Original Article

Effects of school nurse-led health education to reduce malnutrition among primary school children in Bangladesh: Cluster nonrandomized controlled trial

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Abstract

Background: Malnutrition is a major health concern among children especially in low and middle-income countries. However, there are limited studies on school health in Bangladesh. This study aimed to reduce malnutrition among primary school children in Bangladesh by increasing awareness and knowledge through school nurse-led health education. **Methods and Materials:** A prospective, open-label, parallel-group (1:1), cluster nonrandomized controlled trial on primary school children conducted in rural Bangladesh. The study lasted 13 months between September 2021 and September 2022. Four schools were selected and assigned to the intervention and control groups (CGs). Next, school nurses provided evidence-based health education to the children in the intervention group (IG) for 9 months to improve awareness and knowledge of malnutrition. Data were collected at baseline, midline, and endline. **Results:** Overall, 604 children were enrolled at the baseline; among them, 455 (CG, $n = 220$; IG, $n = 235$) completed the study. Changes in the malnutrition rate—the primary outcome—were not significant ($P = 0.225$). However, after adjusting the endline data with baseline and sociodemographic data, the children's body mass index improved significantly in the IG than in the CG ($P < 0.05$). Changes in eating behavior, and awareness and knowledge of malnutrition—the secondary outcomes—significantly differed between the groups ($P < 0.001$). **Conclusion:** The school nurse-led health education program significantly improved primary school children's awareness and knowledge of malnutrition. This study revealed the effectiveness of school nurses in reducing malnutrition among children, which may decrease future morbidity and mortality rates in children.

Keywords: Health education, health-related behaviour, malnutrition, nutritional deficiency, primary school children, school nurse

Introduction

Malnutrition is a major health concern with children being the most vulnerable population worldwide.[1] Malnutrition is a leading cause of death associated with several communicable and noncommunicable diseases namely pneumonia, anemia,

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and infectious diseases.[1-6] In higher-income countries, although the undernutrition rate was lower compared with overnutrition, however, low- and middle-income countries (LMICs) had higher prevalence for both under- and overnutrition.[7,8] Malnutrition affects children's physical growth and mental development which may last for a lifetime.[9,10]

In Bangladesh, malnutrition rate is high among 5–12 years school-going children[11] due to low case detection, limited health education, poor health assessment, and access to primary care providers.[12] Furthermore, malnutrition is firmly related to children's eating behavior,[13] dietary literacy[14] and diversity,[15] awareness and knowledge regarding malnutrition, and their parents as well.[16,17]

Health education is a significant requirement for the children's nutritional status improvement.[17-22] In many developed countries, school nurses have a significant role in children's health development through school health services,[23,24] and contribute to reducing communicable and noncommunicable diseases.[25-29] Additionally, appropriate skilled and evidence-based health education for children is the foremost intervention for sustainable positive changes in health behavior, awareness development, and knowledge acquisition.[30-32] These prerequisite activities have not yet been addressed in Bangladesh schools, although a limited number of nongovernmental organizations address this issue through school health programs.[33] However, in Bangladesh, there is no health checkup system in schools for children which leads to undesirable effects on primary care providers. Therefore, this study aimed to reduce malnutrition by increasing awareness and knowledge through school nurse-led health education among primary school children in Bangladesh.

Study Framework

According to this study framework [Figure 1], school nurses are the most vital determining factors and outcomes as predictors are the fundamental elements. We developed a Health Awareness Program for Primary School Children (HAPSC) and implemented an interventional study involving the pilot placement of trained school nurses in a school setting in Bangladesh to provide evidence-based health education to primary school children and their parents. School nurses collaborated with schools,[34] children including their parents,[35] and community health workers (CHWs) as an assistant.[36] The school nurses focused on child engagement including their parents to boost the effectiveness of health education. These experimental connections create a community obligation aimed at positive changes in outcomes through HAPSC.[37] School nurses provided health assessments, checkups, and evidence-based health education to the children as a study intervention. Notably, health assessments, checkups, and evidence-based health education are interrelated concepts. Evaluation and feedback, such as sharing a children's baseline health report with their parents, motivated them to be more concerned about their children's health-related factors. We hypothesized that school nurse placement and evidence-based health education would significantly increase health awareness and knowledge among primary school children to prevent malnutrition.

Materials and Methods

Study design and duration

This was a prospective, open-label, parallel-group (1:1), cluster nonrandomized controlled trial with a pre-and post-test design. The study duration was 13 months, between September 2021 and September 2022. In Figure 2, the study was reported following the consolidated standards of reporting trials[38] and registered by the Clinical Trial Registry (NCT05012592). We considered changes in malnutrition as the main primary outcome and changes in children's eating and drinking behavior and awareness and knowledge of malnutrition as the secondary outcomes. Results related to other secondary outcomes will be reported in future studies.

