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RESEARCH ARTICLE

# Impact of a school-based nutrition educational intervention on knowledge related to iron deficiency anaemia in rural Karnataka, India: A mixed methods pre–post interventional study

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## Abstract

**Objective:** To understand the extent to which adolescent awareness about anaemia and anaemia prevention can be changed by nutrition messages received at school.

**Design:** Mixed-methods pre–post intervention study.

**Setting:** Three government schools in Bagalkot, Belagavi and Raichur districts of Karnataka, India.

**Population:** Students of grade six and seven and teachers involved in implementing the intervention.

**Methods:** An educational intervention was co-developed by school teachers and nutrition experts using locally adapted resource materials that consisted of lectures, role play and practical demonstrations. Seven half-hour educational sessions were delivered by school teachers over 7 weeks to 455 students. Pre- and post-intervention tests measured changes in adolescents' knowledge about anaemia. Semi-structured in-depth interviews with teachers and focus groups with students explored their reactions to the intervention.

**Main outcome measures:** Knowledge score related to anaemia.

**Results:** The percentage of children with correct scores increased by 7.3–49.0 percentage points for the tested questions after implementation of the intervention. The mean knowledge score increased by $3.67 \pm 0.17$ ($p < 0.01$). During interviews, teachers and students highlighted high acceptance of the intervention and materials, an increase in awareness, a positive attitude towards changing behaviour around diet, an increase in the demand for iron and folic acid supplements and improved sharing of messages learned with peers and families. Challenges expressed included need for further training, time limitations and hesitancy in teaching about menstruation and pregnancy.

**Conclusions:** Educational interventions carried out for adolescents by teachers in schools are effective in improving awareness and attitude related to anaemia and its prevention.

Shumona Sharmin Salam and Umesh Ramadurg contributed equally to this study.

KEYWORDS
adolescent, anaemia, education, nutrition, school

## 1 | INTRODUCTION

Despite several decades of programming, anaemia continues to be a critical public health problem in India, affecting 59% of adolescent girls and 31% of boys aged 15–19 years of age.[1] These rates are an increase from the 2015/16 estimates and has raised concerns regarding the effectiveness of anaemia prevention programmes.[2,3] In India, the prevalence of anaemia is highest in the early years, decreases until about 11 years of age and then increases again during adolescence, particularly in girls because of the start of menstruation and as a consequence of early marriage and teenage pregnancy.[4–8] Nutritional anaemia due to lack of iron, folate or vitamin B12 is the most prevalent cause of anaemia in this age group[6] and has long-term negative implications on growth and development, school performance and work productivity.[8–12] Anaemia during adolescent pregnancy is associated with poor pregnancy outcomes such premature births, low birthweight, and perinatal and maternal mortality.[8,13,14]

The Government of India has highlighted the importance of improving the nutrition of adolescents by modifying schemes originally aimed at the welfare of pregnant women and children. The Scheme for Adolescent Girls (SAG), the *Kishori Shakti Yojana*, RMNCH+A initiative, Sneha Clinics, the National Iron Plus Initiative, the Anaemia *Mukt Bharat* (Anaemia-free India) initiative and *POSHAN Abhiyaan*, all include special features for empowering and improving the health and nutrition of adolescents. The revamped Anaemia *Mukt Bharat* initiative aims to break the intergenerational cycle of anaemia and focuses on six groups likely to benefit, six institutional mechanisms and six interventions.[15,16] Several of these interventions, such as weekly iron and folic acid (IFA) supplementation, anaemia testing and treatment, deworming and education, specifically target adolescent boys and girls.[15]

