

# ANTHROPOMETRIC MEASUREMENTS AND NUTRITIONAL DEFICIENCIES AMONG ADOLESCENT GIRLS IN EAST KHASI HILLS, MEGHALAYA.

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## ABSTRACT

The present study was conducted among 467 unmarried adolescent girls (13-18 yrs) with an aim to assess the anthropometric measurements and to screen for nutritional deficiencies among adolescent girls in East Khasi Hills District of Meghalaya, India. Data on Sociodemographic and clinical examination were collected using a pre-tested semi-structured questionnaire. Parameters viz., height and weight were recorded and BMI was calculated. From the 476 adolescent girls, 55.88 % were aged between 13-15 years, 63.03 % belonged to nuclear families, 69.96 % followed Christianity and 33.82 % belonged to low-income groups. The average standing height and body weight were significantly lower than the ICMR standards ( $p < 0.01$ ) demonstrating growth deficit. The BMI analysis showed that 20 % of the adolescent girls were underweight, 6.09 % were overweight and 1.26 % were obese. Iron Deficiency Anaemia (IDA) was noticed in 35.5 % of adolescent girls, indicating a moderate public health concern. Vitamin C deficiency was observed in 19.6 % of the adolescent girls showing signs of spongy and bleeding gums, also classified as a mild public health problem. Vitamin A deficiency (VAD) was observed in 5 % of adolescent girls and it was classified as a mild public health problem. Additionally, 33.3 % of adolescent girls had Vitamin D deficiency, presenting with muscle and bone pain. In view of these findings, implementing targeted micronutrient interventions is imperative to mitigate deficiencies and strengthen the overall nutritional profile.

**Keywords:** Adolescent girls, Anthropometry, Iron Deficiency, Meghalaya, Nutritional deficiencies.

## INTRODUCTION

Adolescence is an important stage in life, as it is the period when physical, emotional, intellectual changes and developments occur. During this stage, hormones cause physical changes such as puberty and the growth of organs, while the brain continues to develop, allowing for higher-level thinking and abstract

ideas. This stage is the stepping stone for the journey to adulthood, as adolescence gain more independence and take on responsibilities. Adolescent girls are the future mothers; therefore, they wield an important influence in the development of a country.

According to the Centres for Disease Control and Prevention (CDC), anthropometry

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provides a valuable assessment of the nutritional status of children and adults (Fryar *et al.*, 2016). Nutritional anthropometry is an important tool to determine the nutritional status. Quantitative measures of the body taken non-invasively are called anthropometric measurements. The principal core elements of anthropometry involve standing height, body weight, and body mass index (BMI), which are essential for evaluating nutritional status (Casadei and Kiel, 2022). Among anthropometric indices, the body mass index is being more closely linked to nutritional factors rather than genetic ones (Weir *et al.*, 2023)

Clinical observation is the process of careful clinical examination of a person to ascertain their nutritional status. Clinical observation or inspection is one of the most important aspects of physical examination because it leads to diagnosis and treatment. During clinical observation, the clinician uses all their senses to patient effectively. Additionally, they can also identify any underlying clinical symptoms that are not visible to the naked eye (Dover *et al.*, 2023)

Adolescent girls constitute 11.82 percent of the total population of Meghalaya with an

estimated female adolescent population of 3,50,605 (Statistictimes, 2024). Malnutrition remains a significant concern in the East Khasi Hills district, particularly among adolescent girls aged 13 – 18 years, however, its extent has not been specifically quantified in this age group (Radhakrishnan *et al.*, 2021).

Due to the lack of reliable prevalence data and targeted intervention strategies, this issue raises serious public health concerns. Therefore, the present study was undertaken to assess the socio-economic status, body weight, height and clinical signs of adolescent girls aged 13 to 18 years in the East Khasi Hills district of Meghalaya, using nutritional anthropometry and clinical examination.

## MATERIAL AND METHODS

The present study was conducted in the East Khasi Hills districts, Meghalaya, where the state capital Shillong, is located. The towns in East Khasi Hills are the most populous and have the most schools and colleges. Therefore, the lack of prevalence data and intervention strategies remains a pressing issue.

