The Micronutrient Consumption in Indian Elementary School Children across Socioeconomic Strata

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Abstract: *Background*: The adequate intake of micronutrients in school children has a significant long term beneficial effect on a child's overall development and performance. Thus, identifying sub-clinical deficiencies, monitoring micronutrient intake in a child's diet, and subsequently treating each is of paramount importance. The present study aimed to determine the daily micronutrient consumption in elementary school children across socioeconomic strata (SCE) compared to age-specific, recommended daily allowance (RDA).

Subjects/Methods: Three hundred and sixty-six **(**366) healthy, school-going girls and boys between the ages of 6 -14 years volunteered for the study. Socioeconomic status was assessed using the urban socioeconomic status grid questionnaire, and micronutrient consumption was determined by the 24-hour recall questionnaire and the Dietcal software.

Results: Seventy per cent of the children tested had a BMI in the normal range, and approximately 15.84% of the children were underweight, of which 82% were in the Mid-low SCE strata. Paradoxically, an equal number of children (15%) were overweight, of which 89% belonged to the high SCE strata. Overall, a large number (70-90%) of children were found deficient (compared to RDA) in the intake of micronutrients, and there were significant differences between children belonging to the high and mid-low SCE strata in the intake of Calcium (10 -14 year), Iron (6 - 12 year) and Vitamin B6 (for 10 -14 year). Additionally, the deficiency in the consumption of Calcium, Iron, Vitamin B6, Vitamin 12, and Vitamin A was the most in the older children, while the consumption of Magnesium and Vitamin C across all age groups was within the recommended daily allowance (RDA).

Conclusions: Elementary schools across socioeconomic status and age groups reported severe deficiencies in the consumption of micronutrients. Interestingly, in-spite of the accessibility to nutritious food, children belonging to the high SCE strata were also deficient in micronutrient intake. Hence, it is important to re-focus our attention from gross caloric intake to the consumption of micronutrient-rich foods.

Keywords: Micro-nutrients, School children, Socioeconomic status.

INTRODUCTION

School children are in their most active phase of growth and experience exponential physical as well as cognitive development. During these growing years, the nutritional intake of a child plays an important role in providing sustenance to the development of overall abilities, which continues into adolescence and adulthood. It has been suggested that severe health-related problems due to poor nutritional status, particularly of micronutrients, in children, is one of the most common causes of a number of bodily ailments, poor physical performance, unsatisfactory academic performance, and low school enrolment [1-4].

Normal nutritional status is achieved when a well-balanced meal, with an intake of both macro and micronutrients, is consumed regularly. Macronutrients are those nutrients that the body needs in large amounts to provide the body with energy or calories. On the other hand, micronutrients are those nutrients that the body needs in smaller amounts but are important for energy metabolism, the synthesis of blood cells, amino acids, etc. The adequate intake of micronutrients has been shown to positively impact a child's cognitive abilities, physical function, and fitness children who suffer from inadequate micronutrient intake, also known as hidden hunger, manifest with reduced vitality. Over time, it will insidiously lead to poor health and reduced wellbeing.

Globally it is estimated that approximately seven per cent (7.3%) of the population suffers from micronutrient deficiencies, and importantly, low and middle-income countries (LMIC) such as India account for 98% of the world's undernourished people [5,6]. Micronutrient deficiencies can occur at any age but are more prevalent in children, and thus cumulatively can have a long term impact across the life span [7]. It is well documented that this deficiency influences the overall development in children, including their cognitive abilities, [8,9] physical performance, [10-12] and fitness

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levels [13-15]. Consequently, micronutrient deficiencies can have a significant negative impact on academic and extracurricular performance [16,17].

According to reports, India seems to be transitioning through an interesting paradox of the coexistence of both undernutrition and over-nutrition in children [18]. This contradiction is probably due to extreme diversity in socioeconomic (SCE) status, cultural backgrounds, attitudes, and belief systems. However, regardless, the risk of micronutrient deficiency is high in India [19]. In recent years several studies link micronutrient deficiency in children below the age of eleven (<11) years to specific diseases as a result of deficiencies due to Iron, Iodine, Vitamin B6, and B12 alone or in combination [20,21]. It is important to note that the body does not make that micronutrient, and thus deficiencies are primarily a result of inadequate consumption of the food we eat. Thus, the monitoring of micronutrient intake in a child's diet, identifying sub-clinical deficiencies, and treating them earlier in life is of paramount importance. Also, it has always been assumed that children from low SEC strata, regardless of under nourishment or over nourishment, suffer micronutrient deficiencies to a greater extent than children belonging to high socioeconomic strata [22]. Given the paucity of literature that has examined micronutrient intake in typically developing Indian elementary school children across different socioeconomic strata, the objectives of the current study were two-fold: (1) determine the intake of micronutrients in elementary school children compared to age-specific, recommended daily allowance (RDA), [23] and (2) determine the intake of micronutrients in elementary school children across socioeconomic strata.

