1.4	10.93±1.5	NS
Boys	6.901±0.9	9.611±2.1	7.260±1.9	10.389±2.0	7.227±0.4	11.585±1.9	
Girls	7.381±0.8	9.721±1.9	7.629±1.3	9.692±1.8	11.102±03	9.773±1.2	

B= boys, G = girls. Figure in parenthesis is sample size (n). NS = not significant. *Independent T-tests – Significance at P<0.05 ** Difference between girls and boys significant.

Serum zinc levels, macronutrient deficiency and dietary intake: Results from the baseline data indicated that the school children suffered from macronutrient deficiencies. More than 20% of children from both experimental (28.5%) and control schools (25.5%) were stunted with a Z-score of -2SD. The slight improvement in results after intervention is likely due to the short period of feeding. Data from dietary patterns 24-hour recall and food frequency showed low consumption of fruits and vegetables and seeds, which are rich sources of micronutrients. Results also indicated that there was a high consumption of cereals, which have phytates that can negatively influence micronutrient absorption (IZA, 2008). Consumption of micronutrient rich foods like soybean was also low (80% did not consume it at all while only 3% reported to be consuming on a daily basis). A detailed report of the baseline study and nutritional status after the intervention is reported elsewhere (Kamau *et al*., 2008).

DISCUSSION

Results on serum zinc levels presented here confirm the argument that individuals with macronutrient deficiencies that are usually exhibited through stunting, wasting and underweight are also likely to have micronutrient deficiency (hidden hunger). Majority of the children had low serum zinc levels, which slightly improved after the feeding trial. This could be explained by the fact that the children were receiving the feeding (porridge) once a day while most of the other meals of the day were taken at home. Although helpful, the portion provided (1 cup per day) may not yield significant results within a short timeframe. Factors like food choice at home, reliance on cereals and the time at which the blood sample was collected (after a meal or a fasting period, when the subject has not eaten for about 6 hours) could affect serum zinc levels. Results suggest that a longer feeding period could have yielded more significant effects of corn soy blend supplementation.

Serum zinc levels have shown a positive relationship with stunting, an indicator of macronutrient deficiency. Studies done on children from different subgroups to compare zinc status and stunting levels showed a positive linear growth line with children with higher levels of serum zinc reporting Z scores of less than -2SD (Brown, 1998). Evidence from research shows that mean zinc concentration in plasma of a group of people can be an indicator of the population's zinc status. Dietary assessment of zinc levels in any human population offers challenges in the sense that it requires quantitative estimation of the likely absorption of zinc from mixed diets and the fact that anti-nutrients such as phytates in cereals and legumes inhibit absorption and utilization of zinc (Brown, 1998). Thus, households in resource poor settings or those whose staples are mainly cereals and legumes could suffer zinc deficiency (Ruel & Levin, 2002).

Furthermore, research has shown that populations that rely on plant-based diets, often lacking in diversity, tend to suffer micronutrient deficiencies, including zinc (Harvest Plus, 2006). This could explain the low zinc levels observed among the children in the current study in Suba District, which is resource poor (GoK, 2005), and lacks diet diversity (Ohiokpehai *et al*., 2007). High levels of dietary zinc are concentrated in seeds, vegetables, fruits and animal products (Ruel & Levin, (2002) and poor households may lack the resources to diversify their diets.

Based on the outcome of this study, we conclude that supplementation of food with corn-soy blend can significantly improve the nutritional status of a population. A longer feeding period is necessary to more conclusively measure the effect of the corn-soy blend on serum zinc levels. Parents are therefore encouraged to introduce and consume more of corn-soy blended foods at home. It would also be valuable for schools with feeding programmes to introduce corn-soy blends or products as part of school meals. The government and other stakeholders can also use the findings of this study to encourage production of soya beans in Nyanza and Western provinces of Kenya. It is highly recommended that a similar study giving larger portions of the corn soy blend be conducted for a longer period and results compared to those of this study.

The corn-soy blend used in the study costs thirty six thousand and five hundred (36,500) Kenyan shillings per tonne (about 500 USD at time of study). We therefore calculated that a cup (100 gram) of the food would cost nine (9.0) Kenyan shillings. Since this cost could be too high for the households in the study area, practical training was provided on how to process this corn-soy mixture in different ways e.g. roasting, frying and grilling and how to mix (1 part legume to 3 parts cereals) with the possibility of adding dried fish or vegetables and/or fruits. Therefore an exit strategy that factored in sustainability of the intervention was put in place from the start.

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