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SOYBEAN (*Glycine max*) COMPLEMENTATION AND THE ZINC STATUS OF HIV AND AIDS AFFECTED CHILDREN IN SUBA DISTRICT, KENYA

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ABSTRACT

The HIV and AIDS pandemic continues to ravage families and communities throughout the world particularly Sub-Saharan Africa. The scourge is associated with malnutrition specifically underweight, stunting and wasting among school children most of whom are orphaned by HIV. Subsequently, inadequate food supply at the household level has led to micronutrient deficiencies especially zinc. The purpose of this study was to assess the nutritional status of children aged 6-9 years in HIV and AIDS affected households in Suba District and to determine the effect of soybean complementation on zinc status of the children. Suba District, Kenya is resource-poor with high levels of food insecurity and lack of diet diversification. Experimental study design was employed in this study. Multi-stage, stratified and simple random sampling strategies were used to identify a total of 158 HIV and AIDS affected children from rural communities of Suba District who formed the study sample. Of these, one-hundred and six (106) children from both Sindo and Lambwe primary schools were put on a feeding trial; they were fed on corn-soy blend daily for three months. Fifty-two (52) children selected from Ong'ayo Primary School formed the control group and were not put on the feeding trial. Structured questionnaires were used to gather demographic and socio-economic data from mothers or guardians of the children. Anthropometric measurements (weight and height) were used to assess the nutritional status of children at baseline. Biochemical tests were carried out to determine serum zinc levels of the children between baseline and three months. These tests were analyzed at Kenya Medical Research Institute (KEMRI) Laboratories in Nairobi. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 11.5 and the Nutri-Survey computer soft ware. A probability value of <0.05 was considered significant. Results showed that out of the 158 children, 48 (29.8%) were malnourished; 43.7% were stunted, 22.9% were underweight while 33.3% were wasted. Nearly all (95.7%) the children were deficient in zinc at baseline. There was a significant ($p<0.05$) reduction in zinc deficiency from 95.7% (mean 8.41µm/l) to 70.2% (mean 10.2 µm/l) between baseline and three months of the feeding trial. Children in HIV-affected households in Suba District showed signs of underweight, stunting and wasting. Soybean complementation improved zinc status of the children and should therefore be promoted in the entire community to alleviate malnutrition.

Key words: Underweight, stunting, wasting, zinc, soybean

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INTRODUCTION

The HIV and AIDS pandemic has become a serious health problem in Sub-Saharan Africa (SSA). Estimates indicate that over 40 million people are currently living with HIV and AIDS worldwide, more than 70% of whom are in SSA [1]. The Kenya AIDS Indicator Survey (KAIS) report [2] indicates that the HIV prevalence rate in Kenya rose from 5.9% in 2005 to 7.4% in 2007. Nyanza Province where Suba District is located bore the brunt of HIV and AIDS with the highest (15.3%) prevalence in the country; this is more than double the national prevalence. The scourge has brought about orphan-hood in communities; out of the 12 million orphaned children in SSA [1, 3], 1.1 million are found in Kenya alone [4]. Majority of households affected by HIV and AIDS are chronically food insecure leading to child malnutrition. In Tanzania and Zambia, orphans were reported to be more likely to be stunted and wasted compared to children with parents [5].

Further, studies have shown that there exists a relationship between protein-energy malnutrition (PEM) (inadequate intake of food) and micronutrient deficiencies especially of zinc. However, there are other causes of stunting and wasting such as growth hormone deficiency, hypothyroidism, chronic bacterial infections and calcium metabolic disorders. Although severe zinc deficiency is rare, mild-to-moderate zinc deficiency is quite common throughout the world [6]. 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 SSA regions [7]. These deficiencies are prevalent among children and people experiencing recurrent infections, and lacking access to a varied diet particularly proteins, fruits and vegetables [8]. 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. In 2002, about 1.4% of deaths world-wide were attributed to zinc deficiency [7].

Food complementation is one way of mitigating the impact of malnutrition among children in HIV/AIDS affected households. Research findings have shown that complementary feeding improves the nutritional status and micronutrient level of malnourished children [9]. The purpose of this research was to assess the nutritional status of children aged 6-9 years in HIV/AIDS affected households and assess the effect of food complementation on their zinc status. This paper presents results of a feeding trial in which children aged 6-9 years from HIV and AIDS affected households were provided with a nutrient-rich porridge made from corn-soybean blend to complement their diets daily for 3 months and their nutritional status monitored for 3 months. A control group which was not on the feeding trial was included for comparison purposes.