METHOD

Participants

Three hundred and sixty-six **(**366) healthy elementary school children, both girls and boys, between the ages of 6 -14 years, and who understood simple instructions in English or the local language, were recruited for the study. Children with known medical conditions and or disabilities were excluded from the study. All participants voluntarily assented, and their parents consented before they participated in the study. Approval for the study was taken from the school management and the institutional ethical committee prior to the start of the study.

Instruments

Body Mass Index (BMI)

The height and weight of all participants were recorded with the help of a stadiometer and a digital weighing machine, respectively. The BMI for each child was calculated using the formula, Weight (Kg) / Height * Height (m)

Dietary Intake Questionnaire

The children's micro-nutritional status was assessed using the Dietary Intake Questionnaire [24]. Children were requested to recall the quantity and type of food items and or beverages, including snacks consumed by him/her during the past 24 hours.

Diet Cal Software

The micronutrient intake for Calcium, Iron, Magnesium, Vitamin A, C, B6, and B12 was calculated with the help of DIET CAL† (version 10), a software used for dietary assessment and planning. Data from the 24-hour recall questionnaire was manually entered into the software, and the amount of micronutrient intake was calculated using standard methods [25].

Socioeconomic (SCE) Status Gird Questionnaire

SCE status was assessed using the urban socioeconomic status grid questionnaire. The questionnaire categorized each child on the basis of property, land ownership, and financial status of the person (s) responsible for running the household [26].

Procedure

School authorities and/or principals of public and government schools located in the East Zone of Delhi/ NCR were approached for permission to conduct the study. Following written permission from the authorities, consent from the parents and student ascent, a participant sample was identified using a screening questionnaire. The SCE questionnaire was given to the child's parents to assess their socioeconomic status, while BMI was calculated using a standard height and weight formulae†. The children's nutritional status was assessed with a 24-hour recall questionnaire, and the micronutrient intake was calculated offline using the DIETCAL computer software program for each child. Student 't' tests were

†DIETCAL Software- Version 10, Profound Solution 2015, India.

used to compare micronutrient intake with age-specific RDA across gender and SCE categories. All comparisons were evaluated at $p < 0.05$.

RESULTS

Demographics

A total of three hundred and sixty-six (366) elementary school children with a mean age of 11.05 ±1.66 years completed the study. The sample consisted of 61% of girls and 39% boys. The demographics of the sample are shown in Table **1**. Fifty-three per cent (53%) of the children belonged to the high SCE strata, 39.6% from the middle SCE strata, and 7.3% from the low SCE strata. As participants from the low SCE category were relatively few, this category was merged with the middle SCE category to create a mid-low SCE category (46.9%) for the purpose of all statistical comparisons going forward.

Further categorizations using age-specific BMI percentiles were used to divide the sample into normal, underweight, and overweight categories. Accordingly, it was observed that 70.49% of the total sample (out of 366) had Normal BMI, 15.84% of the children were underweight, and 15.02% of the children were overweight/ obese. The number of underweight children was maximum in the Mid-low SCE strata (27.48%), while the overweight/ obese children were from the high SCE strata (25.2%) (Table **1**).

Micronutrient Deficiency in Elementary School Children of Age 6 - 9 Years

As seen in Table **2**, we found a large percentage of children in this age group were deficient in the intake of all the micronutrients tested, except for Magnesium, where only a small number were deficient. Similarly, children belonging to both SCE strata were deficient in micronutrients except Magnesium.

Not surprisingly, as seen in Table **3**, the daily intake of all the micronutrients, except Magnesium, were also found to be significantly lower than the recommended daily allowance; however, there were no differences between children belonging to the high and mid-low socioeconomic status in the intake of Calcium, Magnesium, and the vitamins tested. Magnesium's

Table 1: Percentile Distribution of Children that were Underweight and Overweight According to Age, Gender, and Socioeconomic Status

Age Years	Female (%) N= 223			Male (%) N= 143			High SCE (%) N= 194			Mid Low SCE (%) N= 172		
	U	N	O	U	N	O	U	N	O	U	N	O
6-9 yrs	39.2	60.7	0	21.1	76.3	2.6	21.1	76.3	2.8	17.8	78.5	3.5
10-12 yrs	21.4	65.6	11	0	64.2	35.8	0	58.6	41.4	26.3	62.1	11.6
13-14 yrs	12.5	87.5	0	0	72.7	27.3	0	63.6	54.5	12.5	80	7.5
*Total	17.1	67.5	14.4	3.5	62.8	33.7	5.1	69.7	25.2	27.48	63.1	3.5

U= Underweight, N= Normal, O= overweight.
*Total was calculated with respect to separate N in female (irrespective to SCE), Male ((irrespective to SCE), High SCE (irrespective to gender) & Mid-low SEC (irrespective to gender) Category.

