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Original Research Article

Nutritional status of school age children (6-15 years) using the new WHO growth reference in a rural area of Bengaluru, South India

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Abstract

Background: WHO AnthroPlus is a software which helps us to assess the nutritional status of school-age children and adolescents based on the new WHO Growth Reference 2007. Global Positioning System (GPS) with google earth is an innovative approach to map the spatial distribution of morbidities at the field level. The present study was undertaken to assess the nutritional status of school age children (6-15 years) using the WHO Anthroplus software, to map the spatial distribution of malnourished children using GPS and to list out the comorbid conditions associated with malnutrition. **Methods:** This was a cross sectional study conducted in the rural field practice area of a medical college, Bengaluru. School children in the age group of 6-15years were the study subjects. Sample size was 2730. The schools were selected by simple random sampling and children in these schools were selected. The sample size was equally divided between the age groups 1 to 10 years. The nutritional status was assessed using the new WHO anthroplus software. The GPS coordinates of the schools and a sub sample of malnourished children were recorded and the spatial map generated using the Google Earth software. **Results:** The prevalence of thinness, stunting, underweight and overweight/obesity were 30%, 19.3%, 35.9% and 5.7%. The spatial map generated using GPS showed distribution of malnourished children in the study area. Most common comorbidities among malnourished children were dental caries/oral conditions (28.2%), URTI (13.4%), skin diseases (6.3%) and anemia (5.3%). **Conclusions:** The WHO anthroplus software was helpful in assessing the nutritional status of children accurately. The prevalence of underweight, stunting and thinness were higher compared to overweight/obesity. The spatial map constructed using GPS and google earth showed the distribution of malnourished children accurately.

Key words: Anthroplus, GPS, nutritional status, school children, WHO growth charts (5 – 19 yrs).

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Introduction

School age is a dynamic period of physical growth as well as of mental development of the child. Health problems due to miserable nutritional status in school-age children are among the most common causes of low school enrolment, high absenteeism, early dropout and unsatisfactory classroom performance. The present scenario of health and nutritional status of the school-age children in India is very unsatisfactory. The national family health survey (NFHS III) data show that 53% of children in rural areas are underweight, and this varies across states.[1] Chronic undernutrition in childhood is linked to slower cognitive development and serious health impairments later in life that reduce the quality of life of individuals. Nutritional status is an important index of this quality. In this respect, understanding the nutritional status of children has far-reaching implications for the better development of future generations.[2]

The reference previously recommended by WHO for children above 5 years of age, i.e. the National Center for Health Statistics (NCHS)/WHO international growth reference, had several drawbacks. In particular, the body mass index-for-age reference, developed in 1991, only started at 9 years of age, grouped data annually and covered a limited percentile range. Many countries pointed to the need to have body mass index (BMI) curves that start at 5 years and permit unrestricted calculation of percentile and *z*-score curves on a continuous age scale from 5 to 19 years. Hence the data from the 1977 National Center for Health Statistics (NCHS)/WHO growth reference (1–24 years) were merged with data from the new under-fives growth standards 2006'(new growth reference for 0-5 years children obtained from a Multicentre Growth Reference Study conducted in 6 countries) cross-sectional sample (18–71 months) to smooth the transition between the two samples and thus the new WHO growth references (2007) for 5-19 years were developed. The new curves were closely aligned with the WHO Child Growth Standards at 5 years, and the recommended adult cut-offs for overweight and obesity at 19 years. They fill the gap in growth curves and provide an appropriate reference for the 5 to 19 years age group.[3] WHO AnthroPlus is a new software which is freely downloadable and helps us to assess the nutritional status of school-age children and adolescents based on the WHO Reference 2007 for 5-19 years and has been used in this study.[4] There are no published studies available in India using the using the WHO anthroplus software to assess the nutritional status of school age children.

