ORIGINAL ARTICLE

Global Positioning System – A new tool to measure the distribution of anaemia and nutritional status of children (5-10years) in a rural area, South India

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Abstract

Introduction: The Global Positioning System (GPS) is a satellite based navigation system which is of late being used in the health field. **Objectives:** 1.To describe the geographical distribution of anaemia and malnutrition with GPS; 2.To assess the prevalence of anaemia and malnutrition in children aged 5-10 years. **Subjects and methods:** This exploratory study was conducted over a period of 2 months in the rural field practice area of a medical college situated in Bangalore during the months of June - July, 2012. Children in the age group of 5-10 years of age were the study subjects. **Results:** GPS was used for the describing the geographical distribution of anaemia and nutrition status on the Google earth map. The prevalence of anaemia in the study subjects was 8.7%.The prevalence of underweight, stunting, thinness and severe thinness among the study subjects was 52.8%, 28.5%, 23.5 % and 29.1% respectively, however overweight and obesity was observed only in 0.9 % and 1.2% of the study subjects respectively. **Conclusion:** GPS was easy to use and was able to demonstrate the actual distribution of morbidity at the household level in the rural area.

Key Words

Global Position System (GPS); anaemia; stunting; thinness

Introduction

The advent of new technology has revolutionised ways in which information on problems of health are disseminated. Global Positioning System(GPS) is one such tool which can be used to show the actual information of morbidity and mortality at the field which will help in better understanding of distribution of diseases and help in accurate planning of interventions in the community.

The Global Positioning System (GPS) is a satellite based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and distributes them. GPS technology requires the space segment, control segment and user segment. Space segment consist of at least 24 satellites orbit the earth twice a day in a specific pattern. These satellites are so spaced that GPS receiver anywhere in the world can receive signals from any four of them. Control segment consist of monitor stations, master control stations, ground antennas. The user segment consist of GPS receiver which collects and processes signals from the GPS satellites which are in view and then uses the information to determine and display the location, speed time and distance, etc., in any weather condition anywhere in the world 24 hours for free. [1] Currently GPS technology is used in agriculture, aviation, environment, surveying, defense, rail, navigation, public safety, etc.

Similarly information of health issues with GPS will give a better picture of the problem and help in accurate interventions at the grass root level especially in implementation of public health programmes by the state.

The NFHS-III data suggests that the prevalence of anaemia was as high as 70% in 0-5 years of age. [2] There are some studies which had observed the prevalence of anaemia decreased with in the 5-10 years of age. [3,4] There are no studies where GPS has been used to study anaemia and nutritional disorders in the age group of 5-10 years.

Aims & Objectives

The present study was conducted with the following objectives:

1. To describe the geographical distribution of anaemia and malnutrition with GPS,
2. To assess the prevalence of anaemia and malnutrition in children aged 5-10 years.

Material and Methods

The present exploratory study was conducted over a period of 2 months in two primary health centres areas attached to a medical college situated in Bangalore during June - July, 2012.Children in the age group of 5-10 years of age were included in the study. After approval from the institutional ethical committee a total of 323 subjects (10% of the children in age group 5-10 years residing in the area) were selected by simple random technique based on the inclusion and exclusion criteria. Subjects were selected only after Informed consent form was signed by the parent/ legal guardian. At the household, the standard guidelines for anthropometry measurement by the WHO multicentric growth reference study (2006) was followed for measurement of height ,weight and Body Mass Index (BMI) in children aged 5-10 years. [5] Similarly the new WHO growth reference available for school aged children and adolescents in the age group of 5-19 years (height for age, weight for age and Body Mass Index(BMI) was used and children were classified as under nutrition, stunted, thinness, overweight or obese. Each index provides different information about growth and body composition, which is used to assess nutritional status. [6]

Haemoglobin estimation was done at the household with a portable haemoglobin estimation instrument HemoCueHb301 analyser with a drop of venous blood within 40 seconds of withdrawal into the microcuvette. The HemoCueHb 301 system was calibrated against the hemiglobincyanide (HiCN) method, the international reference method for the determination of the haemoglobin concentration in blood. The equipment is factory calibrated and needs no further calibration.[7] Classification of anaemia was based on the guidelines given by the WHO. [8,9,10]

A hand held GPS (GarminGPS72H) was used to measure the GPS coordinates in the area. [1] The GPS coordinate was marked in front of the household of every subject who was included, North and East coordinates on the GPS instrument was recorded. Subsequently these coordinates were plotted on the Google earth map with the help of a computer. The position of a GPS receiver was calculated by measuring the distance between itself and three or more GPS satellites. Each satellite is equipped with an atomic clock. When first powered on, GPS devices undergo an initialization period, during which they acquire signals from the satellites and synchronize the GPS clock with the satellite's atomic clock. GPS device constantly receive and analyze radio signals from the satellites, calculating precise distance to each satellite being tracked. GPS devices use trilateration, a mathematical technique, to determine user position, speed and elevation.The data was analysed and described using SPSS -11 software.