Table 2: The Percentage of Children with Micronutrient Deficiency in 6 – 9 Years, Including the Percentage of Deficient Children in the High and Mid-Low SCE Strata

Micro-nutrients	All students N= 67	High SCE N= 38	Mid-Low SCE N= 29
Calcium	82.08%	86.85%	75.87%
Iron	92.53%	97.37%	82.76%
Magnesium	17.91%	7.89%	27.58%
Vitamin B6	62.69%	57.9%	68.97%
Vitamin B12	31.34%	28.94%	31.03%
Vitamin C	43.28%	39.47%	44.82%
Vitamin A	85.07%	86.85%	82.76%

Table 3: Comparison of Total Micronutrients Consumed by Elementary School Children Age 6 – 9 Years Relative to RDA and Comparison between High and Mid-Low SCE Students

Micronutrients	RDA	Overall		SCE		
		Mean ±SD	Overall vs RDA p-value	High Mean ±SD	Mid-Low Mean ±SD	High vs mid-low p-value
Calcium	600 mg/d	453.83 (± 186.9)	< 0.05*	426.41 (± 177.2)	489.1 (± 196.3)	>0.05
Iron	16 mg/d	11.28 (± 3.4)	< 0.05*	10.11 (± 3.23)	12.83 (± 3.12)	< 0.05*
Magnesium	100 mg/d	165.66 (± 63.8)	< 0.05*	175.68 (± 56.1)	152.53 (± 71.6)	>0.05
Vitamin B6	1.6 mg/d	1.34 (± 0.5)	< 0.05*	1.39 (± 0.5)	1.26 (± 0.4)	>0.05
Vitamin B12	0.6 µg/d	0.43 (± 0.3)	< 0.05*	0.41 (± 0.3)	0.43 (± 0.4)	>0.05
Vitamin C	40 mg/d	46.37 (± 24.5)	< 0.05*	43.64 (± 19.4)	49.97 (± 29.8)	>0.05
Vitamin A	600 µg/d	355.41 (± 171.1)	< 0.05*	364.83 (± 166.1)	343.07 (± 179.5)	>0.05

overall intake was found to exceed RDA values, and there was no difference between the two groups.

Interestingly, iron deficiency was significantly greater in the high socioeconomic strata (10.11 mg/d) compared to the mid-low SCE group (12.83 mg/d), albeit together, the intake of both groups was significantly lower than the RDA.

Micronutrient Deficiency in Elementary School Children of Age 10 - 12 Years

As seen in Table **4**, we found a large percentage of children in the 10 - 12 age group who were deficient in the intake of Calcium, Iron, and Vitamin B6 of considerable significance was that more than ninety per cent of this age group had iron deficiency.

However, as seen in Table **5**, compared to RDA, all the children were deficient in the micronutrients tested, except magnesium and vitamin C. Magnesium for both male and female, as with the 6-9 year children, continued to be more than the required RDA values for both SCE strata. It is important to note that the intake of Iron for both males and females was significantly lower than the daily recommended allowance (RDA). It was also observed that the mid-low SCE children had a significantly lower intake of Iron than children belonging to the high SCE group.

The overall intake of Vitamin A, B6, and 12 compared to RDA was significantly lower; however, there was no difference between the two SCE groups.

Micronutrient Deficiency in Elementary School Children of Age 13 - 14 Years

In 13 - 14-year-old children, there was a significantly large number of children across both SCE strata who were deficient in the intake of Calcium, Iron, vitamin B6, and Vitamin A. Interestingly, it is important to note that the percentage of children with a deficiency in magnesium intake also increased compared to the other age groups (Table **6**). However, when the intake of micronutrients was compared with RDA values, it was found that there was a significant reduction of intake of all micronutrients, except for Magnesium and Vitamin C. As with other age groups, the intake of Magnesium exceeded RDA values. The comparisons

Table 4: The Percentage of Children with Micronutrient Deficiency in 10 – 12 Years of Age Group, the Percentage of Deficient Children in the High and Mid-Low SCE Strata

Micro-nutrients	All students N= 248	High SCE N= 145	Mid-Low SCE N= 103
Calcium	54.03%	39.32%	75.73%
Iron	94.76%	92.42%	98.06%
Magnesium	28.63%	23.45%	34.95%
Vitamin B6	74.20%	66.9%	84.47%
Vitamin B12	30.65%	24.14%	39.81%
Vitamin C	52.42%	58.62%	45.63%
Vitamin A	83.87%	84.83%	82.53%

Table 5: Comparison of Total Micronutrients Consumed by Elementary School Children Age 10 – 12 Years Relative to RDA and Comparison between High and Mid-Low SCE Students

Micronutrients	RDA	Overall		SCE		
		Mean ±SD	Overall vs RDA p-value	High Mean ±SD	Mid-Low Mean ±SD	High vs mid-low p-value
Calcium	800 mg/d	609.59 (±424.5)	< 0.05*	697.69 (±314.2)	485.58 (±309.4)	< 0.05*
Iron (Male)	21mg/d	13.57 (±4.7)	< 0.05*	13.82 (±4.7)	10.42 (±3.5)	< 0.05*
Iron (Female)	27mg/d	10.95 (±4.9)	< 0.05*	12.10 (±5.4)	10.20 (±4.4)	< 0.05*
Magnesium (Male)	120 mg/d	186.34 (±72.5)	< 0.05*	189.86 (±74)	141.18 (±25.7)	< 0.05*
Magnesium (Female)	160 mg/d	197.71 (±84.2)	< 0.05*	196.22 (±74.3)	198.60 (±90.1)	>0.05
Vitamin B6	1.6 mg/d	1.16 (±0.5)	< 0.05*	1.29 (±0.6)	0.98 (±0.5)	< 0.05*
Vitamin B12	0.6 µg/d	0.47 (±0.2)	< 0.05*	0.47 (±0.4)	0.47 (±0.3)	>0.05
Vitamin C	40 mg/d	41.46 (±22.6)	>0.05	39.52 (±21.9)	44.14 (±23.3)	>0.05
Vitamin A	600 µg/d	374.81 (±174.8)	< 0.05*	369.32 (±176.6)	382.54 (±172.9)	>0.05

