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Intestinal helminth infections and dietary diversity score predict nutritional status of urban schoolchildren from southern Ethiopia

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Abstract

Background: Undernutrition is a major public health problem in developing countries like Ethiopia where schoolchildren are among the vulnerable groups. However, limited attention has been given for the nutritional status of schoolchildren including the lack of available evidence on the magnitude and modifiable risk factors in different parts of the country. Thus, we aimed at determining the magnitude and predictors of undernutrition among schoolchildren in Arba Minch town, southern Ethiopia.

Methods: A school-based cross-sectional study was conducted in March and April, 2014 involving 532 schoolchildren aged 7 to 14 years. A two-stage probability sampling procedure was applied to select study schools and subjects. Anthropometry measurements were taken using standardized techniques and calibrated equipment. Intestinal parasite infections were determined from stool samples using direct saline method and formal ether concentration technique; whereas data on demographic and relevant risk factors were gathered through structured interview of caretakers. Bivariate and multivariable logistic regressions were used to identify predictors of stunting and wasting in the study population.

Results: The prevalence of stunting and wasting were 26.0% (95% CI: 22.3, 30.1%) and 11.7% (95% CI: 9.1, 14.9%), respectively. In multivariable model, poor household wealth [AOR (95% CI) = 3.2 (1.2, 8.5)], living in large family [AOR (95% CI) = 2.3 (1.0, 5.1)], lack of maternal formal education [AOR (95% CI) = 4.1 (1.8, 9.4)], low Dietary Diversity Score [AOR (95% CI) = 2.3 (1.2, 4.7)], *A. lumbricoides* [AOR (95% CI) = 5.0 (2.7, 9.4)], hookworm [AOR (95% CI) = 8.0 (4.0, 15.8)] and *T. trichuria* [AOR (95% CI) = 6.3 (2.8, 14.1)] infections were associated with stunting. Wasting status was independently associated with not living with both parents [AOR (95% CI) = 2.0 (1.0, 4.1)], poor household wealth [AOR (95% CI) = 8.9 (2.0, 39.2)], and recent illnesses [AOR (95% CI) = 6.3 (3.1, 12.6)].

Conclusions: Both acute and chronic malnutrition are prevalent among schoolchildren in the study area where intestinal parasite infections, poor dietary quality and common illnesses are important modifiable risk factors. A comprehensive school-based health and nutrition intervention involving parents may help to alleviate the problem including regular deworming and promotion of personal hygiene and balanced diet.

Keywords: Nutritional status, Intestinal parasite infection, Dietary diversity, Schoolchildren, Ethiopia

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Background

In developing countries, childhood undernutrition is a major public health problem with schoolchildren and adolescents among the most vulnerable groups [1]. Worldwide, 159 million children are estimated to be stunted and 50 million suffer from acute malnutrition with the majority living in the developing world [2]. Even though stunting mostly occurs during the first 2 years of life [3], it continues to accumulate throughout the school years [4]; whereas acute malnutrition and micronutrient deficiencies are among the most recurrent health problems in schoolchildren [5]. The adverse effects of malnutrition in schoolchildren are not limited to poor health and physical growth, but also hamper intellectual capacity, social skills and school performance with far reaching consequences on future economic and human development of societies [6–11].

Multiple and complex factors contribute to malnutrition and poor growth of schoolchildren with poor nutrition and infections being the immediate causes [12]. Studies showed dietary factors like low meal frequency [13], consumption of less diverse diet [14], inadequate intake of carbohydrates [15] and household food insecurity [15] are important determinants of nutritional status in schoolchildren. Recurrent childhood illnesses like diarrhea, respiratory infections and intestinal parasites also contribute to malnutrition through decreased food intake, impaired nutrient absorption, direct losses and stimulation of the immune system that diverts energy and nutrients from structural and physiological functions [16, 17]. The impact of intestinal parasite infection on nutritional status of schoolchildren has received special attention considering its high prevalence and recurrent occurrence in this age group [18]. Studies found higher stunting and underweight risk among schoolchildren with hookworm infection, trichuriasis and ascariasis [15]. Family wealth, maternal education, household size, and age and sex of a child are among the several socio-demographic predictors of malnutrition commonly reported in studies from developing countries [13, 15, 19].