Study area, recruitment, and eligibility criteria

This study was conducted in two rural unions of North Matlab, Chandpur District, Bangladesh. The study participants were children of both sexes who were studied in grades 1–5 from four primary schools. The CHWs visited the children's houses and explained the study's purpose to them including their parents. Next, CHWs checked the children's eligibility criteria, enrolled them in the study with their consent. The inclusion criteria were as follows: those (children and their parents) who agreed to give consent and were willing to participate, receive health checkups and laboratory investigation, respond to the questionnaire, and stay in the same school and area until study completion. Children who did not meet the eligibility criteria were excluded. Additionally, we excluded children in grade 5 who completed primary school after baseline data collection and had to be transferred to another school or area.

Allocation and study procedure

Two schools from each union were purposively allocated into the intervention group (IG) and control group (CG).[39] After enrollment, survey and health assessment data, such as height, weight, and BMI, were collected at baseline (T0). Next, we prepared and trained school nurses to conduct health educational interventions. Afterward, similar data were collected in both groups at midline (T1, 5 months after T0) and endline (T2, 12 months from T0). Baseline health reports of children in both groups were provided to their parents as study feedback. The report was made in Bengali (the local language) and English, which included normal ranges and WHO-recommended growth curves, and recommended re-examination of children later based on irregular results.

Training of school nurses and assistants

We recruited three nursing faculty members (registered nurses) from a reputed nursing college in Dhaka, Bangladesh, who had studied school nursing. They trained 10 undergraduate nursing

