

# Underweight and Associated Factors Among Teenage Adolescent Girls in Resource-poor Settings: A Cross-sectional Study

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**Background and Purpose:** Understanding the undernutrition status of teenage adolescent girls living in urban slums and its associated factors is meaningful to formulate customized health strategies. This study aimed to determine the prevalence of being underweight and associated factors among teenage adolescent girls in urban slums.

**Materials and Methods:** In this cross-sectional study, we enrolled a total of 418 teenage adolescent girls from five of 210 urban slums of Varanasi district, Uttar Pradesh, India employing two-stage probability sampling for the selection of households and subjects, between September 2016 and July 2017. The study of underweight subjects was assessed with BMI for age using standard criteria. Factors associated with being underweight were determined by multivariable logistic regression analysis.

**Results:** Of 418 study subjects, 49.76% (208/418) were underweight. Results revealed that sociodemographic factors such as teenage adolescent girls who were from SC/ST (schedule caste/schedule tribe) caste/ethnicity (adjusted odds ratio (AOR)=2.02, 95%CI: 1.00–4.23), subjects whose father's education level was primary or lower (AOR=1.87, 95%CI: 1.12–3.11), and number of people in the family >4 (AOR=2.18, 95%CI: 1.18–4.03) were associated with being underweight. Likewise, dietary behavior-related factors such as vegetarian (AOR=2.21, 95%CI: 1.25–3.92), and <3 meals per day (AOR=2.36, 95%CI: 1.40–3.98) than their counterparts were associated with being underweight. In addition, teenage adolescent girls from food-insecure households (AOR=3.33, 95%CI: 2.01–5.51) were more likely to be underweight than those from food-secure households.

**Conclusion:** The higher burden of underweight among teenage adolescent girls in Indian urban slums needs to be addressed through specific public health interventions such as by improving education, providing education regarding dietary behavior, and having access to sufficient, safe, and nutritious foods.

**Keywords:** cross-sectional study, teenage girls, urban slums, undernutrition, underweight, India

## Introduction

Undernutrition is a universal health concern that affects mainly children and adolescents from low- and middle-income countries (LMICs).<sup>1,2</sup> Undernutrition occurs as a result of insufficient macro- and micronutrient intakes and manifests in four forms: wasting, underweight, growth stunting, and nutritional deficiencies.<sup>1</sup> According to a World Bank report, India accounts for more of the world's undernourished children than any other country, which has huge consequences on childhood and adolescent morbidity and mortality and the national economy.<sup>3</sup> A study being conducted across

eight Indian mega-cities among women with a specific focus on slum–non-slum demonstrated that being underweight was significantly higher in slum dwellers, while being overweight was notably higher in non-slum areas.<sup>4</sup> A number of previous Indian studies<sup>5–7</sup> frequently reported higher percentages (range: 16%–30%) of being underweight among slum-resident adolescent girls from different urban areas.

Adolescents (10–19 years old) comprise one quarter of the world's population.<sup>8,9</sup> This time of life is critically important because it is during this period that rapid growth and development occurs, and thus, adolescents require higher nutrient intakes.<sup>10,11</sup> Furthermore, health and food behaviors are shaped during this period,<sup>12,13</sup> and thus, adolescents are more vulnerable to health and nutrition concerns than other age groups. More importantly, adolescent girls need good quality nutritive foods in sufficient quantity to cope with the added nutritional requirements associated with onset of maturity, menstruation, participation in various physical activities,<sup>14,15</sup> and to reduce health risks and break the intergenerational cycle of malnutrition.<sup>16,17</sup>

Researchers in recent studies overlooked several important predictors of underweight adolescent girls such as sociodemographic and socioeconomic factors,<sup>18,19</sup> parental education,<sup>18,20</sup> occupation,<sup>20</sup> dietary habits<sup>5,18</sup> and food insecurity.<sup>21,22</sup> It is well known that being underweight is one of the major public health concerns in teenage adolescent, especially school-aged children in South East Asian countries as it impacts health, cognition, and educational achievements.<sup>3,23</sup> Moreover, it is well-known that the poor health and adverse nutritional wellbeing of teenage adolescent girls can have far-reaching consequences of intergenerational cycle of malnutrition, productivity, and economy losses.

In the current study setting of the urban slums of Varanasi, Uttar Pradesh, India, data depicted the poor health and wellbeing measures,<sup>24</sup> and to the best of researchers' knowledge, scarce research has been performed of this kind in the current study settings. Although researchers have addressed the relation between adolescent girls' nutritional status and their associates in many Indian resource-poor settings, understanding the underweight status among teenage adolescent girls living in urban slums and its associated factors is meaningful to formulate evidence-based customized preventative and promotional strategies. The aim of this study was to determine the prevalence of underweight teenage adolescent girls and to identify associated factors among those residing in the urban slums of Varanasi district, India.