In Ethiopia, the most recent nationwide survey reported that significant proportion of schoolchildren and adolescents are malnourished with stunting and wasting prevalence of 23 and 22%, respectively [20]. On the other hand, limited nutrition policy and program attention has been given to this age group partly due to the lower magnitude and mortality risks compared to preschool children. However, the period of school age and adolescence is the time where nutritional insults continue to result in long term consequences and is the last opportunity to compensate early growth faltering and associated consequences [21–24]. The limited attention given to the problem includes the lack of available evidence on the nutritional status and the important modifiable risk factors among schoolchildren living in different social and environmental conditions in the country including in the current study area. Therefore, we aimed at determining the magnitude and predictors of undernutrition among schoolchildren in Arba Minch town, southern Ethiopia.

Methods

Study setting, design and sampling

A school-based cross-sectional study was conducted in March and April, 2014 among schoolchildren in Arba Minch town, the capital of Gamo Goffa zone under the Southern Regional State of Ethiopia located 505 kms from Addis Ababa. The district has a tropical ecology with altitude of 1,250 m, annual temperature of 29.7^{0}C and rainfall of 700 mm. The town has a total population of 100,440 and 21 primary schools that enrolled 17,029 students with universal primary school enrollment reported by the local education authorities in 2014.

Sample size was determined based on formula for single population proportion to estimate a stunting prevalence of 22.3% from the National Survey [20] using 95% level of confidence and 5% precision. We included a total of 532 study participants aged 7 to 14 years after considering a design effect of 1.8 and non-response rate of 10%. Study participants were selected using a two-stage sampling procedure applying the Probability Proportional to Size (PPS) sampling approach. In the first stage, systematic sampling technique was used to select 6 study schools from the total of 21 primary schools found in Arba Minch town. Then, equal number ($n = 89$) of study participants were sampled from each study school using computer generated random numbers.

Data collection and measurements

Six diploma nurses fluent in the local language were recruited to conduct A face-to-face interview of participants' mothers/caregivers at their home and carryout anthropometry measurements of children at the study schools. Nurses received 3 days intensive training with practical sessions at the start of the study by two health officers who also supervised the actual data collection. A pre-tested structured questionnaire was deployed to gather data on demographic characteristics, wealth status and different risk factors of nutritional status including water and sanitation practices, health service utilization, recent illnesses, dietary intake and household food security status. Household wealth was assessed using selected items reflecting household assets, utilities and housing characteristics from the Ethiopian Demographic and Health Survey [25]. Principal Components Analysis was applied to generate latent factors with the first factor used to categorize households into wealth tertiles [26].

The individual Dietary Diversity Score (DDS) based on nine food groups was calculated for each study child using 24-h qualitative dietary recall data [27]. Food security status of study households was assessed using the Household Food Insecurity Access Scale (HFIAS) questionnaire validated and used in other developing countries [28]. The HFIAS has 9 questions that assess household's experience during the last 1 month regarding different domains of food insecurity including the feeling of uncertainty about food supply, insufficient quality of food, and insufficient food intake and/or its physical consequences. Based responses to the questions, households were categorized as food-secure or food-insecure according to the recommendation.

Anthropometry measurements of weight and height were carried out using standardized techniques and calibrated equipment [29]. Body weight was measured to the nearest 0.1 kg using electronic digital scale (SECA 876, Germany). Height measurement was done to the nearest 0.1 cm using stadiometer with a sliding head bar (SECA 213, Germany). All measurements were done with children wearing their school uniform and in barefoot. Children's age was obtained from school registries and converted to months according to the recommendation [30]. Height-for-age z scores (HAZ) and BMI-for-age z scores (BAZ) were determined based on the WHO 2007 reference population using the WHO AnthroPlus version 1.0.1 [31].