The advent of new technology has revolutionized ways in which information on health problems are disseminated. Global positioning system (GPS) is one such tool that can be used to accurately map the distribution of morbidity and mortality in the field which in turn will help in better planning of interventions in the community. It is a satellite based navigation system which sends and receives signals to and from the satellites placed around the earth. Global positioning system technology has the potential to improve our understanding of distribution of morbidity and mortality by providing information on location (latitude, longitude, and altitude); however, because the technology is relatively new, only a handful of such research studies currently exist.[5,6]

Hence in this context the present study was undertaken to assess the nutritional status of school age children (6-15 years) using the WHO Anthroplus software, to map the spatial distribution of malnourished school children using Global Positioning System and to list out the comorbid conditions associated with malnutrition.

Materials and Methods

This was an exploratory study conducted in the field practice area of the Rural Health Training Centre of a medical college in Bengaluru from January 2014 to November 2014. Approval from the Institutional Ethics Committee was obtained. School (government, aided and private) children in the age group of 6-15 years were the study subjects. A sample size of 2730 was arrived at taking the prevalence of underweight children in rural areas as 53%[1], relative precision as 5% and design effect of 2.

All schools in the study area were line listed. Schools were selected by simple random sampling. In each school, all the children in the age group of 6-15years were selected. The total sample was divided between age groups 6-15years such that each age group had equal representation of students (2730 being the total sample size, 273 children were from the age group of 6yrs, 273 from 7yrs, 273 from 8yrs and so on till 15yrs). In this manner schools were selected till the required sample size was reached. Children absent on the day of examination were excluded.

Informed consent from the heads of the schools was obtained before examining the children. Height and weight of the subjects were recorded in the metric system using standardized techniques recommended by WHO. [7] A stadiometer capable of measuring to the accuracy of 1mm was used to measure the height. The subjects were made to stand without footwear and heals, buttocks, shoulders and occiput touching the measuring rod, hands hanging by the side. The head was held comfortably upright with the top of the head making firm contact with the horizontal head piece. Height was rounded off to the last completed millimetre. Omron digital weighing scale capable of measuring the weight with accuracy of 100g was used to record the weight. The subjects were instructed to stand on the weighing scale with light clothing, without footwear, with feet apart and looking straight. The height, weight, date of birth and date of visit of the subject were then entered in the *WHO Anthroplus software* to obtain the Z score and percentile value for the parameters *weight for age, height for age and BMI for age.* A detailed clinical examination of the children was also done, and co morbidities if any were recorded. The GPS coordinates of the schools (location in relation to latitude and longitude) were recorded using the Garmin 72H GPS receiver in terms of __° __' N and __°__' E. A sub sample (10%) of the malnourished children (selected randomly) were visited at their household to record the GPS coordinates of their household. The GPS coordinates of the household and schools were entered into the google earth software to generate the spatial map.

The data was entered in Microsoft Excel-10 and analyzed using SPSS v.21.0. Z test was used to test the difference in the distribution of malnutrition between sexes. Chi Square test was used to test the association between co morbidities and malnutrition. Kruskal Wallis test was used to test difference of Z scores and percentiles of BMI for age, height for age and weight for age between age groups. Mann Whitney test was used to test the difference of Z scores and percentiles of BMI for age, height for age and weight for age between sexes. Correlation was also tested between age and Height for age Z score (HAZ), BMI for age Z score (BAZ), Weight for age Z score (WAZ).

Results

A total of 2730 children (1380 males and 1350 females) were examined. Overall 64.2% were found to be normal, 9.1% were found to have severe thinness, 20.9% thinness, 4.4% overweight and 1.4% obesity (table I).Severe thinness was found to be highest among 12 years i.e., 12.1%, thinness among 10 years i.e., 24.9%, overweight among 14 years i.e., 8.4% and obesity among 11, 14 and 15yrs i.e., 1.8% (table I). Thinness and severe thinness were higher among males (24.2% and 12.5%) compared to females (17.6% and 5.6%), whereas normal category, overweight and obesity were higher among females (5.1% and 1.5%) compared to males (3.8% and 1.2%) and the difference of BAZ between sexes was found to be statistically significant for severe thinness, thinness and normal categories (*P*<0.01,<0.01 and <0.01) and not significant for overweight and obesity (*P* = 0.09 and 0.46) by Z test.