Regardless of these interventions, findings from our recent study in rural Karnataka and other studies have revealed gaps in community awareness of adolescent anaemia and its prevention, poor dietary behaviour, low compliance with regular IFA consumption and lack of adequate nutrition education in schools.[17–21] Students and teachers described a vigilance-oriented approach, i.e., supervised swallowing of IFA tablets, without any meaningful communication on what they were receiving and why.[22] In addition to addressing supply-side barriers and careful programming, studies have continually highlighted a need to implement interventions to address demand-side barriers by improving awareness and changing behaviours surrounding diet and iron consumption.[4,16,19,23–27] Vir et al. highlighted counselling as a critical component along with the provision of IFA tablets to improve uptake. In their study, monthly counselling sessions on the positive effects of IFA intake contributed to a high compliance rate of over 85%.[27] Khapre et al., during their evaluation of the implementation of the Weekly Iron and Folic Acid Supplementation programme in Rishikesh, India, also report the lack of use of any information, education and communication materials as a barrier and recommend effective and frequent training for teachers.[25,28] Similarly, Priya et al.[19] report misconceptions among the adolescents about IFA tablet consumption and highlight the need to address these through effective communication for the Weekly Iron and Folic Acid Supplementation programme to be successful.[19] To this end, we conducted research to understand the extent to which adolescent students' awareness about anaemia and anaemia prevention can change through short, targeted nutritional education intervention delivered by teachers at school. In addition, we also explored adolescent students' and teachers' reactions to the intervention including acceptability, perceived benefits and challenges in implementation of the intervention.

## 2 | METHODS

### 2.1 | Design and setting

To investigate the effects of targeted nutritional education, a mixed-methods pre–post intervention study was conducted in three purposively selected government schools of North Karnataka, one each in Bagalkot, Belagavi and Raichur districts. The three districts are adjoining, but have different health indicators, with Belagavi having the best and Raichur, the least favourable. A typical class had about 35–40 students, with most schools having two classes for one grade. All students in grades six and seven in the three schools were invited to participate in the study. Our preliminary research as well as discussions with school teachers revealed that many girls drop out of school after grade seven, which is the year in which children finish higher primary school and are expected to change schools. Therefore, these grades were chosen to ensure that most girls have access to the intervention. Written informed consent was obtained from the students' parents and assent was given by the students. Pre-intervention and post-intervention tests were used to measure changes in adolescents' awareness due to the intervention, and qualitative interviews were used to capture reactions to the intervention.

### 2.2 | Nutrition education intervention: Co-development process and delivery

The nutrition education intervention was co-developed through multiple deliberations and discussions with community leaders, local school teachers and local nutrition experts. The team discussed and decided on the content, mode of delivery, the educators and target beneficiaries for

the intervention. The community leaders suggested topics to be covered in addition to knowledge about food, which have a bearing on good nutrition. Teachers gave inputs about the content, language and pictures used, and formatting of display material. The nutrition experts ensured overall relevance of the proposed topics and material. A multimodal learning approach was used as a basis to develop the intervention. The resource materials were adapted from the resources available for the Anaemia *Mukt Bharat* programme and the National Institute of Nutrition. The final intervention materials included illustrative, pictorial, and colourful books, cards, wall charts, hand-books for teachers and food samples (legumes, grains, dry fruits, vegetables). Emphasis was placed on ensuring that materials developed were appealing to children and easy to understand. All materials were translated into the local language (Kannada) with photos of local foods added, and messages were modified as appropriate for the Kannada language. The education intervention was delivered through teachers and divided into seven sessions containing lectures, role-play and practical demonstrations. Teachers were chosen as educators by the co-development team to ensure sustainability of the intervention and students of grades six and seven were chosen, considering the higher attrition among older students. The sessions covered: (1) balanced diet; (2) anaemia and its importance; (3) anaemia in pregnancy; (4) diet and anaemia – iron-rich foods; (5) IFA supplementation; (6) myths and facts about IFA, dos/ don'ts of IFA consumption; (7) good habits to be adopted and (8) summary and mantras for adolescent health. The intervention was delivered in Kannada in sessions of approximately half an hour once every week for 7 weeks.

A total of 11 teachers (one male and ten female) from the three schools were initially provided with a 1-day in-person training on the materials and approach before the start of the intervention. Regular online weekly refresher training was conducted during the intervention to reinforce the material and resolve any challenges.