Stool samples were collected using clean, dry and leak proof cups labeled with subject id and name. Three experienced laboratory technologists conducted detection of stool parasite infection both on the site and at a central lab in Arba Minch College of Health Sciences. On site examination of specimen within 30 min of sample collection was done to capture Hookworms ova before hatching through time. Direct saline method was applied for detection of helminths ova and protozoan cyst and/or trophozoites [32]. We repeated the onsite examination at the central lab to increase parasite detection rate using the formal ether concentration technique following the WHO Standard Operating Procedure [32].

Statistical analyses

Data were coded, entered and cleaned using Epi-data v. 3.1 and statistical analyses were performed using Statistical Package for Social Studies (IBM SPSS v 20.0). Proportions and means (SD) were used to describe the study population by nutritional status and the different explanatory variables. Bivariate logistic regression was done to identify the differentials of nutritional status (stunting and wasting) in the study population. Multivariable logistic regression models were fitted to determine the independent predictors of stunting and wasting status among the explanatory variables. Stepwise backward procedure was applied by including the variables with significant or marginally significant association ($p \leq 0.1$) during bivariate regression and those variables found to be important predictors in the literature. The need for considering a clustering effect by school was assessed using model with random intercept school and found not important; rho = 0.00 ($p = 0.498$) and 0.01 ($p = 0.090$) for the wasting and stunting models, respectively. We verified absence of multicollinearity among the explanatory variables using the variance inflation factor (<10) and tolerance (>0.1). Model adequacy was assessed using the Omnibus tests of model coefficients ($P < 0.05$) and the Hosmer and Lemeshow test of goodness of fit ($P > 0.05$). All tests were two-sided and statistical significance was considered at $p < 0.05$.

Ethics

The study protocol was approved by the Ethical Review Board of Jimma University. At the start of the study, verbal consent was obtained from mothers/primary caretakers of the study children and children's assent was asked before data collection. Deworming of children with intestinal parasite infection was carried out in collaboration with the local health office.

Results

Of the 532 schoolchildren sampled, data was collected from 511 (96.1%) whereas the remaining 17 children were not found during data collection and 4 were older than 14 years. Mean (SD) age of the study participants was 10.6 (2.4) years with majority (63.6%) between 10 and 14 years. Most (86.3%) of the children were living with both of their parents, whereas 70 were living with one of their parents (10.5%) or with other people (3.1%) like grandparents, relatives or fosters. Majority of participants' households were male headed (87.9%) and with family size of at least 5 people (64.8%). About two-third (65.8%) of the study children were from food insecure households and more than half (55.0%) of them had a DDS of ≤ 4. During the 2 weeks prior to the study, 169 (33.1%) of the participants experienced illness including diarrhea (40.8%), acute febrile illnesses (38.5%) and acute respiratory infections of which only 81 (47.9%) received medical care. Intestinal parasite infection was detected in 285 (55.8%) children of which 87 (17.0%) had more than one infection. Regarding the type of parasite infection found in children were, *A. lumbricoides* 107 (37.8%), Hookworms 75 (26.6%), *T. trichiura* 54 (19.1%), *H.nana* 44 (15.6%), *G.lamblia* 42 (14.8%), *Taenia spp.* 24 (8.5%), *E.histolytica* 23 (8.2%), *S.mansoni* 11 (3.9%), *E.vermicularis* 9 (3.2%) *and S.stercoralis* 2 (0.7%).

The mean (SD) HAZ and BAZ of the study participants were -1.37 (0.94) and -0.63 (1.06), respectively. The prevalence of stunting (HAZ < -2SD) and wasting

Table 1 Stunting by relevant characteristics of schoolchildren, Arba Minch town 2014

