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Evaluation of a Community-Based Intervention to Improve Dietary Patterns and Nutritional Self-Efficacy among Adolescents in Two Districts of Odisha

Research Article

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Abstract

Background: A high prevalence of under nutrition and micronutrient deficiencies among adolescents has been observed in South Asia due to restricted dietary variety and unhealthy dietary habits. The present study aimed to assess the change in the health and nutrition practices of adolescents in the Bolangir and Nuapada districts of Odisha after 2-year community-based intervention.

Methods: The baseline and endline were conducted using a quantitative cross-sectional research method with boys and girls (10-19 years). Predesigned, pretested, semi-structured questionnaires were developed to capture information on socio-demographic profiles, knowledge and practices related to diets and dietary patterns, access to Anganwadicenters, WASH habits, and self-efficacy. The intervention included four group-based structured education sessions and community-based events like role plays, video shows, games-based learning, and folk dances. In total, 673 boys and girls at baseline and 793 at end line participated in the surveys. We employed linear and logistic regression analysis to estimate the degree of change in outcomes at end line compared to the baseline and dose-response analysis to estimate the effect of the intervention.

Results: The median (interquartile range) age of boys and girls was 15 (12-16) years both at baseline and end line. There was a 3.97 unit and 4.70 unit increase in the self-efficacy score at the end line compared to the baseline ($p<0.001$) after adjusting for age, education, community, and monthly family income among boys and girls, respectively. Moreover, the dose-response analysis showed an increment in iron folic acid tablet consumption with an increasing number of sessions among boys and girls.

Conclusions: The community-based interventions involving education sessions have a positive impact on improving nutritional self-efficacy and dietary practices among adolescents. Therefore, community-based interventions should be implemented on a broader scale to improve the nutritional status of adolescents.

Keywords: Diet; Self-efficacy; Vegetables; Fruit; Iron; Adolescent

Abbreviations

FFQ: Food Frequency Questionnaire**;** WASH: Water, Sanitation and Hygiene; IFA: Iron-Folic Acid; GLV= Green Leafy Vegetables; UK: United Kingdom; USA: United States of America

Introduction

The World Health Organization defines an adolescent as 10-19 years of age, bridging the gap between childhood and adulthood. [1,2] The transition phase involves rapid physical, cognitive, and psychosocial growth and development.[2]Adolescents are recognized as a significant asset at the family, societal, and national level and can be considered as the second window of opportunity for nurturing before adulthood.[2, 3]

Globally, at present, 1.3 billion adolescents exist, constituting 16%

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of the world's population.[4] India is home to 253 million adolescents, accounting for the largest adolescent population in the world.[5] However, adolescent health and nutrition are major concerns all over the world, especially in low- and middle-income countries.[6]A high prevalence of under nutrition among adolescents has been observed in South Asia, with an increasing burden of overweight and obesity.[7] The burden of stunting and thinness among adolescents was 27.4% and 24.4%, respectively. In contrast, the rates of overweight and obesity were 4.8% and 1.1%, respectively[8]. Micronutrient deficiencies are also prevalent among adolescents; 16-37% of adolescents had different types of micronutrient deficiencies, such as Vitamin A, Vitamin D, zinc, Vitamin B12, and folate.[9] In developing nations, adolescents tend to have a restricted dietary variety, primarily relying on plant-based foods. However, their consumption of fruits and vegetables is limited. Concurrently, there is a noticeable rise in the consumption of high-calorie snacks and beverages, especially in urban regions.[10]

The uneven distribution of under nutrition and micronutrient deficiencies varies based on geographical locations, ethnic groups, genders, religious affiliations, and other socio-demographic characteristics.[11] Evidence suggests that the socio-demographic elements of adolescents are associated with malnutrition, such as gender, religion, wealth index, and educational qualifications.[12] For instance, adolescents with senior secondary grades or above had lower odds of having low-mixed diets as compared to illiterate or had obtained education up to primary or middle grades. Furthermore, adolescents from marginalized communities were identified as significant predictors of having low-diversity diets.[12, 13]

As per the findings of the Comprehensive National Nutrition Survey (2016-18), the majority (55.4%) of the adolescents followed a vegetarian diet pattern, while more than one-third (36.4%) preferred a non-vegetarian, and the rest were eggetarian.[9] A significant variation in the dietary habits of adolescents (10-19 years) was observed across various states in India. Notably, the consumption of milk and milk products and fruits was less frequent among adolescents (10-19 years) in Odisha; however, the majority (90.9%) included pulses or beans and green leafy vegetables (88.9%) in their diet, followed by eggs (64.6%), fish (58.1%), and chicken or meat (44.5%).[9]Research indicates that diets in India primarily revolve around cereals and lack sufficient inclusion of other essential nutritional components.[14] However, the studies assessing dietary patterns among adolescents are limited.[15]