## 2.3 | Data collection

Pre- and post-intervention tests on knowledge about anaemia were conducted with the participating adolescents before and after the education sessions. A structured pretested Knowledge Assessment Questionnaire with a maximum score of 18 was administered in Kannada. Post-intervention testing was conducted ~1–2 weeks after the last classroom session. In addition, post-intervention semi-structured in-depth interviews (IDIs) with seven teachers and six focus group discussions (FGDs) with students, two in each district (one for girls and one for boys), were conducted to elicit information and opinions about the intervention. All questions were open-ended and covered experiences with the intervention, learnings, benefits and challenges among others. Each IDI/FGD was conducted in a private location within the school premises. Written informed consent was obtained before the IDIs/FGDs. Each FGD had six participants and the IDIs/FGDs lasted between 30 and 105 minutes. With the permission of the participants, the entire IDI/FGD was audio-recorded and a note-taker additionally took handwritten notes. Immediately after each IDI/FGD, a short summary of the IDI/FGD was prepared, noting any important points or challenges to facilitate data analysis.

## 2.4 | Data analysis

For quantitative data, descriptive statistics, including means, standard deviations, percentages, and frequencies, were used to illustrate respondents' characteristics and intervention participation. Pre- and post-knowledge scores were calculated, and paired *t* tests were used to determine significant changes in knowledge scores after the implementation of the intervention. The score obtained was also categorised as low (score between 0 and 5), medium (score between 6 and 11) and high (score between 12 and 18). Statistical analyses were performed using the statistics programme STATA 17.0 (www.stata.com). Qualitative data were analysed using an inductive thematic approach. Transcripts were read by team members to develop a separate coding framework for FGDs and IDIs, based on the topic guides. Coded sections were reviewed to generate themes, and team discussions were held to cross-check findings. NVivo v 12 Analysis Software (QSR International Pty Ltd., Burlington, MA, USA) was used for analysing the qualitative data.

# 3 | RESULTS

## 3.1 | Background characteristics of participants

A total of 455 children were enrolled in the study, about 60% were 11–12 years of age and 56% were girls (Table 1). The children were studying in year 6 (51.9%) or 7 (48.1%) during the implementation of the intervention (Table 1). A total of 413 (90.8%) children participated in both the tests: 419 (92.1%) in the pre-intervention test and 447 (98.2%) in the post-intervention test. The seven teachers participating in the IDIs were 30–45 years of age.

## 3.2 | Intervention compliance

Table 1 shows the attendance rates (percentages) of children in the education sessions. About 71% (86.1% in Belagavi, 64.5% in Raichur and 63.1% in Bagalkot) of the children attended a majority[6,7] of the sessions. Average attendance ranged from 5.7 to 6.3 sessions across the districts.

## 3.3 | Impact of the intervention on knowledge

Baseline or pre-intervention knowledge of several aspects related to anaemia, iron and iron-rich food, IFA supplements

**TABLE 1** Background characteristics and attendance in education sessions by district.

| | Bagalkot ($N=149$) | | Belagavi ($N=151$) | | Raichur ($N=155$) | | Total ($N=455$) | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| Age | | | | | | | | |
| 11–12 years | 88 | 59.1 | 72 | 47.7 | 111 | 71.6 | 271 | 59.6 |
| 13–14 years | 61 | 40.9 | 79 | 52.3 | 44 | 28.4 | 184 | 40.4 |
| Sex | | | | | | | | |
| Male | 60 | 40.3 | 64 | 42.4 | 78 | 50.3 | 202 | 44.4 |
| Female | 89 | 59.7 | 87 | 57.6 | 77 | 49.7 | 253 | 55.6 |
| Grade | | | | | | | | |
| Six | 85 | 57.1 | 64 | 42.4 | 87 | 56.1 | 236 | 51.9 |
| Seven | 64 | 43.0 | 87 | 57.6 | 68 | 43.9 | 219 | 48.1 |
| Sessions attended | | | | | | | | |
| 0–2 sessions (low) | 5 | 3.4 | 4 | 2.6 | 6 | 3.9 | 15 | 3.3 |
| 3–5 sessions (medium) | 50 | 33.6 | 17 | 11.3 | 49 | 31.6 | 116 | 25.5 |
| 6–7 sessions (regular) | 94 | 63.1 | 130 | 86.1 | 100 | 64.5 | 324 | 71.2 |
| Mean (SD) sessions attended | 149 | 5.67 (1.24) | 151 | 6.25 (1.32) | 155 | 5.70 (1.43) | 455 | 5.87 (1.36) |

Abbreviation: SD, standard deviation.

and deworming was low, with 13.1%–46.0% of the respondents providing correct answers to the test questions. A significant increase was seen in the percentage of children who provided correct responses to the questions after the implementation of the intervention. The percentage of children with correct scores increased by 7.3–49.0 percentage points for the tested questions except for Q6_6 where most of the children did not mention 'dates' as a source of iron-rich food (Table 2).