The study was conducted from January 2023 to January 2024 and followed a



Fig. 1: Map of the East Khasi Hills included in the study

descriptive cross-sectional design. The sample size was estimated using an online tool available at <http://riskcalc.org:3838/samplesize/>. A total of 476 adolescent girls aged 13-18 years from the East Khasi Hills were included in the study. A Stratified random sampling method was used to select eight different schools from five blocks - Mawlai, Mawpat, Mylliem, Mawphlang and Mawrykneng - dividing the data into various sub-groups (strata) (Wang and Cheng 2020). Permissions were obtained from schools and informed consent was collected from parents and participants, who were asked to sign a consent form.

### **Ethical Approval**

After obtaining ethical clearance from the Avinashilingam Institute of Home Science and Higher Education for Women, Coimbatore (IHEC clearance No. IHEC/21-22/FSN-26) and the Directorate of Health Services (Medical Institute) Shillong, Meghalaya. Additionally, permission was obtained from the Headmasters of the selected schools and individual consent was secured from the parents of the adolescent girls.

### **Sociodemographic**

A semi-structured questionnaire was used to collect the sociodemographic data.

### **Anthropometric Assessment**

The study followed the standard anthropometric assessment guidelines outlined by Casadei and Kiel (2022), for obtaining general information and anthropometric measurements of adolescent girls.

### **Standing Height**

The height of each adolescent was measured in centimeter using stadiometer. The adolescent girls were instructed to stand upright, facing forward, with their bottoms, shoulders and head touching the walls, heels jointly, toes spaced out and hands hanging by their sides.

### **Body Weight**

The digital human weighing scale, with a maximum capacity of 120 kg and minimum divisions of 0.5 kg was used to record body weight of adolescent girls. Adolescent girls were instructed to stand upright on the scale, barefoot and in minimal clothing without leaning on or holding onto anything and their weights were recorded in kilograms (kg) to the nearest 0.1 kilograms. The instrument was calibrated with known weights at regular intervals. Three consecutive reading was collected for each adolescent girl and the average value was recorded.

### **Body Mass Index (BMI)**

BMI has been advocated as the foremost anthropometric measure for assessing nutritional status. The body mass index is calculated using the formula described below (Thomas *et al.*, 1997).

$$\text{BMI} = \frac{\text{Weight (Kg.)}}{\text{Height (meter }^2\text{)}}$$

### **Socio-demographic assessment**

A semi-structured questionnaire was administered to collect information on the participants socio-demographic status. The questionnaire covered variable such as type of family, religion, occupation of the head of the family, annual household income, parental education and occupation, which were used to categorise the participants based on the Kuppuswamy scale.

### **Anthropometric assessment**

The study followed the standard assessment guideline outline by Casadei and Kiel (2022).

### **Clinical Examination**

Clinical examination was conducted to identify visible signs and symptoms of nutritional deficiencies using the World Health

**Table 1. Sociodemographic Profile of Adolescent Girls****n=476**

| Parameters                                          | Criteria                                  | Freq. | Percent |
|-----------------------------------------------------|-------------------------------------------|-------|---------|
| Age (years)                                         | 13-15                                     | 266   | 55.88   |
|                                                     | 16-18                                     | 210   | 44.12   |
| Type of family                                      | Nuclear                                   | 300   | 63.03   |
|                                                     | Joint                                     | 176   | 36.97   |
| Religion                                            | Christian                                 | 333   | 69.96   |
|                                                     | Hindu                                     | 15    | 3.15    |
|                                                     | Seng Khasi                                | 128   | 26.89   |
| Occupation of the Heads of the Families             | Unemployed                                | 23    | 4.83    |
|                                                     | Craft-related trade workers               | 119   | 25.00   |
|                                                     | Agriculture                               | 133   | 27.94   |
|                                                     | Skilled Workers and Shops & Markets       | 85    | 17.86   |
|                                                     | Sales workers                             | 71    | 14.92   |
|                                                     | Working professionals                     | 38    | 7.98    |
| Family Income (Rs)                                  | Rs. 6,293-47,034 (LI) <sup>a</sup>        | 161   | 33.82   |
|                                                     | Rs. 47,035-62,874 (ULI) <sup>a</sup>      | 142   | 29.83   |
|                                                     | Rs. 25,0000 (EWS) <sup>^</sup>            | 103   | 21.64   |
|                                                     | Rs. 25,001- Rs. 50,000 (LIG) <sup>^</sup> | 70    | 14.71   |
| Educational Qualification of the Head of the family | Illiterate                                | 85    | 17.86   |
|                                                     | Dropout                                   | 48    | 10.08   |
|                                                     | Primary school                            | 133   | 27.94   |
|                                                     | Higher Secondary                          | 123   | 25.84   |
|                                                     | Graduate                                  | 71    | 14.92   |
|                                                     | Post graduate                             | 16    | 3.36    |

