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PREVALENCE OF IODINE AND IRON MALNUTRITION AMONG RURAL SCHOOL CHILDREN OF GUJARAT, INDIA

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ABSTRACT : Background-Iodine and iron deficiencies are responsible for reversible brain damage, mental retardation, stunted growth, development and low immunity in school children. The consequences are more severe when encompassed by malnutrition. Higher enormity of all may worsen the situation. **Objective-** To determine the magnitude of micronutrient malnutrition in rural school children of Gujarat, India **Methods -** 947 children, enrolled from 4 schools. Anthropometric measurements, urinary iodine excretion and haemoglobin were assessed. **Results-** Malnutrition was highly prevalent with 70% of children being underweight, 55% children suffered stunting and 45% had lower BMI, using WHO 2007 and CDC 2000. Prevalence of iron deficiency anemia was 99% where as iodine deficiency disorders was 30%. Mean haemoglobin level was 9.17± 1.22 g/dl and median urinary iodine excretion was 145.91µg/l. Adequately iodized salt was consumed by 82.4% population. Though majority of the subjects are consuming iodized salt, the prevalence of iodine deficiency is higher. **Conclusion -** Hence, there is a need to ensure best usage and storage practices for iodized salt. There is an interrelationship between stunting and micronutrient deficiencies. Children are in a transition phase of malnutrition; hence, there is a need to strengthen school meal program, health program and thorough awareness campaigning is required from ground level to the beneficiaries. There is a need to introduce a common vehicle for all; like double fortified salt; to address both the micronutrient deficiencies along with improving upon nutritional status.
Key words: Iodine deficiency disorders, Iron deficiency anemia, Malnutrition, School children, Rural India, Iodized salt consumption, double fortified salt

INTRODUCTION

Compromised nutrition in any age group has been identified as world's most serious health problem and the single biggest contributor to child mortality. Under nutrition is a process which affects not only current generation, but is often extended into future generations. Lack of these essential nutrients-vitamins and minerals continue to be pervasive and they overlap considerably with problem of malnutrition. [14] Growth faltering in malnourished children also hampers intelligence and physical capacity. These in turn lead to slowing down socioeconomic growth, reduces productivity and increased poverty and therefore economic cost of malnutrition becomes very high. [16]

The World Bank estimated [1] that the combined economic cost of micronutrient deficiencies in developing countries could waste as much as 5% of gross domestic product (GDP). Micronutrient Initiative's "National damage assessment Reports" for 80 countries with micronutrient deficiencies has estimated on average, 1% GDP lost due to iron deficiency anemia and iodine deficiency disorders.

Globally there are more than 850 million people undernourished. [3] India being second after Bangladesh with respect to the prevalence of underweight children in the world. India has 49 % of underweight children which contributes to 39 % of the world's underweight children. School children contribute to 21.8% population, of these who are aged between 6-14 years, carry almost 63-73% prevalence of under nutrition. The prevalence varies state to state, depending on socioeconomic status and their residential location. The most affected group is rural population. [6]

Malnutrition in children also encompasses micronutrient deficiencies. Iodine and Iron deficiency are most detrimental. A review of such studies examining the relationship between mental development and severe malnutrition concluded that, school-age children who suffered from early childhood malnutrition generally have poorer IQ levels, cognitive function, school achievement and greater behavioural problems than matched controls, and to lesser extent siblings. The detrimental effect was observed to affect their adolescence and later age [11].

Malnutrition in early stages has been found to have a long term effect on the growth and development of children, particularly on cognitive development. One third of the world's population suffer from anaemia whereas 2.2 billion are iodine deficient. According to NFHS III the prevalence of anaemia is 70- 80 % in children. [18] Anaemia affects the oxygen carrying capacity of the cells and thereby reduces the work capacity of the children. Iron deficiency along with iodine deficiency affects the developing brains, physical and mental growth of the children.

