

## Research Article

**Cite this article:** Getacher L, Ademe BW, and Belachew T (2024). Effect of double-duty interventions on double burden of malnutrition among adolescents in Debre Berhan Regiopolitan City, Ethiopia: a cluster randomised controlled trial. *Journal of Nutritional Science* **13**: e74, 1–12. doi: [10.1017/jns.2024.68](https://doi.org/10.1017/jns.2024.68)

Received: 13 March 2024  
Revised: 9 August 2024  
Accepted: 9 September 2024

### Keywords:

Adolescents; Double burden of malnutrition; Double-duty interventions; Ethiopia; Overnutrition; Undernutrition

### Corresponding author:

Lemma Getacher;  
Email: [lemmagetacher@gmail.com](mailto:lemmagetacher@gmail.com)

© The Author(s), 2024. Published by Cambridge University Press on behalf of The Nutrition Society. This is an Open Access article, distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives licence (<https://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided that no alterations are made and the original article is properly cited. The written permission of Cambridge University Press must be obtained prior to any commercial use and/or adaptation of the article.



# Effect of double-duty interventions on double burden of malnutrition among adolescents in Debre Berhan Regiopolitan City, Ethiopia: a cluster randomised controlled trial

Lemma Getacher<sup>1,2</sup> , Beyene Wondafrash Ademe<sup>2</sup>  and Tefera Belachew<sup>2</sup> 

<sup>1</sup>School of Public Health, Asrat Woldeyes Health Science Campus, Debre Berhan University, Debre Berhan, Ethiopia and <sup>2</sup>Department of Nutrition and Dietetics, Faculty of Public Health, Institute of Health, Jimma University, Jimma, Ethiopia

## Abstract

Combating the double burden of malnutrition (DBM) in adolescents is a critical public health challenge in low-income countries like Ethiopia. However, past efforts have lacked focus and exhibited diverse governance strategies. Therefore, this study assesses the effect of selected double-duty interventions (DDIs) on DBM among adolescents in Central Ethiopia. The DBM status (thinness, normal, overweight/obesity) was determined using WHO AnthroPlus software. A two-arm parallel cluster randomised controlled trial was used among 708 adolescents (356 for the intervention group [IG] and 352 for the control group [CG]) from 13 October 2022 to 30 June 2023. The intervention's effect was analysed through difference-in-difference (DID) analysis and a multivariable multinomial generalised estimating equation (GEE) model with significance set at  $P < 0.05$ . The overall DBM prevalence decreased by nearly 7% (4.7% for thinness, 2.2% for overweight/obesity) in the DID analysis. After adjusting for possible confounders, the GEE model indicated that adolescents in the IG were 34% less likely to have higher DBM than those in the CG (AOR = 0.66, 95% CI [0.46, 0.94]). Additionally, the probability of DBM decreased by 59% at the end line compared to baseline measurements (AOR = 0.41, 95% CI [0.03, 0.92]). Adolescents in the category of time and IG interaction were 44% less likely to have increased DBM (AOR = 0.56, 95% [CI 0.02, 0.38]). Thus, this study underscores the effectiveness of selected DDIs in addressing DBM among adolescents using a health belief model. These results advocate for the integration of DDI strategies into existing nutrition guidelines, programmes, and policies.

The trial was registered prospectively in ClinicalTrials.gov with registration number NCT05574842.

## Introduction

The term double burden of malnutrition (DBM) refers to the simultaneous occurrence of undernutrition and overnutrition (overweight and obesity) in the same individuals, households, and populations at the national and international levels throughout the life course.<sup>(1)</sup> It may, for instance, manifest at the individual level as obesity accompanied by a vitamin or mineral deficiency or as overweight adulthood following childhood stunting. Similarly, it could show up as an overweight or anaemic mother with underweight children or grandparents at the household level. The prevalence of both undernutrition and overweight/obesity can occur in the same community, country, or region when it occurs at the population level.<sup>(1–3)</sup>

According to the WHO, adolescence is the age between 10 and 19 years and serves as a transition between childhood and adulthood.<sup>(4)</sup> Due to accelerated growth and development, it is a crucial time in a person's life after infancy.<sup>(5)</sup> It is also a time when higher food intake is necessary for their rapid growth as a result of developmental changes.<sup>(6,7)</sup>

Multiple types of malnutrition are experienced and faced by all of the global countries at all levels of development and socio-economic status.<sup>(8,9)</sup> Especially in the previous three decades, different regions of the world have experienced accelerated and varying degrees of dietary change. Moreover, the nutrition transition occurred with different changes in health, epidemiologic, demographic, and socio-economic factors coupled with dietary and activity pattern changes. This shift leads to highly increased overnutrition and diet-related non-communicable diseases (DR-NCDs) in addition to the already existing undernutrition and micronutrient deficiency.<sup>(1)</sup> The common driving forces of DBM were early-life nutrition, diet quality, biology-related factors, epigenetics, food environments, food systems, socio-economic factors, and poor governance.<sup>(8,10–12)</sup> Of these, four are the most modifiable drivers for multiple forms of malnutrition. These are dietary quality, early-life nutrition, socio-economic factors

(e.g. poverty, poor educational status, poor occupational status), and food environments (e.g. lack of nutritious foods, increased availability packed foods in the market, processed foods).<sup>(12,13)</sup>

Globally, nearly a quarter of adolescents worldwide are undernourished and overweight, and obesity is increasing rapidly in nearly every country of the globe.<sup>(1,14)</sup> In summary, various studies conducted among adolescents worldwide have revealed that the prevalence of DBM ranges from 2.7% to 73.33%. Specifically, the prevalence of thinness ranges from 3% to 39.4%, overweight ranges from 5.9% to 65%, and obesity ranges from 2.7% to 73.33%.<sup>(15–19)</sup> In African countries, the prevalence of DBM varies significantly. The prevalence ranges from 1.8% to 25%, with specific rates for thinness, overweight, and obesity ranging from 6.3% to 11.2%, 2.2% to 25%, and 1.8% to 6.1%, respectively.<sup>(20–25)</sup> Similarly, in Ethiopia, various studies conducted in the country report the prevalence of DBM ranging from 2.39% to 55.0%. Specifically, the prevalence of thinness ranges from 4.7% to 55.0%, overweight ranges from 3.3% to 20.6%, and obesity ranges from 2.39% to 4.7%.<sup>(26–35)</sup>

To end widespread hunger and eradicate all forms of malnutrition, the UN Decade of Action on Nutrition aims to intensify actions within the global agenda of Sustainable Development Goals (SDGs). This effort addresses both undernutrition and overnutrition. The SDGs 1 ('end poverty') and 2 ('end hunger, achieve food security and improved nutrition') are directly related to tackling DBM. Target 1.1 aims to eradicate extreme poverty by 2030, and target 2.2 aims to end all forms of malnutrition by 2030. Progress towards these goals is slow and uneven, making timely achievement unlikely. Furthermore, the progress to achieve the 2012 global nutrition targets is very slow and unfair. The achievement of these objectives is highly unlikely in the next few years before that date without a miracle.<sup>(1,14,36–38)</sup>

With regard to the nutritional interventions implemented to reduce the effect of DBM, several studies have shown that nutritional interventions are effective in reducing nutrition-related problems.<sup>(39,40)</sup> Although different forms of malnutrition can coexist simultaneously in lower- and middle-income countries (LMICs), most previous nutrition interventions targeted only one form of malnutrition, which is undernutrition.<sup>(11,38,41)</sup> The 2018 WHO guidelines recommend evidence-informed interventions and policies for adolescent nutrition.<sup>(4)</sup> Among the most essential nutritional interventions are (1) promoting healthy diets in adolescents, (2) preventing adolescent pregnancy and poor reproductive outcomes, (3) promoting preconception and antenatal nutritional care in adolescents, (4) providing access to a safe environment and hygiene for adolescents, (5) promoting physical activity in adolescents, and (6) preventing and managing disease in adolescents. Moreover, the 2017 WHO policy brief and the 2020 Lancet Series on the DBM highlight that overweight and obesity are forms of malnutrition that now coexist with the persistent problems of nutritional deficiencies in most countries around the world, especially in LMICs, forming a 'new nutrition reality' that will require new interventions, strategies, programmes, and policies to successfully tackle it.<sup>(11,31,38,41,42)</sup>

