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Association between intestinal helminth infections and underweight among school children in Tikur Wuha Elementary School, Northwestern Ethiopia

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KEYWORDS
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Summary
Background: The association of intestinal helminths with undernutrition varies by locality. The objective of this study was to investigate the nature of the association of helminth infection with the nutritional status of school children in Tikur Wuha Elementary School, northwestern Ethiopia.
Methods: A total of 403 school children were examined for intestinal helminth infection (stool samples) and nutritional status, thick Kato-Katz and anthropometric techniques, respectively during a baseline survey. Among these children, 235 were treated for helminth infection and re-examined for weight changes four weeks after treatment.
Results: Among the 403 study participants, 29.3%, 28.3% and 58.3% were stunted, underweight and infected with intestinal helminths, respectively. In the multivariate regression model, the probability of being underweight was significantly higher in children who were infected with intestinal helminths, aged 5—10 years and male compared with children who were without helminth infection, aged 11—15 years and female, respectively. The association of helminths with low body mass was strong in the case of hookworm infection, and the probability of being underweight significantly decreased with every one-year increase in the age of the children. The means for weight, weight-for-age *z*-scores and body mass index-for-age *z*-scores of the children significantly increased four weeks after treatment for helminth infection, with a single dose of albendazole and/or praziquantel.

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Conclusions: Helminth-infected male children in the 5- to 10-year-old age group were more vulnerable to undernutrition, which decreased four weeks after treatment. Thus, deworming of children living in the area might be important for improving their nutritional status.

Introduction

Malnutrition is a major health threat to people living in developing countries [1]. The most common concerns in children involve deficiencies in growth and cognitive development [2,3]. Several factors are associated with malnutrition, including diet and disease [1]. Helminths may impact host nutrition by triggering an inflammatory response related anorexia and worm burden dependent physiological abnormalities of the gastrointestinal wall that may lead to reduced food intake, malabsorption and blood loss [4,5]. For example, *Ascaris lumbricoides* and *Trichuris trichiura* may damage the intestinal wall, thereby affecting dietary nutrient absorption and appetite [4]. Alternatively, *Schistosoma mansoni* and hookworm infections could lead to the loss of micronutrients from the host due to chronic blood loss from the intestinal wall [4,5].

Studies showed a positive association of helminth infections with undernutrition in children [6—9]. However, the level of association, the specific types of undernutrition and the age groups associated with each intestinal helminth species varied [6—9]. In addition, considering the different mechanisms by which individual intestinal helminth species cause undernutrition and an increase in the intensity of infection when different helminth species co-exist in a host, additive effects can be expected on anthropometric indices during multiple infections [10]. However, the current evidence is conflicting [11]. The type, intensity and prevalence of helminthiasis, the level of endemicity, the presence of a concomitant parasitic infection and other related host factors may all contribute to the observed variation [4].

Information regarding the nature of the relationship between intestinal helminth infections and anthropometric indicators and other related problems are vital to design the most appropriate intervention strategies for a given community in a specific area [4]. In Ethiopia, particularly in the current study area, intestinal helminth infections have been reported to be endemic [12]. However, the available evidence regarding the association of helminth infection with undernutrition is limited. Therefore, this study was conducted to determine the nature of the relationship between intestinal helminth infection and undernutrition in children in Tikur Wuha Elementary School, Jiga District, northwestern Ethiopia.

Materials and methods

Study area and population

This cross-sectional study was conducted in children attending Tikur Wuha Elementary School between February and March 2011. The school is located in Jiga District, approximately 390 km north of Addis Ababa. The province has an elevation of 1917 MASL and an average temperature and rainfall of 18.5 °C and 134.35 mm, respectively. Over 99% of the residents in the area belong to the Amhara ethnic group, residing in a rural area with similar lifestyle and eating habits (3 times/day), and they earn their living as farmers or merchants.

As no similar study has been previously conducted in the current study area, we used another recent report from a different area of the country to determine the sample size [13]. Re-analysis of the data in the report showed a 56% prevalence of undernutrition in children aged 5—15 years [13]. Assuming random sampling and an approximate normality in the distribution of the proportion of events, and taking the sampling error as 5%, or a 95% confidence interval (CI), the lowest number of students that would be representative of the total number of students in the school was 378. In addition, considering that 10% will be lost at the follow-up of four weeks after treatment, we added 25 more children to bring the total to 403 children who were included in the study.