Existing evidence highlights unhealthy dietary habits among adolescents in various Indian settings.[16] Adolescents often consume unhealthy foods due to a lack of knowledge and awareness about the associated health risks. Furthermore, gender plays a significant role in the dietary behaviour of adolescents.[16] Indian studies have reported a strong association between unhealthy eating habits and peer influence, taste preferences, place of residence, gender, and persuasive advertising.[16] For example, the consumption of green leafy vegetables was far lower than that of unhealthy food among adolescent boys and girls in Odisha.[16]On the contrary, the consumption of green leafy vegetables was found to be excess in their diet among the tribal women of Odisha.[18]

Research revealed that the studies implemented multi-faceted intervention strategies to increase fruit and vegetable access or consumption[17] An example of a multiple intervention strategy is an educational series delivered primarily in schools, supplemented by a homework component to actively involve parents. Additional interventions include nutrition programs, group discussions, health education, peer-led approaches, and community gardens, among others. Notably, only 10% of the interventions focused on individual strategies aimed at increasing fruit and vegetable consumption.[17] Furthermore, self-efficacy is considered necessary for behaviour modification as well as the preservation of recently adopted behaviours. Evidence reported a statistically significant correlation between self-efficacy and perceived barriers towards healthy eating habits among adolescents in Port Said city.[19]

Evaluating the eating habits of a population requires using approaches, and among these, Food Frequency Questionnaires (FFQs) are frequently used to assess nutrient intake in population-based studies. This method is relatively inexpensive and puts less burden on the respondents. However, maintaining accuracy and consistency in measuring patterns continues to be a challenge.[20]

Considering the need, MAMTA designed a two-year intervention on health and nutrition education promotion among adolescent boys and girls in two districts of Odisha. The baseline study was conducted to assess the baseline status of the intervention indicators. Then, after two years of intervention, the end line was conducted to assess the improvement in the indicators. The present study assessed the change in the health and nutrition practices of adolescents' post-intervention residing in the *Bolangir* and *Nuapada* districts of Odisha.

Methods

Study design, study population, and study settings: A quantitative cross-sectional research was conducted in four intervention blocks of two districts of Odisha at the beginning and at the end of the intervention. These study sites (*Bolangir* and *Nuapada*) were included as they were a part of the intervention. The study was conducted among adolescent boys and girls (10-19 years) who were unmarried and residing in the areas for the past 1 year. All the individuals who did not provide consent or assents (for adolescents) to participate in the study or suffered a major illness in the past 1 year or migrated were excluded. The baseline study was conducted in 2020 and end line in 2022. The sample size for two districts was reported to be a minimum of 240each for adolescent girls and boys, respectively, both at the baseline and end line. The sample size was equally distributed across the districts and divided equally between early and late adolescents.

The sample size was calculated using below mentioned formula:

$$\mathbf{n} = (\mathbf{2} * [\mathbf{Zcrit}\sqrt{2p3}(1-p3) + \mathbf{Zpwr}\sqrt{p1(1-p1)} + \mathbf{p2}(\mathbf{1}-\mathbf{p2})]^2)/\mathbf{D}^2 \quad [21]$$

Where, **n** = required sample size

P1= Pre-study estimate of the proportional change in the combined health, nutritional, and hygiene indicator value (calculated from the previous project for each category of beneficiary)

P2= Post-study estimate of the proportional change in the combined health, nutritional, and hygiene indicator value (assumption)

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P3= (p1+p2)/2; **D**= P1-P2; **t =** confidence level at 95% (standard value of 1.96)

Zcrit = 1.96; standard normal deviate corresponding to 95% significant criteria

Zpwr = 0.842; standard normal deviate corresponding to 80% statistical power

After adjusting for the design effect (1.2) and a non-response rate (10%), the sample size per beneficiary turned out to be 240. A two-stage sampling technique was used for quantitative data collection of the subjects in four intervention blocks of the two districts. Villages were considered as the primary sampling units (PSUs) and households as the secondary sampling units (SSUs) in a two-stage sampling technique. Twelve villages in each block were selected for the study. The adolescents at the baseline and end line were different as it was not a panel study (or pre-post study).

Study tools

A predesigned, pretested, semi-structured questionnaire was developed to capture information on socio-demographic profiles along with their knowledge and practices related to the diets and dietary patterns of the subjects. The questionnaire was originally formed in English and then translated into the local language (*Odiya*). Same questionnaires were employed both at the baseline and end line, except for a few additional about the intervention at the end line. The questionnaire had four sections, including socio-demographic characteristics, access to *Anganwadi* centers, WASH habits, and dietary practices. WASH habits were accessed by asking questions like place of defecation, washing hands after defecation, handling pets, handling animal wastes, etc. In the dietary practices, we asked about the frequency of the consumption of seven food groups, including green leafy vegetables, fruits, roots and tubers, other vegetables, milk and milk products, cereals, and pulses (lentils). There were eleven options for food frequency, ranging from once a day, twice a day, thrice a day to once a week, fortnightly, occasionally, and never. The daily consumption of the food groups was calculated by replacing the frequency with the appropriate number, such as, for those consuming once a week, the daily consumption was 0.14. Similarly, the daily consumption of those eating 2-3 times a week was 0.35, fortnightly was 0.07, monthly was 0.03, quarterly was 0.01, and occasionally or never was 0.