Results

A total of 323 children were enrolled in the study. 147(45.5%) and 176 (54.5%) of subjects were males and females respectively. The male to female ratio among the study subjects was 0.84: 1. Majority of the subjects 288(89.2%) were living in pucca houses. 247(76.5%) and 74 (22.9%) of subjects were Hindu and Muslim by religion respectively. Majority of subjects were in the age group of 5 and 7 years.

GPS was used for the describing the geographical distribution of anaemia and nutrition status of study subjects on the Google earth map (Figure-I). The accurate and precise location of household of the study subjects was determined by the GPS. Once the GPS co-ordinates were entered, the geography and exact location of subjects with anemic and nutritional morbidity was plotted on the Google earth map. The average distance of the study subjects from the nearest government Primary Health Centre (PHC) or health care provider was about 1.5 km. There was no difference in the distribution of anaemia with regard to the distance from the PHC.

The mean and standard deviation of Height, Weight, BMI and haemoglobinare given in table-I.

The mean haemoglobin was 13.0+ 0.95 g/L and range of haemoglobin estimation was found to be 9.6g/L to 15.7g/L. The prevalence of anaemia in the study subjects was 8.7%.The prevalence of anaemia in male and female children was 11(7.5%) and 17(9.7%) respectively. Majority, 12% and 10 % of the anaemic subjects were in the age group of 5 & 6 years respectively (Table-II).All children with moderate anaemia were girls and 52% of them had a family size of more than 5.

The prevalence of underweight, stunting, thinness, severe thinness among study subjects was 52.8%, 28.5%, 23.5%, 29.1% respectively. However overweight and obesity was 0.9 % and

1.2% of the study subjects respectively (Table-III). Underweight was more common in males (92.3%) of 7 years of age followed by 9 years of age (72.75 and 77.2% in males and females respectively). Stunting was common in females at 10 years and 6 years of age (62.5% and 62.1% respectively). Based on BMI, thinness was observed more common in 9 years of age females (50%), severe thinness was observed more in 10 years of age (57.1 % and 50% in males and females respectively).

15(9.4%) subjects who were detected as underweight were also diagnosed to have anaemia, of which only 2 (1.28%) of the subjects were diagnosed to have suffered from moderate anaemia and majority were diagnosed as mild anaemia. 9 (9.78%) of the study subjects who were detected as stunting were also diagnosed to have anaemia of whom only 2(2.17%) subjects had moderate anaemia. 6 (7.89%) of the subjects detected as thinness had mild anaemia. 58%, 52%, 49% and 61% of the underweight, stunted, thinness and severe thinness subjects had a family size of more than 5.

Only 7(7.44%) subjects detected as having severe thinness also had anaemia, similarly 1(1.06%) subject with severe thinness had moderate anaemia. None of the other subjects had severe anaemia.

Discussion

Global positioning system (GPS) 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.

GPS could be used to assess human location and have the following potential advantages portable (light and small size), free access to the GPS satellites in any part of the world, reasonable cost of the GPS receiver and data could be stored and subsequently retrieved if required. The potential benefits outlined will be more particularly to developing nations where resources are limited. Technological improvements have resulted in portable GPS units with adequate memory to store positional data over time, thus offering opportunities for obtaining location information at low cost. [12]

A major advantage of using GPS is that it provides much needed contextual information (e.g., location) thereby explore potential associations between providing a better understanding of how people are influenced by environmental factors such as housing density, external environment, spatial analysis to explore patterns across time and distance from the nearest health care provider, etc. A spatial approach also has potential to assess the effectiveness of interventions over time and location. [11]

There are a number of considerations when embarking on GPS research and there is no standard approach for the analysis and interpretation of GPS data. Although a relatively new technology, there needs to be some consensus or guidelines for the use of GPS research. This will help established and new researchers to conduct high quality research, while preventing them from making the same trial and error mistakes made by previous researchers. GPS is not without limitations. GPS devices often fail to record position indoors (particularly in concrete buildings), under heavy tree canopy and atmospheric conditions, which can produce error in the calculated distance to the satellite and position. Differential GPS (dGPS) has been used to address this error.11

In its current form, GPS is a useful complementary tool to augment the understanding of distribution of disease in the community rather than a stand-alone measure. Other GPS enabled technology such as cellular telephones and personal digital assistants can be also be used. [11]

Remotely sensed data have allowed the identification and location of remote and small settlements from field data collected from hand-held global positioning system receivers and when used in conjunction with a GIS containing digitized maps, an epidemiological tool of potential power is available.