The mean ± standard deviation score of the students in the pre-intervention test was 5.64 ± 2.66, which significantly increased to 9.32 ± 3.52 after the intervention ($p < 0.01$) (Table 3). The mean difference was 3.67 ± 0.17.

Table 4 and Figure 1 show the pre- and post-intervention test performances of students by district, age, gender and attendance level. The performance of students improved in all districts, and with increasing attendance level. Although knowledge of boys was low compared with that of girls before the intervention, the gap was reduced following the intervention. No major difference was observed by age.

## 3.4 | Reactions to the education intervention

Interviews with teachers and FGDs with students revealed that teachers and students were highly accepting of the interventions, the communication materials used and the education sessions and shared their learnings with peers and families. Perceived benefits elucidated included increase in knowledge, a positive attitude towards behaviour change and an increase in the demand for IFA supplementation. Teachers also highlighted some challenges in implementation and how the intervention could be improved. These are highlighted in the sections below.

### 3.4.1 | Acceptability of the intervention

*Overall high satisfaction and positive feedback about the intervention*

Both teachers and students mentioned that the pictorial nature of the behaviour change communication materials and the multimodal stimulation created interest in the students, including those who had difficulty in reading and writing. During the FGDs, students mentioned that they particularly liked the cards, pictorial book and practical sessions using grains, vegetables and other food items. These are highlighted in the excerpts below:

- '…we have learnt a lot after reading this book. We know things in detail now; we never felt bored while reading.' (Student, FGD)
- '…they want to see pictures and have activities; they can learn better that way.' (Teacher, IDI)
- 'Some children are not very bright, they have difficulty in reading and writing, even such children found the book very useful, they used to see the pictures and understand.' (Teacher, IDI)

*Information sharing and positive response from peers and relatives*

Students also cited that they shared information and materials received with their family members, friends and other

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**TABLE 2** Percentage of children with correct response for each question by test type.

| Topic area | Questions with correct answers | Correct answers | | *p* value |
|---|---|---|---|---|
| | | Pre-test (*n* = 413) (%) | Post-test (*n* = 413) (%) | |
| Anaemia | Anaemia is low iron (haemoglobin) in blood | 40.7 | 75.3 | <0.01 |
| | In India prevalence of anaemia is ~50% | 13.1 | 58.8 | <0.01 |
| | Anaemia can cause | | | |
| | Poor growth | 23.2 | 33.2 | <0.01 |
| | Repeated infections | 45 | 57.4 | <0.01 |
| | Difficulty with studies | 13.6 | 29.5 | <0.01 |
| Iron and iron-rich foods | Iron consumption is mainly needed for blood improvement | 28.3 | 35.6 | <0.05 |
| | The following are iron-rich foods | | | |
| | Meat | 28.3 | 41.4 | <0.01 |
| | Sprouted vegetables | 31 | 39.2 | <0.05 |
| | Groundnut Laddoo | 32.4 | 43.8 | <0.01 |
| | Dates | 19.4 | 17.2 | ns |
| | Green leafy vegetables | 46 | 59.1 | <0.01 |
| | Guava increases the absorption of iron | 38.7 | 59.1 | <0.01 |
| | Tea inhibits the absorption of iron | 38.7 | 63 | <0.01 |
| IFA supplement | The Government of India recommends one IFA tablet be taken by adolescents once a week | 34.6 | 52.3 | <0.01 |
| | The best time to consume an IFA tablet is 1 hour after meals | 34.1 | 83.1 | <0.01 |
| | Blackish stool after IFA tablet consumption is a normal occurrence with iron consumption | 18.6 | 43.6 | <0.01 |
| | The colour of Government-supplied IFA supplements is red/blue/pink | 42.4 | 72.2 | <0.01 |
| Deworming | Deworming is recommended once in 6 months | 36.1 | 68 | <0.01 |

Abbreviation: IFA, iron and folic acid.