Table I: BMI for age Z score (BAZ) categories – comparison between ages

Age (years)	BMI for age Z score category					Total
	<-3SD (Severe thinness)	-3 to < -2SD (Thinness)	-2 to +1SD (Normal)	>+1 to +2SD (Overweight)	>+2SD (Obesity)	
6	23(8.4)	47(17.2)	195 (71.4)	5(1.8)	3(1.1)	273 (100)
7	13(4.8)	65(23.8)	186 (68.1)	6(2.2)	3(1.1)	273 (100)
8	26(9.5)	59(21.6)	176 (64.5)	10(3.7)	2(0.7)	273 (100)
9	27(9.9)	63(23.1)	167 (61.2)	12(4.4)	4(1.5)	273 (100)
10	27(9.9)	**68(24.9)**	163 (59.7)	11(4)	4(1.5)	273 (100)
11	26(9.5)	66(24.2)	165 (60.4)	11(4)	**5(1.8)**	273 (100)
12	**33(12.1)**	64(23.4)	161 -59	13(4.8)	2(0.7)	273(100)
13	32(11.7)	47(17.2)	173 (63.4)	18(6.6)	3(1.1)	273(100)
14	22(8.1)	39(14.3)	184 (67.4)	**23(8.4)**	**5(1.8)**	273(100)
15	20(7.3)	53(19.4)	183(67)	12(4.4)	**5(1.8)**	273(100)
Total	**249(9.1)**	**571(20.9)**	**1753 (64.2)**	**121(4.4)**	**36(1.3)**	**2730 (100)**

Table II: Height for age Z score (HAZ) categories - comparison between ages

Age(yrs)	Height for age Z score category					Total
	<-3 SD (severe stunting)	-3 to <-2 SD (stunting)	-2 to +2 SD (Normal)	>+2 to +3 SD	>+3 SD	
6	9(3.3)	33(12.1)	231(84.6)	-	-	273(100)
7	3(1.1)	48(17.6)	221(81)	1(0.4)	-	273(100)
8	10(3.7)	38(13.9)	224(82.1)	-	1(0.4)	273(100)
9	5(1.8)	39(14.3)	227(83.2)	2(0.7)	-	273(100)
10	6(2.2)	41(15)	226(82.8)	-	-	273(100)
11	12(4.4)	42(15.4)	219(80.2)	-	-	273(100)
12	**16(5.9)**	**56(20.5)**	201(73.6)	-	-	273(100)
13	14(5.1)	50(18.3)	209(76.6)	-	-	273(100)
14	5(1.8)	52(19)	216(79.1)	-	-	273(100)
15	13(4.8)	36(13.2)	224(82.1)	-	-	273(100)
Total	**93(3.4)**	**435(15.9)**	**2198 (80.5)**	**3(0.1)**	**1(0)**	**2730(100)**

Overall median BMI for age percentile (BAP) was 7.70. Median BAP was highest for 14 years children (14.90) and lowest for 10 years children (5.60). The difference of BAP between ages was found to be statistically significant by Kruskal Wallis test (χ^2=45.232, *P*=0.001). Median BAP was higher among females (11.70) compared to males (5.40). The difference of BAP between sexes was found to be statistically significant by Mann Whitney test (Z= -9.027, *P*=0.001).

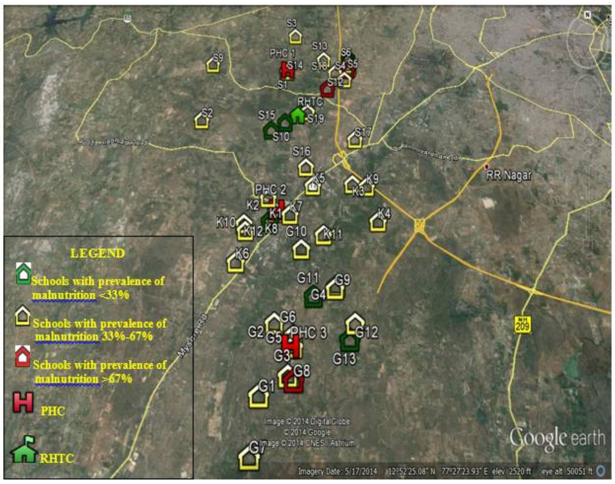
Table III: Weight for age Z score (WAZ) categories –comparison between ages