[13] Geographic information system (GIS) and remote sensing (RS) technologies offer new opportunities for rapid assessment of endemic areas, provision of reliable estimates of populations at risk, prediction of disease distributions and guidance of intervention strategies. [14]

In field surveys GPS can be used as a better method of measuring accurate location and distance (within 15 meters) for effective interventions.

Distance and location are important determinants of accessibility to health. Primary health care centers are the main focal points through which key treatment and prevention interventions are delivered in a rural area. The exact location of study subject household was described by GPS maps, they provide a visual tool to demonstrate the problems in a community. Maps can also provide visual feedback to the community of their progress after interventions. The average distance of the study subjects from the primary health centre was 1.5 kilometers.

Evidence suggests that accessibility to health care among those who live further than 5 km away from a health center may be a key factor to achieve more favorable early childhood health. [15] Climatic, topographic and biological factors determine the distributions of either the infectious agents or the vectors and thereby diseases. New technologies [Geographic Information Systems (GIS), Global Positioning Systems (GPS), Remote Sensing (RS) and spatial statistics] are powerful tools not only for mapping, but also for prediction by exploring environmental indicators for health. [16]

Children in the age group of 5-10 years were included as most of the available literature in India had information about anaemia and nutritional status of children mostly in the age group of 0-5 years.

The prevalence of anaemia was low in the study subjects when compared to national averages. This may be explained by the fact that children in this age group may have had access to community nutrition programmes like mid-day meal programme, ICDS, prophylaxis against nutritional anaemia etc., Muthayya et al had stated that overall anaemia prevalence was only 13.6% in the age group of 5-15 years. In an interesting observation there was a sharp decline in anaemia prevalence from nearly 50% at 5 years of age to close to 10% between 7 and 11 years. This trend was seen in both genders. The anaemia prevalence was lower in boys than girls. [17]

However the estimates prevalence of anaemia in the age group of 5-14 years is 48 % and 43 %.3,4 Prevalence of anaemia was 11.4% in preschool children with 12% and 16% of children with anaemia diagnosed as mild and moderate under nutrition. [18]

The prevalence of stunting, underweight, thinness and severe thinness was high in the study subjects and there was no age trends observed. This observation is similar to national averages. Prevalence of wasting, stunting and underweight was 21.2%, 47.4% and 51.7%respectively in 6-8 Years. There was no significant difference in the prevalence of wasting, stunting and underweight between boys and girls. However a definite age trend was seen in the prevalence of wasting, whereas no such trend was seen in case of stunting and underweight. Although, long term or chronic malnutrition was still high among older children, yet prevalence of recent malnutrition or wasting declined abruptly after the age of 6 years. This may be due to the fact that the older children can pick up food without much parental care in comparison to younger children. 9-10 Years: Prevalence of stunting was 46.5%and 56.1 %in this age group. Prevalence of thinness was found to be 55.5% and 53%. Prevalence of both stunting and thinness was found to be higher among girls.[19] Among adolescent girls in the age group of 10 years living in a slum area, prevalence of stunting was found to be 46.6% and 33.3% as per NCHS and Indian standards respectively. Prevalence of underweight was 46.6% and 26.7% as per NCHS and Indian standards respectively. Prevalence of thinness was 20% as per Indian standards. [20]

One study reported that anaemia prevalence (hemoglobin concentration <120 g/L) ranged from 19-88% across five different cities in India. Overweight and obesity were prevalent among 8.5-29.0% and 1.5-7.4% respectively among school children. [21]

Conclusion

GPS was easy to use and helpful to demonstrate the actual distribution of morbidity at the household level in the PHC area. The prevalence of anaemia was low and nutrition morbidity was high.

Recommendation

GPS can be used as a tool in epidemiological field studies to describe the accurate distribution of morbidity and mortality at the household level.