Table 6: The Percentage of Children with Micronutrient Deficiency in the 13-14 Age Group, the Percentage of Deficient Children in the High and Mid-Low SCE Strata

Micro-nutrients	All students N= 51	High SCE N= 11	Mid-Low SCE N= 40
Calcium	76.47%	81.81%	92.5%
Iron	96.07%	90.9%	95%
Magnesium	45.10%	45.46%	45%
Vitamin B6	74.51%	9.1%	92.5%
Vitamin B12	33.34%	36.37%	32.5%
Vitamin C	50.99%	54.55%	50%
Vitamin A	90.20%	90.91%	90%

Table 7: Comparison of Total Micronutrients Consumed by Elementary School Children Age 13 -14 Years Relative to RDA and Comparison between High and Mid-Low SCE Students

Micronutrients	RDA	Overall		SCE		
		Mean ±SD	Overall vs RDA p-value	High Mean ±SD	Mid-Low Mean ±SD	High vs mid-low p-value
Calcium	800 mg/d	405.08 (±257.3)	< 0.05*	713.20 (±103.8)	320.35 (±219)	< 0.05*
Iron (Male)	32 mg/d	12.76 (±4.3)	< 0.05*	12.76 (± 4.3)	--	NA
Iron (Female)	27 mg/d	9.20 (±3.65)	< 0.05*	--	9.20 (±3.6)	NA
Magnesium (Male)	165 mg/d	172.22 (±55.7)	>0.05	172.22 (± 55.7)	--	NA
Magnesium (Female)	210 mg/d	223.1 (±88.5)	< 0.05*	--	223.1 (±88.5)	NA
Vitamin B6	2.0 mg/d	1.1 (±0.6)	< 0.05*	1.95 (±0.4)	0.86 (±0.4)	< 0.05*
Vitamin B12	0.6 µg/d	0.41 (±0.3)	< 0.05*	0.36 (± 0.3)	0.41 (±0.3)	>0.05
Vitamin C	40 mg/d	39.67 (±20.6)	>0.05	35.41 (±18.2)	40.83 (±21.3)	>0.05
Vitamin A	600 µg/d	384.64 (±152.6)	< 0.05*	322.19 (±150.8)	399.27 (±150.7)	>0.05

Table 8: Food Groups Consumed by Children from High and Mid-Low SCE Category

Food Groups	High SCE	Mid- Low SCE
Milk and Milk products	Milk, Buttermilk, Curd, Cottage cheese (Paneer), Butter, Cheese	Milk, curd
Vegetables and Legumes/pulses	Potato, Okra, Beans, Yellow Lentil (Moong dal), Yellow split peas (Arhar dal), Chickpeas (Chole), Kidney beans (Rajma), black gram lentils (Urad dal)	Potato, okra, yellow lentil (Moong Dal), Chickpeas (Chole), Kidney beans (Rajma)
Grains	Indian Bread (Roti, Stuffed Paratha, plain paratha, puri), Bread Rice	Indian Bread (Roti, Pain Paratha, puri), Rice
Fruits	Banana, guava, grapes, Orange, Apple, Papaya	Banana, Oranges
Meat/Fish/ Poultry/eggs	Egg, chicken, meat	Eggs, Chicken
Junk Food	Pizza, Burger, French fries, Chowmein, chips, biscuits	Chowmein, Chips

across SEC strata for the differential intake across gender were not possible as data was incomplete (Table **7**). This was due to the convenient sampling, and the male students from the mid-low category in the age group of 13-14 years did not volunteer in the study.

Food Group Consumed

As seen in Table **8**, children predominantly consumed a vegetarian diet of cereal and legumes/pulses. Their consumption of animal proteins was primarily in the form of milk, eggs, and chicken. Children from the high SCE category consume a greater variety of milk and milk products, vegetables, legumes, and grains as compared to the mid-low SCE category. In addition, children from mid-low SCE strata consumed fewer fruits, and were limited in their choices compared to children from the high SCE category. Finally, children from the High SCE category ate more junk food compared to children belonging to the mid-low SCE category (please refer to Table **8**).

DISCUSSION

Overall, it was observed that regardless of age, gender, and or socioeconomic status, a representative sample of Indian elementary school children was grossly deficient in the intake of necessary micronutrients that are required for normal development. Regardless of economic status, the diet of children consisted predominantly of cereal and pulses, and to a much lesser extent, fruits, vegetables, milk, and animal proteins. Others have reported it that the cereal, pulse-based Indian diet is quantitatively deficient in micronutrients, particularly Calcium, Iron, and Vitamins [27 34]. It is not surprising thus that a survey done by the International Institute for Applied System Analysis (IIASA) in 2018 found that approximately two-thirds of the Indian population was deficient in micronutrients [28, 35]. It is important to note that the only source of micronutrients is the type of food consumed as the body does not have the ability to produce them. Accordingly, it is imperative that children have access to various food types and that the consumption of essential nutrients be closely regulated by parents and public health professionals, as micronutrients play an important role in the vital functioning of the body thus optimal health.