The study participants were apparently healthy non-febrile children aged 5—15 years who were attending Tikur Wuha Elementary School and who volunteered to participate. Volunteer children who fulfilled the aforementioned inclusion criteria were randomly selected from all grades (1—8) in the school. On the other hand, children older than 15 years and with a recent history of other chronic infections were excluded from the study. Children who did not show up four weeks after treatment for stool diagnosis and weight measurements were also not included in the analysis.

Nutrition assessment

Anthropometric indices such as height (to the nearest 100 cm) and weight (to the nearest 1 kg) were taken from every study participant. Weight was determined using a portable digital balance, and height was assessed with a wooden board fixed with a plastic tape. Children were measured barefoot and in light clothing. The *z*-values for weight-for-age (children aged between 5 and 10 years only) (WAZ), body mass index-for-age (BAZ) and height-for-age (HAZ) were calculated according to the WHO guidelines [14]. Based on the *z*-values, the children were grouped as underweight (BAZ < −2 and/or WAZ < −2) and stunted (HAZ < −2) [15]. Children with *z*-values > −2 for BAZ, WAZ and HAZ were included in the well-nourished group.

In addition to assessing the nature of the association between intestinal helminth infections and undernutrition, the current study also aimed to evaluate whether deworming reduced worm burden and was associated with changes in the nutritional status of the children. Considering that re-infection may underestimate the efficacy of the treatment, the helminth infection status was re-checked four weeks after treatment. Thus, weight measurements used for evaluating changes in nutritional status were also simultaneously performed in children, who were treated for intestinal helminths, four weeks after treatment.

Microscopic examination of intestinal helminths

Volunteer students were given plastic sheets and applicator sticks to collect the stool samples (approximately 5 gram). Stool specimens from each participant were processed using both Kato-Katz and concentration techniques [16]. Two Kato-Katz slides were prepared and examined for each participant immediately after collection of the stool samples. The number of eggs was simultaneously counted in the case of hookworm infection. However, quantitative examination of other helminths from the Kato-Katz slides and the concentration processing and examination was made at the Aklilu Lemma Institute of Pathobiology, Addis Ababa University (ALIPB). Individuals who were positive for *T. trichiura*, hookworm, *A. lumbricoides* and *Hymenolepsis nana* were treated with 400 mg albendazole, and students infected with *Taenia saginata* and *S. mansoni* were treated with praziquantel (40 mg/body weight), under supervision.

Ethical clearance

The study obtained ethical clearance from the Institutional Review Board (IRB) of ALIPB. Permission to conduct the study was also obtained from the school directors. Only those students who assented verbally to participate after providing informed consent were involved in the study.

Statistical analysis

The data were computerized using Excel 2007 and analyzed using STATA version 11 (Stata Corporation, College Station, Texas, USA). Pearson's chi-square test was used to test for differences in the prevalence of stunting, underweight or undernutrition across different categories. McNemar's chi-square test was used to test the differences in the prevalence of underweight in children infected with intestinal helminths, before and after treatment. Differences in the means of anthropometric indices and helminth egg intensities across different categories were evaluated using *t*-tests and ANOVA tests. Multivariate logistic regression analysis was used to test for an association between intestinal helminth infection and stunting or underweight. Multiple linear regression analysis was used to estimate differences in the means of anthropometric indices resulting from helminth infections, age, sex and treatment. The results were considered significant when the *p*-value was less than 5%.

Results

Characteristics of the study population

A total of 403 children (mean age ± standard deviation (SD) = 11.4 ± 2.4; age range = 5—15 years, females = 53.6%, males = 46.4%) provided stool samples, of which 58.3% were infected with intestinal helminths. The prevalences of infection with hookworm, *S. mansoni*, *A. lumbricoides* and *T. trichiura* were 46.9%, 24.6%, 4.2% and 1.7%, respectively. Infection with *T. trichiura* alone was not observed in any of the children. The mean numbers of eggs per gram of *A. lumbricoides*, *T. trichiura*, hookworm and *S. mansoni* infections were 1205.6, 634.3, 191.5 and 72.5, respectively. The prevalence and intensity of helminth infections were comparable between males and females, or between children of age 5—10 years and 11—15 years. Out of 403 children, 29.3%, 28.3% and 46.7% were stunted, underweight and undernourished, respectively. Underweight was more prevalent in males (35.3%) than in females (22.2%) ($p < 0.01$). The prevalence of underweight was higher in children aged 5—10 years (34.5%) than in children aged 11—15 years (24.5%) ($p = 0.026$). However, the prevalence of stunting was comparable between males (33.2%) and females (25.9%) and between children in the age range of 5—10 years (24.0%) and in the age range of 11—15 years (32.3%).