## Materials and Methods

### Study Design, Setting, and Participants

This community-based, cross-sectional study was conducted among teenage adolescent girls residing in five of 210 urban slums in Varanasi, Uttar Pradesh, India. Inhabitants of these slums lack basic amenities, such as adequate housing, electricity, and access to safe drinking water. We employed a two-stage probability sampling design to select a community-based sample. At first, we identified the total number of slums at different locations in Varanasi district from a list obtained from the Varanasi Slum Profile at Glance report 2011.<sup>25</sup> There are a total of 210 slums in the district situated in five different locations, namely—nonhazardous or nonobjectionable sites, proximity to railway lines, near major nallahs/river, along water body bank or bed, and hazardous areas.<sup>26</sup> Of these, we selected one slum from each of these five locations using simple random sampling method. The households' size of these selected slums ranged from 200 to 1200 households. The Second, we identified the required number of households per slums by using probability proportion to size (PPS). A systematic random sampling method was employed to select the households. Finally, teenage adolescent girls (aged 13 to 19 years) were enrolled from selected households. Only one adolescent girl was selected from each household randomly by using a lottery method when there was more than one. Sample size was estimated by using the formula;  $n=(Z_{1-\alpha/2})^2P*Q/L^2$ , assuming a prevalence of being underweight of 42.6% among adolescent girls,<sup>27</sup> and a nonresponse of 10%. As a result, the required sample size was estimated to be 414. Finally, we enrolled the sample to 418 teenage adolescent girls. We sought the help of local community health volunteers in areas, such as Anganwadi/trained dais, during the recruitment process. Of 440 teenage adolescent girls invited to participate, 418 consented (a response rate of 94.56%). Subjects with mental intellectual disability, developmental delay, autism, or any other condition that inhibited communication or the ability to participate in the study were excluded. Details of the study settings, participants, and other methodological details are described elsewhere.<sup>28</sup>

### Data Collection

Data were collected between September 2016 and July 2017 by five nursing graduates using a structured and semi-structured questionnaire. In order to ensure the quality of data collected, two days of training were provided to

all research assistants before data collection and their performance was monitored. The prepared English version questionnaire was thoroughly checked, pretested in the neighboring district, and necessary modifications were made as required. Questionnaires were translated into the local language (Hindi) and then back-translated into English to ensure translations were accurate. The survey questionnaire was composed of three parts: (1) personal profile (sociodemographic and socioeconomic characteristics, dietary behavior), (2) household food security, and (3) mental health states. Anthropometric measurements (height and weight) of the participants were measured by standard techniques and appropriate landmarks.<sup>29,30</sup> Accordingly, weight was measured to the nearest 0.1 kg using a portable weighing machine (Libra, Libra Weighing Machine Limited, Bangkok, Thailand) and height was measured to the nearest 0.1 cm using anthropometer (Hindustan Minerals, The Hindustan Mineral Products Co. Ltd, Kolkata, India). The subjects were in light clothes and asked to remove their footwear before measuring height and weight. The scales were re-calibrated after each measurement. Accuracy of the scales was verified from time to time against known weights.

## Definition of Variables

### Dependent Variable

Underweight status of study subjects was determined as weight in kilograms divided by height in squared meter and converted to a standard deviation score for pre-adults using standards recommended by Cole et al.<sup>31,32</sup> Scores were classified as normal weight as 0 and overweight and obesity as +1 and +2, respectively, while thinness grades 1, 2, and 3 were coded as -1, -2, and -3. Due to a small number of subjects in the various categories, participants were further classified as presence of underweight (scores between -1 and -3) and absence of underweight (scores between 0 and 3).

### Independent Variables

#### Sociodemographic and Socioeconomic Variables

All sociodemographic variables such as age, religion, caste/ethnicity, type of family, head of family, number of people in the family, number of siblings, duration of residence in slums, family income, and educational levels and occupations of subjects and their parents were categorized as previously described.<sup>28</sup> Socioeconomic (SES) status was determined using the modified Kuppaswamy scale (updated in January 2017), which includes five categories based on scores; lower

class <5, upper lower 5–10, lower middle 11–15, upper middle 16–25, and upper class 26–29.<sup>33</sup> Because of the large number of participants in the lower class, it was further classified as: lower (lower and upper), middle (lower middle and upper middle) and upper.<sup>34</sup>