Age (yrs)	Weight for age Z score category: <-3 SD (severely Underweight)	-3 to <-2 SD (Underweight)	-2 to +2 SD (Normal)	>+2 to +3 SD	>+3 SD	Total
6	20(7.3)	63(23.1)	188(68.9)	2(0.7)	0(0)	273(100)
7	**22(8.1)**	81(29.7)	169(61.9)	0(0)	1(0.4)	273(100)
8	**22(8.1)**	**88(32.2)**	163(59.7)	0(0)	0(0)	273(100)
9	**22(8.1)**	75(27.5)	174(63.7)	2(0.7)	0(0)	273(100)
10	0(0)	4(30.8)	9(69.2)	0(0)	0(0)	13(100)
Total	**86(7.8)**	**311(28.1)**	**703(63.6)**	**4(0.4)**	**1(0.1)**	1105 -100

Figures in parentheses indicate percentage within age group

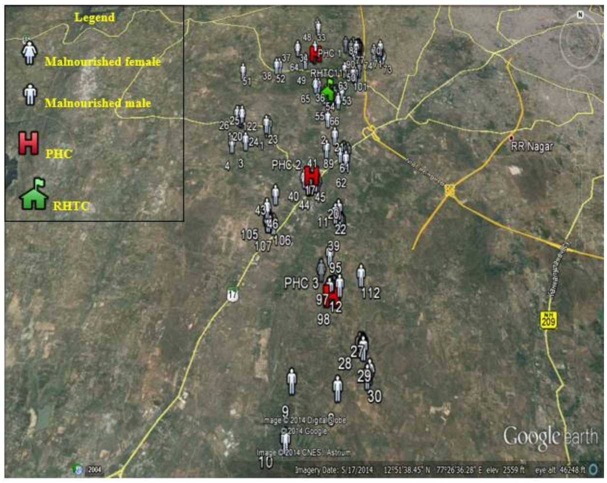
Note: WHO - Weight for age reference is available from birth only till 10 years 0 months (not from 10 years 1 month onwards) because Weight for-age is inadequate for monitoring growth beyond childhood due to its inability to distinguish between relative height and body mass, hence BMI-for-age should be used as complement to height-for-age in the assessment of thinness (low BMI-for-age), overweight and obesity (high BMI-for-age) and stunting (low height-for-age) in school-aged children and adolescents.[3] Hence weight for age was computed for only 1105 children.

Picture 1: Spatial map using GPS and google earth showing prevalence of malnutrition across schools



As per the height for age Z scores (HAZ), 3.4% were found to have severe stunting and 15.9% stunting. Both severe stunting and stunting were found to be highest among 12 years i.e.,5.9% and 20.5% respectively (table II). Severe stunting was observed in 3.4% of males and females. Stunting was more among females compared to males i.e., 17% and 14.9% respectively. The difference of HAZ categories between sexes was not found to be statistically significant for all categories by Z test (P=1, 0.11876, 0.14986, 0.57548, 0.3125 respectively for severe stunting, stunting, normal,>+2 to +3SD and >+3SD categories).

Picture 2: Spatial distribution of households of malnourished children in the study area obtained using GPS and google earth



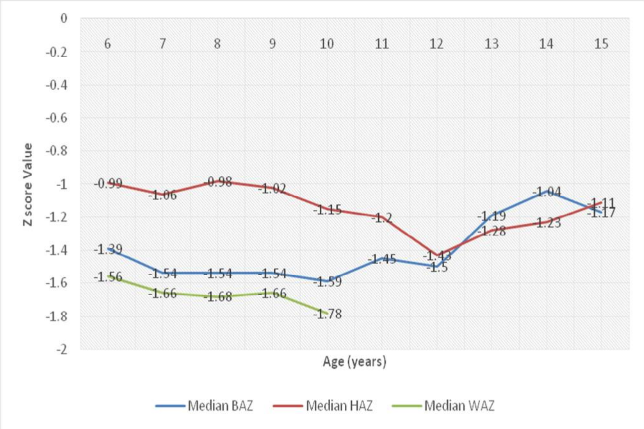
Picture 2 is a zoomed out view at a height of 46248 ft from the ground level and gives an overall picture about the spatial distribution of households of malnourished children in the study area.