Iodine deficiency has a strong correlation with iron deficiency anemia. IDA may impair thyroid metabolism by decreasing oxygen transport, similar to the thyroid impairment due to hypoxia. [10, 22] Chronically hypoxic children will have lower levels of thyroxin (T4) and triiodothyronine (T3). In contrast hypothyroidism may also reduce the need for oxygen transport and delivery to peripheral tissues. Even malnourished state plays a vital role in the mechanism by generating negative energy which in turn will reduce circulating thyroid hormone concentrations and anorexic condition leading to decreased food intake, which is characteristic of IDA. [26]

Population studies have examined the relationship of mild IDD to child growth. The mechanism whereby mild IDD can retard growth and iodine repletion can produce as growth response is reasonably clear with the role of thyroxin in growth and development. Thyroxin aggravates growth hormone and insulin like growth factors [15]

India is poised to show unprecedented economic growth by 2050, respite that India is also one of the 18 priority countries of United Nations who are yet to achieve Universal Salt Iodization (USI). [20] Unless iodine nutrition is maintained, the symptoms and signs of iodine deficiency will recur in a short period of time. Therefore sustenance of the programme is a major aspect to be focused on.

Respite, Gujarat being richest state of India, has its major share in the prevalence of malnutrition and micronutrient deficiencies. The prevalence of stunting is 28-30%, that is nearly 1/3 of the rural school children signifies the long standing chronic malnutrition and the observed prevalence of iron deficiency anemia was 72% among rural school children [2]**.** Mishra et al has reported the prevalence of Iodine deficiency (goitre) as 20.5%. Hence, malnutrition along with iodine and iron deficiencies can be interrelated to each other. Hence, our concern towards preventing malnutrition in these children**.** [17]

School age is a very crucial period of life. There is a transition between childhood to adolescence, a stage where rapid growth occurs. In this stage group of nutritional deficiencies may hinder the expected growth and will challenge growth at physical, physiological and mental fronts.

Hence, the study was designed as there is insufficient data available on iodine and iron malnutrition in rural school children of Vadodara. The broad objective was to assess the nutritional status of rural school children in terms of prevalence and severity of iodine and iron deficiencies.

MATERIALS AND METHODS

The present study was conducted in rural area of Vadodara district, Gujarat, which was further divided into 4 demographic regions based on population and number of schools available. This area comprises of 172 primary government schools. Four schools on a same belt were selected randomly. Permissions from all the schools and District education officer were availed to carry out the work. All the children from 1st to 7th standard of the school were enrolled for the study. The total numbers of registered children were 1184, of which 947 children could complete the study. Exclusion criteria included the children who are not been available in 3 consecutive visits. There was almost 30% absenteeism in rural schools. The higher rate of absenteeism is due to parental negligence towards their child's attendance or education and migration for livelihood. Few children, who were coming from the far off villages, were out of reach most of the times leading to increased absenteeism.

The prevalence of nutritional deficiencies were assessed by,

Anthropometry- Height and Weight- the anthropometric measurements were recorded using standardized scales. Height was measured by wall mounted fiber glass tape with the least count of 0.5 cm. The tape was mounted accurately on the wall perpendicular to the floor. The flat surface of the floor and the wall was taken into consideration for even measurements. This was the feasible method in the rural field level. Standardized bathroom scales were used for weighing with the least count of 0.5 kg. Both the equipments were standardized at regular intervals.

Iodine status- Urinary iodine was estimated using simple microplate method based on Sandell-Kolthoff reaction [19].

Iron status- Haemoglobin estimation Procedure from finger prick blood sample by cyanmethaemoglobin method using filter paper technique [3]

Salt iodine content – Using Spot testing (MBI) kits provided by UNICEF and the iodine concentration was recorded using WHO/ICCIDD/UNICEF guidelines. [12]

Statistical Analysis

The data was entered in windows excel and SPSS. Analysis was carried out for mean, median and standard deviation. Statistical tests like chi-square and ANOVA were applied. The data entered in excel was imported into Epi info package and z score were derived towards CDC standards for undernutrition. Z score for WHO standards were derived using WHO anthro + package of WHO. All the tests were considered significant at $p<0.05$ level. Based on percent prevalence 95% confidence interval (CI) was also calculated.