We also asked about the self-efficacy of adolescents related to resisting the consumption of foods rich in calories and planning a healthy diet using a pretested questionnaire. There were five questions based on a seven-point Likert scale, with responses varying from not at all confident (scored 0) to very confident (scored 7). The individual scores of all five questions were summed up to calculate the aggregate score, the max and min values of which were 0 and 35. The scale had been validated earlier (20). At the end line, we asked if the adolescents attended sessions or events in the program as well as the rating for different components of the program. The rating was based on a three-point Likert scale with responses varying from agrees to neutral to disagree.

Furthermore, a team of data investigators were trained for two days on the data collection techniques and carried out mock surveys under the supervision of the district coordinator and field supervisors before initiating the survey. Continuous supervision and random monitoring were also conducted by the field team and the head office team during data collection. All the questionnaires were developed into an Android-based mobile application using Open Data Kit (ODK). About 5% of the filled performs were screened for the completeness, consistency, and coherence of the data. The data collection during the baseline and end line study was conducted for over 2-3 months.

Intervention

It was a 2-year community-based intervention aimed at improving knowledge, attitude, and practices related to nutrition, health, and hygiene among adolescents across two districts of Odisha, namely *Bolangir* and *Nuapada*. The intervention included four group-based structured education sessions and community-based events like role plays, video shows, games-based learning, and folk dances. The intervention was delivered by the project staff with a minimum education of bachelor's and trained on the topics to be delivered. The structured education sessions were delivered using a flipbook and posters in a group of 20-25 adolescents, separately for boys and girls. The attendance of the sessions was obtained by the staff and maintained in the online management information system. Adolescents and their parents were invited to the community events held regularly over a period of two years. Pamphlets were also distributed towards the end of the events or sessions for self-reading. The content of the flipbooks, posters, sessions, events, and pamphlets was in the local language (*Odiya*).

Ethical clearance

The ethical clearance of the study was obtained from the MAMTA Internal Ethical Review Board for the project. Informed written consent was obtained from all study subjects ≥18 years, while assent was obtained from subjects <18 years and informed consent from their parents. No pressure or coercion was exerted on subjects for participation in the study. Moreover, the information obtained from the subjects was kept confidential to avoid risks associated with the disclosure of sensitive information.

Statistics

The data were presented as percentages and frequencies or mean (Standard Deviation, SD) and median (Interquartile Range). We employed linear regression analysis to find an association for three of the four outcomes, including daily consumption of green leafy vegetables, fruits, and self-efficacy scores, and logistic regression to find an association for the fourth outcome, i.e., the consumption of iron folic acid tablets. The independent variables included baseline or end line status, age, monthly family income, community, religion, and education status of the adolescents. All the outcomes were normally distributed. In addition, we analyzed the dose-response association between the number of sessions attended by the adolescent and the consumption of iron folic acid (IFA) tablets without adjustment for any other factor (only based on the end line data). The effect size was expressed as a beta coefficient (95% Confidence Interval; CI) for general linear regression and odds ratio (OR) (95% CI) for logistic

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regression. All the analyses were done separately for boys and girls. We used STATA version 17.0 for all the analysis. P-value <0.05 was considered a statistically significant value in all the analyses.

Results

There were 4 blocks and 51 villages in total where surveys were done. The median age of boys and girls was similar both at the end line and baseline. Most of the adolescents had studied until the middle school at the time of the surveys. Around 86% of adolescents at baseline and 80-85% at the end line belonged to marginalized families. The predominant religion among the families was Hinduism, comprising 98.8% of the population. Around 14% of girls defecated in the open compared to 19% at the baseline as shown in Table 1.

Almost all of the adolescent boys and girls knew about *anganwadi* centres. It is interesting to note that there was 63.8% increase among boys and 24.2% increase among girls in availing services among *anganwadi* centres. There was a 15% increase among boys and 13% among girls consuming IFA tablets. Though the consumption of green leafy vegetables increased by 18% from baseline to the end line, the consumption of fruits increased by a mere 5% among boys. Similarly, the consumption of green leafy vegetables increased by 46% from baseline to the end line and the consumption of fruits increased by a mere 7% among girls. More than 90% of the adolescents reported to be consuming 3 or more meals in a day during end line as shown in Table 2.

There was a 3.97-unit increase in the self-efficacy score at the end line compared to the baseline (p<0.001) after adjusting for age, education, community, and monthly family income. Similarly, the increase was noted for the daily consumption of green leafy vegetables and fruits among boys (p<0.001). There were three times the odds of consuming IFA at the end line compared to the baseline (OR, 95%CI: 3.05, 2.07-4.48). The adolescent boys with higher grades of education reported an increased daily consumption of green leafy vegetables and IFA tablets as compared to their counterparts as shown in Table 3.

Like boys, girls had 1.91 times the odds of consuming IFA at the end line compared to the baseline (p=0.001). There was a 4.7-unit increase in the self-efficacy scores and a 1.18 unit increase in the daily consumption of green leafy vegetables at the end line among girls (p<0.001). However, no statistically significant difference was noted at the end line in the consumption of fruits among girls. The self-efficacy score was observed to be higher among adolescent girls belonging to the marginalized communities in comparison to their counterparts. Age emerged as a significant determinant influencing the self-efficacy score, as well as the daily consumption of green leafy vegetables and IFA tablets among girls as shown in Table 4.