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Tables

TABLE 1 DISTRIBUTION OF STUDY SUBJECTS BASED ON HEIGHT, WEIGHT AND BMI (N=323)

Age* (in years)	Gender	Height (in cm) Mean±SD	Weight (in kg) Mean±SD	BMI (in kg/m2) Mean±SD	Hb (in g/L) Mean±SD
5	M(n=33)	106.33± 6.40	14.80± 1.79	13.12 ± 1.46	12.5 ± 0.8
	F(n=34)	108.29± 6.22	15.47 ± 3.12	13.12 ± 1.84	12.7 ± 1.0
6	M(n=29)	111.66 ±5.71	16.76 ± 2.91	13.39 ± 1.66	12.8 ± 0.8
	F(n=37)	110.54 ±5.96	15.80 ± 2.37	12.88 ± 1.27	12.5 ± 1.0
7	M(n=26)	116.46±6.08	16.96 ± 3.02	12.48 ± 1.65	12.8 ± 1.0
	F(n=41)	118.12 ± 6.23	17.98 ± 2.57	12.87 ± 1.42	13.0 ± 0.9
8	M(n=23)	120.52 ± 7.94	19.76 ± 4.42	13.54 ± 2.47	13.0 ± 0.8
	F(n=34)	123.03 ± 6.31	21.53 ± 5.17	14.08 ± 2.29	13.0 ± 1.2
9	M(n=22)	128.00 ± 5.89	21.59 ±3.05	13.14 ± 1.32	13.2 ± 1.1

	F(n=22)	125.77± 3.73	20.25 ± 2.89	12.77 ± 1.44	13.0 ± 1.0
10	M(n=14)	131.00 ± 4.47	22.93 ± 4.34	13.33 ± 2.22	13.2 ± 0.8
	F(n=8)	125.75 ± 6.69	21.81 ± 6.41	13.66 ± 2.88	13.1 ± 0.8
**Age in completed years5 years = 5years and 01 day to 5years 365 day, similarly for 6,7,8,9 &10 years*					

TABLE 2 AGE AND SEX WISE DISTRIBUTION OF ANAEMIA IN THE STUDY SUBJECTS (N=323)

Age** (in years)	Gender	Hb (in g/l)*				Total
		≥115	110-114	80-109	<80	
5	M (n=33)	30(90.9)	3(9.1)	-	-	33 (100.0)
	F(n=34)	30(88.2)	3(8.8)	1(2.9)	-	34 (100.0)
6	M(n=29)	27(93.1)	2(6.9)	-	-	29 (100.0)
	F(n=37)	32(86.5)	3(8.1)	2(5.4)	-	37(100.0)
7	M(n=26)	24(92.3)	2(7.7)	-	-	26 (100.0)
	F(n=41)	38(92.7)	3(7.3)	-	-	41(100.0)
8	M(n=23)	22(95.7)	1(4.3)	-	-	23 (100.0)
	F(n=34)	31(91.2)	2(5.9)	1(2.9)	-	34(100.0)
9	M(n=22)	20(90.9)	2(9.1)	-	-	22(100.0)
	F(n=22)	20(90.9)	1(4.5)	1(4.5)	-	22 (100.0)
10	M(n=14)	13(92.9)	1(7.1)	-	-	14(100.0)
	F(n=8)	8(100.0)	-	-	-	8(100.0)
Total		295(91.3)	23(7.1)	5(1.5)	-	323(100.0)

Note: Figures in parenthesis indicate percentage
** Hemoglobin in gram per liter, WHO classification of anaemia in 5-11year children: No anaemia (≥115g/l),Mild anaemia(110g/l-114g/l), Moderate anaemia (80g/l-109g/l), Severe anaemia (<80g/l).*