Ethical Approval

Approval for the study was obtained from the ethical committee of the home institution ethical board (Ethical approval No. F. C. Sc FN ME70). Consent to carry out survey with the students was availed from the Education Department, GOG, Principals of the schools and parents of the children. Children were also demonstrated and explained the purpose and their willingness was also taken into consideration.

RESULTS

The age range of the subjects was 5-15 years. The mean age was 9 years. The data on anthropometric parameters revealed that gender difference did not depict a significant difference in height and BMI of the subjects, whereas there was a difference in mean weights of the subjects. Table 1.

Table 1: Mean anthropometry of the children

Parameters (Mean± SD)	Girls (N=431)	Boys (N=516)	Total (N=947)
Age (Years)	9.33 ±2.30	9.08 ± 2.34	9.19 ± 2.32
Height (Cms)	122.74± 12.84	121.49 ± 12.09	122.06 ± 12.45
Weight (Kg)	21.17± 6.54	20.54 ± 5.33	20.83 ± 5.92
BMI (wt/ht^2)	13.70 ±1.92	13.68 ± 1.42	13.69 ± 1.67

Prevalence of Malnutrition

The prevalence of malnutrition in the study subjects is been depicted in Table 2. The comparison between WHO and CDC standards, reflected the prevalence of stunting (HAZ <-2SD) which was 45% using both the classifications.Prevalence of underweight (WAZ<-2SD) and thinness (BAZ <-2SD) were 70% and 60% respectively. Hence, the results suggest that only 30% of the subjects followed normal growth pattern with normalcy in all the standard measures of nutritional status. The prevalence of malnutrition was found very high amongst rural children. Ranges defined using 95% CI reveals the prevalence of underweight ranged from (69.10 - 75.01) depicting that, there are 75% of the children in the rural setups have been targeted by prolonged chronic malnutrition.

Table 2: Prevalence of malnutrition among children

Parameters	CDC 2000	95% CI	WHO 2007	95% CI	Total (N)
	N (%)		N (%)		
Wt/Age <-2SD	683 (72.1)	69.19-75.01	397 (68.9)	65.03-72.77	CDC=947 WHO=571
Ht/Age <-2SD	435 (45.9)	42.66-49.14	442 (46.7)	43.08-49.92	947
BMI/Age <-2SD	531 (56.1)	52.88-59.32	487 (51.4)	48.16-54.64	947

Note: WHO 2007 classifies Wt/Age up to 10 yrs. of age. Numbers in the parenthesis depicts percent prevalence

Severity of malnutrition revealed that, 15% of the children were severely stunted (confirmed by both the classifications) and an average of 37% of the subjects were underweight, double the stunted. Whereas the prevalence of severe thinness was also notably high, reflected by the results of both the classifications Table-3.

Table 3: Percent Severity of malnutrition among children

Categories	Weight for Age		Height for Age		BMI for Age	
	CDC	WHO	CDC	WHO	CDC	WHO
Normal	8	8.2	19.6	19.1	16.6	17.5
Grade1	19.9	22.9	34.4	34.2	27.3	31
Grade2	28.8	34.2	31.7	32.4	24.9	29.7
Grade3	43.3	34.7	14.3	14.3	31.2	21.8

Prevalence of micronutrient deficiencies

The prevalence of micronutrient deficiencies was expected to be higher due to their malnourished status. This reflects a total sum the micro and macro nutrient deficiencies together**.** The prevalence of iodine deficiency was observed to be 30% among both the genders with median UIE (145.91µg/l) significant at ($P<0.001$) higher than the expected (100 µg/l) due to large variations among individual urinary iodine levels. Almost 99% of the subjects were suffering from iron deficiency anemia. Mean haemoglobin value was 9.17 gm/dl, moderate category of iron deficiency anemia. Significant difference observed between both the gender ($p<0.05$). (Table 4)