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MATERIALS AND METHODS

The experimental research design was used in this study, and specifically a two-group design [10] which allowed for an in depth investigation of the study sample (experimental group and a control group) over three months. Three primary schools (Ong'ayo, Lambwe and Sindo) formed the case studies and provided the children for the study. These three schools were appropriate because of the intensity of work the study demanded; they did not have a school feeding program and were in close proximity to each other hence proper supervision. A sampling frame of 565 children was constituted as follows: 125, 200 and 245 children from Ong'ayo, Lambwe and Sindo Primary Schools, respectively. Each of these schools formed a stratum from which 53 children were selected using the simple random sampling strategy [10, 11]. A total of 158 children were finally selected to form the study sample. Lambwe and Sindo were chosen as the experimental schools while Ong'ayo represented the control school.

A pre-test was done at baseline January, 2007 on all the children before the feeding trial begun. This involved taking both anthropometric measurements and serum zinc status. At three months May, 2007 a post-test was done and the feeding terminated. Children on the feeding trial received porridge made from corn-soybean blend daily for three months. Structured questionnaires were prepared and pre-tested using 5% of the children not involved in the study. Anthropometric measurements specifically height and weight were carried out by the researcher on each child using standard anthropometric equipment and procedures [12]. Body weight measurements were taken with minimum clothing using an electronic scale (Camry, Model BR9012, Germany). Height was taken while the child was standing straight using a portable stadiometer (Model 26SM 200cm, Germany). Each measurement was taken three times and the average considered adequate for analysis.

Ethical concerns, blood collection, separation and storage

This research was approved by the Institute of Research and Ethics Committee (IREC) Moi University, the Ministry of Education Science & Technology Nairobi, and the Medical Officer of Health and Suba District Hospital. The universal standards as recommended by WHO in drawing blood samples and the safety of both the technicians of drawing blood and the subjects were followed [7]. These include: (a) Clear explanations of the procedures to the parents in a parents/guardians-teachers and researchers' meeting held in the school compound before the samples were drawn. The procedure was also explained to the school children before blood was drawn from them. This was necessary as the sight of blood and a needle prick appeared to frighten some of them. Reassuring terms and empathy were also used on them: **(**b**)** Written and signed consent was obtained from parents/guardians of the children and the respondents' confidentiality was assured. Blood samples were not taken from the children who did not agree to have their blood samples taken: (c) Care was exercised around bio-hazardous materials. The children were not allowed to play with any of the equipment. Sterile latex gloves were used, only one needle was used

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per child, after pricking the skin, the needle was placed in a puncture-resistant container with a logo for bio-hazardous content which was not left on the table or the floor. The bio-hazardous materials were disposed off properly at the Suba District Hospital.

Five millilitres of blood was drawn from the subject's arm by a qualified laboratory technician from Suba District Hospital (SDH). It was then transferred into a glass centrifuge tube, labelled and immediately wrapped in foil to protect against degradation by light. The samples were then placed in a cool box with ice packs at 8-10 ^{0}C and transported immediately to SDH laboratory for centrifugation. Serum was then separated from plasma by centrifugation at 3,000 revolutions for 10 minutes at room temperature at SDH after which the separated serum samples were transferred into clear sterile cryovials and gently flushed with pure nitrogen gas. The samples were later stored in liquid nitrogen frozen at -70 degrees centigrade [13] awaiting transportation to the Kenya Medical Research Institute (KEMRI) laboratories in Nairobi for further analyses.

Serum zinc analyses

The atomic absorption spectrophotometer (AAS) (Shimadzu AA-680) [14] was used in serum zinc analyses. To determine the zinc values, zinc stock solutions were prepared. The blank solution was made by adding 10 mls of the sodium stock solution into the volumetric flask through a pipette to make up 100 mls. The sample was then prepared by adding 2.25 mls of de-ionised water into polythene test tubes. The serum sample was put into a vortex (a machine that spins ensuring a uniform mix of two liquids) for at least 1 minute. Using a micro pipette, 250 µl of the serum was pipetted into 2.25 mls of the de-ionised water and again put into a vortex for 1 minute. The blank was aspirated, analyzed 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 serum zinc level was considered to be <10.7 µm/l [8, 15].

DATA ANALYSIS

Descriptive data

Descriptive and biochemical data obtained were analyzed using the Statistical Package for Social Sciences (SPSS) version 11.5 [16] while the Nutri-Survey computer software program [17] was used to analyze anthropometric data. Chi-square goodness of fit and cross-tabulation tests were used to explore the descriptive data. Independent T-tests were used to establish whether any differences between means for both the experimental and control schools were significant or not before and after the feeding trial. A probability value of <0.05 level was considered significant.