TABLE 3 PREVALENCE OF UNDERWEIGHT, STUNTING, THINNESS, SEVERE THINNESS, OVERWEIGHT AND OBESITY IN THE STUDY SUBJECTS

Age (in years)*		Weight for age (underweight)	Height for age (stunting)	BMI			
				Thinness	Severe thinness	Overweight	Obesity
5	M (n=33)	15(45.5)	15(45.5)	8(24.2)	6(18.2)	0(0.0)	0(0.0)
	F (n=34)	12(35.3)	6(17.6)	10(29.4)	6(17.6)	0(0.0)	1(2.9)
6	M (n=29)	12(41.4)	7(24.1)	8(27.6)	5(17.2)	0(0.0)	1(3.4)
	F (n=37)	16(43.2)	18(48.6)	11(29.7)	7(18.9)	0(0.0)	0(0.0)
7	M (n=26)	24(92.3)	9(34.6)	6(23.1)	14(53.8)	1(3.8)	0(0.0)
	F (n=41)	18(43.9)	9(22.0)	8(19.5)	14(34.1)	0(0.0)	0(0.0)
8	M (n=23)	15(65.2)	6(26.1)	3(13.0)	10(43.5)	0(0.0)	1(4.3)
	F (n=34)	13(38.2)	7(20.6)	0(0.0)	7(20.6)	0(0.0)	1(2.9)
9	M (n=22)	16(72.7)	4(18.2)	8(36.4)	8(36.4)	0(0.0)	0(0.0)
	F (n=22)	17(77.3)	2(9.1)	11(50.0)	5(22.7)	0(0.0)	0(0.0)
10	M (n=14)	NA	4(28.6)	3(21.4)	8(57.1)	1(7.1)	0(0.0)
	F (n=8)	NA	5(62.5)	0(0.0)	4(50.0)	1(12.5)	0(0.0)
Total(n=323)		158(52.5)	92(28.5)	76(23.5)	94(29.1)	3(0.9)	4(1.2)

Note: Figures in parenthesis indicate percentage,
*2007 WHO Reference; *Age in completed years 5 years = 5years and 01 day to 5years 365 day, similarly for 6, 7,8,9 &10 years;*
NA- not applicable For Weight-for-age, age group 10 yrs covers upto age 120 completed months. The weight-forage is inadequate for monitoring growth beyond Childhood due to its inability to distinguish between relative height and body mass.[6]

Figures

FIGURE 1 GPS MAPPING OF ANAEMIA AND NUTRITION STATUS OF CHILDREN (5-10 YEARS) ON GOOGLE EARTH

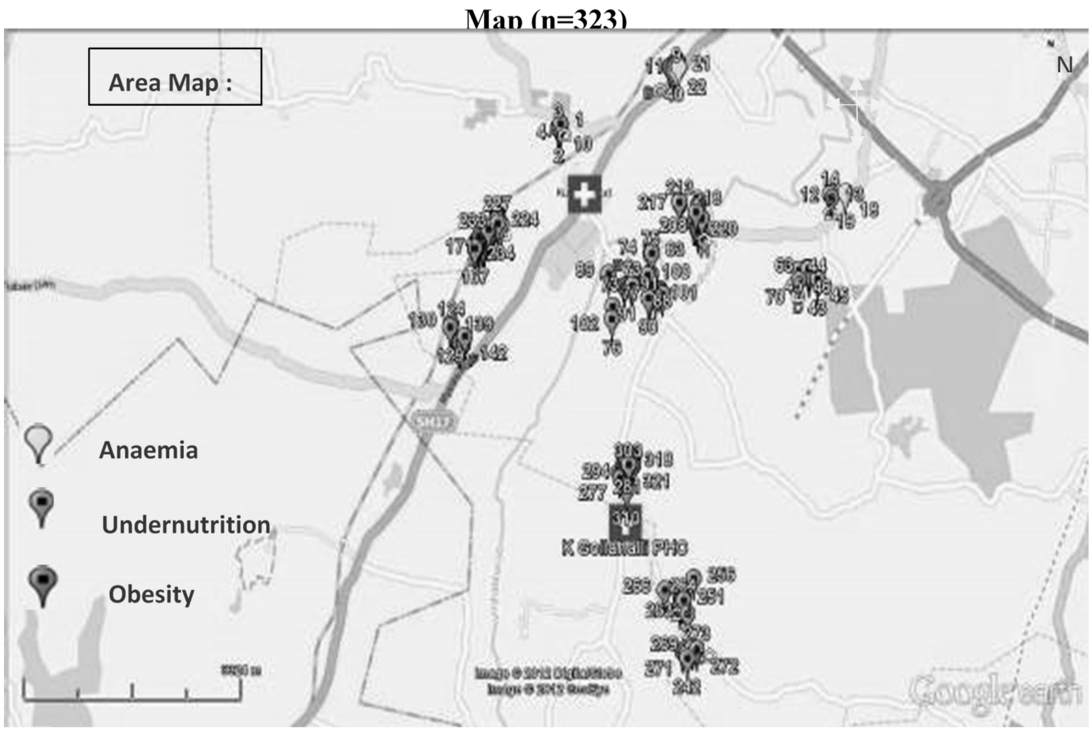

FIGURE 2 GPS MAPPING OF ANAEMIA AND NUTRITION STATUS OF CHILDREN (5-10 YEARS) IN ONE OF THE STUDY VILLAGE ON GOOGLE EARTH MAP