Table 4: Prevalence of iodine and iron deficiencies among children

Deficiencies	Girls N=431	95% CI	Boys N=516	95% CI	Total N=947	95% CI
Presence of Iodine Deficiency	29.7%	25.26 – 34.14	30.2%	26.18 - 32.91	29.95%	26.99 - 32.91
(Using Median UIE µg/l)	144.83***	134.58-155.08	147.43***	138.27 - 156.59	145.91***	139.08 -152.74
Presence of Iron Deficiency Anemia	99.54%	-	99.33%	-	99.37%	-
(Using Hb g/dl) Mean± SD	9.05 ±1.22	8.935-9.165	9.27±1.21	9.17 -9.37	9.17± 1.22	9.09-9.25

Note: 95% CI in IDA is not been shown due to universal prevalence of IDA

Classifying the prevalence of micronutrient malnutrition based on the severity, 18.7% of the subjects had mild deficiency of iodine, and 24.07% had mild iron deficiency. Both the micronutrient deficiencies were observed to be higher in girls compared to boys, reflected in moderate and severe categories. (Figure 1)

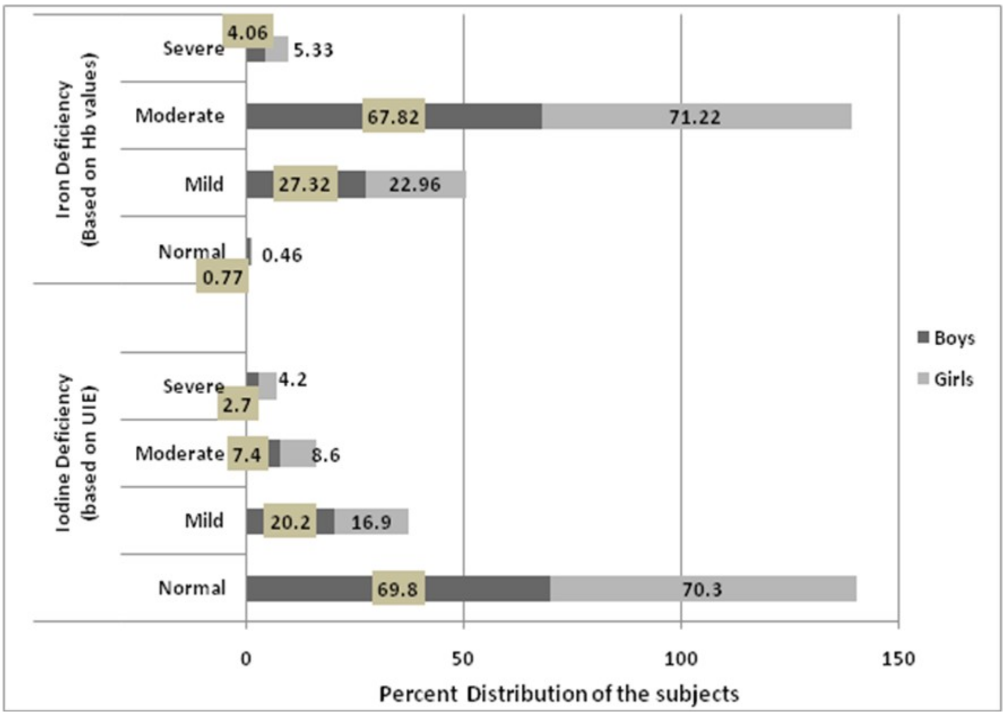

Figure 1: Severity of micronutrient deficiencies among children

There were 302 salt samples collected from the households of the children. The on the spot testing was carried out in the schools. Data revealed that, 1.3% of the samples had no iodine and 16.2% had insufficient levels, where as almost 82.4% were consuming adequately iodized salt. **(Table 5).**

