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The assessment and prediction of malnutrition in children suffering from cancer in Ghana

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ABSTRACT

Childhood cancers such as Burkitt's lymphoma (BL) and Wilms Tumour (WT) are common in Africa. In Ghana, the nutritional status of children with cancers is largely unknown although for most cancers, each step of the continuum from diagnosis to recovery, including chemotherapy, poses nutritional challenges. The study compared thenutritional status of sixty-four children: 32 with BL or WT at a major teaching hospital and 32 age- and sex-matched non-cancer controls in a nearby community, anddetermined the best predictor of malnutrition using 3-day repeated 24-hour dietary recalls, anthropometrics, physical and clinical signs of malnutrition, and biochemical indicators. With the exception of height, the cancer children had significantly lower weight (18.7 versus 27.4 kg), Mid Upper Arm Circumference (MUAC) (14.1 versus 17.8 cm), Triceps skinfold (TSF)(4.9 versus 6.1 cm), Muscle Arm Circumference (MAC) (12.4 versus 1.8 cm) and Body Mass Index (BMI) (14.6 versus 18.4 kg/m^2), and higher levelsof malnutrition by all indicators: wasting=31%, underweight=34% and stunting=51%) compared to the non-cancer controls (wasting=8%, underweight=7% and stunting=43%).Among the cancer children 40% showed physical signs of wasting, 15% oedematous and 40% low haemoglobin (Hb). Food and nutrients intake were similar between the two groups.The cancer group had significantly lower levelsof glutathione ($p=0.003$) and prealbumin ($p< 0.0001$) than their non-cancer counterparts. The best biochemical and anthropometric predictors for malnutrition were Hb and MAC respectively. The findings suggest a high prevalence of malnutrition among childhood cancer sufferers and that the traditional nutritional indicators are able toaccurately predict malnutrition among cancer children in resource limited settings.

Keywords: Burkitt's lymphoma, Wilm's tumour, Anthropometry, Body mass index, Prealbumin.

INTRODUCTION

Nutrition, infection and the functions of the immune system are interrelated(1). Malnutrition can predispose an individual to infection and diseases, and make recovery from disease slower. Likewise, good nutrition enhances immunity and the ability to fight infections and diseases(2, 3). Infections and diseases can lead to malnutrition and nutritional deficiencies by increasing nutrients requirements, utilization, nutrients losses and metabolism as the body tries to generate immune responses against the invading pathogens(1). Diseases, including cancers,therefore have the potential to cause malnutrition and nutrient deficiencies,and vice versa (4).

Cancer is a group of diseases characterized by uncontrolled growth and spread of abnormal cells (5).Though cancer in childhood is quite rare compared with adults, it still causes more deaths than any factor, other than injuries, among children from infancy to age 15 years (NCI, 2009).A 40-month (January, 2008 to December, 2011) reviewof the cancer registry at the Korle Bu Teaching Hospital, Ghana (KBTH)revealed that malignancies accounted for 1.67% of all admissions, with lymphomas. (mainly Burkitt's lymphomas (BL)) being the commonest tumour (67%),

followed by retinoblastoma (8.6%), leukaemia (8.2%) and Wilm's tumour (WT) (7.8%)(6).Treatments for both Burkitt's and Wilms include chemotherapy, radiotherapy, surgery, immunotherapy, bone marrow transplant and others depending on the type and stage of the cancer(7). However, up to 46% of children and young adults with cancer experience malnutrition resulting from the tumour and/or the treatment regimen(8). Thus, nutritional decline is often part of the cancer course and its treatment (9, 10).Pediatric patients undergoing treatment for cancers, have been shown to experience nutritional depletion and weight loss (8)and these have consequences on tolerance to chemotherapy, immune status and survival (11). In this study, we accessed and compared the nutritional status of BL and WT cancer children who received chemotherapy at the Komfo Anokye Teaching Hospital (KATH), Ghana with that of their age and sex-matched healthy cohort to define a local nutritional baseline and propose some malnutrition indices for the cancer childrens.