The BMI of most of the children tested (70.49%) was in the normal range; however, approximately 15.84% of the children were underweight, with a large percentage belonging to the Mid-low SCE strata (82%). Several researchers have reported prevalence rates of undernutrition between 13-30 % from regions across India [29,30], and this has been linked to social status, parent's level of education, availability of nutritious food, lack of breast feeding, access to safe water, etc. [36]. Paradoxically, approximately 15% of our sample were found to be in the overweight/obese category, and not surprisingly, 89% of these children belonged to the high socioeconomic strata. Previous studies have reported over nutrition being prevalent in affluent families [30,31] and have attributed it to a health and nutritional transition in India, which is characterized by the overconsumption of energy-dense food and low physical activity in schools, as well as at home. Children of all ages, it appears, are more interested in playing games on a smartphone while lying in bed and eating chips or a pizza than in going out and playing.

The intake of micronutrients, except magnesium and Vitamin C, were significantly lower than the

recommended daily allowance in all elementary school children regardless of age, gender, or SCE status. Similar results have been reported by Sivakumar *et al*. [32]. This lack of consumption of essential nutrients could be due to low bioavailability, ignorance regarding the importance of diverse food consumption, and/or not eating certain types of food for religious reasons [18]. Additionally, it has been reported that parents' educational status, occupation, birth order of the children, number of siblings, and family income correlate significantly with food consumption and nutritional deficiencies [33,34]. A common misconception is that these factors are relevant only to children from mid-low SCE strata, and thus deficiencies in consumption will primarily be seen in only these children. However, we found similar deficits in micronutrient consumption in children from high SCE strata as well. It appears that parents, regardless of socioeconomic status, focus primarily on the intake of macronutrients rather than providing meals that are a judicious balance between macro and micronutrients.

It is well known that the Indian diet is predominantly a cereal and pulse-based diet [34]. Similarly, it was observed that the daily diet of children in our study, irrespective of SCE status, predominantly consisted of cereals and pulses. Their diet lacked a variety of fresh seasonal fruits, eggs, chicken/meat, fish, and dairy products, similar to what others have also reported in the literature [34, 35]. Also, most of the children in our study were vegetarian. Their cereal-pulse-based Indian diet was thus, qualitatively and quantitatively, deficient in micronutrients, particularly Calcium, Iron Vitamin A, and Vitamin B complex. The National Nutrition Monitoring Bureau (NNMB) has reported that the Indian diet is adequate only in vegetable proteins, but otherwise, to a great extent, is deficient in most essential nutrients [36-38].

Intake of Iron

Iron is a vital micronutrient necessary for human wellbeing and children's development during their growing years, as its availability in the blood determines oxygen-carrying capacity. Consequently, iron deficiencies can lead to severe cognitive and physical deficits that unfortunately continue to manifest well into adulthood. A survey conducted by IIASA (2018) found that Iron deficiency in the Indian population was as high as 90%. In our study, we found that 92-96% of the children, irrespective of age and SCE status, were vegetarians and consumed food that was low in Iron, and thus their intake was much less than the recommended daily allowance (RDA). It has been reported that the Indian vegetarian diet, particularly in the urban areas, has a relatively low density of Iron – approximately 9.0 mg/1000 Kcal [23]. Thus, it is imperative that in order to meet minimum RDA requirements and avoid intake deficiencies, children be provided food that is fortified with this vital micronutrient and or is given iron supplements. It is well established that anaemia secondary to Iron deficiency continues to be a major health problem in India. It is known to adversely affect cognitive capacity, work capacity, and physical and mental endurance [19, 39]. Moreover, long-standing deficits lead to recurrent infections, low immunity, behavioural problems, an inability to develop psychomotor skills, and consequently result in poor academic performance and social development [39]

Intake of Vitamins (A, B6, B12, and C)

Vitamins are essential micronutrients that serve as building blocks and help by facilitating the efficient functioning of all body systems. They are needed, albeit in small quantities, to sustain healthy living and are abundantly available in a well-rounded, healthy food plan that consists of fruits, vegetables, cereals, and meat products [40]. Vitamins are of two kinds – fat-soluble (e.g., Vitamin A) that can be stored in fat, and water-soluble (e.g., Vitamin B, C), which are absorbed in the intestines, while the excess is excreted out and hence need to be replenished daily. Unfortunately, the body does not have the capability to produce them, and thus they have to be consumed by eating food products that contain vitamins or supplemented through medicines. In this study, astoundingly it was observed that elementary school children of both genders, of all ages, and regardless of SCE status, had a low intake of foods that contained Vitamin – A(83- 90.2 %), B6 (62- 74%), B12 (30-33%) and C (43-52%), and were significantly below the recommended daily allowance that has been stipulated for Indian school-going children. Similarly, an IIASA survey that examined the Indian diet using the National Sample Survey of consumption Expenditure found the food consumed by Indians to be severely deficient in a number of micronutrients, including essential Vitamins.