Intestinal helminth infection and nutritional status

The nutritional status of individuals with different intestinal helminth infections is presented in Table 1. The lowest and highest mean scores for BAZ were recorded in children infected with hookworm (mean BAZ = −1.59) and in children who were not infected with any intestinal helminths (mean BAZ = −1.01), respectively ($p < 0.05$). However, differences in the mean HAZ and WAZ scores were not significant in children with different helminth infection status. The prevalence of undernutrition was higher in children infected with hookworm (56.1%) than in children without helminth infection (41.7%) ($Z = 2.43$, 95% CI = 0.03—0.26). Similarly, the prevalence of underweight was significantly higher in children infected with hookworm (38.2%) than in children without a helminth infection (23.2%) ($Z = 2.78$, 95% CI = 0.04—0.25). However, the prevalence of stunting was comparable among children infected with different species of helminths and those who were not infected with any intestinal helminth species.

The relationships between intestinal helminth infections and nutritional status are presented in Table 2. After adjusting for the effects of age and sex in the multiple linear regression model, the differences in the mean BAZ values were significant when comparing children infected with intestinal helminths (lower) and those without intestinal helminths ($\beta = -1.35$, 95% CI = −1.52, −1.19). Children infected with hookworm alone also showed significantly lower mean BAZ values compared with children without intestinal helminths ($\beta = -1.59$, 95% CI = −1.73, −1.26). Similarly, the probability of being underweight was higher among children infected with intestinal helminths of any species (adjusted OR = 1.61, 95% CI = 1.02, 2.53) or hookworm alone (adjusted OR = 2.17, 95% CI = 1.28, 3.66) than children without intestinal helminth

Table 1 Nutritional status of school children in Tikur Wuha School and status of helminth infection, Jiga, northwestern Ethiopia, 2011.

Helminth species	Number positive	Mean of z-values [95% CI]			Prevalence n (%)		
		HAZ	BAZ	WAZ[b]	Stunting (HAZ < −2)	Underweight (BAZ < −2 or WAZ < −2)	Undernutrition (BAZ < −2 or WAZ < −2 or HAZ < −2)
Helminth negative	168	−1.46 (−1.61, −1.31)	−1.01 (−1.25, −0.78)	−1.72 (−2.07, −1.36)	50 (29.7)	39 (23.2)	70 (41.7)
Only *A. lumbricoides*	4	−1.55 (−2.40, −0.69)	−1.05 (−2.32, 0.27)	—	0	1 (25.0)	1 (25.0)
Only hookworm	123	−1.26 (−1.47, −1.04)	−1.59 (−1.73, −1.26)[a]	−1.25 (−1.59, −0.92)	38 (30.9)	47 (38.2)[a]	69 (56.1)[a]
Only *S. mansoni*	33	−1.81 (−2.19, −1.43)	−0.94 (−1.35, −0.53)	−0.58 (−1.85, 0.69)	15 (45.5)	7 (21.2)	16 (48.5)
One species	160	−1.38 (−1.56, −1.19)	−1.37 (−1.57, −1.17)[a]	−1.18 (−1.49, −0.87)	53 (33.1)	55 (34.4)[a]	86 (53.8)[a]
Two species	66	−1.35 (−1.64, −1.07)	−1.36 (−1.70, −1.02)	−1.37 (−1.71, −1.03)	12 (18.2)	18 (27.3)	27 (40.9)
Three species	9	−1.21 (−2.24, −0.17)	−1.15 (−1.69, −0.62)	−1.77 (−2.14, −1.41)	3 (33.3)	2 (22.2)	5 (55.6)
Any helminth	235	−1.36 (−1.51, −1.21)	−1.35 (−1.52, −1.19)[a]	−1.29 (−1.51, −1.08)	68 (28.9)	75 (31.9)	118 (50.2)

[a] Values for difference in mean z for anthropometric indices or prevalence were significant when compared with children without intestinal helminth infection.
[b] Values are calculated for children aged 5—10 years.

Table 2 Association of helminth infection and different anthropometric indicators among school children in Tikur Wuha Elementary School in Jiga, northwestern Ethiopia, 2011.