Double-duty interventions (DDIs) are interventions that have the potential to simultaneously tackle the burden of both undernutrition and overnutrition in a comprehensive manner.<sup>(11,43,44)</sup> These interventions can be achieved in three ways. First, by not harming the existing interventions for malnutrition. Second, through retrofitting the existing intervention to address all types of malnutrition. Third, through the development of de novo integrated interventions (starting from the beginning, anew, or a

new) aimed at the DBM.<sup>(11,38,41)</sup> Selected DDIs applied in this study were optimised through strong education and nutrition behaviour change communication (NBCC) focused on promoting healthy diets (adequate adolescent nutrition, dietary diversity), physical activity (performing proper physical exercise, avoiding sitting for long time), preventing undue harm from energy-dense foods (avoiding junk processed foods, avoiding sugar-sweetened drinks, street fast foods, chips, salt, sugar, etc.), and regulations on marketing foods from the customer side (e.g. buying packed foods frequently).<sup>(11,38,41)</sup>

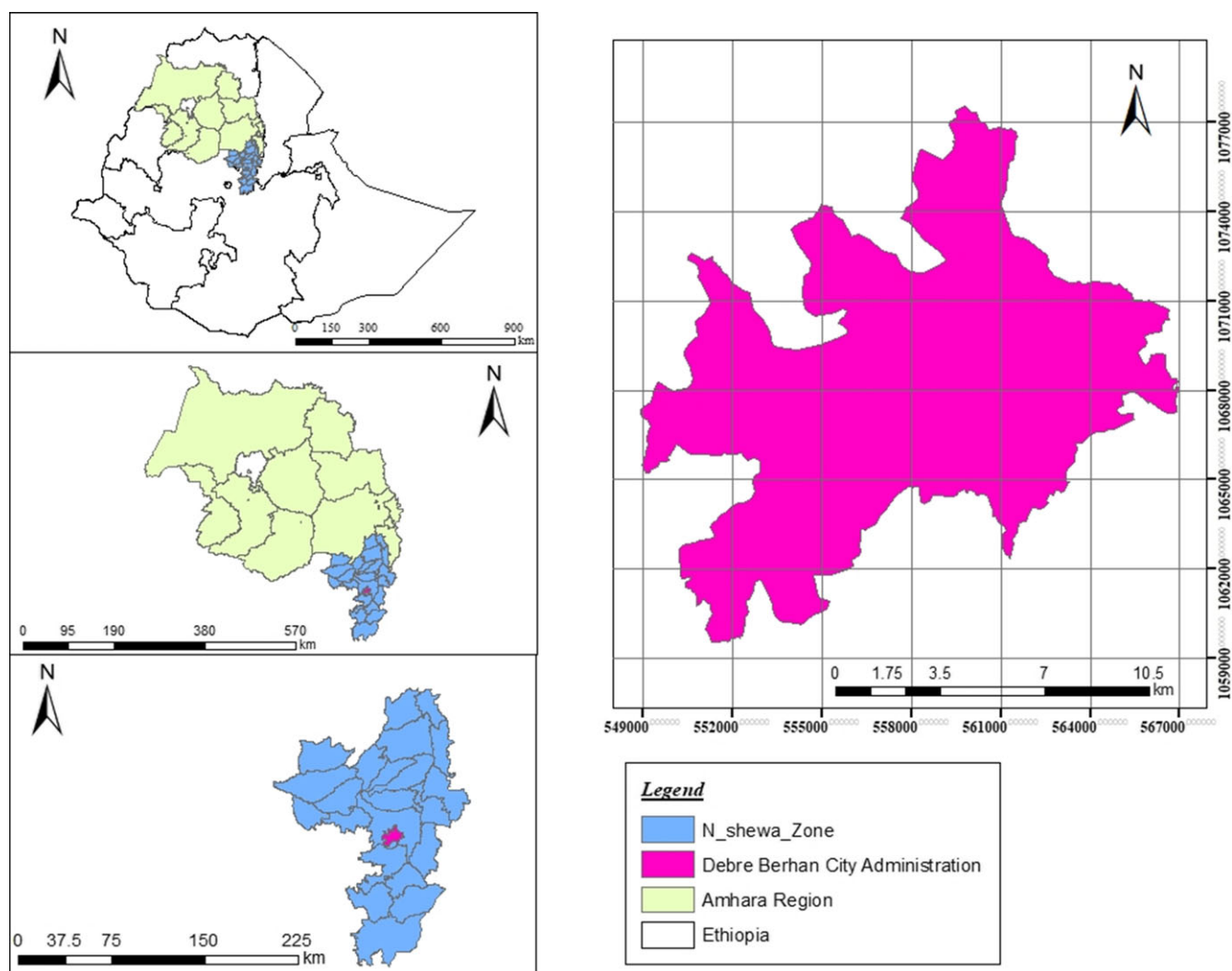
Previously, actions applied to address undernutrition and overnutrition were developed and delivered separately, and they are still isolated from each other. Unintentionally, as some evidence has shown, programmes that address undernutrition have increased risks for obesity and DR-NCDs, especially in LMICs, where food environments are changing rapidly. Until now, different countries of the world, including Ethiopia, have failed to consider these risks in their policies and interventions.<sup>(38)</sup> In contrast, DDIs can simultaneously tackle the risk of both nutritional deficiencies leading to stunting, underweight, or micronutrient deficiencies and obesity or DR-NCDs by the same intervention. These interventions assume that all forms of malnutrition share common determinants that can be addressed through interventions that have a double impact in a holistic approach.<sup>(11,38)</sup>

Evidences show that theory-based behavioural theories are very effective for the acceptance of the intervention.<sup>(45,46)</sup> Among the effective behavioural theories health belief model (HBM) is one of them. The HBM comprises six theoretical constructs assessing individuals' health behaviours: perceived susceptibility, severity, benefits, barriers, cues to action, and self-efficacy. This study evaluates adolescents' perceptions regarding these constructs in relation to DBM. It examines how dietary intake impacts the DBM risk, the consequences of dietary habits on DBM outcomes, views on dietary improvements and physical activity, obstacles to nutritional enhancement, cues prompting action, and confidence in adopting healthy behaviours to improve nutritional status. However, previous studies conducted on the reduction of malnutrition did not use theory-based behavioural theories among adolescents. Hence, to boost the acceptance of the DDIs in the study area, this study applied HBM to reduce DBM. Moreover, there is a gap in interventional research, policies, and actions related to DBM among adolescents and its consequences on their health, nutritional status, frequency of morbidity, and linear growth in developing countries such as Ethiopia.<sup>(31,35)</sup> Most of the studies are cross-sectional with insufficient evidence on DBM. In addition, most studies conducted on the relationship between DBM and its negative effects on adolescent health were mostly from most affluent and moderately affluent countries.<sup>(34,47–50)</sup> Therefore, the main objective of this study was to examine the effect of selected DDIs on the DBM among secondary school adolescents in Debre Berhan City, Central Ethiopia, 2022/23.

## Methods and materials of the study

### Study area, period, and design

This study was conducted in Debre Berhan Regiopolitan City, North Shoa Zone, Amhara Region, Central Ethiopia (Fig. 1). The city is 690 km far from Bahir Dar (the seat of the Amhara region) and 130 km from Addis Ababa (the capital of Ethiopia). It is the capital city of the North Shoa Zone of the Amhara region and was



**Figure 1.** Map of the study area (Source: Municipal of Debre Berhan City administration).

built by Emperor Zara Yakoob. The coordinates for the city are 9°41'N and 39°32'E. This study was conducted from 13 October 2022 to 30 June 2023, using a 9-month two-arm parallel design school-based cluster randomised controlled trial considering schools as a unit of randomisation.

#### **Study population, eligibility criteria, and sample size determination**

The source population of the study was all secondary school adolescents in the city, whereas the study population was all adolescents in six selected clusters of the city during the study period. The inclusion criteria were adolescents who had followed their teaching learning process in the selected schools and who had no intention of leaving the schools until the end of the study. Regarding the exclusion criteria, adolescents who were not able to respond to an interview due to not choosing to participate or illness and who had physical disabilities, including deformities such as kyphosis, scoliosis, and limb deformities that prevent them from standing erect, were excluded from the study.