### Dietary Behavior

The variables related to dietary behavior were as follows: nature of diet (vegetarian: those who consumed diet included milk, dairy products and eggs for at least one year)/nonvegetarian or omnivorous: those who ate meat, including poultry and fish, at least once a week),<sup>35</sup> timings of meals (irregular: those who did not eat any of the regular meal-breakfast, lunch or dinner within two hours time interval for at least one week in the previous month/ fixed: those who ate any of the regular meals—breakfast, lunch or dinner within two hours time interval for at least one week in the previous month), frequency of meals per day (<3 vs ≥3), washing practice for green leafy vegetable (after cutting/before cutting). Types of flour used were classified as sieved (without choker) or unsieved (with choker).<sup>36</sup> Intakes of food items

were determined using a food frequency questionnaire (FFQ)<sup>37</sup> as; daily 2–3 days per week, once a week, sometimes, or occasionally or never. For our analysis, it was further divided into two categories based on consumption patterns. Intake of pulses, green leafy vegetables, other vegetables, and milk were categorized as daily and ≥ once a week, whereas consumptions of fruits and meat and meat products were categorized as sometimes/occasionally and ≥ once a week.

### Household Food Security and Mental Health Status

We adopted The Household Food Insecurity Access Scale (HFIAS) to evaluate food security.<sup>38</sup> This scale classifies individuals into four levels of household food insecurity based on subject recall over the past 30 days: food-secure or mildly, moderately or severely food-insecure. We asked respondents to answer these questions with yes or no response options during the previous four weeks of date of data collection. For those who answered “yes” to a question, a frequency-of-occurrence question was asked, and responses were categorized as: rare (once or twice; response code 1), sometimes (three to 10 times; response code 2), or often (more than 10 times; response code 3). HFIAS scores were used as continuous measures of degrees of household food insecurity and were calculated by summing scores for frequency-of-occurrence

questions for each household. The maximum score for a household was 27, if responded to all nine frequency-of-occurrence questions with a response code of 3 and the minimum score was 0, if the individual answered “no” to all frequency-of-occurrence questions. Thus, higher scores indicated greater food insecurity.<sup>38</sup> Furthermore, the nine food insecurity occurrence questions and nine frequency of occurrence questions were asked to determine how frequently the condition mentioned in the occurrence question occurred. The questionnaire sought the main components of food insecurity, such as, (1) anxiety and uncertainty about household food supply, (2) insufficient quality of food (included food varieties and preferences), and (3) insufficient food intake and its physical consequences.

In order to assess the mental health status of the study subjects, we employed four components of the Mental Health Inventory: anxiety, depression, loss of behavioral control, and psychological distress. These components were further categorized as low, medium or high. The scores were classified as: (1) for anxiety, low 9–24, medium 25–39, and high 40–54; (2) for depression, low 4–10, medium 11–16, and high 17–23; (3) for loss of behavior control, low 9–22, medium 23–38, and high 39–53; and (4) for psychological distress, low 24–60, medium 61–100, and high 105–142.<sup>39–41</sup> Since the proportion of participants in the low category was either very small or zero, we merged low categories into the medium category, and considered one category “low/medium”, and logistic regressions were run (low/medium vs high) as binary outcomes. The details of food insecurity and mental health status measurement is available from our previous publication.<sup>28</sup>

## Statistical Analysis

Data were first entered into EpiData 3.1 and then transferred to SPSS for Windows V. 22.0 (IBM Corporation, Armonk, NY, USA) for the analysis. Multivariable logistic regression was employed to assess associations between independent and outcome variables. We used regression diagnostic procedures to check evidence of multicollinearity or overly influential outliers in the model. However, we did not detect any multicollinearity or overly influential outliers. All variables determined to be important ( $p < 0.10$ ) by univariate analysis were incorporated into the multivariable logistic regression analysis by backward elimination to adjust for simultaneous effects of multiple factors and to control the effects of confounding variables on the response variable. Results are expressed as odds ratios

(ORs) with 95% confidence intervals for binary nutritional status outcomes. All tests were two-tailed and  $p$ -values of  $< 0.05$  were deemed statistically significant.

## Ethics

Ethical approval was obtained from the Ethical Committee of Banaras Hindu University, India (approval number: ECR/526.Inst/UP/2014 Dt.31.1.14). Written informed consent was obtained from either the study subjects who were  $\geq 18$  years of age or from their parents for all those who were  $< 18$  years of age after providing them with comprehensive information about the study. It was made clear to participants that they could leave the study at any time and decide not to respond to any questionnaire. All personal details were removed from files before data analysis.