Table 5: Availability of Iodized Salt at consumer level

Iodine Levels (ppm)	Samples N (%)	Categories
0 ppm	4 (1.3)	No iodine
< 15 ppm	49 (16.2)	Inadequate
≥15 ppm	249 (82.4)	Adequate(Recommended)
Total	**302(100)**	

Note: Numbers in the parenthesis depicts percent prevalence

Table 6 describes the prevalence of micronutrient malnutrition based on nutritional status of the subjects. It was observed that there were 50% of iron and iodine deficient subjects who were normal or mildly underweight. Iron deficiency and underweight has showed significant correlation in both the gender categories. Physical growth and development (Stunting) has showed linear correlation with iron and iodine status of the children, since majority of iron and iodine deficient children were moderately or severely stunted. Severe thinness was observed in 31.24% iron deficient and 28.87% iodine deficient subjects. Severity was higher in boys compared to girls. Hence, these results suggest interrelation between micronutrient deficiencies and effect on nutritional status.

Table 6: Prevalence of micronutrient deficiencies cross tabulated with Nutritional status

Nutritional Grade (Z Score)	Percent Anemic Subjects			Percent Iodine deficient subjects		
	Boys (N=512)	Girls (N=429)	Total (N=941)	Boys (N=156)	Girls (N=128)	Total (N=284)
Weight for Age						
Normal + Mild	271(52.93)	236(55.01)	507(53.87)	75(48.07)	69(53.90)	144(50.70)
Moderate	161(31.44)	138(32.16)	299(31.77)	56(35.89)	45(35.15)	101(35.56)
Severe	80(15.62)	55(12.82)	135(14.34)	25(16.02)	14(10.93)	39(13.73)
Height for Age						
Normal +Mild	138(26.95)	123(28.67)	261(27.23)	37(23.71)	36(28.12)	73(25.7)
Moderate	139(27.14)	132(30.76)	271(28.79)	41(26.28)	41(32.03)	82(28.87)
Severe	235(45.89)	174(40.55)	409(43.67)	78(50)	51(39.84)	129(45.42)
BMI for Age						
Normal+ Mild	216(42.18)	195(45.45)	411(43.67)	65(41.66)	64(50)	129(45.42)
Moderate	119(23.24)	117(27.27)	236(25.07)	43(27.56)	30(23.43)	73(25.7)
Severe	177(34.57)	117(27.27)	294(31.24)	48(30.76)	34(26.56)	82(28.87)

Note: Numbers in the parenthesis depicts percent prevalence

DISCUSSION

Malnutrition

Malnutrition during growth spurt is moreover associated with one or the other micronutrient deficiencies. In such a situation, iron and iodine deficiencies may play an obstructive role. Preschool age is considered as one of the most critical stage of human life where different nutritional deficiencies may occur. Hence, various ongoing programs on prevention mode during early childhood are run in the country. At the juncture of age five, they are considered more or less safe from nutritional disorders and little attention is paid to the quality of life. [(9)] School children are not considered as "at risk" population, but physiologically this period demands unique interventions in the life cycle. [(24)]

Growth spurt in children are observed in their school going day. It's assessment and management can be practiced using growth curves. They are helpful to determine the extent of growth faltering among vulnerable children and management of nutritional status in healthy children. [(2)] WHO (2007) and CDC (2000) has provided standard classifications to measure the nutritional status of the children, but both of them have their own advantages and limitations. Hence, in the present study both the standards have been used to generate authentic data on the prevalence of malnutrition. The difference in the number of subjects for height for age assessment was observed because WHO 2007 does not provide outputs for the children above 10 years, because this indicator does not distinguish between height and body mass where many children are experiencing the pubertal growth spurt and may overestimate the weight when they are actually normal.[(5)] Other two parameters- height for age and BMI for age have been assessed by using both the classifications. The results revealed that around 70% of the subjects are underweight whereas 50% of them are stunted and compromising on BMI levels. This may be due to lack of resources, food and attention by the parents, though Mid Day Meal Programme (MDM) is existing in the country.[(8)]