Out of 417 boys, 208 attended any session, and out of 376 girls, 241 attended any session. A dose-response association was noted in the number of sessions and the odds of consuming IFA among boys and girls (Figure 1) and (Figure 2). There were 25 times the odds of consuming IFA among girls who attended 4 sessions compared to 2.2 times the odds of consuming IFA among girls who attended 1 session without any adjustment for covariates or confounders. More than 3/4th of the adolescent girls and boys agreed that the sessions taken by the staff helped them improve their nutritional knowledge and change their behaviour, and they could share their issues with them as shown in Table 5 and Table 6.

Discussion

We found that our community-based intervention was effective in improving the consumption of IFA tablets among girls and boys. Besides, an improvement in the median daily consumption of green leafy vegetables and fruits, self-efficacy towards eating healthy foods,

Table 1: Distribution of socio-demographic characteristics among adolescent boys and girls at baseline and end line

Variables	Boys (n=757)		Girls(n=709)	
	Baseline (n=340) N (%)	End line (n=417) N (%)	Baseline (n=333) N (%)	End line (n=376) N(%)
Median Age (IQR) in years	14 (12-16)	14 (12-16)	15 (12-17)	14 (12-16)
Education status				
Primary	4 (1.2)	70 (16.8)	0	65 (17.3)
Middle	154 (45.3)	184 (44.1)	185 (55.6)	146 (38.8)
High school	135 (39.7)	108 (25.9)	114 (34.2)	119 (31.6)
Senior secondary and above	47 (13.8)	55 (13.2)	34 (10.2)	46 (12.3)
Community				
General	50 (14.7)	60 (14.4)	66 (20.0)	63 (16.7)
Scheduled caste	54 (15.8)	64 (15.3)	53 (16.0)	59 (15.7)
Scheduled tribe	67 (19.7)	161 (38.6)	70 (21.0)	139 (36.9)
OBC	169 (49.7)	132 (31.6)	144 (43.0)	115 (30.6)
Missing	0	0	1	0
Religion				
Hinduism	336 (98.8)	415 (99.5)	330 (99.1)	370 (98.4)
Others*	4 (1.2)	2 (0.5)	3 (0.9)	6 (1.6)
Median(IQR)income of the family from all sources(Rs.)	5000 (4000-6000)	10000 (5000-12000)	5000 (4000-7000)	10000 (6000-15000)
Type of toilet used				
Kutcha	119 (35.0)	77 (18.5)	132 (39.6)	64 (17.0)
Pakka	117 (34.4)	189 (45.3)	137 (41.1)	245 (65.1)
Open defecation	104 (30.5)	133 (31.9)	64 (19.2)	52 (13.8)
Pakka with flush	0	18 (4.3)	0	15 (4.0)

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Table 2: Access to *Anganwadi* services, WASH habits, and dietary practices among study participants at baseline and end line