<sup>^</sup>HUDCO, 2017; LI-Lower Income; ULI-Upper Lower Income;  
EWS- Economically Weaker Section, LIG- LIG-Low Income Group

Organization (WHO) proforma for nutritional deficiencies. The examination focused on common deficiency indicators such as pallor of the conjunctive and nails (Iron deficiency anaemia), Bitot's spots and night blindness (Vitamin A deficiency), Spongy or bleeding gum (Vitamin C deficiency) and bone muscle tenderness (Vitamin D deficiency).

#### **Data Analysis**

Data were recorded in Microsoft Excel and analyzed using SPSS version 25 (trial version). The tests used in this study were

percentage analysis, mean and standard deviation with a chi-square test and unpaired t-test.

#### **RESULTS AND DISCUSSION**

Table 1 provides information on the sociodemographic features of adolescent girls.

The majority of the selected subjects (55.88 %) were between 13 and 15 years old and belonged to nuclear families (63.03 %). Most of the adolescent girls followed Christianity (69.96%), with a notable proportion identifying as Khasi (26.89 %). The

**Table 2. Mean Body Weight of Adolescent Girls Compared with ICMR Standards**

**n= 476**

| Age (yrs) | Sample size | ICMR Standard (kg) | Mean Body Weight(kg) | SD   | Mean Difference | t <sub>value</sub>  |
|-----------|-------------|--------------------|----------------------|------|-----------------|---------------------|
| 13        | 97          | 43.6               | 37.92                | 5.04 | -5.68           | -7.17*              |
| 14        | 38          | 46.4               | 41.89                | 4.16 | -4.51           | -4.51*              |
| 15        | 121         | 48.4               | 43.35                | 5.45 | -5.05           | -10.20*             |
| 16        | 143         | 49.7               | 44.63                | 4.65 | -5.07           | -9.00*              |
| 17        | 45          | 50.9               | 46.71                | 5.35 | -4.19           | -5.25*              |
| 18        | 39          | 52.0               | 48.59                | 4.60 | -3.42           | -2.89 <sup>NS</sup> |

Source: ICMR , 2024. NS– Not Significant; \*P <0.01 – Statistically Significant

heads of their families were primarily engaged in craft-related trades (27.94 %) and farming (25.00 %), while others worked as skilled laborers and shop or market workers (17.86 %), sales workers (14.92 %), or professionals (7.98 %); a small percentage were unemployed (4.83 %). Family income varied, with 33.82% falling under the low-income group (Rs. 6,293–47,034) and 29.83% under the upper low-income group (Rs. 47,035–62,874), while 21.64% were from the economically weaker section (up to Rs. 25,000) and 14.71 % from the lower income group (Rs. 25,001–50,000). In terms of education, the majority of heads of

families had completed primary school (27.94 %) or higher secondary education (25.84 %), while 17.86 % were illiterate, 14.92 % were graduates, 10.08 % were school dropouts and only 3.36 % were postgraduates.

### **Anthropometric Measurement**

#### **A. Mean body weight**

Table 2 presents the mean body weight of adolescent girls compared with the ICMR (2024) standard.

The results of the study, where in adolescent girls aged 13 to 18 years were

**Table 3. Mean Standing Height of Adolescent Girls**

**n= 476**

| Age (yrs) | Sample size(N= 476) | ICMR *Standard Height(kg) | Mean Standing Height in(kg) | SD    | Mean Difference | t <sub>value</sub> |
|-----------|---------------------|---------------------------|-----------------------------|-------|-----------------|--------------------|
| 13        | 97                  | 152.2                     | 143.09                      | 5.43  | -9.11           | -16.59**           |
| 14        | 38                  | 154.7                     | 144.03                      | 4.16  | -10.67          | -15.81**           |
| 15        | 121                 | 155.5                     | 145.77                      | 10.84 | -9.73           | -9.87**            |
| 16        | 143                 | 156.9                     | 147.49                      | 5.65  | -9.41           | -19.92**           |
| 17        | 45                  | 157.4                     | 148.04                      | 4.99  | -9.36           | -12.58**           |
| 18        | 29                  | 157.8                     | 148.84                      | 5.15  | -8.96           | -9.69**            |