## Results

### Underweight, Sociodemographic, Socioeconomic Characteristics, Dietary Behaviors, Household Food Insecurity and Mental Health Status of the Study Subjects

Of 418 participants, 49.76% (208/418) were underweight. Of total subjects, slightly more than half (52.0%) of the underweight participants were 17–19 years old, of other backward (OBC) caste/ethnicity (56.7%), from nuclear family (50.2%), were of residence in the slums for  $\leq 30$  year (49.9%), subjects educated to primary level or less (52.3%), and subjects with mothers in the home maker occupation (50.3%) (Table 1).

The result of univariate analysis showed that the study participants' sociodemographic and socioeconomic factors such as subjects with more than four family members in the family, having more than two siblings, working outside (service, business, labor), subjects with parents educated to primary level or less, a father working in agriculture or as a laborer, a family income and socioeconomic status in the first tercile or lower had significantly higher rates of underweight than their counterparts (Table 1). Likewise, the factors related to dietary behavior and intake of food significantly associated with underweight adolescent girls were: vegetarians, irregular intake of meal, meal frequency less than three times/day, washing green leafy vegetables after cutting, intake of vegetables only  $\geq$  once a week, and fruit, and meat and meat products consumption sometimes/occasionally (Table 2). Our study also revealed the

**Table 1** Association Between Being Underweight and Sociodemographic and Socioeconomic Characteristics of Adolescent Girls Living in Resource-poor Settings

| Sociodemographic Characteristics           | Total n=418 (%) | Underweight   |              | OR (95%CI)          |
|--|-----------------|---------------|--------------|---------------------|
|  |                 | Yes n=208 (%) | No n=210 (%) |                     |
| Age  |                 |               |              |                     |
| 13–16 years                                | 216 (51.7)      | 103 (47.7)    | 113 (52.3)   | 0.84 (0.57–1.23)    |
| 17–19 Years                                | 202 (48.3)      | 105 (52.0)    | 97 (48.0)    | Reference           |
| Religion                                   |                 |               |              |                     |
| Hindu                                      | 404 (96.7)      | 201 (49.8)    | 203 (50.2)   | 0.99 (0.34–2.87)    |
| Muslim                                     | 14 (3.3)        | 7 (50.0)      | 7 (50.0)     | Reference           |
| Caste/ethnicity                            |                 |               |              |                     |
| SC/ST (schedule caste/schedule tribe)      | 201 (48.1)      | 93 (46.3)     | 108 (54.7)   | 1.12 (0.63–2.01)    |
| OBC (other backward caste)                 | 157 (37.6)      | 89 (56.7)     | 68 (43.3)    | 1.71 (0.93–3.12)    |
| General (upper caste group)                | 60 (14.3)       | 26 (43.3)     | 34 (56.7)    | Reference           |
| Type of family                             |                 |               |              |                     |
| Joint                                      | 89 (21.3)       | 43 (48.3)     | 46 (51.7)    | 0.92 (0.58–1.48)    |
| Nuclear                                    | 329 (78.7)      | 165 (50.2)    | 164 (49.8)   | Reference           |
| Head of family                             |                 |               |              |                     |
| Male                                       | 374 (89.5)      | 187 (50.0)    | 187 (50.0)   | 1.09 (0.58–2.04)    |
| Female                                     | 44 (10.5)       | 21 (47.7)     | 23 (52.3)    | Reference           |
| Number of people in family                 |                 |               |              |                     |
| >4   | 334 (79.9)      | 177 (53.0)    | 157 (47.0)   | 1.92 (1.17–3.15)**  |
| ≤4   | 84 (20.1)       | 31 (36.9)     | 53 (63.1)    | Reference           |
| Number of siblings                         |                 |               |              |                     |
| >2   | 306 (73.2)      | 165 (53.9)    | 141 (46.1)   | 1.87 (1.20–2.92)**  |
| ≤2   | 112 (26.8)      | 43 (38.4)     | 69 (61.6)    | Reference           |
| Duration of resident in slum               |                 |               |              |                     |
| ≤30 year                                   | 405 (96.9)      | 202 (49.9)    | 203 (50.1)   | 1.16 (0.38–3.51)    |
| >30 year                                   | 13 (3.1)        | 6 (46.2)      | 7 (53.8)     | Reference           |
| Education of subject                       |                 |               |              |                     |
| Primary and lower                          | 149 (35.6)      | 78 (52.3)     | 71 (47.7)    | 1.17 (0.78–1.75)    |
| Secondary and more                         | 269 (64.4)      | 130 (48.3)    | 139 (51.7)   | Reference           |
| Education of mother (n=408)                |                 |               |              |                     |
| Primary and lower                          | 278 (68.1)      | 157 (56.5)    | 121 (43.5)   | 2.21 (1.44–3.40)*** |
| Secondary and more                         | 130 (31.9)      | 48 (36.9)     | 82 (63.1)    | Reference           |
| Education of father (n=379)                |                 |               |              |                     |
| Primary and lower                          | 165 (43.5)      | 100 (60.6)    | 65 (39.4)    | 2.24 (1.48–3.40)*** |
| Secondary and more                         | 214 (56.5)      | 87 (40.7)     | 127 (59.3)   | Reference           |
| Occupation of subjects                     |                 |               |              |                     |
| Working outside (service, business, labor) | 58 (13.9)       | 38 (65.5)     | 20 (34.5)    | 2.12 (1.18–3.79)*   |
| Student                                    | 360 (86.1)      | 170 (47.2)    | 190 (52.8)   | Reference           |
| Occupation of mother (n=408)               |                 |               |              |                     |
| Working outside (service, business, labor) | 90 (22.1)       | 45 (50.0)     | 45 (50.0)    | 0.98 (0.61–1.57)    |
| Homemaker                                  | 318 (77.9)      | 160 (50.3)    | 158 (49.7)   | Reference           |