Deficiencies in Vitamin B (6 and 12) are important for producing energy, metabolic function, healthy cognitive function, and a fully functioning and efficient cardiovascular and nervous system. Consequently, deficiencies in the intake of these Vitamins will gradually lead to cognitive and physical performance

deficits that will permanently and negatively impact the growth and development of a child. Research has documented a strong association between diminished physical performance, decreased endurance levels, and the early onset of lactate accumulation with exercise with Vitamin B 12 deficiencies; and reduced academic levels with low levels of Vitamin B6 [19]. Vitamin A plays an important role in regulating many physiological functions in the body like visual acuity, overall growth and development; while Vitamin C is important for the production of healthy connective tissue, muscles and skin [41]. Foods that are a good source of vitamins are meat, fish, milk, eggs, nuts, citrus fruits, tomatoes, and green vegetables. Significantly, a large part of Indian elementary school children are vegetarian, and it is difficult to meet the RDA through the intake of only vegetables, especially if they do not like to eat green leafy vegetables. It is hence important that Indian school children supplement their diet to include Vitamin supplements, or else they will be in danger stunting or compromising their physical, mental and social development [7, 10].

Intake of Calcium

Calcium plays a vital role in maintaining the strength of the body's musculoskeletal framework, the integrity of the teeth, the smooth functioning of the blood clotting mechanism, and the integrity of the nervous system [42]. Furthermore, it is also required to carry out several important functions, such as coordinated muscle work during physical activity, efficient neurotransmission, and the release of hormones and enzymes for the body systems' efficient functioning. Our study found an inadequate dietary calcium intake across gender and SCE in elementary school children aged 6-14 years. Surprisingly, it was the second most prevalent deficiency in intake amongst the micronutrients studied, ranging from 54.03% to 82.08% (across age groups). Given that elementary school children are in a developmental phase, Calcium's reduced intake can significantly impact neural function, immune function, dental function, and bone and muscle health [43, 44]. It has been reported that long-standing low dietary calcium intake in children during their growing years, particularly in the girl child, leads to decreased bone density, osteoporosis and fractures later in life [44]. This deficiency can be predominantly due to a cereal-based diet, and/or a lack of or a reduced intake of milk or milk products that were reported by children surveyed in this study. Similar results of deficiencies in Calcium intake in Indian populations have been reported by others as well [45, 46].

CONCLUSION

Micronutrient deficiencies due to poor diet is a problem experienced by Indian elementary school children across the country. This ‘hidden hunger’ leads to anaemia, infectious diseases due to a lack of immunity, night blindness etc. Interestingly, as observed in this study, and as reported by others, these deficiencies are primarily due to the consumption of food that is quantitatively and qualitatively low in essential micronutrients, e.g., Vitamins, Calcium, and Iron etc. Micronutrients are required by the body, albeit in small quantities, as they provide the basic scaffolding or molecular framework for the human body's vital functions. In other words, they form the essential physiological building blocks of the human body. It is thus important that to avoid these deficiencies, children consume a diverse range of food products that are rich in micronutrients, such as green vegetables and fruits, and /or supplement the diet with nutrient-dense complementary food.

It is surprising that micronutrient deficiencies exist in Indian elementary school children despite government-aided initiatives, such as the free midday-meal program requiring government-aided schools to provide school children with a free nutritious meal daily. Such programs may focus on caloric intake, i.e., macronutrients, rather than on micronutrients. Thus, it is imperative to supplement the diet of children with nutrient rich food to avoid problems due to micronutrient deficiencies, such as stunted growth, cognitive delays, decreased immunity, etc. It is important to acknowledge that most of the children who participated in this study were vegetarians and primarily consumed a cereal-pulse Indian diet. Surprisingly, despite accessibility to nutrient-rich food, children from the high SCE strata were found to be equally deficient in micronutrient intake. This suggests that it is important to educate families across SCE strata to modify their children's dietary behaviour by increasing the consumption of nutrient dense foods, such as fruits and vegetables. Future multicentre studies should be designed to assess the impact of nutrient-rich food diversification, the comparison of micronutrient intake in over-nourished and under-nourished children, parental attitudes, and the long-term impact of nutrient-rich food consumption in school children.