**TABLE 3** Comparison of test score before and after intervention.

| Score | *n* | Mean ± 2SD | Mean difference ± 2SE | *p* value |
|---|---|---|---|---|
| Pre-intervention test score | 413 | 5.644 ± 2.66 | 3.673 ± 0.17 | <0.01 |
| Post-intervention test score | 413 | 9.317 ± 3.52 | | |

*Note*: Paired *t* test, *t*, df = −21.5, 412.

Abbreviations: SD, standard deviation; SE, standard error.

students, who were appreciative of the topic and materials. This included informing family members about balanced meals, harmful effects of tea, tobacco and alcohol, and benefits and appropriate ways of consuming IFA tablets among others.

One student mentioned: 'We have explained to our family members that we do not get harmed by the tablets in any way. The teachers also take them. They are supplied by the Government. Because we do not eat too many vegetables, this incorporates all that. It has lots of iron content' (Student, FGD).

Another teacher cited, 'Few girls have explained about importance of Iron and folic acid to their sisters or aunts who are pregnant…the girl students have given them correct information. We initially thought teaching people would be difficult, but it wasn't as difficult' (Teacher, IDI).

Additionally, a teacher reflected that education through children may be a better way to bring about a change in the community: 'Also people here don't cooperate much. If we force and tell them about these things, they may not accept. So, the best way to teach them is through children' (Teacher, IDI).

**TABLE 4** Comparison of pre- and post-intervention performance by background characteristics.

| | Pre-intervention test score | | | | | Post-intervention test score | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **Low (0–5) (%)** | **Medium (6–11) (%)** | **High (12–18) (%)** | **Mean** | ***n*** | **Low (0–5) (%)** | **Medium (6–11) (%)** | **High (12–18) (%)** | **Mean** | ***n*** |
| District | | | | | | | | | | |
| Bagalkot | 26.8 | 71.7 | 1.5 | 6.61 | 138 | 7.5 | 49.3 | 43.2 | 10.89 | 146 |
| Belagavi | 47.5 | 51.1 | 1.4 | 5.94 | 139 | 19.2 | 65.1 | 15.8 | 8.22 | 146 |
| Raichur | 73.2 | 26.8 | 0.0 | 4.35 | 142 | 13.6 | 66.5 | 20.0 | 8.79 | 155 |
| Age (years) | | | | | | | | | | |
| 11–12 | 54.7 | 44.9 | 0.4 | 5.25 | 245 | 13.2 | 62.4 | 24.4 | 9.23 | 266 |
| 13–14 | 42.0 | 56.3 | 1.7 | 6.14 | 174 | 13.8 | 57.5 | 28.7 | 9.38 | 181 |
| Gender | | | | | | | | | | |
| Male | 53.6 | 44.2 | 2.2 | 5.39 | 181 | 17.8 | 60.4 | 21.8 | 8.73 | 197 |
| Female | 46.2 | 53.8 | 0.0 | 5.80 | 238 | 10.0 | 60.4 | 29.6 | 9.74 | 250 |
| Intervention attendance | | | | | | | | | | |
| Low | 66.7 | 33.3 | 0.0 | 3.25 | 12 | 27.3 | 63.6 | 9.1 | 8.18 | 11 |
| Medium | 49.1 | 49.1 | 1.9 | 5.52 | 106 | 13.9 | 63.5 | 22.6 | 9.27 | 115 |
| Regular | 48.8 | 50.5 | 0.7 | 5.75 | 301 | 12.8 | 59.2 | 28.0 | 9.33 | 321 |
| Total | 49.4 | 49.6 | 1.0 | 5.62 | 419 | 13.4 | 60.4 | 26.2 | 9.29 | 447 |