MATERIALS AND METHODS

Subjects and ethical considerations

The study was conducted at the Pediatric Oncology Unit (POU) of the Komfo Anokye Teaching Hospital (KATH), Kumasi, Ghana and Bonwire,a town located 20 km north east of Kumasi, Ghana. A total of sixty-four children (26 with BL, 6 with WT and 32 healthy children)were recruited for the study. The 32 healthy children were from Bonwire. Ethical approval for the study was obtained from the Committee on Human Research, Publications and Ethics of KNUST and KATH (CHRPE/ KNUST/ KATH/ 17/11). The eligible cancer participants were children who were clinically/ histologically diagnosed with BL or WT by a physicianand were without any other complications. These children were just about to commence chemotherapy at the time of recruitment and they were not to be on any nutritional supplement as well. The healthy recruits were likewise not to be on any nutritional supplement. Once recruited, thesocio-demographic data of the children and their carers were obtained.

Anthropometric assessment

The weight, height, mid upper arm circumference (MUAC) and tricep skin fold (TSF) of the children were measured. Weight was measured to the nearest 10 g using a Seca electronic scale (Seca Ltd, Birmingham, UK) with either no or light cloth on. Height was recorded to the nearest 1 mm using a wooden stadiometer without shoe. MUAC was measured using a flexible non-stretched tape to the nearest 1 mm. Tricep skin fold was measured according to the method of (12) to the nearest 0.1 mm. BMI was calculated as weight (kg)/ height (m^2). Muscle arm circumference (MAC) was calculated using the formula MAC= MUAC 0.1 (3.14 × TSF) according to (13). Using the anthropometric measures, children were classified as underweight (weight-for-age-3 standard deviation), stunted (height-for-age <-3SD) or wasted (weight-for-height <-3SD) using the WHO international growth standards as reference.

Haematological and biochemical markers assessment

Haemoglobin level, prealbumin, zinc and reduced glutathione levels were measured from venous blood samples obtained from both the cancer and healthy children. Haemoglobin assay was done using the Drabkin's solution method (sodium bicarbonate, potassium cyanide and potassium ferri-cyanide) and absorbance measured using Spectrophotometer Humalyzer Junior (United Kingdom) at 546 nm. A commercial ELISA kit was used for prealbumin assay according to manufacturer's instruction. The serum zinc measurement was performed by measuring the optical density of the complex formed between zinc and 2-(5-bromo-2-pyridylazo)-5-(N-propyl-N-sulfopropylamino)(5-BR-PAPS) at 560 nm using the Spectra Max 190 micro plate reader (USA). The improved 5, 5'-dithiobis -2-nitrobenzoic acid(DNTB) method was employed in measuring the concentration of reduced glutathione (GSH) in serum and optical density measured at 412 nm.

Clinical malnutrition assessment

Clinical signs of malnutritionincluding visible wasting, bilateral pitting oedema, dermatitis and anaemia were assessed through observation and examination by a nutritionist.

Dietary Assessment

Dietary intake was assessed by a repeated 24-hour dietary recall. This was done by recording food intake of subjects for 2 weekdays and a weekend as recommended by(14). The amount of food intake was estimated using household measures. Using the weights/handy measures of the Dietetic group of the Dreyfus Health Foundation of Ghana, the respective masses of food taken by subjects were recorded after identifying with a measure. Composite foods such as stew, soups and drinks whose weights/handy measures not found in the handy measure tables were weighed using an electronic balance (Camry, China, Max weight 20 kg). The masses of the food intakes were analysed into their nutrient components using nutrient calculators obtained from nutrient intake tables. The averages nutrients intake for the 3-day recall were then calculated.