Overall median Height for age percentile (HAP) was 12.70. Median HAP was highest for 8 years children (16.20) and least for 12 years children (12.60). The difference of HAP between ages was found to be statistically significant by Kruskal Wallis test (χ^2=54.49, P=0.001). Median HAP was higher among males (12.85) compared to females (12.4) and the difference of HAP between sexes was found to be statistically not significant by Mann Whitney test (Z= -0.977, P=0.328).

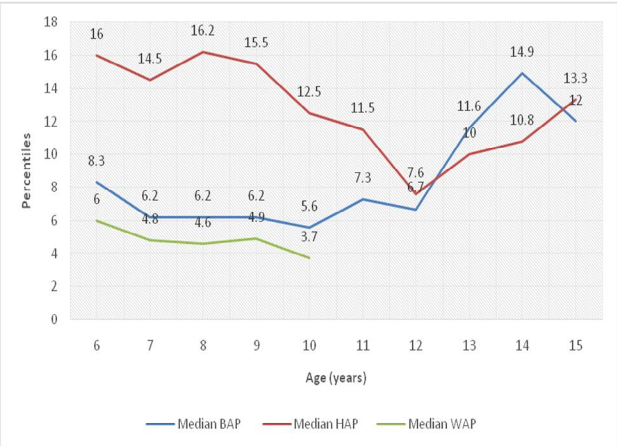
As per the weight for age Z scores, 7.8% were found to be severely underweight, and 28.1% underweight. Prevalence of severe underweight was highest among 7, 8 and 9 years i.e.,8.1% each and underweight among 8 years i.e., 32.2% (table III). Prevalence of severe underweight was higher among males (9.5%) compared to females (6.1%) and underweight was higher among females (29.3%) compared to males (27%). The difference of WAZ categories between sexes was not found to be statistically significant for all categories except for severe underweight category by Z test (P=0.036, 0.407, 0.841, 0.322 and 0.322 respectively for severe underweight, underweight, normal, >+2 to +3 SD and >+3 SD categories).Overall median Weight for age percentile (WAP) was 5.00. Median WAP was highest for 6 years children (6.00) and least for

10 years children (3.70). The difference of WAP between ages was found to be statistically not significant by Kruskal Wallis test (χ^2=0.853, *P*=0.931). Median WAP was higher among females (5.50) compared to males (4.50). The difference of WAP between sexes was found to be statistically not significant by Mann Whitney test (Z= -1.562, *P*=0.118).

Graph 1: Comparison of medians of BMI for age Z score(BAZ), height for age Z score (HAZ), and weight for age Z score (WAZ) across ages



Graph 2: Comparison of medians of BMI for age pecentile (BAP), height for age percentile (HAP), weight for age percentile (WAP) across ages



Picture 1 is the spatial map using GPS and google earth displaying the prevalence of malnutrition across different schools and picture 2 is the spatial map showing the distribution of households of malnourished children in the study area.

There was a weak positive correlation of age with BAZ (r = +0.091) and weak negative correlation of age with HAZ (r = -0.099) and WAZ (r = -0.019). All these correlations were found to be statistically significant (P=0.001) except that between age and WAZ (P=0.538). Coefficient of determination (r^2) values 0.008, 0.010 and 0.0004 imply 0.8%, 1% and 0.04% change in BAZ, HAZ and WAZ respectively can be attributed to age.

The most common comorbidities among malnourished children were dental caries/ oral conditions (28.2%), followed by URTIs (13.4%), skin diseases (6.3%) and anaemia (5.3%). A total of 717 out of 1227 malnourished children had comorbid conditions as against 774 out of 1503 normal children (and the difference was found to be statistically significant (*P*=0.0003) by Chi Square test. The odds ratio was found to be 1.324.

Graph 1 compares the *medians* of BAZ, HAZ and WAZ across ages. There is no significant net change in median BAZ between 6-10 years (the curve runs more or less parallel to the X-axis). And from 10 years onwards there is a gradual rise till 15 years. HAZ curve shows a gradual decrease till 12 years followed by a gradual rise till 15 years. WAZ curve runs more or less parallel to HAZ curve showing a gradual decrease till 10 years. In the graph 2 *medians* of BAP, HAP and WAP are compared across ages which also show a similar finding.