The sample size was calculated using the G power 3.1.9.2 programme with a power of 80.5% for Fisher's exact test (proportions for inequality and two independent groups) using

a double proportion formula, a precision (alpha) of 5%, a 10% loss to follow-up, a design effect of 2, and proportions of indicators of DBM ( $P_0 = 15.8\%$ <sup>(51)</sup> and  $P_1 = 6.2\%$ <sup>(28)</sup>). Thus, the calculated sample size was 648. Thus, 324 children in the intervention group (IG) and 324 children in the control group (CG) were enrolled with an allocation ratio of one. However, due to the cluster sampling method, the final sample size used for the study was 745. Of these, at baseline measurement, 742 adolescents (IG = 375, CG = 367) received complete information and were randomly assigned to intervention and control groups. At end-line measurement, 708 respondents (IG = 356, CG = 352) were included in the study.

#### **Sampling techniques, randomisation, and recruitment**

A multistage cluster sampling technique was applied to select adolescents from respective secondary schools in the Debre Berhan Regiopolitan City (DBRPC), which were divided into five sub-cities and thirty-seven kebeles. There are ten schools in the city. Of these schools, eight are government and two are private schools. Using a simple random sampling method, six secondary schools were selected from ten schools randomly and allocated into intervention and control groups using a randomisation table. The number of adolescents in each selected cluster was taken from all

these school documentations. For the data collection and providing the interventions, sections were used in the selected schools. When an eligible study participant was absent during the first visit, a revisit was conducted three times. They were considered nonresponsive if the study participants were absent in three visits. Schools in the city were considered as clusters for the unit of randomisation instead of individuals to prevent contamination of message of the intervention as well as for better logistical suitability. To avoid information contamination, nonadjacent kebeles that contained these schools were randomly assigned into intervention and control groups using a simple random method.

### Intervention packages of the study

The packages of the DDIs were modified and adapted from the 2017 WHO policy brief report and Hawkes *et al.*<sup>(52)</sup> These interventions were delivered through robust NBCC focused on the promotion of healthy diets (adequate adolescent nutrition, dietary diversity), physical activity (do moderate intensity physical exercise, avoiding sitting for a long time), prevention of undue harm from energy-dense foods (avoiding junk processed foods, avoiding sugar-sweetened beverages, street fast foods, chips, salt, sugar, fats, etc.), and regulations on marketing foods from the customer side point of view (e.g. avoiding buying packed foods frequently).<sup>(11,52)</sup>

In a school-based setting, an NBCC tool using a theory-based HBM was used to deliver the intervention packages of this study in the sections of selected schools through multimodal approaches. The interventions were provided for secondary school adolescents within the selected intervention schools, particularly in the selected section of the students. Each adolescent had at least twelve contacts through multimodal approaches (NBCC through direct contact in the class of students, school media and health clubs established in each school, brochure, message text, and phone call). The first contact was cluster-based NBCC, nutrition education, and nutrition counselling on the core points of the intervention package through school visits. During this communication, a client-centred communication approach was used to recognise the nutritional problems of adolescents in the study area. After the first contact, a one-page brochure was prepared in the local language (Amharic) with the core messages of the intervention package and delivered for each of the IG adolescents to take home. For data collection and measurement, the data were collected and measured from selected adolescents.

Nutrition educators and communicators considered the adolescents' identified gaps during baseline data collection affordable, acceptable, and available diets and dietary recommendations. NBCC was delivered every 2 months (at the first, third, fifth, and 7 months) throughout the study period using NBCC tools. On average, each communication took 60–90 min at the cluster level. The communications and intervention packages were given after the baseline data collection had finished. The communication was focused on school adolescents' nutrition, physical activity, control of highly energy-dense and junk foods, control of purchased market foods, and causes, effects, and consequences of DBM. The study participants were reminded of the key mottos of the interventions highlighted during the training through text messages every 2 months and phone calls every 2 months. However, the CG received the standard care given by the health care system. The compliance of the intervention was measured by the number of participants who attended the NBCC, number of participants who received the message, number of

participants who received the phone call, and number of participants who received the leaflet, frequency, and attendance of participants for the training sessions (Supplementary file 1).

### Data collection methods, procedures, and measurements

#### Data collection methods and procedures

To collect the required data for this study, a pretested and structured interviewer-administered questionnaire was used. It was first organised in the English language and delivered in a face-to-face approach in the class of respondents. To easily run the data collection process, this questionnaire was translated into the language spoken in the study area (Amharic) by language experts. Then, to retain its reliability, it was translated back to English by an independent language expert for both languages. A digital system data collection using a Kobo toolbox tool was performed. Twelve and six health professionals (nurses and health officers) were the data collectors and supervisors of the study, respectively.

The questionnaire included questions related to the dependent variable, which is the double burden of malnutrition (DBM). Additionally, the questionnaire addressed several independent variables such as sociodemographic factors, dietary practice, home garden practice, meal frequency, and HBM theoretical constructs. The HBM constructs included perceived susceptibility to DBM, perceived severity of DBM, perceived benefits of preventing DBM, perceived barriers to preventing DBM, cues to action, and self-efficacy for the prevention of DBM. The questionnaire also includes about DDI packages. Sociodemographic data were collected at baseline to establish the initial context. Questions related to adolescent dietary practices, HBM theoretical constructs, and anthropometric measurements were assessed at both baseline and end-line periods to assess changes over time and evaluate the impact of the interventions.

The nutrition behaviour change communicators and supervisors of the nutrition communication process were six bachelor's degree nutritionists and three master's degree nutritionists, respectively. Based on their previous nutrition communication experience, nutrition communicators and supervisors were selected for communication services. Before the actual data collection, they participated in a 3-d exhaustive training with fieldwork and role-playing activities. The training was focused on the data collection procedures, intervention packages, tools, objectives of the study, and ethical issues using a training manual prepared by the research team. In addition, to preserve workers relieved of consistent measures over time after 3 months of intervention enactment, a 1-d extra training was given for both nutrition communicators and supervisors.

#### Measurements

The weight of secondary school adolescents was measured to the nearest 0.1 kg using a calibrated portable electronic digital scale with the participants' shoes taken off and wearing light clothes (Seca Germany Brand). A known object weight was used to check the validity of the scale between the measurements and every morning. A CV of less than 0.03 (<3%) was performed for the standardisation of the anthropometrists. Furthermore, the height was measured to the nearest 0.1 cm using a portable wooden height-measuring board with a sliding head bar following standard anthropometric techniques with the shoe removed. The participants were positioned at the Frankfurt Plane. Moreover, the four points (shoulder, calf, heel, and buttocks) touched the vertical stand, and their shoes were taken off. Calibration rods were used to

check the stadiometer before starting the measurement. All anthropometric measurements were collected in duplicate, and the average values were used for analysis if there were variations in measurements.

The WHO AnthroPlus software was employed for the analysis of anthropometric data. Through the application of this software, the outcome variable was categorised into three groups (thinness, normal weight, and overweight/obesity). Thinness was categorised as having a z-score less than  $-2$ , while overweight/obesity was categorised as having a z-score greater than  $+1$ . The Wealth Index was derived using principal component analysis, which considered various household assets such as domestic animals, durable assets, and housing characteristics. Subsequently, the variable was categorised into three groups: poor, medium, and rich. Home garden refers to the cultivation of vegetables and fruits within the participants' compound. It was assessed using a single question: 'Do you have a home garden in your compound? The meal frequency was assessed based on how often participants reported eating meals within a 24-h period.

### Data quality control and intervention fidelity

#### Data quality control

To maintain the quality and reliability of the questionnaire, pretest, retranslation, and contextualisation of the adapted and further developed English language version questionnaire into the Amharic language version were performed by an Amharic language speaker who qualified in the Amharic language. Again, retranslation back to the English language was done by a person who qualified in the English language. To retain the consistency of the two versions, a comparison was made. The data collection was carried out using the translated and pretested Amharic version questionnaire. After the pretest was completed, the questionnaire was further modified. All the details of the study were informed by the interviewers during data collection. Data collectors were trained for 3 d lasting 4 h for each session in the morning and afternoon on the objective of the study, manner of data collection, data collection tools, and the pattern of how each variable on the questionnaire is measured. There was also a practical session and actual demonstration on how to interview and take anthropometric measurements.