Statistical Analyses

Comparisons of the general characteristics of the cancer group against the non-cancer group were performed using unpairedt tests, chi (χ 2) tests, or Fisher exact tests where appropriate for categorical data.GraphPad Prism version 5.00 for windows was used for these statistical analyses (GraphPad software, San Diego California USA, www.graphpad.com). The relationship between anthropometric and biochemical measures were investigated using age and gender-adjusted Pearson correlations.This analysis was performed using SPSS for windows version 20 (International Business Machine, 2011). The discriminative abilities of anthropometric and biochemical markers for identifying malnutritional cases were computed by means of ROC area under curve analysis. Sensitivity and specificity of sex-specific cut-off points for the various anthropometric and biochemical markers were also determined. This analysis was done using Medcalc version 12.1.4.0, www.medcalc.org. A p-value < 0.05 was used to ascertain statistical significance.

RESULTS AND DISCUSSION

In this study population, the prevalence of BL was higher than WT (Table not shown) which was in conformity with the (15), which showed BL to constitute about 50% of childhood cancers in Ghana. The mean age of children with cancer in our study was also similar to other studies conducted in Ghana and Africa between 2000 and 2007 (16, 17). The mean age of the children with WT corroborated with that of another study which reported that 78% of children with Wilm's tumour were diagnosed at 1-5 years of age with peak incidence occurring between age 3 and 4 (18). Of the 32 children with cancer, 10 had jaw Burkitt's, 16 had abdominal Burkitt's and 6 had Wilms tumour. The mean age (7.82±0.63)of the healthy children (control group) was slightly higher than that of the cancer group (6.34±0.57)but not statistically significant. (Table 1).Compared to the control groups, the averages of all the anthropometric markers such as weight and MUAC weresignificantlylower (p<0.0001) in the cancer group.

Table I Comparison of mean anthropometric and biochemical/haematological measurement between non-cancer (Control) and cancer children (Cancer)

Parameter	Total (n=64)	Control (n=32)	Cancer (n=32)	p-value
Age (years)	7.03±0.43	7.82±0.63	6.34±0.57	0.085
Height (cm)	114.90±2.51	118.40±3.81	111.80±3.30	0.12
Weight (kg)	22.73±1.40	27.36±2.40	18.68±1.19	0.001
BMI (kg/m^2)	16.51±0.56	18.36±0.66	14.55±1.05	0.001
TSF (cm)	5.49±0.29	6.12±0.47	4.93±0.31	0.037
MUAC (cm)	15.80±0.40	17.80±0.54	14.05±0.36	<0.0001
MAC (cm)	14.00±0.35	15.79±0.43	12.44±0.36	<0.0001
Hb (g/dl)	10.28±0.39	13.20±0.27	7.74±0.18	<0.0001
Zinc (Mm)	0.0059±0.0027	0.0059±0.004	0.0060±0.00058	0.8793
Glutathione (µM)	63.91±9.11	62.37±1.23	13.80±1.28	0.0003
PreAlbumin (ng/ml)	472.40±17.12	590.30±14.96	369.10±11.76	<0.0001

Data presented as mean ±standard error of mean (SEM). Comparison was done using unpaired t-test.

The mean levels for haemoglobin(10.3 in cases versus 13.2 g/dl in controls, p<0.0001), reduced glutathione (63.91 in cases versus 62.37µM controls, p=0.0003) and prealbumin (472.40 in cases versus 590.30 in controls, p<0.0001)were all significantly lower in the cancer children compared to the healthy children.When stratified by gender, anthropometric and biochemical markers of nutritional status were not different between males and femalesin the cancer or the control group.(Data not shown)

Although nutrients intake of children affected by cancer did not significantly differ from their non-cancer counterparts, the cancer children consistently recorded lower measures of both anthropometric and biochemical/haematological markers of nutritional status assessment (Table 1 and 2). These suggested a high prevalence of undernutrition in the cancer group. Similar nutrients intake between the two groups suggests that the malnutrition observed in the cancer children was likely due to the effect of the cancer by perhaps increasing nutrients requirements and utilization, nutrients loss and altered metabolism rather than inadequate nutrients intake (1, 19). MUAC and TSF are indicators for the amount of fat and muscle in the upper arm and thickness of subcutaneous fat respectively and are used in determining malnutrition levels in children (20). The significant differences in MUAC and TSF (Table I) also indicated that children with cancer had low body fat and muscle and subcutaneous fat, and therefore were malnourished.