**\*\*P= <0.001 \*ICMR 2024**

assessed for their body weight, showed that the mean body weight for all age groups was consistently lower than the ICMR standard values. Among the 476 selected subjects, the mean weight at age 13 was  $37.92 \pm 5.04$  kg compared to the ICMR standard of 43.6 kg. Similarly, mean weights for ages 14 to 18 were  $41.89 \pm 4.16$  kg,  $43.35 \pm 5.45$  kg,  $44.63 \pm 3.65$  kg,  $46.71 \pm 5.35$  kg and  $48.59 \pm 4.60$  kg respectively, all lower than their corresponding ICMR standards of 46.4 kg, 48.4 kg, 49.7kg, 50.9 kg and 52 kg. An independent t- test showed that these differences were statistically significant ( $p < 0.01$ ) for all age groups except age 18, where the differences was not significant. This indicates a noticeable growth deficit among the adolescent girls in the study when compared to national standards recommended by ICMR (2024).

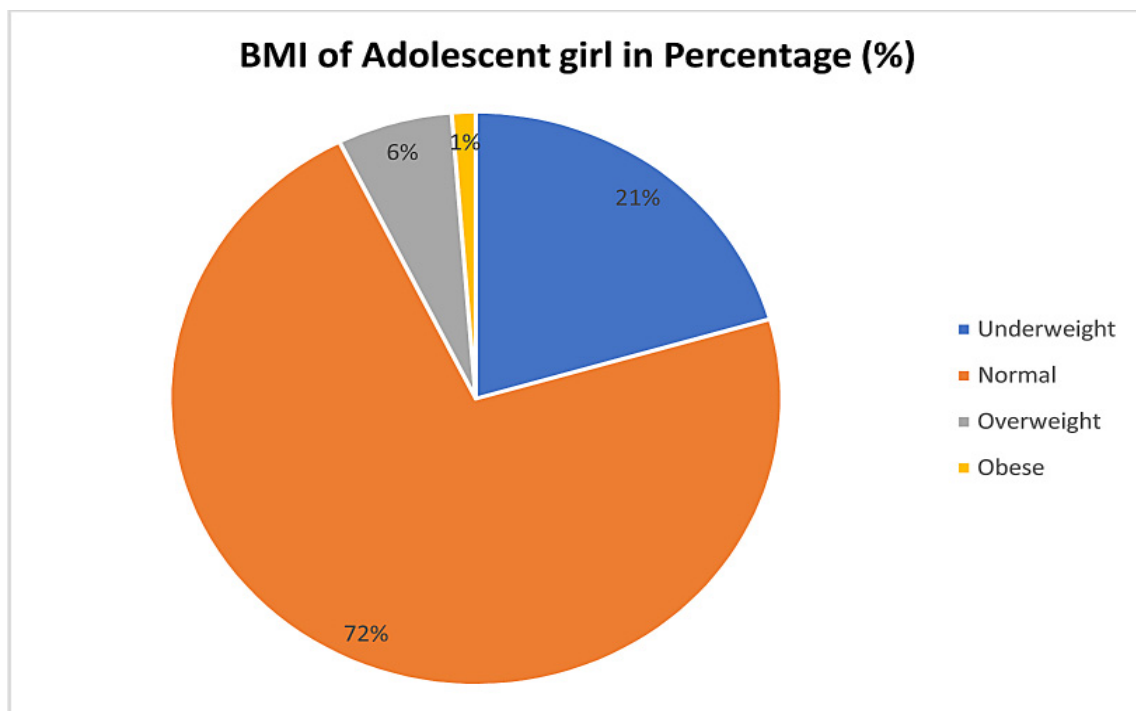
### B. Mean standing height

Table 3 provides the mean standing height of adolescent girls compared with the ICMR reference value (2024).

The average height of adolescent girls aged 13-18 years was 143.09 cm, 144.03 cm, 145.77, 147.49 cm and 148.04 and 148.84 cm, respectively, indicating a gradual improvement in height with age. However, all age groups did not surpass the respective ICMR 2022 standards. Statistical analysis revealed significant deviations from the ICMR standards, with the mean differences ranging from -8.96 cm to -10.67 cm and t-values between -9.69 and -19.92, are highly significant ( $p < 0.01$ ). Despite the general trend of increasing height with age, the average heights of the adolescent girls remained notably below the ICMR standard throughout.