A standardisation exercise was conducted for anthropometric measurements to reduce interobserver error. The relative technical error of measurement (% TEM) was calculated to minimise random errors in these measurements. Data collectors' accuracy in taking anthropometric measurements was standardised with their trainer during training and pretesting. For each adolescent, two separate height and weight measurements were taken, and if the variation between the two measurements exceeded 0.1 kg for weight or 0.1 cm for height, the measurements were repeated. The functionality of digital weight scales was verified each morning using a known weight before data collection began. Additionally, before every weight measurement, data collectors ensured that the scale reading was exactly at zero. School adolescents were encouraged to feel comfortable during the interview, and interviewers were informed about the confidentiality of the responses, assuring participants that their information would not be shared beyond the research team. Adolescents who were willing to participate and had signed informed consent documents from their parents or guardians, along with their own assent forms, were then interviewed.

#### Intervention fidelity

To assess the fidelity of the DDI, criteria were set up according to the National Institutes of Health Behavioural Change Consortium recommendations.<sup>(53)</sup> The fidelity criteria included checklists to assess the DDI design, training of nutrition behaviour change communicators, process of NBCC, receipt of the interventions, and enactment of skills gained from the DDI.<sup>(54–60)</sup>

The DDI design had a theoretical background to be implemented in this study.<sup>(41,44,61)</sup> In this study, for both the intervention and control arms, equal numbers of clusters were taken from each cluster to balance the variations between different clusters in the city. Moreover, to overcome the possibility of information contamination between clusters, nonadjacent kebeles that contain the schools were selected by creating a buffer zone between adjacent clusters. In addition, the trial used a CG to compare the effectiveness of the DDIs. Furthermore, the intervention process was pretested in an area other than the study area with a similar set-up before the application of the actual trial. In addition, each cluster received equivalent numbers and frequencies of NBCC. Additionally, to make the process homogenous, the lengths of interactions within an IG were comparable and analogous.

Nutrition behaviour change communicator training was prearranged and provided in a group using a training manual, role-playing, demonstrations, and mock communication practice. The knowledge and skill of communicators were assessed using practical evaluation and before and after training tests. The process evaluator evaluated the communication sessions by randomly selecting for process evaluation, and all selected sessions were evaluated. The process evaluator rated the communicator using a 'yes/no' rating system on items such as using a communication guide, provision of the whole content, duration and frequency of communication, preparedness, accuracy, and ability to properly respond to questions.

Intervention receipt was assessed using checklists on the knowledge of the secondary school adolescents on DDI packages through interviewing about their understanding of the core contents of the intervention. Intervention enactment was also assessed using the checklist on a demonstration of food preparation and consumption of the adolescents.

Due to the nature of the DDIs, participant allocation concealment was not possible. However, data collectors, participants, and intervention providers were blinded to the study hypotheses. In addition, by using and labelling a nonidentifiable unique number, the data entry clerk was blinded until data analysis was finalised. The communication process was supervised by the supervisors and principal investigator. An interim analysis was performed to see the status and effect of the intervention. The trial was terminated since the predicted outcome was met and statistically valid experiments were obtained via statistical tests and adjusted models.

#### Data management and analysis methods

The principal investigator conducted a visual inspection of all the completed questionnaires to ensure they were complete and consistent. Data collection was carried out using the Kobo toolbox online tool, and the collected data were exported to SPSS version 25 for cleaning, which involved addressing missing values and outliers before proceeding with the analysis. Simple descriptive statistics, such as simple frequency distribution, mean (standard deviation), and percentages were employed to summarise the demographic,

socio-economic, and adolescent-related characteristics of the participants. For continuous data, normality assumptions were assessed using various methods, such as histograms, mean, median, mode, and Kolmogorov–Smirnov test, which was chosen due to the sample size being greater than 50.

To compare and contrast the baseline characteristics of the intervention and control groups, a chi-square test was conducted. Anthropometric measurements within the intervention and control arms were compared using paired and independent *t* tests, respectively. The analysis included all study respondents who followed the predetermined protocol and guidelines. The final analysis included adolescents who actively participated in all organised gatherings and provided end-line data, constituting a per-protocol analysis. The model fitness (goodness of fit) was assessed using the quasi-likelihood under the independence model criterion.

The difference-in-difference (DID) analysis between the intervention and control arms was compared using a McNemar test. Moreover, a generalised estimating equation (GEE) model was employed to evaluate the impact of the DDI on the outcomes of interest over time, which accounts for the correlation between repeated measurements (before and after interventions) and the clustering of data within subjects. The model utilised a multinomial probability distribution, which is suitable for analysing data with multiple nominal outcome categories. The multinomial categories of the outcome variable were thinness (undernutrition), normal, and overweight/obesity (overnutrition). To determine the relationship between the intervention and the outcomes, a cumulative logit link function was used. This link function allows for the modelling of nominal response variables, such as the different categories of DBM status in this study. In addition, an exchangeable working correlation structure was employed within the GEE model. The exchangeable structure assumes that the correlations between repeated measurements within the same cluster (e.g. participants within the same school) are equal. This structure accounts for the potential correlation between observations within the same cluster and helps to adjust for the clustering effect in the analysis. Furthermore, the model was adjusted for variables including time of measurement (baseline and end line), group (intervention and control group), the interaction between time of measurement and IG (i.e. end-line measurement\*IG), sex of adolescents, home garden practice, father's educational status, residence, and alcohol use. The interaction between time (baseline and end line) and intervention was used to assess the effect of the intervention on DBM. Adjusted ORs with corresponding 95% CIs were calculated. Statistical significance was defined as results with *P* values less than 0.05.

## Results

### Sociodemographic characteristics of the respondents

In this investigation, 745 study participants were enrolled during the baseline data collection. At the baseline measurement, 742 (IG = 375, CG = 367) adolescents were provided full information and randomly assigned to the intervention and control groups. At the end-line measurements, 708 (IG = 356, CG = 352) respondents strictly adhered to the protocol. During the baseline data investigation, there was no significant variation between the intervention and control groups' baseline sociodemographic characteristics (*P* > 0.05) (Table 1). The detailed baseline

**Table 1.** The baseline sociodemographic characteristics of adolescents in the intervention (*n* = 375) and control (*n* = 367) groups in Debre Berhan City, 2022/23

Variables	Categories	Intervention group	Control group	<i>P</i> value
		Frequency (%)	Frequency (%)	
Sex	Male	155 (41.3)	199 (54.3)	0.081
	Female	220 (58.7)	168 (47.7)	
Age	10–13	0 (0)	1 (0.3)	0.96
	14–16	183 (48.8)	153 (41.6)	
	17–19	192 (51.2)	213 (58.1)	
Residence	Urban	304 (81.1)	213 (58.1)	0.061
	Rural	71 (18.9)	154 (41.9)	
Family size	≤ 5	237 (63.2)	220 (59.9)	0.362
	> 5	138 (36.8)	147 (40.1)	
Grade level	Grade 9 <sup>th</sup>	94 (25.0)	142 (38.7)	0.513
	Grade 10 <sup>th</sup>	120 (32.0)	92 (25.1)	
	Grade 11 <sup>th</sup>	88 (23.5)	61 (16.6)	
	Grade 12 <sup>th</sup>	73 (19.5)	72 (19.6)	
Ethnicity	Amhara	371 (98.9)	365 (99.4)	0.232
	Oromo	2 (0.55)	1 (0.3)	
	Others*	2 (0.55)	1 (0.3)	
Religion	Orthodox Tewahido	342 (91.2)	358 (97.6)	0.807
	Muslim	8 (2.1)	6 (1.6)	
	Protestant	24 (6.4)	3 (0.8)	
	Others**	1 (0.3)	0 (0)	
Wealth Index	Poor	38 (10.1)	36 (9.8)	0.807
	Middle	254 (67.7)	167 (45.5)	
	Rich	83 (22.2)	164 (44.7)	

\*Tigrai, Gurage.

\*\*Pagan.