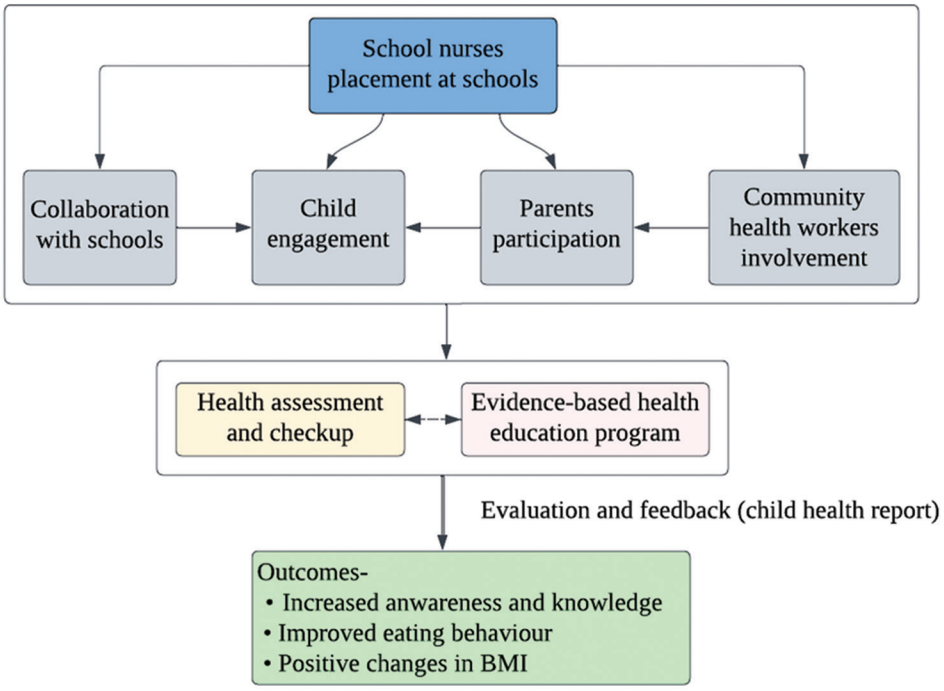

Figure 1: Study framework

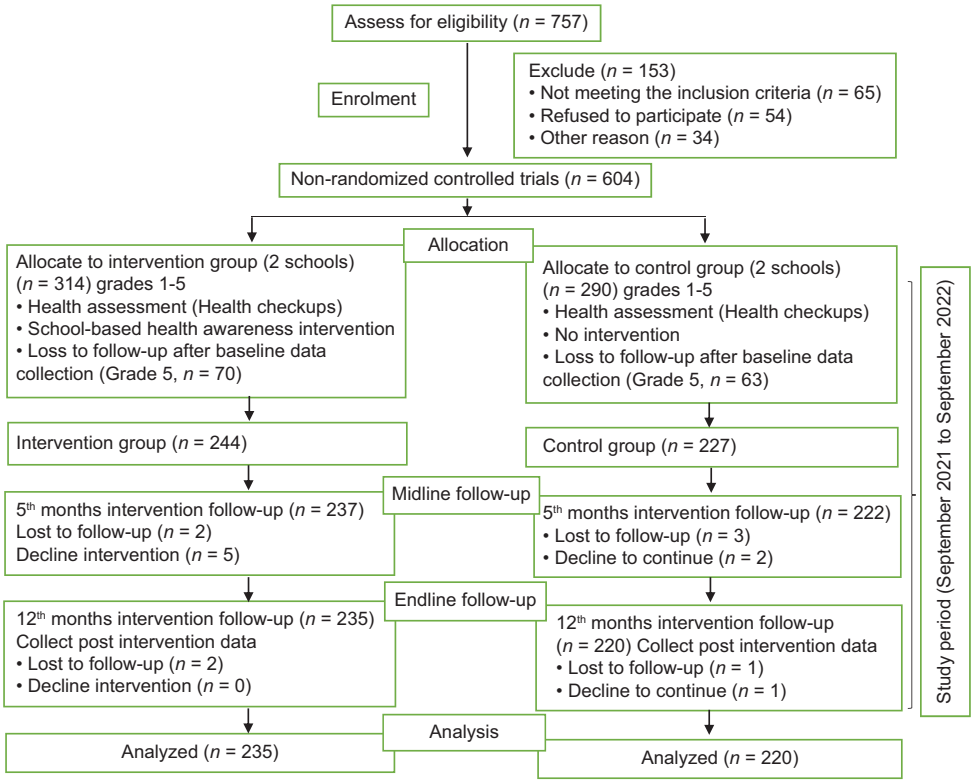

Figure 2: Study flow chart

students to assist the school nurse. The sessions were conducted for 1 month (total 36 h) in three modes: face-to-face, online, and group discussions including practice. Additionally, the CHWs received brief sessions on this study, administration, and data collection, including health assessment methods and educational materials.

Health education for intervention group

Children of IG received health education at school through HAPSC for 9 months. Specifically, they received 45-min educational sessions every week of the month, except when school was closed due to holidays or unavoidable circumstances (COVID-19 outbreak). During schools' holiday, school nurses provided health education through telephone calls. All sessions were organized with fun play-based, and conducted face-to-face, asking questions, small group discussions, roleplay, group work, and hands-on practices.[31] The content was prepared using the dietary guidelines for Bangladesh.[34,40] Additionally, we prepared a few health education materials for the children, such as booklet, my health record notebook, poster, food models/pictures, and short message leaflet (Multimedia Appendix-1). The contents focused on the food pyramid; benefits of food; eating breakfast and the ideal composition of a meal with nutritive and functional values; and effects of unhealthy food.[32,34] To facilitate the understanding of grades 1–2 children, we used hand-made posters with many pictures and food models. However, the educational content for children grades 1–5 was similar. Lastly, the CHWs provided health education to the children's parents twice during the first month and once a month throughout the intervention period.

Regular follow-up for control group

The children in CG participated in all follow-up activities; however, they received no health education throughout the intervention period. At the end of the study, the educational materials and the study findings were shared with them.[41]

Outcome measurement

Primary outcome

The primary outcome of this study was the change in malnutrition rate among children as determined using BMI. The BMI was calculated using the WHO formula: BMI = weight (kg)/ height^2 (m)^2. Children's nutritional status and BMI-for-age were measured by comparing the z-scores against the 2007 WHO growth reference tables for children aged 5–19 years.[42,43] The cut-off values for overweight and obesity are > +1 standard deviation (SD) and > +2SD, respectively, and the cut-off value for thinness is < – 2SD.

Secondary outcomes

We developed questionnaires that were pretested among 120 primary school children from different schools to ensure content validity and reliability.

Eating and drinking-related behavior data

The questionnaire included children's practices of eating meals thrice a day such as eating carbohydrate and protein-containing foods and vegetables. The CHWs provided the survey form to the children's parents with appropriate instructions and asked them to complete it based on their children's 7-day meal frequency.

Awareness and knowledge of malnutrition

We assessed the children's awareness and knowledge of malnutrition using a quiz test questionnaire (10 questions) and the responses were classified into two categories: 0= "do not know"" or "no," and 1= "yes". The range of scores was from 0 to 10 with higher scores indicating a greater level of awareness and knowledge, and Cronbach's alpha was 0.861.

Study sample size

The sample size was determined using the G Power software (Version 3.1.9.4) with an effect size of 0.70 for school-based intervention[44] and a confidence level of 0.95.[45] The expected minimal sample size was 110, 55 for the IG and 55 for the CG. Nevertheless, we invited all the schools' children to participate and enrolled all who expressed interest by providing consent. At T0, 604 children participated and completed all the surveys and health checkups.

Quality control

The study activities were monitored and the well-trained staff were recruited. Additionally, to avoid possible contamination from the dissemination of information in the IG, we divided the schools into two areas based on different unions.