Dipika (2014) reported that the weight and height of girls between the ages of 7 and 9, 10 and 12 were considerably ( $p < 0.05$ ) less than the reference value. (126.4 cm and 142.7 cm) and weight (19, 26.9 and 31.5 kg) respectively.

Majumder *et al.*, (2024) reported that the newly proposed Indian growth references



**Fig. 2.** BMI of Adolescent girls in different age group (N= 476)

**Table 4: Clinical signs on nutritional deficiencies of Adolescent Girls**

**n=476**

| SIGNS                              | East Khasi Hills      |      |                       |      |                           |      |       |
|------------------------------------|-----------------------|------|-----------------------|------|---------------------------|------|-------|
|                                    | Rural Area<br>(n=276) |      | Urban Area<br>(n=200) |      | Total<br>(N= 476)    (÷²) |      |       |
|                                    | No                    | (%)  | No                    | (%)  | No                        | (%)  |       |
| Loss of appetite                   | 96                    | 34.7 | 20                    | 10   | 106                       | 22.2 | 38.64 |
| Oedema                             | 0                     |      | 1                     |      | 1                         |      | 1.38  |
| Muscle wasting                     | 110                   | 23.1 | 50                    | 10.5 | 160                       | 33.6 | 11.47 |
| Irritability                       | 56                    | 11.7 | 37                    | 7.7  | 93                        | 19.5 | 0.24  |
| Hair- Loss of luster/discolored    | 45                    | 9.4  | 29                    | 6.1  | 74                        | 15.5 | 0.29  |
| Dry or rough skin/Hyperkeratosis   | 84                    | 17.6 | 43                    | 9    | 127                       | 26.6 | 4.73  |
| Eyes-pale/ dull                    | 135                   | 28.3 | 34                    | 7.1  | 169                       | 35.5 | 51.58 |
| Angular Stomatitis                 | 30                    | 6.3  | 12                    | 2.5  | 42                        | 8.8  | 3.42  |
| Dermatitis                         | 10                    | 2.1  | 1                     | 0.2  | 11                        | 2.3  | 5.01  |
| Bleeding Gums                      | 50                    | 10.5 | 67                    | 14   | 117                       | 24.5 | 14.8  |
| Bitot's Spot/Conjunctival Xerosis  | 14                    | 2.9  | 18                    | 3.7  | 32                        | 6.7  | 2.85  |
| Dental caries/ Teeth discoloration | 67                    | 14   | 80                    | 16.8 | 147                       | 30.8 | 13.43 |
| Red/ Pigmented/Tongue/Ulceration   | 60                    | 12.6 | 36                    | 7.5  | 96                        | 20.1 | 1.01  |

reveal a consistent downward shift in growth distributions when compared to the WHO global standards, with the exception of the first six months of life. Notably, when applying these India-specific references, the observed rates of growth faltering among Indian children and adolescents dropped by more than 50% compared with the estimations derived from the WHO growth standards.

### C. Body Mass Index (BMI)

Fig. 2 provides the BMI of adolescent girls compared with the Asian-Indian Specific BMI guidelines.

The normal BMI range between (18.5-22.9 kg/m<sup>2</sup>) encompasses the majority 72 % (343) of respondents. However, 20.5% (98) were underweight and had a BMI (<18.5 kg/m<sup>2</sup>), 6.09 % (29) were overweight with a BMI between (23-24.9 kg/m<sup>2</sup>) and only 1.26 % (6) were classified as obese with a BMI (>25 kg/m<sup>2</sup>).

A similar finding by Siraj *et al.*, (2018) showed that about 21 % were early

adolescents (10–13 years) the proportion of underweight. Conversely, girls in the mid and late-adolescent age groups exhibited a significantly lower risk of being underweight, indicating a marked decrease in the prevalence of underweight as age increases

Ravula *et al.*, (2024) reported on the age-specific nutritional status of adolescent girls, revealing key differences between early and late adolescence. The study found an overall prevalence of underweight, stunting, and thinness at 23%, with early adolescents showing a higher rate (26%) than late adolescents (20%). The combined prevalence of underweight and stunting was 17.70%, again higher in early adolescents (22.69%) than in late adolescents (13.06%).