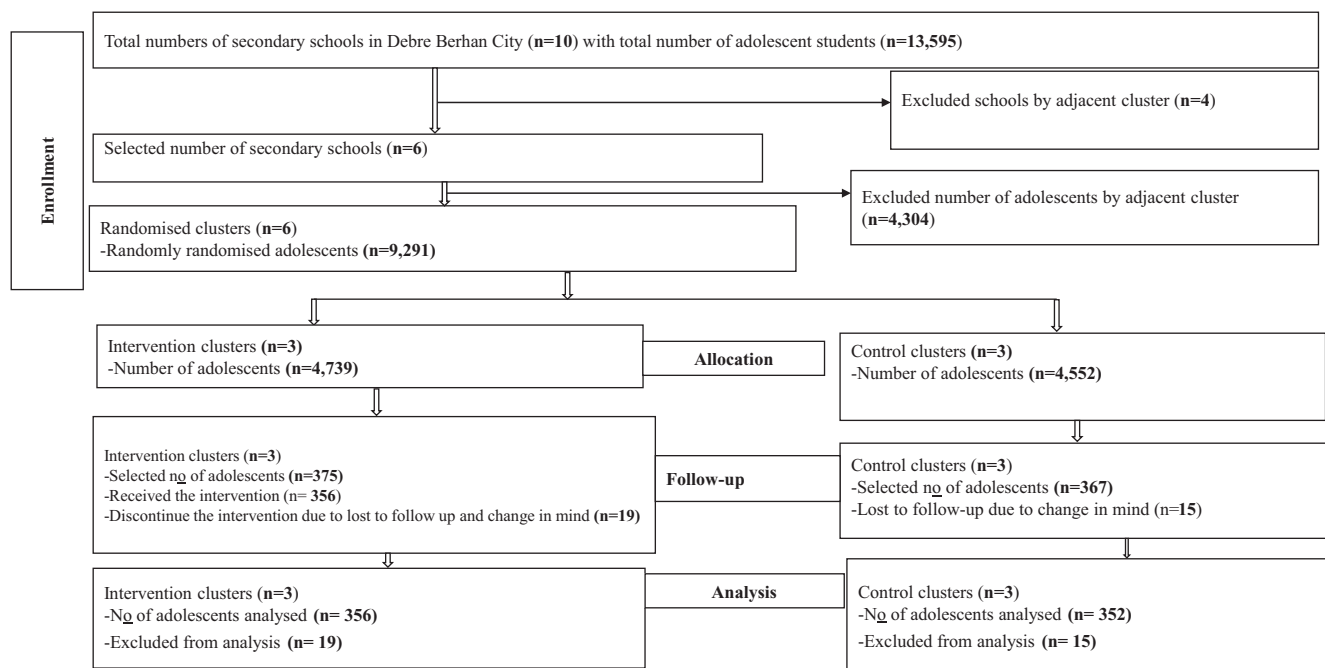
sociodemographic characteristics of the respondents were published before.<sup>(31)</sup> The results of this trial were reported using Consolidated Standards of Reporting Trials (CONSORT) guidelines<sup>(62,63)</sup> (Fig. 2).

### Comparison of HBM constructs before and after the intervention

An independent and paired sample *t* tests were conducted to compare the six HBM constructs of adolescents about DBM between and within intervention and control groups. The scores of the HBM constructs among the IG improved significantly (*P* < 0.05) from baseline to end-line visits compared to the CG. Except for perceived susceptibility and self-efficacy, there was no visible change in the HBM constructs at the baseline measurements (Table 2). In this study, the correlation between HBM construct

**Table 2.** The comparison of the health belief model (HBM) construct scores within and between the intervention and control groups among school adolescents in Debre Berhan City, Ethiopia, 2022/23

HBM construct	Study period	Health belief model construct score			P value
		Intervention arm (mean [± SD])	Control arm (mean [± SD])	Mean difference (95% CI)	
Perceived susceptibility	Baseline	2.96 (0.83)	2.69 (0.54)	0.26 (0.16, 0.36)	< 0.001
	End line	3.53 (1.03)	3.32 (0.54)	0.21 (0.08, 0.33)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	
Perceived severity	Baseline	3.07 (0.71)	3.08 (0.64)	-0.01 (-0.11, 0.09)	0.855
	End line	3.48 (1.01)	2.94 (0.64)	0.54 (0.41, 0.66)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	
Perceived benefits	Baseline	3.03 (0.65)	3.14 (0.53)	0.07 (-0.02, 0.15)	0.124
	End line	3.35 (1.06)	2.87 (0.54)	0.48 (0.35, 0.61)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	
Perceived barriers	Baseline	3.07 (0.66)	3.15 (0.51)	-0.08 (-0.16, 0.01)	0.067
	End line	3.44 (1.01)	2.87 (0.51)	0.57 (0.45, 0.68)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	
Cues to action	Baseline	3.27 (0.68)	3.23 (0.51)	0.04 (-0.51, 0.12)	0.416
	End line	3.32 (1.08)	2.78 (0.53)	0.53 (0.41, 0.65)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	
Self-efficacy	Baseline	3.13 (0.68)	2.98 (0.52)	0.15 (0.06, 0.23)	< 0.001
	End line	3.41 (1.02)	3.04 (0.52)	0.37 (0.26, 0.49)	< 0.001
	P value	< 0.001	< 0.001	< 0.001	

**Figure 2.** Schematic presentation of the sampling procedure for the participant selection process based on CONSORT guideline criteria.

scores and BAZ (BMI-for-age z scores) was compared both within and between the intervention and control groups. Adolescents in the IG outperformed those in the CG and their baseline scores in

terms of their HBM construct scores ( $P < 0.05$ ). All HBM components showed a significant positive connection with BAZ after the intervention was implemented ( $P < 0.05$ ) (Table 3).

**Table 3.** Correlations between BAZ and HBM constructs among school adolescents in Debre Berhan City, Ethiopia, 2022/23

Variables	Perceived susceptibility	Perceived severity	Perceived benefit	Perceived barrier	Cues to action	Self-efficacy	BAZ
Perceived susceptibility	1						
Perceived severity	0.779**	1					
Perceived benefit	0.742**	0.874**	1				
Perceived barrier	0.699**	0.822**	0.905*	1			
Cues to action	0.685**	0.799**	0.876**	0.903*	1		
Self-efficacy	0.680**	0.786**	0.860**	0.886**	0.891**	1	
BAZ	0.780**	0.886**	0.790**	0.672*	0.871**	0.923*	1

BAZ, BMI-for-age z-score; HBM, health belief model.

\*Correlation is significant at the 0.05 level (2-tailed).

\*\*Correlation is significant at the 0.01 level (2-tailed).

**Table 4.** The difference-in-difference analysis of double burden of malnutrition (DBM) by time of measurements and groups among adolescents in Debre Berhan City, Ethiopia, 2022/23

Variable	Intervention group (IG) (n = 731) n (%)			Control group (CG) (n = 719) n (%)			Difference-in- difference (DID)
	Baseline (n = 375)	End line (n = 356)	Difference (EL-BL)	Baseline (n = 367)	End line (n = 352)	Difference (EL-BL)	
DBM status							
Thinness	59 (8)	23 (3.2)	-36 (-4.8)*	51 (6.9)	49 (6.8)	-2 (-0.1)*	-38 (-4.7)*
Normal	282 (38.0)	318 (44.1)	36 (6.1)*	300 (41.4)	286 (40.4)	-14 (-0.1)*	22 (6.2)*
Overnutrition	34 (4.6)	15 (2.1)	-19 (-2.5)*	16 (2.1)	17 (2.4)	1 (0.3)*	-18 (-2.2)*
Overall DBM	93 (12.6)	38 (5.3)	-55 (-7.3)*	66 (9.0)	67 (9.4)	1 (0.4)*	-56 (-6.9)*

\*P < 0.005, DID = IG-CG

### Effect of double-duty interventions on DBM among adolescents

#### Effect interventions on DBM using difference-in-difference (DID) analysis

Adolescents in the IG had lower DBM status because of the DDI than those in the CG. In the IG at the end-line measurement, the overall prevalence of DBM among the IG was decreased by 6.9% in the study area using the McNemar test. More specifically, thinness was decreased by 4.7%, and overnutrition was reduced by 2.2% compared to the CG (P < 0.05) (Table 4)

#### Effect interventions on DBM using the GEE model

At the end of the measurement, adolescents in the IG showed a substantial improvement in their nutritional status. After adjusting for potential confounders, the multivariable GEE model analysis revealed that adolescents in the IG had a 67% lower proportion of being thinness (AOR = 0.33, 95% CI [0.21, 0.53]) and 49% lower proportion of being overweight/obese (AOR = 0.51, 95% CI [0.32, 0.82]) than those in the CG. In addition, adolescents in the IG were 34% less likely to have DBM (thinness and overnutrition) than those in the CG (AOR = 0.66, 95% CI [0.46, 0.94]). Besides, the likelihood of DBM decreased by nearly 60% (AOR = 0.41, 95% CI [0.03, 0.92]) among adolescents at the end-line measurement compared to the baseline. Similarly, adolescents in the time-group interaction were 44% less likely to have higher DBM status (AOR = 0.56, 95% CI [0.02, 0.38]) compared to their counterparts (Table 5).