Data analysis

A per-protocol set analysis was conducted to explore this study's efficacy. The continuous variables are expressed in mean and SD using the Mann–Whitney *U* test. Additionally, categorical variables are expressed as frequencies and percentages and were assessed using the Chi-square test (χ^2) performed in the SPSS for Windows version 26.0 (IBM Corp, Armonk, NY, USA). To observe the changes between both groups, covariance was analyzed using R software version 4.2 (R Foundation for Statistical Computing, Vienna, Austria).[46]

The BMI changes (BMI levels: −2SD, −1SD, +1SD, and + 2SD) categorized into three groups: 1 = decreased, 2 = no changed, and 3 = increased. Furthermore, Chi-square and Wilcoxon rank-sum tests were performed to compare the distribution between groups. To assess the changes in BMI between the groups, multivariate analysis was performed using a General Linear Model with a gamma-log-link distribution. BMI differences (from T2 to T0) were considered response variables, and age and BMI at T0 were adjusted variables. Some children showed abnormal changes; therefore, we removed 21 respondents who showed (±) 2SD as the outlier.

Regression analysis was used to compare the intervention effects, with both groups as independent variables, children's awareness and knowledge and behavioral data at T2 as dependent variables, and the data at T0 as covariates. The gamma distribution was used to model non-normally distributed data. During eating behavior analysis, the denominator value negative binomial model was used, and the general linear model (link = log) function in the MASS package of R was used to estimate a negative binomial distribution model. The significance level was set at $P < 0.05$.

Results

A total of 604 children were enrolled, allocated into CG ($n = 290$) and IG ($n = 314$) and participated in baseline data collection. During the intervention period, 70 children (24.1%) in CG and 79 (25.2%) in IG dropped out for unavoidable reasons. Therefore, 220 children in the CG and 235 in IG completed the study.

The sociodemographic data of children in both groups were similar except for their academic grades ($P = 0.011$), religion ($P = 0.008$), and their mother's educational level ($P = 0.039$) [Table 1]. Additionally, 263 (57.8%) were female, and each academic grade had >50 children, except for grade one. The family income of 168 respondents (36.90%) was <10,000 BDT (approximately <100 USD) per month, and approximately 50% of their fathers were employees in both groups.

The chronological changes in the children's BMI categories according to WHO at each time point were revealed; the number of underweight children in each group increased [Figure 3]. The changes in BMI categories—the primary outcome of this study—were considered as "decreased," "not changed," and "increased" from T0 to T2. BMI "increased" in IG was 13 [Table 2], higher than the expected frequency of 9.41; however, BMI changes between the groups were not statistically significant. However, the mean (SD) of all children's raw data of weight, height, and BMI was slightly increased for both sexes at each time point periodically [Supplementary Appendix 1].

Table 1: Sociodemographic characteristics of the participants (n=455)

Variables	Control Group (n=220)	Intervention Group (n=235)	p
Gender			
Male	97 (44.1)	95 (40.4)	0.429
Female	123 (55.9)	140 (59.6)	
Academic grades			
1	56 (25.5)	31 (13.2)	0.011**
2	58 (26.4)	70 (29.8)	
3	51 (23.2)	67 (28.5)	
4	55 (25.0)	67 (28.5)	
Age			
5	1 (0.5)	0 (0.0)	0.105
6	33 (15.0)	15 (6.4)	
7	43 (19.5)	50 (21.3)	
8	51 (23.2)	57 (24.3)	
9	48 (21.8)	53 (22.6)	
10	31 (14.1)	47 (20.0)	
11	9 (4.1)	10 (4.3)	
12	4 (1.8)	3 (1.3)	
Religion			
Islam	214 (97.3)	215 (91.5)	0.008**
Hindu	6 (2.7)	20 (8.5)	
Family income (per month)			
Do not know	12 (5.5)	7 (3.0)	0.167
<10,000 BDT	74 (33.6)	94 (40.0)	
10,000-20,000 BDT	111 (50.5)	102 (43.4)	
>20,000 BDT	23 (10.5)	32 (13.6)	
Occupation of the child's father			
Employee	119 (54.1)	112 (47.7)	0.255
Business	35 (15.9)	48 (20.4)	
Expatriate workers	39 (17.7)	36 (15.3)	
Others	27 (12.3)	39 (16.6)	
Occupation of the child's mother			
Housewife	209 (95.0)	219 (93.2)	0.415
Others	11 (5.0)	16 (6.8)	
Educational level of child's father			
Primary level or lower	184 (83.6)	188 (80.0)	0.316
Secondary level or above	36 (16.4)	47 (20.0)	
Educational level of child's mother			
Primary level or lower	191 (86.8)	187 (79.6)	0.039*
Secondary level or above	29 (13.2)	48 (20.4)	