(Continued)

Table 1 (Continued).

| Sociodemographic Characteristics   | Total n=418 (%) | Underweight   |              | OR (95%CI)          |
|------------------------------------|-----------------|---------------|--------------|---------------------|
|                                    |                 | Yes n=208 (%) | No n=210 (%) |                     |
| Occupation of father (n=379)       |                 |               |              |                     |
| Agriculture/labor                  | 124 (32.7)      | 76 (61.3)     | 48 (38.7)    | 2.95 (1.32–3.18)**  |
| Service/business                   | 255 (67.3)      | 111 (43.5)    | 144 (56.5)   | Reference           |
| Family income                      |                 |               |              |                     |
| First tercile                      | 156 (37.3)      | 103 (66.0)    | 53 (34.0)    | 3.15 (1.95–5.07)*** |
| Second tercile                     | 123 (29.4)      | 52 (42.3)     | 71 (57.7)    | 1.18 (0.72–1.95)    |
| Third tercile                      | 139 (33.3)      | 53 (38.1)     | 86 (61.9)    | Reference           |
| Socioeconomic status               |                 |               |              |                     |
| Lower (lower/upper lower)          | 200 (47.8)      | 128 (64.0)    | 72 (36.0)    | 2.48 (1.30–4.73)**  |
| Middle (lower middle/upper middle) | 170 (40.7)      | 60 (35.3)     | 110 (64.7)   | 0.76 (0.39–1.46)    |
| Upper                              | 48 (11.5)       | 20 (41.7)     | 28 (58.3)    | Reference           |

Notes: \* $p < 0.05$ ; \*\* $p < 0.005$ ; \*\*\* $p < 0.0001$ .

association of household food insecurity and mental health states with underweight among adolescent girls in univariate analysis. Accordingly, adolescent girls with household food insecurity, those with high level of anxiety, depression, loss of behavioral control and psychological distress were significantly associated with being underweight (Table 3).

### Associations Between Being Underweight and Sociodemographic Variables, Dietary Behavior, and Household Food Insecurity

Table 4 shows multivariable logistic regression analysis results for being underweight among the study subjects. Teenage adolescent girls who were from SC/ST (schedule caste/schedule tribe) caste/ethnicity were more likely to (AOR=2.02, 95%CI: 1.00–4.23) to be underweight than general (upper caste group). Subjects whose father's education level was primary or lower (AOR=1.87, 95%CI: 1.12–3.11) had higher odds of being underweight than those whose father's education level was secondary and higher. In addition, vegetarians than nonvegetarians (AOR=2.21, 95%CI: 1.25–3.92), and those who consumed <3 meals a day than those who consumed  $\geq 3$  meals a day (AOR=2.36, 95%CI: 1.40–3.98), number of people in family >4 vs  $\leq 4$  (AOR=2.18, 95%CI: 1.18–4.03) were found to have higher odds of being underweight. Similarly, teenage adolescent girls from food-insecure households (AOR=3.33, 95%CI: 2.01–5.51) were more likely to be underweight than those from food-secure households.

### Discussion

This study shows that half of the teenage adolescent girls, 49.76% (208/418) living in the selected urban slums of Varanasi district, India, were underweight, and that teenage adolescent girls who were from schedule caste/schedule tribe caste/ethnicity, those with a father educated to a primary level or lower, having more than four people in the family, with a vegetarian diet, those who consumed fewer than three meals per day, and those with household food insecurity were found to have higher odds of being underweight.