Variables	Boys (n=757)		Girls (n=709)	
	Baseline (n=340) N (%)	End line (n=417) N (%)	Baseline (n=333) N (%)	End line (n=376) N(%)
Know about *Anganwadi* centers				
Yes	291 (85.6)	416 (99.7)	315 (94.6)	376 (100.0)
No	43 (12.6)	1 (0.2)	18 (5.4)	0
Don't know	6 (1.8)	0	0	0
Availed services from *Anganwadi* centers				
Yes	23 (6.70)	294 (70.5)	232 (69.6)	353 (93.8)
No	268 (78.8)	123 (29.5)	83 (25.0)	23 (6.1)
Don't know/No	49 (14.4)	0	18 (5.4)	0
Consume IFA tablets				
Yes	63 (18.5)	140 (33.5)	214 (64.3)	290 (77.1)
No	277 (81.5)	277 (66.4)	119 (35.7)	86 (22.8)
Frequency of the consumption of IFA tablets				
Once a week	33 (9.7)	26 (6.2)	202 (60.7)	60 (15.9)
Two or more	0	40 (9.6)	0	169 (44.9)
Occasionally	10 (2.9)	68 (16.3)	12 (3.6)	57 (15.1)
Don't remember	20 (5.9)	6 (1.4)	0	4 (1.0)
Did not consume IFA	277 (81.5)	277 (66.4)	119 (35.7)	86 (22.8)
Washing hands				
After defecation				
Yes	324 (95.3)	414 (99.3)	319 (95.8)	375 (99.7)
No	16 (4.7)	3 (0.7)	14 (4.2)	1 (0.3)
Before eating food				
Yes	308 (90.6)	391 (93.7)	324 (97.3)	367 (97.6)
No	32 (9.4)	26 (6.3)	8 (2.4)	6 (1.6)
NA	0	0	1 (0.8)	3 (0.8)
Before cooking or serving food				
Yes	22 (6.5)	325 (77.9)	50 (15.0)	350 (93.1)
No	0	19 (4.5)	283 (85.0)	9 (2.4)
Not applicable	318 (93.5)	73 (17.5)	0	17 (4.5)
After cleaning child's poop				
Yes	35 (10.3)	336 (80.6)	38 (11.4)	335 (89.1)
No	21 (6.2)	13 (3.1)	265 (79.6)	14 (3.7)
Not Applicable	284 (83.5)	68 (16.3)	30 (9.0)	27 (7.2)
After handling pets				
Yes	200 (58.8)	358 (85.8)	182 (54.6)	329 (87.5)
No	54 (15.9)	10 (2.4)	103 (31.0)	18 (4.8)
Not applicable	86 (25.3)	49 (11.7)	48 (14.4)	29 (7.7)
After cleaning animal's waste				
Yes	164 (48.2)	362 (86.8)	169 (50.7)	328 (87.3)
No	69 (20.3)	13 (3.1)	109 (32.7)	14 (3.72)
Not applicable	107 (31.5)	42 (10.0)	55 (16.5)	34 (9.0)
Median (IQR) daily consumption of food groups				
Green vegetables	1 (1-2)	2 (1-3)	1(0.1-1.0)	2 (1-3)
Roots and tubers	2 (1-3)	1 (0.35-3)	1 (0.07-2)	1 (0.14-3)
Other vegetables	1 (0-1)	1 (0.14-3)	1 (0.07-2)	1 (0.14-3)
Cereals	2 (2-2)	1 (0.14-3)	2 (0.35-2)	1 (0.35-3)
Milk	0 (0-0.14)	0.35 (0.03-1)	0.35 (0-1)	0.35 (0.03-1)
Pulses	1 (1-2)	1 (0.14-2)	2 (1-2)	1 (0.14-1)
Fruits	0 (0-0.14)	0.03 (0-0.35)	0.07 (0-0.35)	0.03 (0-0.35)
Consumption of food groups once or more daily (*yes responses only*)				
Green vegetables	275 (80.4)	411 (98.5)	173 (52.0)	369 (98.1)
Roots and tubers	297 (87.3)	309 (74.1)	185 (55.5)	257 (68.3)
Other vegetables	238 (70.0)	297 (71.2)	183 (55.5)	250 (66.4)
Cereals	329 (96.7)	281 (67.4)	230 (69.0)	280 (74.4)
Milk	66 (19.4)	172 (41.2)	120 (36.0)	186 (49.5)
Pulses	325 (95.5)	260 (62.3)	253 (76.0)	263 (70.0)
Fruits	59 (17.3)	97 (23.2)	57 (17.1)	90 (24.0)
Median (IQR) self-efficacy score for healthy nutrition	15 (14-18)	21 (17-24)	15 (13-18)	19 (22-25)
No of major meals a day				
1	4 (1.2)	8 (1.9)	3 (0.9)	17 (4.5)
2	89 (26.2)	9 (2.1)	147 (44.1)	19 (5.0)
3 or more	247 (72.6)	400 (95.9)	183 (55.0)	340 (90.5)
Think that you consume a healthy diet				
Yes	301 (88.5)	350 (83.9)	282 (84.7)	347 (92.3)
No	6 (1.8)	3 (0.7)	10 (3.0)	2 (0.5)
Don't know	33 (9.7)	64 (15.3)	41 (12.3)	27 (7.2)

Abbreviations: IQR: Interquartile Range; IFA: Iron Folic Acid tablets; WASH: Water and Sanitation Hygien

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Table 3: Adjusted linear and logistic regression models to show associations of self-efficacy scores and other dietary practices with baseline and end line after adjusting for socio-demographic determinants among boys

Determinants	Self-efficacy scores§ ß(95% CI); p-value	Daily consumption of GLV¶ ß (95% CI); p-value	Daily consumption of fruits# ß (95% CI); p-value	Consumption of IFA (yes)¥ OR (95% CI); p-value
Status				
End line	**3.97 (3.20, 4.74); <0.001**	**0.83 (0.69, 0.96); <0.001**	**0.21 (0.12, 0.31); <0.001**	**3.05 (2.07, 4.48); <0.001**
Baseline	*Reference*	*Reference*	*Reference*	*Reference*
Education status				
Middle (5th – 8th)	0.21 (-1.08, 1.51); 0.75	**-0.44 (-0.66, -0.21); <0.001**	0.03 (-0.12, 0.20); 0.65	**2.53 (1.23, 5.21); 0.01**
High school (9th – 10th)	-0.58 (-2.16, 0.98); 0.46	**-0.69 (-0.96, -0.41); <0.001**	0.10 (-0.08, 0.30); 0.28	**7.22 (3.03, 17.21); <0.001**
Secondary and above (11th onwards)	-0.96 (-2.87, 0.94); 0.32	**-0.90 (-1.23, -0.56); <0.001**	-0.12 (-0.36, 0.12); 0.32	**13.06 (4.62, 36.85); <0.001**
Primary (1st-4th)	*Reference*	*Reference*	*Reference*	*Reference*
Community				
Scheduled caste	-0.33 (-1.59, 0.93); 0.60	0.20 (-0.01, 0.42); 0.06	-0.04 (-0.19, 0.12); 0.63	1.62 (0.88, 2.98); 0.11
Scheduled tribe	**-1.32 (-2.44, -0.20); 0.02**	0.07 (-0.12, 0.27); 0.44	**-0.16 (-0.30, -0.02); 0.02**	1.18 (0.68, 2.04); 0.55
Other backward classes	**-1.10 (-2.17, -0.04); 0.04**	0.10 (-0.08, 0.28); 0.27	0.0 (-0.12, 0.14); 0.94	1.18 (0.70, 2.01); 0.52
General	*Reference*	*Reference*	*Reference*	*Reference*
Age (years)	0.06 (-0.13, 0.26); 0.53	**0.03 (0.0, 0.07); 0.04**	0.02 (-0.004, 0.04); 0.09	**0.87 (0.77, 0.97); 0.01**
Family income monthly (Rs.)	-0.2 *10^{-4} (-0.7 *10^{-4}, 0.18*10^{-4}); 0.25	-2.3*10^{-6} (-9.9*10^{-6}, 5.31*10^{-6}); 0.55	-4.8*10^{-6} (-1.0*10^{-6}, 6.8*10^{-7}); 0.08	1.0 (0.99, 1.00); 0.33