*<0.05, **<0.01, ***<0.001

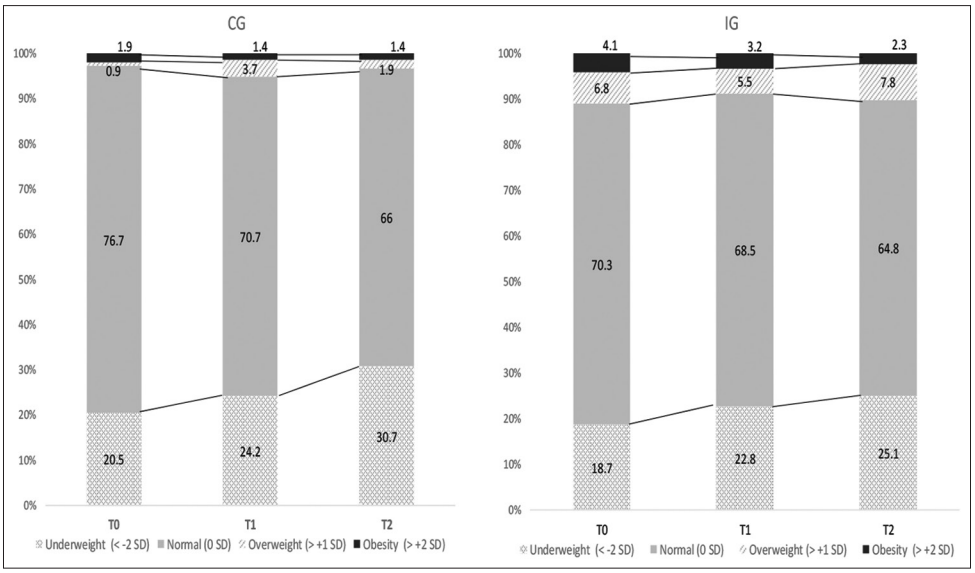

Figure 3: Frequency of BMI changes (according to World Health Organization cut-off value, 2007) of both groups at each time point. Notes: IG = intervention group, CG = control group, BMI = body mass index, SD = standard deviation

Table 2: Body mass index categorical change between groups after and before intervention (*n*=434)

Categories	Control Group (*n*=215) *n* (%)	Intervention Group (*n*=219) *n* (%)
Decreased	28 (13.0)	33 (15.1)
No changed	181 (84.2)	173 (78.9)
Increased	6 (2.8)	13 (5.9)

χ^2=2.982, df=2, *P*=0.225

Gamma regression analysis was conducted on BMI changes after adjusting the T2 with T0; the intervention positively influenced BMI at T2 [Exp(β) =1.105, SE (standard error) =0.026, t = 3.869, $P < 0.001$], which was statistically significant between the groups [Table 3]. Moreover, the primary outcome was further adjusted with sociodemographic data, revealing significant intervention effects on BMI at T2 [Exp(β) =1.108, SE = 0.034, t = 2.984, P = 0.003]. The father's educational qualifications as a covariate strongly influenced family income and higher educational qualifications significantly influenced the child's BMI at T2 (P = 0.027).

Additionally, to assess intervention effects, we described the children's BMI (mean ± SD) by all ages and divided the underweight children (lower than the WHO cut-off value: −2SD to − 1SD) into − 2SD group as an underweight group and the rest (−1SD, +1SD, and + 2SD) into a nonunderweight group at T2 from T0 in both groups [Supplementary Appendix 2]. The children in the − 2SD group had more improvement (0.48) in BMI than the rest (0.20). In the − 2SD group, children in IG showed significantly greater improvement in BMI difference than those in CG (P = 0.008). Therefore, the intervention had favorable effects on the children.

The gamma regression analysis revealed that the intervention significantly positively affected the awareness and knowledge of malnutrition at T1 [Exp (β) =1.135, SE = 0.035, t = 3.678, $P < 0.001$] and T2 [Exp (β) =1.692, SE = 0.037, t = 14.358, $P < 0.001$] [Table 4]. Additionally, IG had a significantly higher mean score than that of CG.

The negative binomial regression analysis indicated that intervention significantly positively affected the eating behavior at T1 [Exp (β) =1.428, SE = 0.060, χ = 3.388, $P < 0.00$] and T2 [Exp (β) =1.225, SE = 0.062, χ = 5.742, $P < 0.001$] after adjusting for T0 [Table 5].

Discussion

This is the first school nurse-led study conducted to reduce child malnutrition and improve awareness and knowledge of malnutrition in Bangladesh. The results revealed that school nurse-led health education had satisfactory effects on the groups at each time point (T1 and T2). The BMI categorical changes between the groups were not statistically significant. Although the raw data of the children's height, weight and BMI were gradually increased at each time point. However, in this study, the pattern of Bangladeshi children's growth is not adequate, which leads to an increasing number of poor BMI at T0 to T2 compared with WHO standard reference. The prior study explored similar findings such as high malnutrition, vitamin deficiency, poor growth pattern, and poor BMI compared with standard reference for the same-aged group of children, and several studies failed to find out malnutrition for 5–15 years of children.[47-49] Nevertheless, comparing the adjusted BMI changes, the number of malnourished children was reduced, and the changes in children's BMI in IG were positively significant.