### Discussion

This study employed the impact of selected DDI packages on DBM using an HBM to boost the acceptance of the intervention among adolescents in the study area. In the IG at the end-line measurement, the overall prevalence of DBM was reduced compared to the baseline measurements. Moreover, adolescents in the IG demonstrated a significant improvement in their nutritional status than the CG.

In DID analysis, when compared to adolescents in the CG, the proportion of adolescents who had DBM was considerably lower in the IG. Adolescents in the IG saw a nearly 5% decrease in thinness and more than 2% decrease in overnutrition. The total prevalence of DBM within the IG had dropped by almost 7% compared to the control arm. This result was in line with different studies performed elsewhere. Different forms of malnutrition were the focus of a systematic review conducted in LMICs, which consolidated the evidence on the impact of interventions on adolescent nutrition and educational outcomes.<sup>(64)</sup> Interventions to enhance nutrition and prevent obesity had a marginal impact on lowering BMI, according to a systematic review and meta-analysis.<sup>(65)</sup> According to studies performed in Indonesia,<sup>(66)</sup> Kenya,<sup>(67)</sup> Mexico<sup>(68)</sup> and South Africa,<sup>(69)</sup> the nutritional status (overweight and obesity) of teenagers has decreased as a result of a combination of nutrition education and physical activity intervention. However, none of them execute the full packages of DDIs to lower DBM on both sides. The present study applied double-duty nutrition interventions together with physical activities that are appropriate for DBM over the previous evidence.



**Table 5.** Modelling the effect of intervention on DBM using generalised estimating equation model<sup>a</sup> among adolescents in Debre Berhan City, Ethiopia, 2022/23

Parameter	Category	AOR (95% CI)	P value
DBM status	Thinness	0.33 (0.21, 0.53)	0.001
	Normal	Ref.	
	Overnutrition	0.51 (0.32, 0.82)	0.005
Group	Control group	Ref.	
	Intervention group	0.66 (0.46, 0.94)	0.023
Time	Baseline	Ref.	
	End line	0.41 (0.03, 0.92)	0.035
Time *group interaction	End line*IG	0.56 (0.02, 0.38)	0.042
	Baseline*IG	Ref.	
	Baseline*CG	Ref.	
	End line*CG	Ref.	

AOR, adjusted OR; DBM, double burden of malnutrition; Ref., reference category; IG, intervention group; CG, control group.

<sup>a</sup>The model was adjusted for various variables such as meal frequency, home garden practice, age, sex of adolescent, father's education, residence, alcohol use, etc.

According to the GEE model analysis, after the implementation of DDIs, adolescents in the IG had a nearly 50% reduction in being overweight/obese and a 67% reduction in being thin than those in the CG. Additionally, adolescents in the IG had a more than 33% reduction of DBM than adolescents in the CG. The proportion of DBM was decreased by nearly 60% among adolescents in the end-line measurement compared to adolescents in the baseline measurement. Similarly, adolescents in the time-group interaction category had a 44% reduction of DBM than their counterparts. This is consistent with studies conducted in Ethiopia,<sup>(70)</sup> Brazil,<sup>(71)</sup> global,<sup>(65)</sup> LMICs,<sup>(64)</sup> small island developing states,<sup>(72)</sup> Croatia,<sup>(73)</sup> Ghana,<sup>(74)</sup> Turkey,<sup>(75)</sup> and Poland.<sup>(76)</sup> Nevertheless, the present study implemented a comprehensive approach by combining diverse nutrition interventions and appropriate physical activities specifically designed for individuals with DBM. This approach aimed to effectively reduce DBM on both sides of the crisis. By incorporating a wider range of interventions, the study sought to build upon and expand the existing body of evidence in this field.

As a significant practical implication, it's noteworthy that Ethiopia ratified a food and nutrition policy in 2018, with the overarching goal of achieving food and nutrition security for all its citizens.<sup>(77,78)</sup> However, it's crucial to recognise that the current policy framework lacks comprehensive integration of DDIs, which are specifically designed to simultaneously tackle the coexistence of undernutrition and overnutrition. This gap in policy inclusivity implies that the existing strategies may not effectively address the multifaceted challenges posed by DBM. Therefore, a compelling recommendation arises for the policy to undergo updates, incorporating these intervention packages, not only within the confines of the study area but also on a national scale. By integrating DDIs into the policy framework, Ethiopia can proactively address the intricate interplay between undernutrition and overnutrition, thus mitigating their adverse health effects. Such a strategic update holds the potential to significantly reduce the prevalence of malnutrition across the country and alleviate the associated consequences, thereby fostering improved health outcomes and overall well-being among the population. In developing countries like Ethiopia, researchers and decision-makers can tailor DDIs to address DBM by focusing on contextual

adaptation, stakeholder engagement, capacity building, and robust monitoring and evaluation.

When considering the strengths and limitations of the study, one notable strength is its incorporation of a theory-based HBM, coupled with a DDI approach, which effectively enhanced the implementation of interventions. Additionally, the study employed a multimodal delivery method, utilising text messages, phone calls, and targeted communication to promote behaviour change and educate participants. However, the study did have some limitations. One such limitation was the potential for recall bias, social desirability bias, and reporting bias. To mitigate these limitations, the researchers took thorough measures to ensure accurate reporting and minimise biases through rigorous protocols and careful attention to data collection and analysis.

## Conclusion

Owing to the implementation of the DDIs, adolescents in the IG experienced a lower prevalence of DBM compared to those in the CG. The IG demonstrated a significant reduction of nearly 5% in the levels of thinness and more than 2% in overnutrition in comparison to the CG. At the end of the trial, the total prevalence of DBM within the study area had decreased by approximately 7% in the IG. Furthermore, adolescents in the IG showed a substantial improvement in their nutritional status at the end of the measurement period in the GEE model. Given these positive outcomes, it is recommended that the DDIs supported by HBM be integrated into national guidelines as part of the country's overall strategy and nutrition policy. By doing so, the interventions can be disseminated on a larger scale, leading to an improved nutritional status and a reduction in the occurrence of DBM among adolescents nationwide.

**Supplementary material.** The supplementary material for this article can be found at <https://doi.org/10.1017/jns.2024.68>.

**Availability of data and materials.** The dataset supporting the conclusions of this article is available from the corresponding author upon reasonable request.

**Acknowledgements.** We would like to express our deepest thanks to Jimma University and Debre Berhan University for their financial support. We are also grateful to the study participants, data collectors, supervisors, language translators, office administrators, and everyone who participated directly or indirectly in the accomplishment of this study.

**Authors' contributions.** LG: Participated in the conception and design of the study, performed the data collection, performed the statistical analysis, and served as the lead author of the manuscript. BWA and TB: Participated in the design of the study, revised subsequent drafts of the paper, supported statistical analysis, and critically reviewed and finalised the manuscript. All authors read and approved the final manuscript.

**Funding.** Jimma University and Debre Berhan University funded this study through minister of education of Ethiopia. The funders had no role in the data collection, data analysis, and interpretation of the results.

**Competing interests.** The authors have declared that no competing interests exist.

**Consent for publication.** None declared.

**Ethical consideration.** The study was conducted following the criteria of the Helsinki Declaration and the principles of good clinical practice.<sup>(79)</sup> The research protocol was approved by the Institutional Review Board (IRB) of Jimma University, and ethical clearance was obtained on 10 August 10 2022 with a reference number of JUIH/IRB/104/22, which is before the starting date of data collection. Written informed consent was secured from each participant's parents/guardian and an assent form from adolescents before starting the trial to confirm willingness after clarification of the study purpose and its benefits. For parents/guardians of adolescents who could not read and write, a fingerprint was used. The study participants were assured that they were free to withdraw their consent and discontinue participation in the study without any form of prejudice at any time during the study period. Privacy and confidentiality of the collected data were ensured throughout the study. Moreover, the trial was prospectively registered in Clinical Trials.gov with the registration number NCT05574842.