Abbreviations:ß: Beta coefficient; CI: Confidence Interval; GLV: Green Leafy vegetables;IFA: Iron Folic Acid;OR: Odds Ratio
§R^2: 15%; ¶R^2: 26%; #R^2: 4%; ¥We applied logistic regression analysis; reference category was 'no'
p-value<0.05 was considered a statistically significant value. All the statistically significant association is highlighted in bold

Table 4: Adjusted linear and logistic regression models to show associations of self-efficacy scores and other dietary practices with baseline and end line after adjusting for socio-demographic determinants among girls

Determinants	Self-efficacy scores§ ß(95% CI); p-value	Daily consumption of GLV¶ ß (95% CI); p-value	Daily consumption of fruits# ß (95% CI); p-value	Consumption of IFA (yes)¥ OR (95% CI); p-value
Status				
End line	**4.70 (3.83, 5.57); <0.001**	**1.18 (1.04, 1.32); <0.001**	-0.01 (-0.12, 0.10); 0.84	**1.91 (1.33, 2.77); 0.001**
Baseline	*Reference*	*Reference*	*Reference*	*Reference*
Education status				
Middle (5th – 8th)	-1.43 (-3.0, 0.15); 0.07	-0.14 (-0.40, 0.11); 0.26	0.05 (-0.15, 1.25); 0.60	1.02 (0.52, 1.98); 0.95
High school (9th – 10th)	**-2.46 (-4.48, -0.45); 0.01**	**-0.44 (-0.77, -0.12); 0.006**	0.09 (-0.16, 0.35); 0.48	0.76 (0.32, 1.79); 0.53
Secondary and above (11th onwards)	**-3.04 (-5.61, -0.47); 0.02**	**-0.74 (-1.15, -0.33); <0.001**	0.10 (-0.22, 0.43); 0.51	0.49 (0.16, 1.48); 0.21
Primary (1st-4th)	*Reference*	*Reference*	*Reference*	*Reference*
Community				
Scheduled caste	**-3.54 (-4.91, -2.16); <0.001**	-0.20 (-0.42, 0.01); 0.07	0.10 (-0.07, 0.28); 0.24	1.15 (0.67, 1.99); 0.59
Scheduled tribe	**-3.24 (-4.44, -2.04); <0.001**	-0.04 (-0.23, 0.15); 0.68	0.03 (-0.12, 0.18); 0.70	**2.24 (1.35, 3.72); 0.002**
Other backward classes	**-3.51 (-4.66, -2.36); <0.001**	-0.03 (-0.21, 0.14); 0.71	0.08 (-0.06, 0.22); 0.29	1.36 (0.86, 2.14); 0.18
General	*Reference*	*Reference*	*Reference*	*Reference*
Age (years)	**0.30 (0.03, 0.57); 0.03**	**0.05 (0.01, 0.10); 0.01**	-0.002 (-0.037, 0.032); 0.88	**1.18 (1.05, 1.33); 0.004**
Family income monthly (Rs.)	**-0.5*10^{-4} (-1.6*10^{-4}, -0.1*10^{-4}); 0.01**	-4.6*10^{-6}(-12.3*10^{-6}, 2.98*10^{-6}); 0.23	-4.9*10^{-6}(-11.0*10^{-6}, 1.21*10^{-6}); 0.11	1.0 (0.99, 1.0); 0.75

Abbreviations:ß: Beta coefficient; CI: Confidence Interval; GLV: Green Leafy vegetables;IFA: Iron Folic Acid;OR: Odds Ratio
§R^2: 15%; ¶R^2: 26%; #R^2: 4%; ¥We applied logistic regression analysis; reference category was 'no'
p-value<0.05 was considered a statistically significant value. All the statistically significant association are highlighted in bold

Table 5: Adolescent boys' rating of the program at the end line on a scale from agree to disagree (n=208)