Undernutrition has been a major public health issue in India. According to UNICEF's 2011 State of the World's Children Report, undernutrition among teenage adolescent girls was higher (47%) in India than in any other country.<sup>42</sup> A recent Indian study cautioned that rates of malnutrition among adolescent girls, pregnant and lactating women, and children are alarmingly high and stated that the reasons for higher rates among nutritionally vulnerable populations were maternal nutritional status and lactation behavior, women's education, and sanitation.<sup>43</sup> In our study, we found half of the teenage adolescent girls were underweight, which is consistent with another study performed in a similar setting,<sup>44</sup> but this differs from the rates found in a study conducted in urban slums in South India based on National Center for Health Statistics (NCHS) and Indian standards measurements (42.6% and 22.9%, respectively).<sup>27</sup> A study in several African countries reported substantially lower prevalence of undernutrition among adolescent girls than that found in the present study.<sup>45</sup> These varied results among various countries

**Table 2** Associations Between Being Underweight and Dietary Behaviors Among Adolescent Girls in Resource-poor Settings

| Dietary Behavior and Intake of Food        | Total n=418 (%) | Underweight   |              | OR (95%CI)          |
|--|-----------------|---------------|--------------|---------------------|
|  |                 | Yes n=208 (%) | No n=210 (%) |                     |
| Nature of diet                             |                 |               |              |                     |
| Vegetarian                                 | 103 (24.6)      | 60 (58.3)     | 43 (41.7)    | 1.57 (1.00–2.46)*   |
| Nonvegetarian                              | 315 (75.4)      | 148 (47.0)    | 167 (53.0)   | Reference           |
| Timing of meal                             |                 |               |              |                     |
| Irregular                                  | 260 (62.2)      | 153 (58.8)    | 107 (41.2)   | 2.67 (1.77–4.03)*** |
| Fixed                                      | 158 (37.8)      | 55 (34.8)     | 103 (65.2)   | Reference           |
| Frequency of meal (per day)                |                 |               |              |                     |
| <3   | 145 (34.7)      | 101 (69.7)    | 44 (30.3)    | 3.56 (2.31–5.47)*** |
| ≥3   | 273 (65.3)      | 107 (39.2)    | 166 (60.8)   | Reference           |
| Types of flour used                        |                 |               |              |                     |
| Sieved (without choker)                    | 339 (81.1)      | 176 (51.9)    | 163 (48.1)   | 1.58 (0.96–2.60)    |
| Unsieved (with choker)                     | 79 (18.9)       | 32 (40.5)     | 47 (59.5)    | Reference           |
| Washing of green/leafy vegetable           |                 |               |              |                     |
| After cutting                              | 157 (37.6)      | 95 (60.5)     | 62 (39.5)    | 2.00 (1.34–3.00)**  |
| Before cutting                             | 261 (62.4)      | 113 (43.3)    | 148 (56.7)   | Reference           |
| Intake of pulses                           |                 |               |              |                     |
| ≥ once a week                              | 90 (21.5)       | 43 (47.8)     | 47 (52.2)    | 0.90 (0.56–1.44)    |
| Daily                                      | 328 (78.5)      | 165 (50.3)    | 163 (49.7)   | Reference           |
| Intake of green leafy vegetables           |                 |               |              |                     |
| ≥ once a week                              | 342 (81.8)      | 175 (51.2)    | 167 (48.8)   | 1.36 (0.82–2.25)    |
| Daily                                      | 76 (18.2)       | 33 (43.4)     | 43 (56.6)    | Reference           |
| Intake of other vegetables                 |                 |               |              |                     |
| ≥ once a week                              | 348 (83.3)      | 181 (52.0)    | 167 (48.0)   | 1.72 (1.02–2.91)*   |
| Daily                                      | 70 (16.7)       | 27 (38.6)     | 43 (61.4)    | Reference           |
| Milk consumption                           |                 |               |              |                     |
| ≥ once a week                              | 359 (85.9)      | 184 (51.3)    | 175 (48.7)   | 1.53 (0.87–2.66)    |
| Daily                                      | 59 (14.1)       | 24 (40.7)     | 35 (59.3)    | Reference           |
| Fruits consumption                         |                 |               |              |                     |
| Sometimes/occasionally                     | 145 (34.7)      | 84 (57.9)     | 61 (42.1)    | 1.65 (1.10–2.48)*   |
| ≥ once a week                              | 273 (65.3)      | 124 (45.4)    | 149 (54.6)   | Reference           |
| Meat and meat product (n=315) <sup>a</sup> |                 |               |              |                     |
| Sometimes/occasionally                     | 241 (76.5)      | 116 (48.1)    | 125 (51.9)   | 1.21 (0.72–2.05)    |
| ≥ once a week                              | 74 (23.5)       | 32 (43.2)     | 42 (56.8)    | Reference           |