## References

- Gavin-Smith B, van Zutphen KG, Kraemer K, *et al.* *Double Burden of Malnutrition: Crisis and Opportunity of the Double Burden Or the New Norm*. Basel: Sight And Life; 2018.
- Shrimpton R, Mbuya NV, Provo AM. *The Double Burden of Malnutrition in East Asia and the Pacific: Evidence And Lessons For A Multisectoral Response. Discussion Paper. World Bank Group, Health, Nutrition and Population*. Washington, DC: World Bank Group; 2016.
- Shimpton R, Rokx C. *The Double Burden of Malnutrition: A Review of Global Evidence. Health, Nutrition and Population (HNP) Discussion Paper*. Washington, DC: World Bank; 2012.
- WHO. *Guideline: Implementing Effective Actions for Improving Adolescent Nutrition*. Geneva: WHO; 2018.
- Azzopardi PS, Hearps SJC, Francis KL, *et al.* Progress in adolescent health and wellbeing: tracking 12 headline indicators for 195 countries and territories, 1990–2016. *Lancet*. 2019;393(10176):1101–1118.
- Das JK, Salam RA, Thornburg KL, *et al.* Nutrition in adolescents: physiology, metabolism, and nutritional needs. *Ann N Y Acad Sci*. 2017;1393(1):21–33.
- Nicholson A, Fawzi W, Canavan C, Keshavjee S. *Advancing Global Nutrition for Adolescent and Family Health: Innovations in Research and Training*. Dubai, United Arab Emirates: Harvard Medical School Center for Global Health Delivery–Dubai; 2018.
- Development Initiatives. *Global Nutrition Report 2017: Nourishing the SDGs*. Bristol, UK: Development Initiatives; 2017.
- Development Initiatives. *Global Nutrition Report 2018. Shining a Light on Spur Action on Nutrition*. Bristol, UK: Development Initiatives; 2018.
- IFPRI. *International Food Policy Research Institute. Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition and Sustainable Development*. Washington, DC: IFPRI; 2015.
- WHO. *Double-Duty Actions for Nutrition. Policy Brief. Department of Nutrition for Health and Development World Health Organization*. Geneva, Switzerland: WHO; 2017.
- Wells JC, Sawaya AL, Wibaek R, *et al.* The double burden of malnutrition: aetiological pathways and consequences for health. *Lancet*. 2020;395:75–88.
- Popkin BM, Corvalan C, Grummer-Strawn LM. Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet*. 2020;395:65–74.
- IFPRI. *Global Nutrition Report 2015: Actions and Accountability to Advance Nutrition & Sustainable Development*. Washington, DC: IFPRI; 2015.
- Tanwi TS, Chakrabarty S, Hasanuzzaman S. Double burden of malnutrition among ever-married women in Bangladesh: a pooled analysis. *BMC Womens Health*. 2019;19(1):2–9.
- Shafiee S, Mesgarani M, Begum K. Assessment of nutritional status among adolescent boys in an urban population of South India. *Glob J Health Sci*. 2015;7(3):335–344.
- Miranda M, Bento A, Aguilar AM. Malnutrition in all its forms and socioeconomic status in Bolivia. *Public Health Nutr*. 2020;23(S1):S21–8.
- Zhou S, Ye B, Fu P, *et al.* Double burden of malnutrition: examining the growth profile and coexistence of undernutrition, overweight, and obesity among school-aged children and adolescents in urban and rural counties in Henan Province, China. *J Obes*. 2020;2020:2962138.
- Massad S, Deckelbaum RJ, Gebre-Medhin M, Holleran S, Dary O, Obeidi M, *et al.* Double burden of undernutrition and obesity in Palestinian schoolchildren. *Food Nutr Bull*. 2016;37(2):144–152.
- Erismann S, Knoblauch AM, Diabougou S, Odermatt P, Gerold J, Shrestha A, *et al.* Prevalence and risk factors of undernutrition among schoolchildren in the plateau central and centre-ouest regions of Burkina Faso. *Infect Dis Poverty*. 2017;6(1):1–14.
- Nicholaus C, Martin HD, Kassim N, Matemu AO, Kimiywe J. Dietary practices, nutrient adequacy, and nutrition status among adolescents in boarding high schools in the Kilimanjaro region, Tanzania. *J Nutr Metab*. 2020;2020:3592813.
- Dain ASL, Sagalova V, Sodjinou R, *et al.* Levels and trends of adolescent girl's undernutrition and anemia in West and Central Africa from 1998 to 2017. *J Glob Health*. 2021;11:1–6.
- Tluway FD, Leyna GH, Mmbaga EJ. Magnitude and factors associated with overweight and obesity among adolescents in semi-rural area of Babati District, Tanzania. *Tanzan J Health Res*. 2018;20(2):1–9.
- Akinlade AR, Afolabi WAO, Oguntola EB, Agbonlahor M. Prevalence of obesity among adolescents in senior secondary schools in Oyo State, Nigeria. *J Nutr Heal Food Sci*. 2014;2(4):1–5.
- Musa DI, Toriola AL, Monyeki MA, Lawal B. Prevalence of childhood and adolescent overweight and obesity in Benue State, Nigeria. *Trop Med Int Heal*. 2012;17(11):1369–1375.
- Berbada DA, Haidar J, Gebremichael G, Haftu D. Magnitude of double burden of malnutrition and its associated factors among selected in-school adolescents: evidence from South Ethiopia. *Int J Nutr Metab*. 2017;9(4):30–37.
- Getacher L, Ademe BW, Belachew T. Mapping the national evidence on double burden of malnutrition in Ethiopia: a scoping review protocol. *BMJ Open*. 2021;11(11):e050805.
- Gebreyohannes Y, Shiferaw S, Demtsu B, Bugssa G. Nutritional status of adolescents in selected government and private secondary schools of Addis Ababa, Ethiopia. *Int J Nutr Food Sci*. 2014;3(6):504.
- Mengesha D, Asres D. Prevalence of underweight, overweight and its associated factors among adolescent students in Finote Selam Town, Amhara Region, Ethiopia. *J Nutr Heal*. 2020;8(2):123–134.
- Teji K, Dessie Y, Assebe T, Abdo M. Anaemia and nutritional status of adolescent girls in Babile District, Eastern Ethiopia. *Pan Afr Med J*. 2016;24(62):1–10.
- Getacher L, Ademe BW, Belachew T. Double burden of malnutrition and its associated factors among adolescents in Debre Berhan Regiopolitan