Statement	Agree N(%)	Neutral N(%)	Disagree N(%)	Missing/didn't respond N(%)
Education sessions taken by MAMTA staff improved my knowledge about health and nutrition	187 (90.0)	15 (7.2)	0	6 (2.8)
Education sessions taken by MAMTA staff helped me improve my behaviour or practices related to health and nutrition	168 (80.7)	33 (15.8)	1 (0.5)	6 (2.8)
Community events organized by MAMTA staff helped me gain my knowledge about health and nutrition	170 (81.7)	20 (9.6)	5 (2.4)	13 (6.2)
The sessions taken by MAMTA staff were of good quality	158 (76.0)	32 (15.4)	6 (2.9)	12 (5.7)
MAMTA staff answered my queries or questions whenever I asked	166 (79.8)	28 (13.5)	2 (0.9)	12 (5.7)
I can discuss any of my health issue with MAMTA staff which are difficult to talk with others	164 (78.9)	27 (13.0)	2 (0.9)	15 (7.2)
I would like MAMTA staff to continue the Jagriti campaign to spread health and nutrition information in our communities	162 (78.0)	21 (10.9)	9 (4.3)	16 (7.7)
I communicated with and connected other women/girls/boys in the villages with the program	154 (74.0)	35 (16.8)	4 (2.0)	15 (5.7)

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Table 6: Adolescent girls' rating of the program at the end line on a scale from agree to disagree (n=241)

Statement	Agree N(%)	Neutral N(%)	Disagree N(%)	Missing/didn't respond N (%)
Education sessions taken by MAMTA staff improved my knowledge about health and nutrition	226 (93.8)	9 (3.7)	0	6 (2.5)
Education sessions taken by MAMTA staff helped me improve my behavior or practices related to health and nutrition	207 (85.9)	24 (9.9)	2 (0.9)	8 (3.3)
Community events organized by MAMTA staff helped me gain my knowledge about health and nutrition	203 (84.3)	22 (9.1)	3 (1.2)	13 (5.4)
The sessions taken by MAMTA staff were of good quality	202 (83.8)	19 (7.9)	2 (0.8)	18 (7.5)
MAMTA staff answered my queries or questions whenever I asked	198 (82.2)	21 (8.7)	2 (0.8)	20 (8.3)
I can discuss any of my health issue with MAMTA staff which are difficult to talk with others	208 (86.3)	11 (4.5)	0	22 (9.1)
I would like MAMTA staff to continue the Jagriti campaign to spread health and nutrition information in our communities	191 (79.3)	19 (7.9)	8 (3.3)	23 (9.5)
I communicated with and connected other women/girls/boys in the villages with the program	198 (82.1)	18 (7.4)	3 (1.2)	22 (9.1)

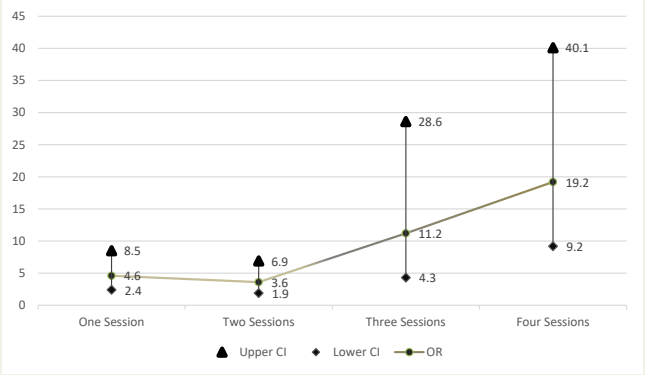

Figure 1: Dose-response association between no of sessions and the odds of consuming IFA tablets among boys (not attending any session was the reference point).

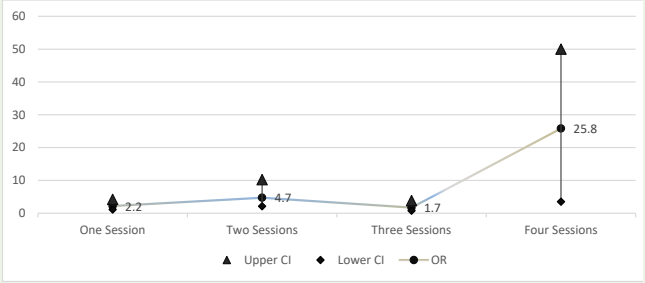

Figure 2: Dose-response association between no of sessions and the odds of consuming IFA tablets among girls (not attending any session was the reference point).

and perception about eating healthy food was noted from baseline to the end line. We noted an improvement in the hand wash habits before cooking or serving food at the end line from the baseline. The dose-response analysis showed an increment in the IFA tablet consumption with an increasing number of sessions. The boys and girls who participated in MAMTA's education sessions gave good feedback on the quality of sessions and events.