The intervention: composition of the corn-soybean blend

Soy beans were chosen because of their high nutritional content of 40% protein, 20% oil, 35% carbohydrate, micronutrients and essential amino acids such as cysteine, tryptophan and glutamin which may help to reduce the level of PEM experienced by

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children. The corn-soybean blend was prepared and packed by Nutro-Food Company situated in the Export Processing Zone (EPZ) Athi River, Kenya. The composition was according to WFP recommendation ratio of carbohydrate to soybeans which is 3:1 thus 75g of maize was blended with 25g of soybeans. Each child on the feeding trial was served with 100g of corn-soybean blend prepared as porridge and served as a mid-morning snack in school everyday for three months between February and May, 2007. This feed yielded 363.8 kcal and 23.7 g of protein. At the end of the school week (Friday) each child was provided with 500g of CSB flour as a take-home ration. This would be prepared for the child and four other vulnerable children at home during the weekends to ensure continuity of the feeding trial.

In addition, all the children in the study were de-wormed, given vitamin A supplements and long lasting insecticide treated mosquito nets for control of malaria; malaria is an endemic disease in the region. This was guided by principles of Essential Package of Nutrition and Health [18] which includes; nutrition, education, hygiene, breastfeeding, food interventions, micronutrient supplementation, household water treatment and parasite control in particular de-worming. In addition, nutrition education was taught to the parents/guardians of these children at the beginning of the research project and at the end. This included information on balanced diet, hygiene, importance of immunization and seeking medical attention when sick, family planning methods and household water treatment. Community members including parents/guardians of the school children were trained on soybean processing and utilization and sustainable agriculture for the continuity of the program and to enhance food security in the area.

RESULTS

Socio-economic characteristics of the respondents

Data were obtained from 158 parents or guardians of children affected by HIV and AIDS at baseline. The mean household size was (4.7 ± 1.28). Results also indicate that 67.4% of the mothers had attained-primary school education with 18.9% and 1.2% having attained secondary and college education, respectively. None of the mothers had university education. The mean household income was Ksh 2,000 ($31.25) per month. This translates to a daily income of about Ksh 66 ($1.03) (Table 1).

Profiles of the children

One hundred and fifty eight (158) HIV and AIDS affected school children aged 6-9 years formed the study sample. The average age of the children was (7.2 ± 0.086), median 7.0 and mode 6. The male children constituted 43.5% while females were 56.5%. Three quarters (77.7%) had their mothers alive and living with them while over half of the pupils (60%) had their fathers alive and living with them. About 12.6% of them had lost their mothers. Further, 25% had lost their fathers while 2 pupils (1.3%) did not know their fathers' whereabouts.

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Nutritional Status of the children at baseline

Table 2 shows that the total number of malnourished children was 48 (29.9%); of whom 22.9% of the children were underweight, 43.7% stunted and 33.3%. wasted. The number of children who were stunted was significantly higher ($\chi^2 = 7.364$; df = 2; p=0.001) than those who were underweight and wasted. These results show that stunting was most prevalent among the study children, followed by wasting and underweight. Further, Table 2 indicates the number of children with moderate (<-2SD) and severe (<-3SD) malnutrition.

Serum zinc deficiency

At baseline (January, 2007), nearly all the children in all schools (95.4%) had low serum zinc of less than 10.7µm/l. There was a significant improvement (p<0.05) after the intervention in all the schools with the percentage of those with low serum zinc reducing from 95.4% at baseline to 70.2% after the intervention. This change may be attributed to the intervention. Ong'ayo school which was not on the feeding program also improved the levels of serum zinc (Table 3).

Table 4 shows that the difference between the three schools at baseline was not significant (p>0.05) with a difference of less than two percent points. Mean serum zinc was also not significantly different (p>0.05) at baseline for all schools. Sindo Primary School reported the highest mean serum zinc 10.3 µm/l, which was close to the normal levels of 10.7µm/l. From these means therefore, the situation in Sindo Primary School was mild. The overall mean improved from 8.41µm/l to10.2 µm/l among all the children studied. Positive improvements were also noted in the median. This improvement at three months is attributed to the intervention. Ong'ayo Primary School which was the control school improved from 10.3 µm/l-10.94 µm/l. While this was not expected for the control school, it is likely that the vitamin A supplement given (200 micrograms) at baseline to all the children improved absorption of dietary zinc resulting in improvement in zinc status.