Discussion

Conventionally the measurements of the children had to be plotted against age in months, in 3 separate WHO growth charts (BMI for age, height for age and weight for age) manually. This could only give the category of the Z score (i.e., underweight, stunting etc.,) and percentile (i.e., below 3rd percentile, between 3rd to 97th percentile etc.,) grossly but not the exact Z score and percentile value. Also BMI had to be computed by the researcher for each subject and then plotted on to the growth chart which used be a tedious task. The advantage of WHO anthroplus software apart from being standardized, is that it allows computation of the exact Z score and percentile values for all these parameters instantaneously, on entry of height, weight and age of the subject. The Z score and percentile values help in comparison between individuals and also interstate and international comparisons. These values will also help in assessing the improvement/deterioration in the nutritional status with time both at individual level as well as state and national levels. The software is freely downloadable from the WHO website.

In this study the prevalence of thinness was found to be similar to the findings of few other studies where the prevalence of thinness was found to be 28.3%, 34.3% and 33.4%.[8,9,10] On the contrary another study reported the prevalence of thinness as 5%.[11]The probable reason for the difference could be because all the children in the latter study were from urban background contrary to our study and also differences in the age groups. In this study the prevalence of overweight/obesity was found to be 5.8% which is in contrast to other studies where it was found to be 1.3%, 1.7 %, and 0.8% [8,9,10]. The reason for this difference could be the difference in age groups and different sociocultural backgrounds of the study subjects as well as different reference standards used in these studies. Kamath et al., reported the prevalence of overweight/obesity as 3.3%. They also noted the prevalence of thinness was more among boys (6.9% in boys and 3.9% in girls) and overweight/obesity among girls (3.6% in girls and 3% in boys) similar to our study.[11] In this study one third of the children were found to be underweight which is similar to the findings of another study where the prevalence was 34.2%[9] which is in contrast to other studies where the prevalence was 24.5% and 3.6%.[12,13] The reason for this difference could be the difference in age groups and ethnicities of the study subjects and also different reference standards used. In this study one fifth of the children were found to have stunting which was similar to the findings of other studies, 18.5% and 23.7%.[2,10] In contrast other studies reported the prevalence of stunting as 3.3% and 6.4%.[13,14] The difference could be due the differences in the ethnicities as well as age groups of the study subjects.

In this study GPS was used to visually depict the schoolwise prevalence of malnutrition as well as location of the households of the malnourished children. This information can be used to assess the factors responsible for malnutrition at schools as well as households (like socio economic background of the children attending the schools, coverage by school health services, quality of midday meals, poor road connectivity, topography, distance to health centre etc,) and also in better planning of intervention strategies (with respect to manpower , logistics etc.). The advantage of spatial map constructed with GPS technology and google earth is that information is available visually and data can be saved permanently to be retrieved latter at any point in time for cross checking or comparison and trend analysis.[15]

A study by Saxena et al., revealed that GPS data could be used for mapping out the distribution of malaria vector mosquitoes, along with monitoring and evaluation of malaria control activities in various countries and also for risk mapping in analyzing the past as well as the present trends.[16] Coburn et al., used GPS data to show the geographical distribution of HIV infected patients and observed that this data could be used to implement the rollout of treatment as prevention in an efficient manner.[17] Masthi et al.,have used GPS to accurately describe the distribution of anemia and malnutrition cases, animal bite cases and Cholera cases in an outbreak of Cholera at the field level and have observed that GPS was a useful tool in mapping the morbidities at the field level.[5,18,15]

The prevalence of underweight, stunting and thinness were higher compared to overweight/obesity in the study subjects. WHO Anthroplus software was easy to use and very useful in assessment of nutritional status of children accurately. GPS with google earth was very useful in the construction of the spatial map showing distribution of malnourished children accurately, and there was significant association between malnutrition and comorbid conditions. Hence The WHO Anthroplus software may be used as an effective tool to assess the nutritional status of school age children and adolescents and GPS/google earth may be used to describe the geographical distribution of malnutrition accurately at the field level.

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