The malnutrition rate among the children was consistent with previous reports that 38% of school-aged children are stunted, 41% are underweight, and 48% are wasted.[11] Moreover, the

Table 3: Body mass index comparison (*n*=434)

Variables	Exp β (estimate)	95% CI		Std. Error	*t*	*P*
		Low	High			
Adjusted baseline model						
(Intercept)	2.476	2.013	3.044	0.109	8.327	<0.001***
Group intervention	1.105	1.051	1.163	0.026	3.869	<0.001***
BMI (baseline)	1.001	0.989	1.012	0.006	0.128	0.898
Age (month)	1.001	0.999	1.002	0.001	1.198	0.231
Adjusted T0 and sociodemographic model						
(Intercept)	2.275	1.793	2.884	0.125	6.600	<0.001***
Group						
Intervention	1.108	1.036	1.186	0.034	2.984	0.003***
Control	ref					
Gender						
Female	1.029	0.977	1.082	0.026	1.078	0.282
Male	ref					
BMI (baseline)	1.014	0.992	1.037	0.011	1.257	0.210
School						
School (A)	0.945	0.877	1.019	0.038	-1.473	0.142
School (B)	0.947	0.881	1.018	0.037	-1.474	0.141
School ©	ref					
BMI categories (baseline)	0.935	0.862	1.014	0.042	-1.617	0.107
Age (month)	1.001	0.999	1.002	0.001	0.980	0.328
Father's educational qualification						
No education	ref					
Primary level	1.001	0.945	1.061	0.030	0.030	0.976
Secondary level	1.022	0.939	1.114	0.044	0.509	0.611
Higher secondary level	1.043	0.919	1.188	0.065	0.649	0.517
Graduate level or above	0.843	0.727	0.983	0.077	-2.221	0.027*

Multivariate general liner models gamma log-link for the BMI difference (T2-T0) with sociodemographic determinants. Note, BMI=body mass index, CI=confidence interval; Std. Error=standard error, *<0.05, **<0.01, ***<0.001

Table 4: Awareness and knowledge changes regarding malnutrition between groups (n=455)

Outcome variable	Coefficients	Exp β (Estimate)	95% CI		Std. Error	*t*	*P*
			Low	High			
Awareness & knowledge related to malnutrition							
T1	(Intercept)	5.514	4.468	5.134	0.033	51.119	<0.001***
	Group	1.135	1.574	1.818	0.035	3.678	<0.001***
	Baseline	1.009	0.991	1.016	0.006	1.556	0.1203
T2	(Intercept)	4.785	5.160	5.894	0.035	44.176	<0.001***
	Group	1.692	1.061	1.215	0.037	14.358	<0.001***
	Baseline	1.003	0.998	1.021	0.006	0.483	0.63

General liner model: family=Gamma (link=log). Note, CI=confidence interval; Std. Error=standard error, *<0.05, **<0.01, ***<0.001

Table 5: Eating behavior changes between groups (*n*=455)

Outcome variable	Coefficients	Exp β (Estimate)	95% CI		Std. Error	*Z*	*P*
			Low	High			
Eating behavior							
T1	(Intercept)	6.977	6.253	7.925	0.059	32.988	<0.001***
	Group	1.428	1.089	1.377	0.060	3.388	<0.001***
	Baseline	1.023	1.000	1.024	0.006	2.05	<0.04
T2	(Intercept)	7.036	6.159	7.908	0.062	31.467	<0.001***
	Group	1.225	1.265	1.613	0.062	5.742	<0.001***
	Baseline	1.012	1.011	1.037	0.006	3.725	<0.001***

Note, CI=confidence interval; Std. Error=standard error. Negative binomial model, *<0.05, **<0.01, ***<0.001

children's BMI and malnutrition rates were closely associated with their sociodemographic status and parents' educational level. A higher educational level of children's fathers positively influenced children's BMI improvement.[35,50,51] The factors for the high burden of malnutrition in Bangladesh can be broadly categorized as sociodemographic, access, health, physical, and low-health literacy factors.[6,12,52] In this study, BMI was the only indicator used to assess malnutrition. Previous researchers used similar indicators among children of similar age groups[39,53,54] and acknowledged that uncontrolled BMI is associated with noncommunicable diseases in later stages of human life.[5] Therefore, regular BMI monitoring is essential for children to monitor health issues during early adulthood.