DISCUSSION

Malnutrition among the children

Malnutrition among the children in this study was higher than the Nyanza Province prevalence rates which show stunting at 31.1%, wasting 2.3% and 15.8% underweight [19]. The results compare closely to findings from Tanzania where the death of a mother was associated with an average decline of 1 standard deviation in children's height hence HIV- affected children were more likely to be stunted [20]. Further, it was found that the 650,000 children orphaned by HIV in Zambia, were more likely to be stunted than non-orphans [21]. In Zimbabwe, a similar trend was reported where stunting was (22% versus 17%), underweight (34% versus 26%) among orphans than non-orphans [21]. In Indonesia, maternal orphans had a 15% probability of being wasted [21]. Kikafunda and Namusoke [22] found high prevalence of underweight among HIV and AIDS orphans from Rakai District in Uganda. These results show

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that stunting, underweight and wasting are a common problem among children orphaned by HIV and AIDS.

According to the Recommended Dietary Allowances (RDAs) [23] the daily intake for children aged 6-9 years is 1,800 kcals and 34 g protein. The food frequency questionnaire and the 24-hr recall data, however, showed that children took an average of 740 kcals and 16 g of protein daily [23]. These amounts are less than half of the RDA and, therefore, not adequate for the growth of children. This confirms that inadequate food intake is one of the likely causes of malnutrition as reported elsewhere [24].

Foods commonly consumed by households were porridge, *ugali* made from millet, maize, sorghum and cassava. Fish was the most commonly consumed protein. There was low consumption of beef, fruits, vegetables and soybeans which are rich sources of zinc. Instead, there was a high consumption of cereals which are high in phytates that can negatively influence absorption of zinc. Further, earlier reports indicate that Suba District like other neighbouring districts experiences food insecurity, low economic status, poor dietary practices, among other challenges such as the HIV and AIDS scourge; this could probably explain the low zinc status. This, coupled with low household income which is not enough to meet the daily food budget and other household expenditures such as medical needs, frequency of infections and other illnesses could have been responsible for the levels of malnutrition seen among children in this study [24].

Serum zinc status

Serum zinc is the standard measurement of zinc status in the human body. In this study although majority of the children had low serum zinc levels at baseline which improved after the feeding trial, this improvement could have been higher. The children were receiving the feed (porridge) once a day while most of the other meals of the day were taken at home. This portion (1 cup) may not yield significant results within a short time. 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) could affect serum zinc levels. Serum zinc levels resulting from zinc supplementation have shown significant positive correlations with macronutrient deficiency. Studies done on children for a period of 3 months from different subgroups to compare zinc status and stunting levels showed a positive linear growth line in children with higher levels of serum zinc reporting z scores of less than -2SD [25]. From the literature, the role of zinc in protein metabolism and linear growth has been widely documented, hence deficiency is associated with 'zinc growth failure' [26]. Further, O' Dell [27] showed that zinc is useful in protein synthesis and cell development and deficiency of zinc disrupts normal cell development and is associated with growth failure [26, 27]. This literature could explain the high levels of malnutrition and particularly stunting which have been seen in this study.

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Literature shows that anti-nutrients such as phytates found in cereals and legumes affect zinc absorption [25]. This indicates that households in resource-poor settings, whose staples are mainly cereals and legumes could experience zinc deficiency. Suba District is resource-poor with a poverty index of 64% [28]. It is likely that poor households may lack the resources to diversify diets. Results from this study showed that mothers prepared porridge and *ugali* from mixed flours which contain phytates, while according to the food frequencies beef and other organ meats were rarely eaten [24]. These two reasons could have been responsible for the zinc deficiency seen in this study at baseline. This is because high levels of dietary zinc are concentrated in seeds, vegetables, fruits and animal products.

Education levels and specifically maternal education can also influence zinc levels. Studies have shown that households with educated mothers had children with better zinc status than households with low levels of education [25]. In the present study, none of the mothers had attained university education, a factor that could compromise zinc status. Nutrition education given to the parents during this study could have played a role in improving zinc status particularly in the control school. Morbidity patterns have also been documented to negatively influence zinc status [29]. Diseases like malaria and other infections as reported elsewhere have also been known to compromise zinc status in humans [24].