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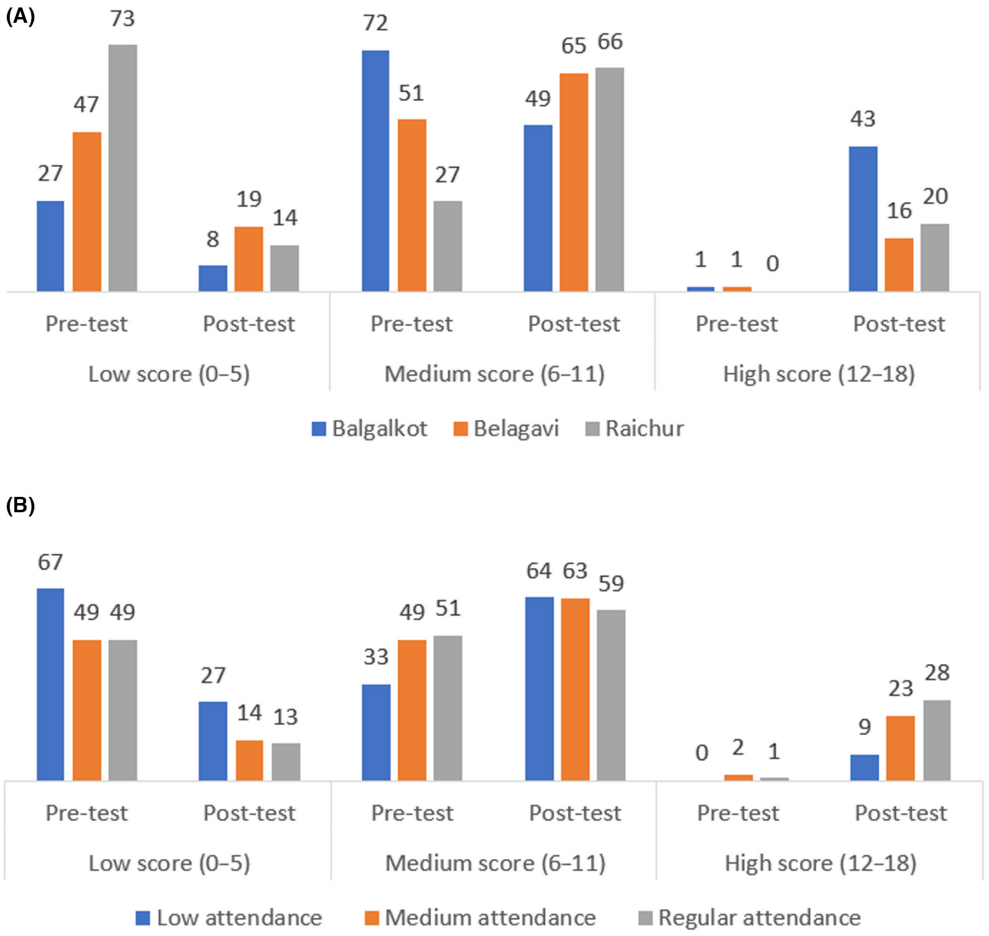


**FIGURE 1** Pre-test and post-test performance (A) by district, and (B) by attendance intensity.

### 3.4.2 | Perceived benefits of the intervention

*Increase in knowledge*

Participating teachers and students expressed that these topics were either new to them or that they did not have in-depth knowledge. Teachers perceived that their knowledge had increased after the training and after reviewing the materials, as one teacher mentioned: 'We did not even know that anaemia exists in pregnancy…Now through this syllabus, we have attained basic knowledge about why a pregnant woman has anaemia' (Teacher, IDI). Similarly, students shared several positive influences of the education sessions on their knowledge and awareness regarding anaemia, iron consumption, anaemia in pregnancy, balanced diet, etc.:

- 'Earlier I never used to eat well or consume tablets. After these classes, I am aware of how to eat good food.' (Student, FGD)
- 'We learnt about parasitic infection and tablets to consume for that…they were health related. We didn't know previously, and the topics were new.' (Student, FGD)

*Positive attitude towards behaviour change*

Although our study was not intended to measure change in behaviour, we asked teachers and students whether there were any changes after the implementation of the education sessions. Findings reflect a change in attitude and behaviour regarding vegetable consumption, exercise, handwashing, reducing junk food, tea, tobacco and alcohol consumption and an increase in the demand for IFA tablets. For example, teachers as well as students mentioned that there was more acceptance of eating vegetables during the mid-day meal after the sessions:

- '…before this project began, we used to make sure that they ate all the vegetables… but now, they are doing it voluntarily.' (Teacher, IDI)
- 'I used to not eat vegetables at school, but now I eat. After the lessons we have started eating properly. Earlier our teachers used to repeatedly tell us, but we used to ignore.' (Student, FGD)

Similarly, a teacher shared an incident where a student showed her father the pictures and spoke to him about the negative effects of tobacco: 'See, if you continue to drink and chew tobacco, you will get all these diseases.' The teacher further mentioned: 'He rang me up immediately that night and thanked me. He said his daughter has "changed my mind in this manner".' (Teacher, IDI).