Health education alone did not affect BMI changes; hence, we involved school authorities, CHWs, and parents. The CHWs continued periodic visits to the children's home and encouraged the parents to positively change their daily lives based on health education. The intervention had positive effects, especially on underweight children, although a few showed improvements. Prior research explored the scope of improvement in child health status through school-based[18,34,37] and community-based health education involving their parents and primary care providers.[55,56] Therefore, individual approaches that consider the risk groups of children are vital in ensuring progressive changes.

The secondary outcomes of this study significantly differed between the IG and CG, which provides robust evidence that school nurse-led health education is effective for primary school children in school settings in Bangladesh, and may be relevant to other LMICs.[19,57,58] Therefore, increasing awareness and knowledge of health and preventive practices are key to minimizing malnutrition.[32,57] Health education from childhood is sustainable for a nation, and a school environment is a suitable place for children to learn healthy lifestyles and behaviors to prevent malnutrition.[59,60] Furthermore, longer intervention periods support the exploration of more findings.[61] As children's parents repeatedly participated in health education, they became more concerned about their child's health.[62] Thus, parents' knowledge level could influence children's health status.[16,63,64] Notably, we shared the children's health report with their parents; hence, they became more concerned about their children's health after acquiring health information.[65]

According to previous studies, school nurses are professionally unique, and their placement at school is vital in improving behavioral changes among children which is a way to make constructive rapport with primary care providers.[23,56,58] Additionally, school nurse placement creates a healthy and supportive environment and promotes child educational development.[18,66] However, reducing child malnutrition sustainably is still challenging in developing countries due to poor socioeconomic status.

This study had some limitations. First, the schools were nonrandomly selected, and a few variables were statistically significant at baseline, which might affect the study outcomes. Furthermore, the schools were from only rural unions. Thus, the efficacy of education is not conclusive as we did not cover urban areas in Bangladesh. Second, the study was conducted during the COVID-19 pandemic; therefore, we could not extensively assess the intervention. Third, we did not include 5th-grade children in the analysis, which may have affected the results. Lastly, a self-reported questionnaire (dietary behavior) could be a possible source of bias.

Conclusion

This study demonstrates the effectiveness of the first school nurse-led evidence-based health education through positive changes in the outcomes for primary school children. Overall, it provides evidence for further expansion of health educational interventions to accumulate evidence in Bangladesh, particularly in resource-poor settings. We recommend for developing countries; it is obligatory to establish an authorized certified school nursing program and placement of school nurses in the school setting to improve the children's health status in the future.

Ethical Policy and Institutional Review Board Statement

This study followed the ethical standards of the 1975 Helsinki Declaration (revised version 2013) and was approved by the Institutional Review Board (2021/OR-NSU/IRB/0701) from a University in Bangladesh. Before participating in the study, all the children provided verbal assent, and written informed consent was obtained from their parents (or legal guardian). We informed all the children and their parents about the research purpose, privacy, anonymity, no/minimal risk to participate in this study, and their right to withdraw from the study at any point without explanation. Data were recorded using a unique number for each participant to prevent duplication and identification.

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Conflicts of interest

There are no conflicts of interest.

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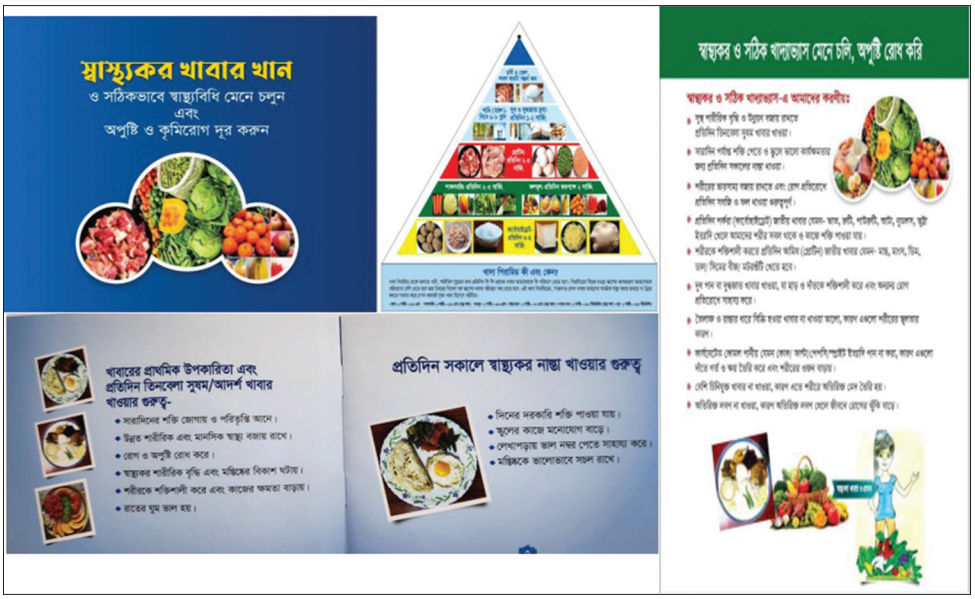