### Clinical Examination

Table 4 shows the clinical signs of nutritional deficiencies in adolescent girls from urban and rural areas.

The prevalence of pale/dull eyes was 35.5 %, indicating that iron deficiency anemia (IDA) was more common in urban girls (28.3 %), while muscle wasting (33.6 %) dental caries (30.8 %) suggested vitamin D deficiency, with muscle wasting higher in urban areas (23.2 %) and dental issues more in rural areas (16.8 %). Dry/rough skin (26.6 %) was more frequent in urban girls (17.6 %), while bleeding gums (24.5 %) indicated Vitamin C deficiency, higher in rural areas (14 %). Red tongue pigmentation (20.1 %) indicating folate deficiency, which is more common in urban girls (12.6 %). Other notable signs included irritability (19.5 %), angular stomatitis (8.8 %), Bitot's spot (6.7 %) linked to Vitamin A deficiency (higher in rural areas) and dermatitis (2.3 %) suggesting Vitamin B3 deficiency. The chi-square analysis revealed significant differences for pale/dull eyes ( $\chi^2=51.58$ ) and loss of appetite ( $\chi^2 = 38.64$ ), with notable variation in muscle wasting ( $\chi^2= 11.47$ ), bleeding gums (14.8) and dental caries/teeth discoloration ( $\chi^2 = 13.43$ ), while irritability ( $\chi^2= 0.24$ ), hair loss/luster (0.29) and red/pigmentation tongue ( $\chi^2 = 1.01$ ) showed no significant association with the area, implying that some clinical signs may be influenced by geographical or socio-economic factors others remain consistent across urban and rural populations.

According to WHO (2024), a prevalence of anaemia between 20.0 % and 39.9 % is considered to have moderate Public Health Significance (PHS). As shown in Table 3, 35.5 % of adolescent girls in East Khasi Hills had Iron Deficiency Anaemia (IDA), placing the district within the WHO moderate PHS category. In addition, 33.3 % of the girls demonstrated Vitamin D deficiency and 19.6 % had Vitamin C deficiency. Both fall under the WHO classification of mild to moderate public health concerns defined as 10-29 % for vitamin C and 20-39 % for vitamin D. Furthermore, 6.7 % of the participants were found to have Vitamin A Deficiency (VAD), which, according to WHO (2-9 %) indicates mild PHS.

The study revealed that majority of the respondent fell in the Lower income group category and the education levels of family heads were found to be at primary level, thus lack of income support and awareness on balanced nutrition. These findings are supported by Sarna *et al.*, (2020) noted that iron deficiency anaemia remains the most common form of anaemia among adolescents, with a national prevalence of 28.4 % (4064 of 14,300). Similarly, Bhalsod *et al.*, (2019) reported high rates of nutritional deficiencies in adolescents with Vitamin B complex deficiency most common (21.9 %), followed by protein-energy malnutrition (10.1 %), fatty acid deficiency (10.9 %), vitamin C deficiency at (8.4 %) and vitamin A deficiency at (7.4 %). Namita *et al.*, (2018) also found that 37.5% of the rural girls, particularly those under 12 years showing signs both tribes revealed that vitamin C deficiency was the most widespread, often indicated by spongy and bleeding gums, followed by iron deficiency anaemia. Taken together, these findings and supporting studies highlight a consistent and concerning burden of micronutrient deficiencies among adolescents, particularly among rural and tribal populations, underscoring the urgent need for targeted nutritional interventions and public health strategies.

## CONCLUSION

The study revealed alarming rates of undernutrition (20.5 %) and multiple micronutrient deficiencies among adolescent girls in the East Khasi Hills district of Meghalaya. Anthropometric measurements, when compared with ICMR (2022) standards, showed significant deficits in body weight and growth parameters. Clinical signs further confirmed a high prevalence of iron deficiency (35.5 %), vitamin D deficiency (30.8 %), fluoride deficiency and vitamin C deficiency (19.6 %), all of which point to a critical public health concern in this population. These findings underscore the urgent need for multi-

faceted interventions focused on nutritional education, improved dietary intake and targeted public health strategies. Raising awareness with nutritionally vulnerable groups, particularly adolescent girls through school based programs, community engagement and policy level support could play a vital role in combating malnutrition and promoting long term health outcomes in the region.

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