In a cohort study of Indian children, a low baseline plasma zinc level predicted a higher incidence of diarrhoea [8]. The national micronutrient survey report confirmed that low serum zinc levels were associated with diarrhoea, hookworm infection, anaemia and general malnutrition [29]. Zinc supplementation has been shown to reduce either incidence or severity of infections such as diarrhoea, pneumonia and malaria among children [8, 30]. Further, zinc supplements have also proved useful in the growth of children [25] this is due to its effects on appetite [26] and risk of infection [31].

CONCLUSION

Based on the results of this study, malnutrition determined by weight-for-age, weight-for-height and height-for-age was common among children in HIV-affected households in Suba District and stunting is more prevalent than underweight and wasting. Nearly all the children suffered zinc deficiency. The underlying factors may include deepening food insecurity, frequent infections, low maternal education attainment and poverty. Corn-soybean complementation caused a significant improvement in zinc status of the study children in the experimental schools and nutrition education in the absence of a feeding program can improve zinc status of malnourished children.

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RECOMMENDATIONS

The agricultural sector through agricultural officers should promote agricultural activities such as production of alternative sources of protein; soybean and other legumes to provide an abundant supply of protein-rich foods for the families and in particular children should be encouraged. Communities in such resource-poor setting may not afford diverse diets. In order to eradicate zinc deficiencies, UNICEF, the Ministry of Public Health and Sanitation and the government should formulate policies towards increasing the density of zinc in foods commonly consumed, supplementation, food fortification and dietary diversification. The Ministry of Public Health and Sanitation through the district health officers should strengthen efforts towards strengthening nutrition education both in schools and in the community.

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Table 1: Summary of the socio-economic characteristics of the respondents

Socio-economic characteristic	Results
Mean HH size	4.7±1.28
Male respondents	29.4%
Female respondents	70.6%
Mean age of respondents	33.5±0.49
Mean total HH income (pm)	Ksh 2,000 ($31.25)
Total number of respondents	**158**

HH-household pm-per month

Table 2: Percentage of underweight, stunting and wasting among the study children at baseline (n=48)

Weight-for-age n (%) (Underweight)		**Weight-for-height n (%) (Wasting)**		**Height-for-age n (%) (Stunting)**	
< -2 SD	< - 3 SD	< -2 SD	< - 3 SD	< -2 SD	< - 3 SD
10	1	15	1	18	3
11 (22.9%)		**16 (33.3%)**		**21 (43.7%)**	

< - 2 SD moderate deficiency**; < - 3 SD** severe deficiency

Table 3: Prevalence of Zinc deficiency among the school children in the three study schools before and after feeding trial

School	*Reference Data (Cut-off Points)		Prevalence (%)		Chi-square test P<0.05
	Serum Zinc µm/l	definition of Deficiency[1,2]	Before %	After %	
Lambwe(Exp.sch n=53(before) n= 49 (after)	<10.7 >10.7	Low None	96.3 3.7	73.6 26.4	0.0491 0.0121
Ong'ayo(Contr) n=52 (before) n= 49 (after)	<10.7 >10.7	Low None	94.3 5.7	61.4 38.6	0.0432 0.0111
Sindo (Exp.sch) n=53 (before) n=49 (after	<10.7 >10.7	Low None	95.7 4.3	75.7 24.3	0.0499 0.0251
Total n=158(before) n=147 (after)	<10.7 >10.7	Low None	**95.4** **4.6**	**70.2** **29.8**	0.0421 0.0193
*Definition of Deficiency[1,2] = MoH, Kenya, 2003 and IZiNCG, 2004					

Exp. sch: Experimental school

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Table 4: Mean and median distribution of serum Zinc among the study schools

School	*Reference Data (Cut-off Points)	Mean 95%CI		**T-test	Median	
	Normal Serum Zinc µm/l	Before	After		Before	After
Lambwe (Exp.school) n=54(before) n= 43 (after)	Above 10.7	7.25±0.7 **2.49 points difference**	9.743±1.2	Not sig.	7.46	9.18
Ong'ayo (Control school) n=53 (before) n= 44 (after)	Above 10.7	10.3±1.1 **0.6 points difference**	10.94±1.3	Not sig.	7.80	10.15
Sindo (Exp.school) n=47 (before) n=37 (after	Above 10.7	7.67±1.5 **2.29 points difference**	9.95±0.9	Not sig.	7.94	9.33
Total n=154(befor) n=134(after)	Above 10.7	8.41±0.9 **1.19 points difference**	10.2±1.1	Not sig.	7.73	9.56

*Definition of Deficiency[1,2] = MoH, Kenya, 2003 and IZiNCG, 2004
**Paired Sample T-test –significance at $P<0.05$

Exp. sch: Experimental school

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