Variables	Total (%)	Stunted (%)	COR (95% CI)[a]	AOR (95% CI)[b]
Demographic and wealth factors				
Child sex				
Male	256 (50.1)	77 (30.1)	1.5 (1.0, 2.3)*	
Female	255 (49.9)	56 (22.0)	1	
Child age (yrs)				
7–9	186 (36.4)	42 (22.6)	1	
10–14	325 (63.6)	91 (28.0)	1.3 (0.9, 2.0)	
Child lives with both parents				
Yes	441 (86.3)	107 (24.3)	1	
No	70 (13.6)	26 (37.1)	1.9 (1.1, 3.1)*	
Maternal education				
No formal education	86 (17.9)	52 (60.5)	12.0 (6.9,20.9)**	4.1 (1.8, 9.4)*
Primary school	85 (17.7)	34 (40.0)	5.2 (3.0, 9.1)**	2.4 (1.0, 5.4) **
Secondary & above	309 (64.4)	35 (11.3)	1	1
Wealth				
Low	192 (37.6)	99 (51.6)	19.2 (9.3,39.7)**	3.2 (1.2, 8.5)**
Medium	148 (29.0)	25 (16.9)	3.7 (1.7, 8.1)*	1.5 (0.6, 3.9)
High	171 (33.4)	9 (5.3)	1	1
Household size				
≤ 4	180 (35.0)	12 (6.7)	1	1
≥ 5	331 (65.0)	121 (36.6)	8.1 (4.3, 15.1)**	2.3 (1.0, 5.1)**
Nutritional factors				
Household food-security				
Food-secure	175 (34.2)	29 (16.6)	1	
Food-insecure	336 (65.8)	104 (31.0)	2.3 (1.4, 3.6)*	
Child DDS[c]				
Low (≤ 4)	281 (55.0)	117 (41.6)	9.5 (5.5, 16.7)**	2.3 (1.2, 4.7)**
High (>4)	230 (45.0)	16 (7.0)	1	1
Health related factors				
Illness during the last 2 weeks				
Yes	169 (33.1)	82 (61.7)	5.4 (3.5, 8.2) *	
No	342 (66.9)	51 (38.3)	1	
A.lumbricoides				
Yes	107 (21.0)	72 (67.3)	11.6 (7.1,18.8)**	5.0 (2.7, 9.4)*
No	404 (79.0)	61 (15.1)	1	1
Hookworm				
Yes	75 (15.0)	56 (74.7)	13.7 (7.7,24.4)**	8.0 (4.0, 15.8)*
No	436 (85.0)	77 (17.7)	1	1
T.trichuria				
Yes	54 (10.6)	41 (75.9)	12.5 (6.4,24.3)**	6.3 (2.8, 14.1)*
No	457 (89.4)	92 (20.1)	1	

Table 1 Stunting by relevant characteristics of schoolchildren, Arba Minch town 2014 *(Continued)*

H. nana				
Yes	44 (8.6)	12 (27.3)	1.1 (0.5, 2.1)	
No	467 (91.4)	121 (25.9)	1	
G.lamblia				
Yes	42 (8.0)	7 (16.7)	0.5 (0.2, 1.3)	
No	469 (92.0)	126 (26.9)	1	

[a]COR: Crude odds ratio
[b]AOR: Adjusted odds ratio, odds ratios adjusted for lack of maternal formal education, poor household wealth status, large household size, low child DDS, *A.lumbricoides,* hookworm and *T.trichuria* infection
[c]Child Dietary Diversity Score based on single 24 H recall; low: 4 or less food groups consumed; high: at least 5 food groups were consumed
[*]Significant at *P*-value <0.05, [**]Significant at *P*-value <0.01

(BAZ < -2SD) were 26.0% (95% CI: 22.3, 30.1%) and 11.7% (95% CI: 9.1, 14.9%), respectively. The prevalence of severe stunting (HAZ < -3SD) was 3.7% (95% CI: 2.3, 5.7%) and severe wasting (BAZ < -3SD) was 2.9% (95% CI: 1.7, 4.8%).