Multimedia Appendix 1: Educational materials (booklet, leaflet and poster)

Supplementary Appendix 1

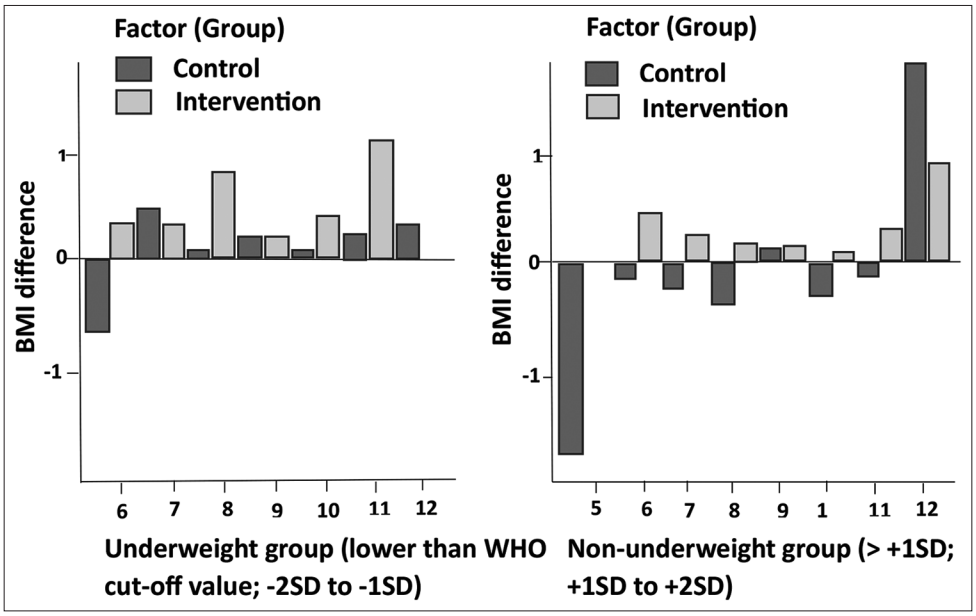
Supplementary Appendix 1: The mean (SD) values of height, weight, and body mass index among the children in terms of gender for both groups at each time points

Variables		Boy (mean (SD))			Girl (mean (SD))		
	Times	Overall (*n*=186)	Control group (*n*=95)	Intervention group (*n*=91)	Overall (*n*=248)	Control group (*n*=120)	Intervention group (*n*=128)
Height (cm)	T0	127.08 (9.92)	125.25 (8.99)	128.99 (10.52)	126.88 (9.33)	125.20 (8.89)	128.45 (9.50)
	T1	130.75 (10.03)	129.19 (9.08)	132.37 (10.74)	130.68 (9.46)	129.16 (9.11)	132.09 (9.60)
	T2	132.32 (10.00)	130.95 (9.11)	133.74 (10.71)	132.44 (9.50)	131.16 (9.27)	133.64 (9.60)
Weight (kg)	T0	24.19 (6.09)	23.05 (4.51)	25.38 (7.23)	24.15 (6.43)	22.95 (5.52)	25.26 (7.02)
	T1	25.74 (6.63)	24.51 (4.90)	27.03 (7.88)	25.81 (6.86)	24.60 (6.12)	26.94 (7.33)
	T2	26.35 (6.86)	25.01 (4.77)	27.76 (8.32)	26.57 (7.29)	25.21 (6.40)	27.85 (7.85)
Body mass index	T0	14.77 (2.02)	14.58 (1.65)	14.97 (2.33)	14.79 (2.31)	14.47 (1.89)	15.09 (2.61)
	T1	14.86 (2.13)	14.58 (1.77)	15.15 (2.42)	14.91 (2.39)	14.56 (2.05)	15.23 (2.63)
	T2	14.85 (2.15)	14.49 (1.67)	15.22 (2.51)	14.92 (2.50)	14.46 (2.11)	15.35 (2.76)

Note, T0=Baseline, T1=Midline, T2=Endline, and SD=Standard deviation

Supplementary Appendix 2

Body mass index differences from T2 to T0 of both groups



Note. The Wilcoxon rank sum test showed that (1) The increase in BMI of the underweight group was higher in the intervention group (BMI difference = 0.48) than the control group (BMI difference = 0.07) from T2 to T0, which was statistically significant (p = 0.008). (2) The increase in BMI in the non-underweight group was higher in the intervention group (BMI difference = 0.20) than in the control group (BMI difference = 0.07) from T2 to T0, which was statistically significant (p = 0.001)

Note. BMI = body mass index, WHO = World Health Organization, SD = standard deviation.