Using the WHO growth standards, <-3 standard deviation (SD) for severe malnutrition, -3SD to -2SD for moderate malnutrition and above -2SD for normal, percentage wasting was (31% cancer vrs 8% control), underweight was (34% cancer vrs 7% control) and stunting (51% cancer vrs 43% control) as shown in Table 2. About 22% of the cancer children, compared to 3% of control, were either severely or moderately and acutely malnourished using the WHO MUAC cut-off <115. MAC and TSF, divided and defined by thirds (lower, middle or upper thirds) showed

that for the cancer group, majority of the children (88% and 72%) were found in combined middle and lower third for MAC and TSF respectively as compared to 81% and 40% of the control children (Table 2). Using Hb cut off point of 11 g/dl, all the cancer children were anaemic compared with 3% of the non-cancer children. Also 22% of the cancer children had lower GSH levels compared to the control.

Table II Prevalence of malnutrition between cancer and healthy children (control) using anthropometric and biochemical markers Data represented proportions with the corresponding percentage in parenthesis. The proportions were compared using X^2 and fisher exact test, where appropriate. BMI: Body Mass Index, MUAC: Mid upper arm circumference, MAC: Muscle arm circumference, TSF: Tricep skin fold, Hb: Haemoglobin

Parameter	Total (64)	Control (32)	Cancer (32)	p-Value
BMI for Age				
Severely malnourished	7(10)	0(0)	7(21.9)	0.0001
Moderately malnourished	10(15)	1(3.7)	9(28.1)	
Normal	47 (75)	31 (96)	16 (50)	
Height for Age				
Severely malnourished	7(10)	3(11.1)	4(12.5)	0.8838
Moderately malnourished	23 (36)	12(44.4)	11(34.4)	
Normal	32 (50)	15(46.9)	17(53.1)	
Weight for Height				
Severely malnourished	1(4)	0(0)	1(8)	0.2969
Moderately malnourished	4 (15)	1(8)	3(23)	
Normal	21 (81)	12 (92)	9 (69)	
Weight for Age				
Severely malnourished	5(8)	0(0)	5(15.6)	0.0306
Moderately malnourished	8 (12)	2(7.4)	6(18.8)	
Normal	46(72)	25(92.6)	21(65.6)	
MUAC				
Severely malnourished	3 (5)	0 (0)	3 (9)	0.0658
Moderately malnourished	5 (8)	1 (3)	4 (13)	
Normal	56 (88)	31 (97)	25 (78)	
MAC				
Lower third	22 (34)	15 (47)	7 (22)	0.0401
Middle third	32 (50)	11 (34)	21 (66)	
Upper third	10 (16)	6 (19)	4 (13)	
TSF				
Lower third	10 (16)	2 (6)	8 (25)	0.0204
Middle third	26 (41)	11 (34)	15 (47)	
Upper third	28 (44)	19 (59)	9 (28)	
Hb				
Anaemia	33 (52)	1 (3)	32 (100)	<0.0001
Normal	31 (48)	31 (97)	0 (0)	
Zinc				
Normal	9 (14)	5 (16)	4 (12)	1
Deficiency	55 (86)	27 (84)	28 (88)	
Glutathione				
Normal	55 (86)	30 (94)	25 (78)	0.1477
Deficiency	9 (14)	2 (6)	7(22)	
PreAlbumin				
Normal	64 (100)	32 (100)	32 (100)	1
Deficiency	0 (0)	0 (0)	0 (0)	