On bivariate association, the occurrence of stunting among schoolchildren was significantly associated with different socio-demographic (child sex, wealth status, living with parents, household size and maternal education), nutritional (household food insecurity and child DDS) and health related factors (illness during last 2 weeks and the occurrence of intestinal parasite infections like *A.lumbricoides,* hookworms and trichuriasis). After adjusted for important covariates in a multivariable model, the variables that independently predicted stunting status were poor household wealth [AOR (95% CI) = 3.2 (1.2, 8.5)], living in large family (≥5) [AOR (95% CI) = 2.3 (1.0, 5.1)], lack of maternal formal education [AOR (95% CI) = 4.1 (1.8, 9.4)], low child DDS (≤4) [AOR (95% CI) = 2.3 (1.2, 4.7)], and infections of *A.lumbricoides* [AOR (95% CI) = 5.0 (2.7, 9.4)], hookworm [AOR (95% CI) = 8.0 (4.0, 15.8)] and *T.trichuria* [AOR (95% CI) = 6.3 (2.8, 14.1)] (Table 1).

Acute malnutrition (wasting) among the schoolchildren significantly differed by maternal education status, status of living with parents, household wealth, household size, household food security status, child DDS, and hookworm and *T.trichuria* infections. However, in multivariable model, not living with both parents [AOR (95% CI) = 2.0 (1.0, 4.1)], poor household wealth [AOR (95% CI) = 8.9 (2.0, 39.2)], and occurrence of illness in the past 2 weeks [AOR (95% CI) = 6.3 (3.1, 12.6)] were the variables that remained to be independent predictors of wasting (Table 2).

Discussion

The current study found stunting and wasting prevalence of 26 and 12% among schoolchildren in Arba Minch town. The magnitude of stunting in this study was comparable with the nationwide estimate (22%) for the same age group and reported in other studies in Ethiopia [15, 20, 33]. On the other hand, acute malnutrition as indicated by wasting was relatively low compared to the nationwide prevalence (23%) and other studies which could be due to a lesser drought and related nutritional insults in the study area compared to some areas of the country [20, 34]. Stunting was higher among boys than girls (30 vs. 22%; *p*-value = 0.037); a similar finding to previous studies from Ethiopia and other countries [1, 13, 20]. This could be due to earlier start of adolescent growth spurt in girls that may compensate to some extent for prior nutritional insults. A study on African schoolchildren showed stunting persists in boys until the age 16 years whereas for girls compensatory growth occurs starting from 12 years [35]. Poor household wealth, lack of maternal formal education, large family size (≥5), low DDS (≤4) and intestinal helminth infections were found to be the important predictors of chronic malnutrition (stunting) among the schoolchildren, whereas poor household wealth, not living with both parents and recent illnesses independently predicted acute nutritional status (wasting).

Intestinal helminth infections were the most important independent predictors of stunting status among the variables assessed in this study. The odds of stunting was 5 times higher among the schoolchildren infected with *A.lumbricoides* [AOR (95% CI) = 5.0 (2.7, 9.4)], 8 times higher in the presence of hookworm infection [AOR (95% CI) = 8.0 (4.0, 15.8)] and about 6 times more in children with *T.trichuria* infection [AOR (95% CI) = 6.3 (2.8, 14.1)]. This finding is consistent with what has been reported in previous surveys [15, 36] and intervention studies that showed improved growth performance after schoolchildren were treated with anthelminthic drugs [37–40]. Intestinal helminth infections could affect linear growth and nutritional status through several mechanisms including decline in food intake [39, 41]; nutrient wastage from blood loss, malabsorption and diarrheal episodes [41, 42]; and suppression of hormones required for bone growth like the growth hormone (GH) and insulin-like growth factor-1 (IGF-1) [43]. The WHO recommends regular school-

Table 2 Wasting by relevant characteristics of schoolchildren, Arba Minch town 2014