Our findings agree with the results of a systematic review that evaluated community-based interventions aiming to improve the accessibility to or intake of fruits and vegetables among children and adolescents aged 5-18 years and their parents. The review primarily encompassed studies conducted in the *UK, USA, and Finland*. [22] Diverse methodologies were employed, including health-related education programs targeting increased fruit and vegetable consumption, the establishment of kitchen gardens, and utilization of the internet, telephone, and media across multiple settings such as schools, communities, homes, and online platforms.[22]. The studies conducted in *Uttar Pradesh, West Delhi, Nagpur, and Chandigarh* used similar approaches as ours to improve the self-efficacy among adolescents.[23]

In our intervention, self-efficacy emerged as a crucial outcome. This is noteworthy as previous studies have indicated that, in addition to nutrition knowledge and preferences, self-efficacy is linked to an increased consumption of fruits and vegetables.[22] In India, schools have been a common location for conducting interventions among adolescents using audio-visual aids, print media, and educational sessions to significantly enhance both knowledge and the consumption of fruits and vegetables.[24, 25] This is in concordance with our findings at the community level. We found a statistically significant difference ($p<0.001$) in the self-efficacy scores and the daily consumption of green leafy vegetables among adolescents in our study. One of the plausible explanations for an increase in the consumption of green leafy vegetables among adolescents could be seasonal availability, particularly since the end line was conducted in winter (December, 2022). However, we did not find any dose-response association between the number of sessions and the consumption of fruits and vegetables among adolescents.

Furthermore, findings of the previous studies suggest that adolescent's age, family income, education status, and gender are correlated with the intake of fruits and vegetables.[26, 27]Consistent with these findings, our study also observed similar associations. The purpose of our community-based interventions was to improve the existing knowledge and dietary practices of adolescents. After adjusting the socio-demographic determinants, we found that adolescents with higher grades of education ($p<0.001$) had an increased consumption of green leafy vegetables. Contrarily, we did not find any significant association between social class and the daily

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consumption of fruits and vegetables among adolescents, except for adolescent boys belonging to the scheduled tribe, who exhibited decreased daily consumption of fruits compared to the general category. This is in concordance with the previous research indicating a concerning trend in the consumption of fruits within the Indian population, with lower castes demonstrating significantly lower intake of fruits and vegetables compared to upper castes.[27]

Our intervention also centered on educating adolescents on anaemia identification, prevention, and management through various community-based interventions. Notably, we found a significant increase in the consumption of iron-folic acid tablets from baseline to end line among adolescents. Various community-based interventions such as educational programs using audio-visual aids, IFA supplementation through trained peer educators along with nutritional education, community-based meetings, audio messages, and automated phone calls were conducted to educate adolescents to increase the consumption of IFA tablets.[28–31] The duration of the intervention period varied from 3 months to 12 months.[28–31]

Implementations such as the consumption of IFA tablets, nutrition education, and deworming tablets every 6 months had significantly improved anaemia status among adolescents (10-19 years) in *Uttar Pradesh*.[31] The study highlighted that counseling sessions on the positive effect of IFA intake contributed to a high compliance rate of over 85%.[31] Furthermore, a study conducted in *Telangna* showed that nutrition education has significantly increased the knowledge, attitude, and practice scores among adolescent girls (13-17 years).[28] To the best of our knowledge, there is limited evidence on community-based interventions to increase IFA consumption among adolescents in India. A school-based study conducted in *Karnataka* involving adolescents aged 11-14 years revealed that educational sessions not only enhanced knowledge and attitudes but also increased the demand for IFA tablets.[32] Similar findings were also observed in our study that attending education sessions significantly increased the consumption of IFA tablets among adolescents. Moreover, the frequency of consumption of IFA tablets has also increased from baseline to end line.

Furthermore, the reasons could be attributed to higher education, which is associated with an increase in self-efficacy. Linear and logistic regression analysis adjusted for potential socio-demographic determinants found a statistically significant correlation ($p<0.001$) between higher grades of education among boys and increased consumption of IFA tablets in our study. On the contrary, we did not find any significant impact of the education status on the consumption of IFA tablets among girls.

One of the major strengths of our study was the use of educational materials along with engaging activities as well as the involvement and support of local stakeholders for organizing the activities at the community level. Strength was having field staff from the local communities who could effectively communicate and deliver interventions in the communities. The present study should be seen in the light of some limitations. The COVID-19 pandemic had a differential impact on our intervention; due to lockdown and mobility restrictions in the early stages of COVID-19, there were delays in sessions. In addition, the adolescents were hesitant to attend sessions, so convincing and encouraging them was one of the challenges. The geography of the intervention districts was quite scattered and hard to reach as well. Therefore, to sustainably improve knowledge and dietary patterns and improve engagement of adolescents in our sessions, we approached their parents, frontline workers, and school teachers. Lastly, we limited our outcome indicators to the consumption of fruits and vegetables and IFA consumption because of time and resource constraints. Studies have looked at the influence of intermittent iron and folic acid supplementation on cognitive abilities among adolescent girls.[33]

We conclude that community-based interventions involving education sessions have a positive impact on improving nutritional self-efficacy and dietary practices among adolescents. Therefore, implementing community-based interventions on a broader scale holds the potential to enhance the nutritional status of adolescents. However, to our knowledge, there is limited evidence on community-based interventions among adolescent boys and girls in India. Hence, we need to do post-hoc evaluations to prove the effectiveness of many community-based interventions implemented by other civil society organizations. Engaging communities in the design and implementation of interventions promotes health, addresses nutritional deficiencies, and establishes healthy behaviours to ensure sustainability.

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