Prealbumin, a hepatic protein with shorter half-life of 2-4 days compared to albumin with 20 days half-life, is a sensitive clinical marker for malnutrition and has been shown to correlate with patients' outcome in several clinical conditions (21). However, using a cut-off of 170 ng/ml, (22, 23) all the 64 children recruited for the study were found to be in the normal range (Table III). Glutathione provides the reducing capacity for several reactions and aids in detoxification of hydrogen peroxide and other chemicals found in the body (24).Total glutathione is essential in evaluating the redox and detoxification capacity of the free radical or damaged tissues resulting from the cancer or the chemotherapy drugs (25) and low levels observed in the cancer group indicates higher propensity for free radical damage and its consequences. The mean level of reduced glutathione (GSH) in the cancer group was lower (13.8±1.28) than the healthy children (62.3±1.23). Using the cut-off of 4.5 µM as suggested by (26) about 22% of the cancer children, compared with 6% of the non-cancer children were GSH deficient. This was an indication of low antioxidant activity predominantly in the cancer patients and therefore there could be higher propensity for free radical damage and its consequence, especially in the course of chemotherapy.

Also the fact that the cancer children were more anaemic may suggest deficiencies in essential micronutrients such as Iron, Vitamin B_{12} and folate and other minerals associated with blood cell formation, although this was not assessed. The effect of the cancer itself may have contributed to this observation.

Pearson correlation for different anthropometric and biochemical/haematology measures controlling for age and gender, for the cancer and control groups are given in Table III. Serum zinc levels significantly (<0.005) correlated negatively with BMI (-0.378) and weight (-0.457) for the cancer group but not in the control. Reduced glutathione also had a significant positive correlation (0.559, p<0.001) with zinc in the control but not the cancer group. Prealbumin also correlated negatively (-0.447, p<0.05) with glutathione in the non-cancer group.

Table III. Age and gender adjusted Pearson correlation co-efficient between anthropometric and biochemicalindices for healthy (Upper right hand side) and cancer children (Lower left hand sided)

PMT	Height	Weight	BMI	TSF	MUAC	MAC	Hb	Zinc	Glut	PreAlb
Height		0.315	-0.214	-0.159	0.318	0.387	0.12	-0.165	-0.122	0.05
Weight	-0.235		0.795**	0.452*	0.784**	0.611**	-0.275	0.08	-0.043	-0.042
BMI	-0.736**	0.796**		0.455*	0.571**	0.427*	-0.28	0.36	0.186	-0.169
TSF	-0.214	0.298	0.33		0.273	-0.08	-0.121	0.089	-0.292	0.247
MUAC	-0.181	0.661**	0.565**	.572**		0.937**	-0.334	228	0.115	-0.19
MAC	-0.149	.667**	0.550**	0.385*	0.977**		-0.302	0.204	0.225	-0.286
Hb	0.24	0.243	-0.035	-0.011	-0.049	-0.052		-0.366	-0.181	0.34
Zinc	0.105	-0.457*	-0.378*	-0.84	-0.372*	-0.397*	-0.004		0.559**	-0.306
Glut	-0.345	0.004	0.153	0.175	0.082	0.047	-0.237	0.307		-0.447*
PreAlb	-0.129	-0.169	-0.043	-0.162	0	0.042	-0.163	-0.166	0.052	

***.Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). PMT: Parameter, BMI: Body Mass Index, TSF; Tricep skin fold, MUAC: Mid upper arm circumference, MAC: Muscle arm circumference, Hb: Blood haemoglobin, GLUT-Reduced glutathione, PreAlb: Prealbumin.*

Among the cancer group, 21.9% had poor appetite compared with 9.4% of the healthy children; 43.8% cancer patients showed visible severe muscle wasting (Table IV), Almost 16% cancer patients had bilateral pitting oedema with none of the control showing the disorder. Also 43.8% cancer compared with no controls had paleness of the sclera of the eye and more cancer (25%) children compared with controls (12.5%) had diarrhoea one month prior to the study (Table IV). These indicators all suggest poor nutrition and morbidity in the cancer group.