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REFERENCES

[1] Srivastava A, Mahmood SE, Srivastava PM, *et al*. Nutritional status of school-age children - A scenario of urban slums in India. Arch Public Health 2012; 70: 8-12. https://doi.org/10.1186/0778-7367-70-8

[2] St. Leger L, Young IM. Creating the document: Promoting health in schools: from evidence to action. Global Health Promot 2009; 16(4): 69-71. 4. https://doi.org/10.1177/1757975909348138

[3] Rezaeian S, Ahmadzadeh J, Esmailnasab N, Veisani Y, Shayan M, *et al*. Assessment of Health and Nutritional status in children based on School screening programs health scope. Health Scope 2014; 3(1): 1-5. https://doi.org/10.17795/jhealthscope-14462

[4] Karak P, Maiti R, Das P, Karmakar A. Assessment of the nutritional status of school children in rural and urban areas of Bankura, West Bengal. IJPSR 2018; 9(1): 338-345

[5] Food and Agriculture Organization. The State of Food Insecurity in the World: Addressing food insecurity in protracted crises, Report, Rome 2010. Available from: http://www.fao.org/docrep/013/i1683e/i1683e.pdf [Last accessed on 2011 June 11]

[6] Kamath R, Kumar M, Pattanshetty S, Kamath A. Nutritional status assessment of school children in Mangalore city using the multicenter growth reference study WHO 2007 Z-scores. International Journal of Nutrition, Pharmacology, Neurological Diseases 2012; 2(3): 233- 236. https://doi.org/10.4103/2231-0738.99476

[7] Sarma K, Rameshwar. Micronutrients - An Essential Aid to Daily Growth in Children. Indian Pediatrics 2009; 46: S12-19

[8] Benton D. The influence of dietary status on the cognitive performance of children. Mol Nutr Food Res 2010; 54: 457-470. https://doi.org/10.1002/mnfr.200900158

[9] McCann JC, Ames BN. An overview of evidence for a causal relation between iron deficiency during development and deficits in cognitive or behavioral function. Am J Clin Nutr 2007; 85: 931-945. https://doi.org/10.1093/ajcn/85.4.931

[10] Vaz M, Pauline M, Unni US, Parikh P, *et al*. Micronutrient Supplementation Improves Physical Performance Measures in Asian Indian School-Age Children. J Nutr 2011; 141: 2017-2023. https://doi.org/10.3945/jn.110.135012

[11] Weight LM, Noakes TD, Labadarios D, Graves J, Jacobs P, Berman PA. Vitamin and mineral status of trained athletes, including the effects of supplementation. Am J Clin Nutr 1988; 47: 186-91. https://doi.org/10.1093/ajcn/47.2.186

[12] Kapil U, Bhavna A. Adverse effects of poor micronutrient status during childhood and adolescence. Nutr Rev 2002; 60: S84-S90. https://doi.org/10.1301/00296640260130803

[13] Matton L, Thomas M, Wijndaele K, Duvigneaud N, Beunen G, Claessens AL, *et al*. Tracking of physical fitness and physical activity from youth to adulthood in females. Med Sci Sports Exerc 2006; 38: 1114-1120. https://doi.org/10.1249/01.mss.0000222840.58767.40

[14] Desai IK, Kurpad AV, Virginia R. Chomitz, Thomas T. Aerobic Fitness, Micronutrient Status, and Academic Achievement in Indian School-Aged Children. PLoS ONE 2015; 10(3): 1-13. https://doi.org/10.1371/journal.pone.0122487

[15] Subramani Y. Effect of multiple micronutrient supplementation on growth, whole-body endurance, forearm muscle strength, forearm endurance and visual reaction time; [dissertation]. Rajiv Gandhi University of Health Sciences: Bangalore 2010.

[16] Hughes D, Bryan J. The assessment of cognitive performance in children: considerations for detecting nutritional influences. Nutr Rev 2003; 61: 413-422. https://doi.org/10.1301/nr.2003.dec.413-422

[17] Khor GL, Misra S. Micronutrient interventions on cognitive performance of children aged 5-15 years in developing countries. Asia Pac J Clin Nutr 2012; 21: 476-486.

[18] Indian National Science Academy. Micro-nutrient security for India-priorities for research and action. Report 2011.

[19] Swaminathan, Edward BS, Krupa AV. Micronutrient deficiency and cognitive and physical performance in Indian children. European Journal of Clinical Nutrition 2013; 67: 467-474. https://doi.org/10.1038/ejcn.2013.14

[20] Thankachan P, Rah JH, Thomas T, Selvam S, Amalrajan V, Srinivasan K, *et al*. Multiple micronutrient-fortified Rice affects physical performance and plasma vitamin B-12 and homocysteine concentrations of Indian school children. J Nutr 2012; 142: 846-852. https://doi.org/10.3945/jn.111.149021

[21] Umamaheswari K, Bhaskaran M, Krishnamurthy G. Hemamalini, Vasudevan K. Effect of iron and zinc deficiency on short term memory in children. Ind Pediatr 2011; 48: 289-293. https://doi.org/10.1007/s13312-011-0060-7

[22] Karak P, Maiti R, Das P, Karmakar A: Assessment of the nutritional status of school children in rural and urban areas of Bankura, West Bengal. Int J Pharm Sci & Res 2018; 9(1): 338-45.

[23] National Institute of Nutrition. Nutrient requirements and Recommended Dietary Allowances for Indians. Indian Council of Medical Research, Hyderabad 2010.

[24] Gibbson & Ferguson. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries, International Food Policy Research Institute (IFPRI), International Center for Tropical Agriculture (CIAT) 2008.

[25] Kaur G. Profound solutions. DIETCAL software 2015.