*Increase in demand for IFA supplements*

As a result of the COVID-19 pandemic, there was a discontinuation in the supply of IFA tablets in the schools during

the study period. However, several teachers and students expressed that the demand for IFA had increased after the education sessions. Teachers shared that the sessions created an understanding among the students that the food consumed may not be enough to meet their iron requirements and hence they were asking when the school could provide IFA tablets: 'They asked us, "Why are we not being given the tablets?" They asked the headmistress. They have understood the concept that our food does not contain enough iron and hence we need to take the tablets. That is the reason they asked for the tablets.' (Teacher, IDI).

#### 3.4.3 | Challenges in implementation

Participants, particularly teachers, identified some challenges regarding training needs, time constraints and hesitancy in talking to all students together about pregnancy and menstruation. The teachers included in the study varied by background and were not necessarily science teachers. A 1-day training was arranged for all teachers, and some felt that the training duration should have been increased, whereas others expressed that more details should have been included for teachers in the training manual. A few teachers (both male and female) were hesitant to discuss menstruation and pregnancy-related session to all boys and girls together and felt that the students were not interested in the topics or that the topics were more suitable for older students. As one teacher mentioned, '…We called the 7th grade girls separately and told them about changes in body during puberty' (Teacher, IDI). On the contrary, several teachers and students expressed that it was the topic that was most interesting to the students.

Although all teachers expressed interest in continuing the sessions, lack of time was also consistently mentioned as a barrier. To overcome this and ensure sustainability, teachers suggested incorporating these topics as part of the primary and secondary school curriculum: 'Instead of keeping it as a separate subject, if it is incorporated in our subject textbooks, it will be better…if this happens, the basics will be covered in the primary school and as the child goes into higher classes, it will be taught more and more in depth.' (Teacher, IDI). Other suggestions included incorporating more activities, such as drama, plays, and videos to stimulate learning and using these methods to teach other topics.

## 4 | DISCUSSION

### 4.1 | Main findings

The present study demonstrated that an interactive and multimodal nutrition education intervention on knowledge regarding anaemia among a sample of school-going adolescents in rural Karnataka, India was effective. We report a significant improvement in nutrition knowledge and awareness after the implementation of the intervention. IDIs with teachers and FGDs with students reveal high acceptance of the intervention and dissemination of messages learnt with peers and families. Participants highlighted positive outcomes including an increase in their knowledge, a positive attitude towards behaviour change around diet and an increase in the demand for IFA supplements. Challenges expressed were related to the need for further training, time limitations, and hesitancy in talking and learning about information related to menstruation and pregnancy.

### 4.2 | Strengths and limitations

One of the major strengths of the study was the co-development of the education materials and the implementation plan with relevant local stakeholders including teachers and health and nutrition experts to ensure acceptability and viability.[29] Based on repeated discussions with stakeholders, a few key decisions were made. These included incorporating information on balanced diet and health and hygiene in addition to topics related to anaemia, contextual adaptation of existing behaviour change communication materials, implementation of the intervention among grade six and seven students, and involvement of teachers as educators.

The study was designed to measure changes in knowledge, not in behaviour. However, several studies in India have reported a change in behaviour after the implementation of school-based nutrition education interventions. As a result of the planned school closures in response to the COVID-19 pandemic, the post-intervention test was carried out after a gap of only 1–2 weeks, and retention in knowledge was not studied. Also, to sustainably enhance knowledge, the education intervention would need to be repeatedly implemented and among students of different grades. For this pilot intervention, we only focused on students of sixth and seventh grades as suggested by the co-development team.