Table IV Proportion of participants showing clinical signs of malnutrition between Cancer and Non-cancer children

Parameter	Total (64)	Cancer Group (32)	Control Group (32)	p-value
Clinical Signs of Malnutrition				
Sickness for past month apart from cancer	24 (37.5)	16 (50.0)	8 (25.0)	0.0422
Diarrhoea	12 (18.8)	8 (25.0)	4 (12.5)	0.2203
Appetite	54 (51.9)	25 (78.1)	29 (90.6)	0.5639
Wasting	14 (21.9)	14 (43.8)	0 (0.0)	< 0.0001
Oedema	5 (7.8)	5 (15.6)	0 (0.0)	0.0079
Anaemia	14 (21.9)	14 (43.8)	2 (6.2)	< 0.0001
Flaky paints dermatitis	4 (6.2)	4 (12.5)	0 (0.0)	0.0286

The average nutrients intake between the two groups from the 24-hour dietary recalls (Table V) showed that although intake of several nutrients were lower among the cancer children, none was significantly different from that of their healthy cohorts.

Table V Mean dietary intake of macro and some micronutrients by cancer and non-cancer children

FOOD NUTRIENT	CANCER	CONTROL	p-Value
Calorie (Kcal)	1340.0±70.53	1436.0±255.30	0.7359
Protein (g/d)	40.8±4.28	33.9±4.59	0.3333
Fats (g/d)	38.2±6.12	49.5±14.41	0.5091
Carbohydrate (g/d)	209.8±1.66	219.6±28.06	0.7858
Calcium (mg/d)	209.5±20.84	202.9±9.31	0.7858
Iron (mg/d)	7.2±0.52	7.5±1.30	0.858
Vit A (mcg/d)	82.7±18.98	127.1±35.67	0.3332
Thiamine (mg/d)	0.6±0.03	0.6±0.13	1.0000
Riboflavin (mg/d)	0.47±0.07	0.5±0.11	0.7953
Niacin (mg/d)	9.3±1.63	9.4±2.18	0.9908
Pantothenic acid (mg/d)	3.2±0.20	2.8±0.50	0.4989
Vit B 12 (mcg/d)	1.4±0.27	0.8±0.03	0.1182
Vit C (mg/d)	76.9±36.40	105.6±48.30	0.6599
Vit E (mg/d)	4.0±0.83	3.8±0.00	1.0000
Vit K (mcg/d)	15.2±4.83	26.6±6.27	0.2254

Data presented are the outcome of mean nutrient intake from 24- hr dietary recall The mean nutrients± SEM were recorded and then an unpaired t-test analysis done to compute the difference in nutrients intake between cancer and non-cancer (control) children. Vit: Vitamin

In females with cancer, MAC (ROC-AUC: 0.892, p< 0.0001) was the best anthropometric measure for discriminating malnutrition followed by MUAC (ROC-AUC: 0.856, p< 0.0001) and BMI (ROC-AUC: 0.785,

p=0.0013) (Table VI). For males however, MUAC was the best anthropometric measure for discriminating malnutrition (ROC-AUC: 0.887, p< 0.0001) followed by MAC (ROC-AUC: 0.874, p< 0.0001) and BMI (ROC-AUC: 0.854, p< 0.0001). The best biochemical measure for discriminating malnutrition for both males and females was Hb (ROC-AUC: 1, p<0.00001) followed by Prealbumin (ROC-AUC=0.990, p<0.0001 for female and ROC-AUC= 0.980, p< 0.0010 for male).

Specificity and sensitivity of 100% were identified in both male and female for Hb with optimum cut-off point of 9.4 g/dl and 9.1 g/dl, respectively. Using BMI, the optimal cut-off point for malnutrition of ≤ 15.9 kg/m^2 (92.31% sensitivity and 78.95% selectivity) was identified for females and BMI ≤15.8 kg/m^2 for males (78.95% Sensitivity and 84.62% selectivity). Similarly, optimal cut-offs as TSF ≤ 4.00 cm, MUAC ≤ 16.8 cm and MAC ≤ 14.7 cm were identified for females for the various anthropometric markers in determining malnutrition in children with cancer. That of males were TSF ≤ 6.1 cm and MUAC ≤ 14.7 cm. The predicted prealbumin cut-off points for malnutrition identification were ≤ 451.5 ng/ml for females and ≤ 475.7 ng/ml for males with sensitivity of 100% and 94.7% respectively.