**Notes:** <sup>a</sup>Among nonvegetarian only, \*p<0.05; \*\*p<0.005; \*\*\*p<0.0001.

are probably due to the use of different measurement standards, study settings, and other study population attributes. However, it is already known that the inaccessible and hard to reach adolescent girls in terms of basic amenities and healthcare services in India such as those of rural residents,<sup>46,47</sup> and urban slum dwellers<sup>27,44</sup> are mainly suffering from undernutrition. Therefore, teenage adolescent girls residing in slum settings in India should be prioritized in terms of public health

interventions, socioeconomic transformations, and community empowerment in order to reduce the long-standing problem of undernutrition.

We observed the caste/ethnicity as schedule caste/schedule tribe predicted underweight teenage adolescent girls. Previous reports have some conflicting views of the impact of ethnic minority as predictor of adolescents and children being underweight.<sup>48,49</sup> A Chinese study indicated the

**Table 3** Associations Between Being Underweight, Household Food Insecurity, and Mental Health Status Among Adolescent Girls in Resource-poor Settings

| Household Food Insecurity and Mental Health Status | Total n=418 (%) | Underweight   |              | OR (95%CI)        |
|--|-----------------|---------------|--------------|-------------------|
|  |                 | Yes n=208 (%) | No n=210 (%) |                   |
| Households food security                           |                 |               |              |                   |
| Food insecure                                      | 199 (47.6)      | 137 (68.8)    | 62 (31.2)    | 4.60 (3.05–6.95)* |
| Food secure  | 219 (52.4)      | 71 (32.4)     | 148 (67.6)   | Reference         |
| Anxiety  |                 |               |              |                   |
| High   | 150 (35.9)      | 101 (67.3)    | 49 (32.7)    | 3.10 (2.03–4.71)* |
| Low/medium   | 268 (64.1)      | 107 (39.9)    | 161 (60.1)   | Reference         |
| Depression   |                 |               |              |                   |
| High   | 177 (42.3)      | 115 (65.0)    | 62 (35.0)    | 2.95 (1.97–4.41)* |
| Low/medium   | 241 (57.7)      | 93 (38.6)     | 148 (61.4)   | Reference         |
| Loss of behavior control                           |                 |               |              |                   |
| High   | 240 (57.4)      | 139 (57.9)    | 101 (42.1)   | 2.17 (1.46–3.22)* |
| Low/medium   | 178 (42.6)      | 69 (38.8)     | 109 (61.2)   | Reference         |
| Psychological distress                             |                 |               |              |                   |
| High   | 174 (41.6)      | 110 (63.2)    | 64 (36.8)    | 2.56 (1.71–3.82)* |
| Low/medium   | 244 (58.4)      | 98 (40.2)     | 146 (59.8)   | Reference         |

Note: \* $p < 0.0001$ .

burden of excess body weight was higher than that of being underweight in minority girls aged 7–18 years, while a Nepalese study<sup>49</sup> being conducted in a nationally representative adolescent population reported that the Dalit minority ethnic group had lower odds of being thin. Nonetheless, the caste/ethnic-specific efforts are necessary to improve the status of being underweight during adolescence. A lower level of parenteral education positively influenced the occurrence of being underweight among adolescent girls in other studies.<sup>18,20</sup> In line with these previous findings, we also found the paternal education primary or lower level increased the risk of thinness, possibly because parenteral education appears to play a crucial role in providing adequate quantities and qualities of food to children.<sup>50,51</sup> Family size has been shown to have both a positive and negative impact on children and adolescence nutritional status in some previous studies.<sup>52,53</sup> We identified an increasing family size (>4) had higher odds of being underweight in our study subjects. However, there is no biologically plausible mechanism for the effect of family size on the underweight status of adolescent girls. It may be argued that increasing family size might cause decreasing family expenditure in matters relating to health, and poor nutritional access in the family leading to underweight status. It would therefore, be imperative to recommend the sociodemographic attributes

such as parental education, family size, and the existing caste-based system be considered while designing the nutritional intervention in order to reduce the prevalent incidence of being underweight among teenage adolescent girls in resource-poor settings.