### 4.3 | Interpretation (in light of other evidence)

The findings of this study are consistent with previous studies that suggest that nutrition education in schools can improve knowledge and awareness about anaemia; increase demand and improve compliance with IFA supplements; and change adolescent dietary behaviour.[30–34] The pedagogical approach employed in the education sessions differed from conventional approaches in schools and was designed to be interactive and participatory, which we believe crucially contributed towards greater acceptance of the intervention and a positive impact on knowledge and attitude.[35] Similar studies conducted in school settings in India using varied approaches, such as single or multiple interactive education sessions delivered by doctors, trained experts using flipcharts, videos and other interactive methods have been found to improve

knowledge and/or change behaviours related to anaemia and its prevention.[30–33] Evaluation of the Weekly Iron and Folic Acid Supplementation programme in India and other low- and-middle-income countries found that one of the key factors influencing increased uptake of IFA supplements was implementation of a coordinated and timely information education and communication strategy that dispelled misconceptions and rumours, and capitalised on the positive effects.[25,28,36–39] Moreover, as indicated by Joe et al.,[16] increased awareness and subsequent demand-generation by target groups will help address other institutional barriers related to the supply and distribution of IFA supplements.

The present study also reported knowledge about anaemia to be low among boys before the start of the intervention, in concordance with several other studies.[40–42] Although recent data indicate no major gender disparities in the coverage of IFA supplementation in schools, being aware of anaemia itself acts as a motivation for consumption of IFA tablets.[17,18] Equal emphasis must therefore be given to educating both boys and girls about anaemia and its prevention.

The inclusion of nutrition education in formal education programmes targeted towards children in primary schools is one of the most commonly recommended strategies because of its potential in developing positive health, eating and lifestyle habits that may persist into adulthood.[43,44] Murimi et al.[45] highlighted several features of successful school-based nutrition education interventions: engagement of parents, identification of specific behaviours to be modified, ensuring fidelity by training educators, adequate dosage, and age-appropriateness of interventions. Several of these features warranted more attention in the present study, including training, appropriateness of content, dosage and engagement of parents. For example, the role of teachers was essential to intervention success, but they expressed difficulties related to time constraints and training. To resolve time limitations as well as to ensure continuation and viability, they suggested that the content be included in the national curriculum. Gaining an understanding of anaemia motivated teachers to help ensure fidelity and realise project objectives, but this could be further improved by providing adequate training, endorsement and implementing a teacher-friendly intervention.[25,46–48]

Despite co-development of the content of the education sessions, some teachers were hesitant to focus on topics related to menstruation and pregnancy, particularly in the presence of boys. In patriarchal societies like India where gender norms are strict, menstruation and pregnancy are considered as 'women's' topics and exclusion of boys from related discussions can further increase gender disparities.[49,50] Hence, research needs to be conducted to understand how best to include these topics in sessions involving both boys and girls.

One of the benefits of school-based health and nutrition education programmes is that children act to spread the information, bringing it to their homes to achieve transmission of the information to the whole family.[51,52] Our findings reveal the same with students discussing and sharing topics learnt with friends and families. However, to achieve better impact, studies recommend involvement of families and communities in the nutritional education programmes from the beginning.[52–55]

## 5 | CONCLUSION

Appropriate education and counselling on anaemia, iron-rich diet and IFA supplementation is crucial for adolescents and can help to raise awareness about anaemia and its prevention. Our findings indicate that an education intervention employing a multimodal learning approach carried out for adolescents by teachers in schools is effective in improving awareness and attitude related to anaemia and its prevention. Adoption of such intervention in the national curriculum and scale-up may help to make improvements in the nutritional status of adolescents. Future studies to assess impact on behaviours related to diet and consumption of IFA supplements as well as anaemia status will provide insights regarding the effectiveness of the intervention.

### AUTHOR CONTRIBUTIONS

DOCA, GK, BG and SSS contributed to the conceptualisation and design of the study. DOCA, SG, AM, SR and BP provided overall guidance. SSS and UR drafted the manuscript and incorporated all feedback. SSS, UR, UC, GK, BG, JM and SP were involved in data analysis and interpretation. UR, UC, GK, JM, SP, PV, CK and AD were involved in data acquisition and overall implementation of the study. All authors read and approved the manuscript.

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### CONFLICT OF INTEREST STATEMENT

None declared.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### ETHICS APPROVAL

The research protocol was approved by the institutional ethics committees at the three study sites and the University of Sheffield. The Health Ministry's Screening Committee at the Indian Council for Medical Research

approved the project. The trial was registered with the Clinical Trial Registry of India (CTRI/2020/09/027515) on 1 September 2020.

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