Most of the cut-off used for the various anthropometric and biochemical indices were inferred from studies done elsewhere and even in some cases these cut-offs were generated from healthy adults and children or children other than those with cancer (22, 23) . This suggests the need for specific cut-offs for determining malnutrition in children with cancer. The ROC-AUC curve was used to estimate possible cut-offs for various indicators. Overall, comparison of the ROC-AUC of various parameters identified Hb as the best biochemical markers in predicting malnutrition in both males and female children with cancer (Table VI). MAC was the best anthropometric predictor of malnutrition in females whereas MUAC was the best predictor in males. The estimated cut-offs that were generated were found to be different from current literature MUAC= 11.5 cm by WHO versus 16.85 for females and, 14.70 for males and Hb= 11g/dl by WHO versus 9.1 g/dl for female and 9.4 g/dl for males. These suggest the need for specific local cut-offs for various markers of malnutrition for specific diseases.

Table VI. Sensitivity and specificity of anthropometry and biochemical markers as malnutrition identifiers in cancer cases using sex specific ROC-AUC cut-off points

	FEMALE					MALE				
Parameter	**ROC value**	**p-Value**	**Optimal cut-off**	**Sensitivity (CI)**	**Specificity (CI)**	**ROC value**	**p-Value**	**Optimal cut-off**	**Sensitivity (CI)**	**Specificity (CI)**
BMI	0.785	0.0013	≤ 15.89	92.31 (64-99.8)	66.67 (38-88.2)	0.854	<0.0001	≤ 15.77	78.95 (54-93.9)	84.62 (55-98.1)
TSF	0.615	0.2972	≤ 4.00	46.15 (19-74.9)	80 (52-95.7)	0.644	0.1600	≤ 6.10	73.68 (49-90.9)	53.85 (25-80.8)
MUAC	0.856	<0.0001	≤ 16.85	100 (75-100)	66.67 (38-88.2)	0.887	<0.0001	≤14.70	68.42 (43-87.4)	100 (75-100)
MAC	0.892	<0.0001	≤ 14.71	100 (75-100)	73.33 (45-92.2)	0.874	<0.0001	≤13.54	73.68 (49-90.9)	92.31 (64-99.8)
Hb	1.000	0.000	≤ 9.10	100 (75-100)	100 (78-100)	1.000	0.0000	≤ 9.40	100 (82-100)	100 (75-100)
ZINC	0.531	0.7518	≤ 0.00	46.15 (19-74.9)	60 (32-83.7)	0.564	0.4855	>0.00	66.67 (41-86.7)	46.15 (19-74.9)
Glutathione	0.810	0.0007	≤ 27.25	69.23 (39-90.9)	93.33 (68-99.8)	0.781	0.0010	≤ 22.33	68.42 (43-87.4)	84.62 (55-98.1)
Prealbumin	0.990	<0.0001	≤451.52	100 (75.3-100)	93.3 (68-99.8)	0.980	<0.0010	≤ 475.74	94.74 (74-99.9)	100 (75-100)

AUC: Area under the curve BMI: Body Mass Index, MUAC: Mid upper arm circumference, MAC: Muscle arm circumference, TSF: Tricep skin fold, Hb: Haemoglobin.

CONCLUSION

In conclusion we found high malnutrition prevalence in cancer children even though their nutritional intake was similar to that of healthy children of the same sex, age and demographic location. We also find the traditional indices for malnutrition adequately predicted malnutrition in the cancer population. We recommended that larger cohort be used with expanded parameters to confirm and further define other malnutrition indices for diagnostic and/or prognostic purpose in cancer children in resource limited settings.

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