Interestingly, this study revealed that teenage adolescent girls who were vegetarians and had fewer than three meals per day were at significantly higher risk of being underweight. A previous study reported vegetarian adolescent girls were less likely to consume recommended levels of fat, cholesterol, and micronutrients than those with an omnivorous diet, which supports the notion that vegetarian adolescent girls are more at risk of undernutrition.<sup>35</sup> Other studies have also consistently demonstrated a low meal frequency (fewer than two meals/day)<sup>18</sup> and irregular meal times<sup>54</sup> are risk factors of being underweight among adolescent girls. Moreover, household food insecurity has been demonstrated to be a major risk factor, especially during the adolescent period.<sup>28,55</sup> An Ethiopian study concluded household food insecurity among girls was associated with a higher frequency of illness and poor work performance due to poor health, tiredness, and lack of energy.<sup>55</sup> Furthermore, stressed, food-insecure individuals are likely to change their dietary behaviors, and thus increase the risk of being thin.<sup>56,57</sup> Since household food insecurity is more common in low-income and deprived

**Table 4** Multivariable Logistic Regression Analysis of the Association Between Sociodemographic Variables, Dietary Behaviors, and Household Food Insecurity and the Risk of Being Underweight Among Adolescent Girls in Resource-poor Settings

| Characteristics              | Category                                  | AOR (95%CI)         |
|------------------------------|---|---------------------|
| Caste/ethnicity              | SC/ST (schedule caste/<br>schedule tribe) | 2.02 (1.00–4.23)*   |
|                              | OBC (other backward caste)                | 1.26 (0.61–2.58)    |
|                              | General (upper caste group)               | Reference           |
| Education of father          | Primary and lower                         | 1.87 (1.12–3.11)*   |
|                              | Secondary and more                        | Reference           |
| Nature of diet               | Vegetarian                                | 2.21 (1.25–3.92)**  |
|                              | Non vegetarian                            | Reference           |
| Number of people in family   | >4  | 2.18 (1.18–4.03)*   |
|                              | ≤4  | Reference           |
| Frequency of meal intake/day | <3  | 2.36 (1.40–3.98)**  |
|                              | ≥3  | Reference           |
| Food security                | Food insecure                             | 3.33 (2.01–5.51)*** |
|                              | Food Secure                               | Reference           |

**Notes:** All variables considered to be important ( $p < 0.10$ ) in univariate analysis were entered into the multivariable logistic regression analysis. \* $p < 0.05$ ; \*\* $p < 0.005$ ; \*\*\* $p < 0.0001$ .

**Abbreviation:** AOR, adjusted odds ratio.

communities such as among the urban poor, those living in slums, and in the rural population,<sup>28,58–60</sup> health and social measures/strategies must place greater emphasis on such resource-limited settings to reduce the established burden of undernutrition. Our univariate analysis showed a positively associated relation of all four mental health dimensions (high level of anxiety, depression, loss of behavior control, and psychological distress) with teenage adolescent girls' being underweight. However, we did not find such association in the final multivariable logistic regression analysis after adjustment of covariates. Several studies have reported the positive association between diet and being underweight with adolescent girl's mental health status.<sup>61–63</sup> Nonetheless, we could not find literature that explicitly describes the causes of how mental health status affects the nutritional health status in teenage adolescent girls; It might be argued that the reverse causality be true

in our case. In addition, it might also be hypothesized that chronic health conditions such as poor mental health outcomes may lead to household food insecurity;<sup>64</sup> Household food insecurity thus might increase the incidence of being underweight.

This study is of particular importance and has some strengths. To be specific, it is one of the rare studies to investigate the association between undernutrition and mental health status, household food insecurity, dietary behaviors, and personal, social, and economic factors among teenage adolescent girls in the current study setting. Second, the subject response rate was very high (94.56%). Third, already piloted tools were used to gather information. Nevertheless, the study also has its own limitations. First, the study might have suffered from recall bias as much information was collected based on subject self-reports. Second, the study could not capture in detail the influence of dietary diversity, and that of eating disorders on study outcomes. Future studies should understand the impact of dietary diversity, eating disorders and mental health status among others on nutritional status of teenage adolescent girls. Further larger-scale studies are required to identify the factors responsible for adolescent underweight in multiple urban slums across India in order to establish nationwide preventive and promotional strategies to reduce this age-old problem and its adverse health impacts.

## Conclusion

This study shows that half of the teenage adolescent girls in urban slums of Varanasi, district, India, were underweight. The identified predictors of being underweight among teenage adolescent girls were: schedule caste/schedule tribe caste/ethnicity, paternal education a primary or lower, having more than four people in the family, a vegetarian diet, and fewer than three meals a day. In addition, we found household food insecurity to be independently associated with being underweight. Our findings demonstrate that the higher burden of being underweight among teenage adolescent girls in Indian slums need to be addressed through specific public health interventions such as by improving education, educating target populations to modify dietary behaviors, and having access to adequate amounts of safe, nutritious foods.

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## Disclosure

The authors report no conflicts of interest in this work.

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