[26] Market Research Society of India 2011, *mruc.net* › sites › default › files › NEW SEC System

[27] National Nutrition Monitoring Bureau (NNMB). Diet and nutrition status of populations and Prevalence of hypertension among adults in rural areas. Technical Report No 24. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India 2006.

[28] Rao ND, Min J, DeFries R, Ghosh-Jerath S, Valin H, Fanzo J. Healthy, affordable and climate-friendly diets in India. Global Environmental Change 2018; 49: 154-165. https://doi.org/10.1016/j.gloenvcha.2018.02.013

[29] Mondal T, Mondal S, Biswas M.An assessment of Nutritional status of children of the government-aided primary school of west Bengal. International Journal of Elementary Education 2015; 4(3): 41-45. https://doi.org/10.11648/j.ijeedu.20150403.11

[30] Shivaprakash & Joseph. Nutritional Status of Rural School-Going Children (6-12 Years) of Mandya District, Karnataka. International Journal of Scientific Study 2014; 2(2): 39-43.

[31] Ranjani H, Mehreen T, Pradeepa R, Anjana RM, Garg R, Anand K, Viswanathan M Epidemiology of childhood overweight & obesity in India: A systematic review. Indian J Med Res 2016; 143(2): 160-174. https://doi.org/10.4103/0971-5916.180203

[32] Sivakumar B, Vijayaraghavan K, Vazir S, Balakrishna N, Shatrugna V, Sarma KVR, *et al*. Effect of micronutrient supplementation on the health and nutritional status of school children: study design. Nutrition 2006; 22: S1-7. https://doi.org/10.1016/j.nut.2005.07.009

[33] Kwabla M, Gyan C, Zotor F Nutritional status of in-school children and its associated factors in Denkyembour District, eastern region, Ghana: comparing schools with feeding and non-school feeding policies. Nutr J 2018; 17: 8. https://doi.org/10.1186/s12937-018-0321-6

[34] Ministry of Health and Family Welfare (MoHFW), Government of India, UNICEF and Population Council. Comprehensive National Nutrition Survey (CNNS) National Report, Delhi, India 2019.

[35] Nutrition Foundation of India. Nutrition and physical performance in school-age children. Delhi, India 2009.

[36] Srivastava A, Mahmood SE, Srivastava PM, Shrotriya VP, Kumar B. Nutritional status of school-age children - A scenario of urban slums in India. Arch Public Health 2012; 70(1): 8. https://doi.org/10.1186/0778-7367-70-8

[37] Agte V, Jahagirdar M, Chiplonkar S. Apparent absorption of eight micronutrients and phytic acid from vegetarian meals in ileostomized human volunteers. Nutrition 2005; 21(6): 678-685. https://doi.org/10.1016/j.nut.2004.11.007

[38] Yajnik CS, Deshpande SS, Lubree HG, Naik SS, Bhat DS, Uradey BS, Deshpande JA, Rege SS, Refsum H, Yudkin JS. Vitamin B12 deficiency and hyperhomocysteinemia in rural and urban Indians. J Assoc Physicians India 2006; 54: 775-782.

[39] Shridhar K, Dhillon PK, Bowen L, Kinra S, Bharathi AV, Prabhakaran D, Reddy KS, Ebrahim S. Nutritional profile of Indian vegetarian diets--the Indian Migration Study (IMS). Nutrition Journal 2014; 13(55): 1-9. https://doi.org/10.1186/1475-2891-13-55

[40] Luo R, Yue AI, Zhou H, Shi Y, Zhang L, Martorell R, Sylvia S. The effect of a micronutrient powder home fortification program on anemia and cognitive outcomes among young children in rural China: A cluster randomized trial. BMC Public Health 2017: 17: 38. https://doi.org/10.1186/s12889-017-4755-0

[41] McArdle W, Katch F, Katch V. Exercise Physiology: Nutrition, Energy and Human Performance 7th edition. Lippincott Williams & Wilkins publications 2008; 42-78.

[42] Maughan R. Role of micronutrients in sport and physical activity. British Medical Bulletin 1999; 55(No. 3): 683-690. https://doi.org/10.1258/0007142991902556

[43] Beto JA. The role of Calcium in human aging. Clin Nutr Res 2015; 4(1): 1-8. https://doi.org/10.7762/cnr.2015.4.1.1

[44] Institute of Medicine (US) Committee to Review Dietary Reference Intakes for Vitamin D and Calcium; Ross AC, Taylor CL, Yaktine AL, *et al*. editors. Dietary Reference Intakes for Calcium and Vitamin D. Washington (DC): National Academies Press (US) 2011; 2. Overview of Calcium. https: //www.ncbi.nlm.nih.gov/books/NBK56060/

[45] Ekbote VH, Khadilkar AV, Khadilkar VV, Chiplonkar SA, Mughal Z. Dietary patterns with special reference to calcium intake in 2-16-year-old Urban Western Indian children. Indian J Public Health 2017; 61: 188-93. https://doi.org/10.4103/ijph.IJPH_85_16

[46] Harinarayan CV, Ramalakshmi T, Venkataprasad U. High prevalence of low dietary Calcium and low vitamin D status in healthy south Indians. Asia Pac J Clin Nutr 2004; 13(4): 359-364.

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