Micronutrient Deficiencies

The most common reason for growth faltering is the presence of iodine and iron deficiencies together in malnourished children. Cross- sectional studies in developing countries have produced equivocal results on the matter. In mild to moderate iodine deficiency area, there was no correlation between both the deficiencies as iodine deficiency did not differ in anaemic and non-anaemic children. [(25)] Similar results were observed in our study, whereas in Cote d'Ivoire, the relative risk of goitre was 1.9 (95% CI: 1.5, 2.3) higher in the children with IDA compared with iron-sufficient children [(25)]. The reason for no correlation between iron and iodine status in our study can be attributed to the higher prevalence of iron deficiency anemia (99%).

According to the National guidelines [7], the severity of IDD was classified into three categories: <20 µg/l- severe; 20-49.9 µg/l- moderate and 50-99.9 µg/l-mild. The value above 100 µg/l is considered normal. The median urinary iodine level in the study population was 145 µg/l. However a deficiency was observed in 30% of the population, where 9% and 4% of the children were respectively falling in moderate and severe category. This indicates that there is a need to strengthen the efforts to ensure best practices towards usage and storage of iodized salt. Though the availability of iodized salt is 82.4%, prevalence of iodine deficiency is comparatively high. The consumption pattern also coincides with the study results conducted in Saurashtra region of Gujarat where 81% of the population was consuming iodized salt but the prevalence of goitre as 8.8% and median UIE was 110 µg/ [4] . Our study population was iodine sufficient as evidenced by normal median urinary iodine excretion. Persistence of iodine deficiency after adequate iodization has been observed by many authors all over the world, similar to our observation [27].

Children are most adversely affected by iron deficiency due to their growth spurt. [13] WHO/UNICEF/UNU (2001) has recommended [23] cut offs for classifying severity of anemia. Based on these cut offs, the subjects were divided and it was observed that almost all the subjects had mild to severe level of iron deficiency. A recent study in rural Gujarat [2] has depicted the prevalence of IDA as 73% whereas, our study revealed 99%. It was observed that, majority of iodine and iron deficient subjects with 43.67% and 45.42% respectively were severely stunted. Hence, it shows an interrelationship between micronutrient deficiencies and growth hormone majorly IGF1 (Insulin like growth Factor1). Higher prevalence of thinness in boys was observed compared to girls in both the micronutrient deficient groups. It might be due to increase in adipose tissues in females and masculine tissues in males which contribute to increase in surface area. [28]

If iron and iodine deficiencies are not corrected, they may lead to IDA and any of the consequences of IDD, which are associated with an impaired development of mental and physical co ordination. Once afflicted, this impairment is not eradicated even after the anemia has been treated, impairing school achievements in older children.

The study observations call for a regular and well monitored school health program. All the indicators throw light on the real picture of nutritional status of rural Gujarat after six decades of our independence. The results reflect that the prevalence of malnutrition and micronutrient deficiencies is very high despite the ongoing mid day meal program. Since, most of the subjects are falling into mild and moderate categories of micronutrient deficiencies, dietary diversifications and awareness campaigning from ground level to the beneficiaries is required. There is a need to introduce a fortified food vehicle which can be used by all in same amounts and more or less in equal quantities. The cost of the product should be feasible for all and it should require minimum technical integrations, thus can be produced at a local level. Double fortified salt can be used as such a tool to supplement micronutrients to the vulnerable population at a feasible cost. [21] The study widens our views and application to achieve the MDGs by combating both micronutrient deficiencies, when they are encompassed with a higher enormity of malnutrition.

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