Variables	Total (%)	Wasted (%)	COR (95% CI)[a]	AOR (95% CI)[b]
Demographic and wealth factors				
Child sex				
Male	256 (50.1)	31 (12.1)	1.1 (0.6, 1.8)	
Female	255 (49.9)	29 (11.4)	1	
Child age (yrs)				
7–9	186 (36.4)	23 (12.4)	1	
10–14	325 (63.6)	37 (11.4)	0.9 (0.5,1.6)	
Child lives with both parents				
Yes	441 (86.3)	43 (9.8)	1	1
No	70 (13.6)	17 (24.3)	3.0 (1.6, 5.6)*	2.0 (1.0, 4.1)**
Maternal education				
No formal education	86 (17.9)	17 (19.8)	3.2 (1.6, 6.4)*	
Primary school	85 (17.7)	11 (12.9)	1.9 (0.9, 4.2)	
Secondary & above	309 (64.4)	22 (7.1)	1	
Wealth				
Low	192 (37.6)	43 (22.4)	24.4 (5.8, 102.4)*	8.9 (2.0, 39.2)**
Medium	148 (29.0)	15 (10.1)	9.5 (2.1, 42.4)*	5.2 (1.1, 23.9)**
High	171 (33.4)	2 (1.2)	1	1
Household size				
≤ 4	180 (35.0)	6 (3.3)	1	
≥ 5	331 (65.0)	54 (16.3)	5.7 (2.4, 13.4)**	
Nutritional factors				
Household food-security				
Food-secure	175 (34.2)	13 (7.4)	1	
Food-insecure	336 (65.8)	47 (14.0)	2.0 (1.1, 3.9)*	
Child DDS[c]				
Low (≤ 4)	281 (55.0)	48 (17.1)	3.7 (1.9, 7.2)**	
High (>4)	230 (45.0)	12 (5.2)	1	
Health related factors				
Illness during the last 2 weeks				
Yes	169 (33.1)	48 (28.4)	10.9 (5.6, 21.2)**	6.3 (3.1, 12.6)*
No	342 (66.9)	12 (3.5)	1	1
A.lumbricoides				
Yes	107 (21.0)	17 (15.9)	1.6 (0.9, 2.9)	
No	404 (79.0)	43 (10.6)	1	
Hookworm				
Yes	75 (15.0)	17 (22.7)	2.7 (1.4, 5.0)*	
No	436 (85.0)	43 (9.9)	1	
T.trichuria				
Yes	54 (10.6)	11 (20.4)	2.1 (1.0, 4.4)**	
No	457 (89.4)	49 (10.7)	1	

Table 2 Wasting by relevant characteristics of schoolchildren, Arba Minch town 2014 *(Continued)*

G.lamblia			
Yes	42 (8.0)	20 (47.6)	9.7 (4.9, 19.4)**
No	469 (92.0)	40 (8.5)	1
E.histolytica			
Yes	23 (4.5)	14 (60.9)	14.9 (6.1, 36.4)**
No	488 (95.5)	46 (9.4)	1

[a]COR: Crude odds ratio
[b]AOR: Adjusted odds ratio, odds ratios adjusted for child not living with both parents, poor household wealth and illness during the past 2 weeks
[c]Child Dietary Diversity Score based on single 24 H recall; low: 4 or less food groups consumed; high: at least 5 food groups were consumed
*Significant at *P*-value <0.05, **Significant at *P*-value <0.01

based deworming programs with a target to cover at least 75% of school-aged children at risk by the year 2020 [44].

Low child DDS (≤4) in the current study was significantly associated with stunting status [AOR (95% CI) = 2.3 (1.2, 4.7)] suggesting that a diet habitually low in micronutrients may have contributed to stunting in the current study. DDS is a recommended qualitative indicator of micronutrient adequacy of a diet [27, 45] and has been shown to predict growth of children in other studies [14, 46, 47]. On the other hand, DDS was not independently associated with wasting status; a similar finding to previous studies that reported DDS was associated with stunting, but not with wasting [14, 46, 47]. DDS may not necessarily reflect variation in energy intake of children as a child may have optimal energy intake from a monotonous starch based diet with low diversity. Other factors resulting in acute nutritional insult like recent illnesses might also attenuated a possible association between diet and wasting status in our population.