- City, Ethiopia: a multinomial regression model analysis. *Front Nutr.* 2023;10:1–13.
32. Tarekegn BT, Assimamaw NT, Atalell KA, *et al.* Prevalence and associated factors of double and triple burden of malnutrition among child-mother pairs in Ethiopia: Spatial and survey regression analysis. *BMC Nutr.* 2022;8(1):1–12.
  33. Gezew A, Melese W, Getachew B, Belachew T. Double burden of malnutrition and associated factors among adolescent in Ethiopia: a systematic review and meta-analysis. *PLoS One* 2023;18:e0282240.
  34. Taklual W, Baye S, Mekie M, Andualem T. Double burden of malnutrition among female adolescent students in Bahir Dar city, Amhara, Ethiopia. *Biomed Res Int.* 2020;2020:6249524.
  35. Getacher L, Ademe BW, Belachew T. Understanding the national evidence on the double burden of malnutrition in Ethiopia for the implications of research gap identifications: a scoping review. *BMJ Open.* 2023;13(12):1–12.
  36. Development Initiatives. *Global Nutrition Report 2020: Action on Equity to End Malnutrition.* Bristol, UK: Development Initiatives; 2020.
  37. FAO, IFAD, UNICEF, WFP, WHO. *The State of Food Security and Nutrition in the World 2019. Safeguarding Against Economic Slowdowns and Downturns.* Rome: FAO; 2019.
  38. Hawkes C, Ruel MT, Salm L, Sinclair B, Branca F. Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms. *Lancet.* 2020;395:142–155.
  39. Bhutta ZA, Das JK, Rizvi A, *et al.* Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *Lancet.* 2013;382(9890):452–477.
  40. WHO. *Protecting, Promoting and Supporting Breastfeeding in Facilities Providing Maternity and Newborn Services.* Geneva: WHO; 2017.
  41. Hawkes C, Demaio AR, Branca F. Double-duty actions for ending malnutrition within a decade. *Lancet Global Health.* 2017;5:e745–e746.
  42. Pradeilles R, Baye K, Holdsworth M. Addressing malnutrition in low- and middle-income countries with double-duty actions. *Proc Nutr Soc.* 2019;78:388–397.
  43. Ruel M, Hawkes C. Double duty actions to tackle all forms of malnutrition (P10-053-19). *Curr Dev Nutr.* 2019;3:814.
  44. Hawkes C. *From What to How: The Role of Double-Duty Actions in Addressing the Double Burden.* Kaiseraugst: Sight and Life; 2018.
  45. Glanz K, Bishop DB. The role of behavioral science theory in development and implementation of public health interventions. *Annu Rev Public Health.* 2010;31:399–418.
  46. Hagger MS, Weed M. DEBATE: do interventions based on behavioral theory work in the real world? *Int J Behav Nutr Phys Act.* 2019;16(1):1–10.
  47. Alamu EO, Eyinla TE, Sanusi RA, Maziya-Dixon B. Double burden of malnutrition: evidence from a selected Nigerian population. *J Nutr Metab.* 2020;2020:5674279.
  48. Alem AZ, Yeshaw Y, Liyew AM, *et al.* Double burden of malnutrition and its associated factors among women in low and middle income countries: findings from 52 nationally representative data. *BMC Public Health.* 2023;23(1):1–16.
  49. Santos R, Jerome CS, Azandjeme C, Mizehoun-Adissoda C, Metonnou C. Prevalence and predictors of double burden of malnutrition within households in Africa: a systematic review. *Food Nutr Sci.* 2023;14(10):908–927.
  50. Mekonnen S, Birhanu D, Menber Y, Gebreegziabher ZA, Belay MA. Double burden of malnutrition and associated factors among mother–child pairs at household level in Bahir Dar City, Northwest Ethiopia: community based cross-sectional study design. *Front Nutr.* 2024;11:1340382.
  51. Hadush G, Seid O, Wuneh AG. Assessment of nutritional status and associated factors among adolescent girls in Afar, Northeastern Ethiopia: a cross-sectional study. *J Health Popul Nutr.* 2021;40(1):2.
  52. Hawkes C, Ruel MT, Salm L, Sinclair B, Branca F. Double-duty actions: seizing programme and policy opportunities to address malnutrition in all its forms. *Lancet.* 2020;395:p142–155.
  53. Bellg AJ, Resnick B, Minicucci DS, *et al.* Enhancing treatment fidelity in health behavior change studies: best practices and recommendations from the NIH behavior change consortium. *Heal Psychol.* 2004;23(5):443–451.
  54. Murphy SL, Gutman SA. Intervention fidelity: a necessary aspect of intervention effectiveness studies. *Am J Occup Ther.* 2012;66(4):387–388.
  55. Borrelli B. The assessment, monitoring, and enhancement of treatment fidelity in public health clinical trials. *J Public Health Dent.* 2011;71:S52–63.
  56. Gearing RE, El-Bassel N, Ghesquiere A, Baldwin S, Gillies J, Ngeow E. Major ingredients of fidelity: a review and scientific guide to improving quality of intervention research implementation. *Clin Psychol Rev.* 2011;31(1):79–88.
  57. Campbell BK. Fidelity in public health clinical trials: considering provider-participant relationship factors in community treatment settings. *J Public Health Dent.* 2011;71:64–65.
  58. Borrelli B, Sepinwall D, Bellg AJ, *et al.* A new tool to assess treatment fidelity and evaluation of treatment fidelity across 10 years of health behavior research. *J Consult Clin Psychol.* 2005;73(5):852–860.
  59. Toomey E. The implementation fidelity of infant feeding interventions to prevent childhood obesity: a systematic review. *Ann Behav Med.* 2019;53(1):75–97.
  60. Demilew YM, Alene GD, Belachew T. Effects of guided counseling during pregnancy on birth weight of newborns in West Gojjam Zone, Ethiopia: a cluster-randomized controlled trial. *BMC Pediatrics.* 2020;20:466.
  61. WHO. *Double-Duty Actions for Nutrition. Policy Brief.* Geneva: WHO; 2017.
  62. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMC Med.* 2010;8(18):1–9.
  63. Campbell MK, Piaggio G, Elbourne DR, Altman DG. Consort 2010 statement: extension to cluster randomised trials. *BMJ.* 2012;345(7881):1–21.
  64. Shinde S, Wang D, Moulton GE, Fawzi WW. School-based health and nutrition interventions addressing double burden of malnutrition and educational outcomes of adolescents in low- and middle-income countries: a systematic review. *Matern Child Nutr.* 2022;2022:e13437.
  65. Salam RA, Hooda M, Das JK, *et al.* Interventions to improve adolescent nutrition: a systematic review and meta-analysis. *J Adolesc Heal.* 2016;59(2):S29–39.
  66. K I, Anwar F, Kustiyah L, Riyadi H. The impact of nutrition education and physical activity on changes in nutritional status in adolescents overweight and obesity. *Teikyo Med J.* 2022;45(02):5651–5662.
  67. Florence W, Ochola S, Irene O. Physical and nutrition education intervention improves body weight status of adolescents in Uasin Gishu county, Kenya: a cluster-randomized controlled trial. *Curr Res Nutr Food Sci.* 2020;8(1):318–332.
  68. Shamah Levy T, Morales Ruán C, Amaya Castellanos C, Salazar Coronel A, Jiménez Aguilar A, Méndez Gómez Humarán I. Effectiveness of a diet and physical activity promotion strategy on the prevention of obesity in Mexican school children. *BMC Public Health.* 2012;12(1):152.
  69. Grace J, Biggs C, Naicker A, Moss S. Effect of physical activity and nutrition education on body mass index, blood pressure and biochemical variables in overweight and obese adolescents. *Ann Glob Heal.* 2021;87(1):1–13.
  70. Paponetti MK, Zwolski C, Porter R, Paterno MV. Leveraging the construct of physical literacy to promote physical activity for youth with obesity – a qualitative analysis of physical therapists’ perceptions. *Obes Pillars.* 2023;5:100054.
  71. Cunha DB, da Souza BSN, Pereira RA, Sichieri R. Effectiveness of a randomized school-based intervention involving families and teachers to prevent excessive weight gain among adolescents in Brazil. *PLoS One* 2013;8(2):1–8.
  72. Augustus E, Haynes E, Guell C, *et al.* The impact of nutrition-based interventions on nutritional status and metabolic health in small island developing states: a systematic review and narrative synthesis. *Nutrients.* 2022;14(17):1–22.
  73. Jovanovi’ GK, Jankovi’ S, Žeželj SP. The effect of nutritional and lifestyle education intervention program on nutrition knowledge, diet quality, lifestyle, and nutritional status of Croatian school children. *Front Sustain Food Syst.* 2023;7:1019849.
  74. Wiafe MA, Apprey C, Annan RA. Impact of nutrition education and counselling on nutritional status and anaemia among early adolescents: a randomized controlled trial. *Hum Nutr Metab.* 2023;31:200182.

75. Akdemir M, Donmez L, Polat H. The effect of nutritional and physical activity interventions on nutritional status and obesity in primary school children: a cluster randomized controlled study. *Kuwait Med J*. 2017;49(2):105–113.
76. Zalewska M, Maciorkowska E. Dietary habits and physical activity of 18-year-old adolescents in relation to overweight and obesity. *Iran J Public Health*. 2019;48(5):864–872.
77. FDRE. *Food and Nutrition Policy*. Addis Ababa, Ethiopia: Federal Democratic Republic of Ethiopia; 2018.
78. EPHI & NIPN. *The National Nutrition Program (2016–2020) Progress Analysis: Evidence for the Upcoming Food and Nutrition Strategy Development*. Addis Ababa, Ethiopia: The Ethiopian Public Health Institute (EPHI) and National Information Platform for Nutrition (NIPN); 2020.
79. World Medical Association. WMA Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA* 2013;310:20.