Children from food-insecure households had significantly higher stunting and wasting than their counterparts from food-secure households, but the association disappeared while adjusted for important covariates in the multivariable models. We also found weak association between household food-security status and dietary quality of our children; of children with low dietary quality (DDS ≤ 4), 49.1% were from food-secure and 58.0% were from food-insecure households. These findings suggest that dietary inadequacy among schoolchildren in this study transcended beyond household food security status. Additional factors like poor quality of available foods, lack of awareness about balanced diet and intra-household food maldistribution could have affected efficient utilization of available household resources that highlights the importance of nutrition education about the importance of diverse and nutritious diet to support optimal health and growth of schoolchildren.

Among the socio-demographic factors, lack of maternal formal education, large family size (≥ 5), poor household wealth and not living with both parents were important predictors of undernutrition in our study population, as was the case in studies reported elsewhere [13, 15, 19, 34, 48, 49]. Education of mother's on health and nutrition has been shown to play an essential role in the practice of diversified food consumption, health care seeking behavior and utilization and generation of income [50]. It is also reasonable to assume that stunting is more prevalent in children from large families since resources including food, nurturing and health care could be constrained [13, 15, 48]. Living with a single parent could also affect access to resources and time available for child care.

Stunting reflects a chronic nutritional insult that majority occurs during the early years of life. On the other hand, in the absence of direct health and nutrition interventions, early growth faltering tends to persist and further accumulates throughout the school age and early adolescence [4, 21, 51]. This time of the lifecycle also opens the opportunity to curb lost growth during early life and break the intergenerational cycle of malnutrition. The pubertal growth spurt is the period of the second most rapid growth providing the last chance to intervene before final height is attained [52]. Longitudinal follow-up of children in developing countries showed stunted children could catch-up with their genetic potential at least partially between 8 and 15 years suggesting investment during this time may have a potential return both at individual and societal levels [21–24]. However, this opportunity could be missed by poor health and dietary factors that can cause further nutritional insult and limit the potential for catch-up growth. The current study showed high prevalence of undernutrition among schoolchildren where direct health and nutrition program targeted to schoolchildren is not available. Effective public health and nutrition interventions are required to alleviate nutrition and health problems of the schoolchildren and associated adverse effects on health and schooling. A comprehensive school-based health and nutrition intervention including prevention of intestinal helminth infections through regular mass deworming activities and promoting personal hygiene and balanced diet in skill-based health and nutrition education involving parents may help to address the problem in the current study population.

In this study, we used a school-based sampling of study participants though the high primary school enrollment rate in the study area improves generalizability of our findings to all children in the community. Dietary Diversity Score of children was based on caretakers' recall of the previous day intake which did not include foods consumed outside home. However, food consumption outside home was not common among the target age group in this community. We also did not control for past nutritional status of children in our analyses.

Conclusions

The current study showed that both acute and chronic malnutrition are prevalent among schoolchildren in the study area. High prevalence of intestinal parasite infections, poor dietary quality and common illnesses are the important modifiable risk factors for undernutrition among schoolchildren in the current study.

Abbreviations

A. lumbricoides: *Ascaris lumbricoides*; AOR: Adjusted odds ratio; BAZ: BMI-for-age z scores; COR: Crude odds ratio; DDS: Dietary Diversity Score; epg: Eggs per gram stool specimen; HAZ: Height-for-age z scores; HFIAS: Household Food Insecurity Access Scale; IBM SPSS: International Business Machines Statistical Package for Social Studies; IPI: Intestinal parasite infections; PPS: Probability Proportional to Size; *S. mansoni*: *Schistosoma mansoni*; SD: Standard deviation; *T. trichuria*: *Trichuris trichuria*; WHO: World Health Organization

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Availability of data and materials

All datasets and materials supporting our findings can be found from the corresponding author on reasonable request.

Authors' contributions

TG and AA conceived the study and conducted data analysis and interpretation; TG implemented the study and wrote the manuscript with support from AA. All authors revised and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent to publication

Not applicable.

Ethics approval and consent to participate

The study protocol was approved by the Ethical Review Board of Jimma University and was registered with the reference number of RPGC/323/2014. At the start of the study, verbal consent was obtained from mothers/primary caretakers of the study children and children's assent was asked before data collection. Deworming of children with intestinal parasite infection was carried out in collaboration with the local health office.

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