Helminth species	Adjusted[b] β = [95% CI]			Adjusted[b] OR [95% CI]	
	HAZ	BAZ	WAZ[a]	Stunting (HAZ < −2)	Underweight (BAZ < −2 or WAZ < −2)
Helminth negative	Reference	Reference	Reference	Reference	Reference
Only *A. lumbricoides*	−0.15 (−1.14, 0.83)	−0.16 (−1.72, 1.41)	—	—	1.89 (0.18, 19.56)
Only hookworm	0.22 (−0.02, 0.47)	−0.47 (−0.81, −0.13)	0.44 (−0.08, 0.95)	1.03 (0.61, 1.72)	2.17 (1.28, 3.66)
Only *S. mansoni*	−0.28 (−0.66, 0.11)	0.12 (−0.46, 0.71)	1.28 (−0.09, 2.65)	1.73 (0.78, 3.84)	1.08 (0.41, 2.85)
One species	0.13 (−0.10, 0.36)	−0.33 (−0.64, −0.01)	0.53 (0.04, 1.03)	1.09 (0.67, 1.76)	1.86 (1.12, 3.08)
Two species	0.15 (−0.15, 0.44)	−0.34 (−0.78, 0.09)	0.40 (−0.21, 1.01)	0.49 (0.24, 1.02)	1.27 (0.65, 2.46)
Three species	0.29 (−0.39, 0.99)	−0.03 (−1.08, 1.02)	−0.12 (−1.22, 0.99)	1.09 (0.26, 4.62)	0.61 (0.12, 3.23)
Any helminth	0.14 (−0.08, 0.35)	−0.32 (−0.59, −0.04)	0.44 (0.04, 0.84)	0.90 (0.58, 1.40)	1.61 (1.02, 2.53)

[a] WAZ (weight for age *z*-value) calculated for individuals aged 5–10 years.
[b] Adjusted (from multivariate linear and logistic regression analysis): adjusted for effects of age and sex.

infection. However, the differences in the means of HAZ and WAZ between children infected with different intestinal helminth species and children without intestinal helminth infections were not significant. Similarly, the probability of being stunted was comparable among children infected with different intestinal helminth species when compared with children without intestinal helminth infections. In the multivariate model adjusted for the effects of helminth infection and age or sex, being underweight was higher among males (AOR = 1.93, 95% CI = 1.23, 2.99) and among children in the age group 5—10 years (AOR = 1.76, 95% CI = 1.12, 2.76) than females and children in the age group 11—15 years. Similarly, the probability of being underweight significantly decreased with an increase in the age of the children (adjusted OR = 0.89, 95% CI = 0.81, 0.98). However, differences in the mean intensities of hookworm, *S. mansoni* and *A. lumbricoides* infections were not significant between children who were underweight and those who were normal in the multivariate regression model. The BAZ and WAZ scores were also less correlated to the egg counts of hookworm, *S. mansoni* and *A. lumbricoides*.

Of the 235 children who were infected with intestinal helminths and treated with anti-helminthics, 203 (86.4%) were cured. The remaining 32 children who remained positive after treatment showed a significant reduction in the mean egg counts. The mean values for weight, BAZ and WAZ for intestinal helminth-infected children before treatment showed significant changes four weeks post-treatment using a single dose of albendazole (400 mg) and/or praziquantel (40 mg/kg body weight) (Table 3). These changes showed significant associations with age and sex in female children of the age group 5—10 years. The mean weight of helminth-infected individuals significantly increased from 29.98 to 30.16 four weeks after treatment ($t = -2.09$, $p = 0.047$). The mean values of WAZ and BAZ for children infected with intestinal helminths before treatment significantly increased from −1.32 to −1.19 ($t = -2.78$, $p = 0.006$) and −1.37 to −1.29 ($t = -2.35$, $p = 0.019$), respectively, four weeks post-treatment. The prevalence of underweight in children infected with intestinal helminths also significantly decreased after treatment ($\chi^2 = 4.84$, $p = 0.027$).

In the multivariate linear regression model adjusted for sex and status of helminth infection (intensity and number of species) before treatment, the mean increase in BAZ after treatment was significantly negatively associated with an increase in the age of the children ($\beta = -0.04$, 95%

Table 3 Nutritional status of school children in Tikur Wuha Elementary School in Jiga four weeks after receiving a single dose of antihelminthic treatment, northwestern Ethiopia, 2011.

	Number examined	Before treatment	After treatment	Mean gains/ percent reduced	Paired *t*/McNemar's χ^2 (*p*-value)
Mean weight ± SD	235	29.98 ± 7.99	30.16 ± 7.89	0.18	−2.09 (0.047)
Age (years)					
5–10	80	22.81 ± 3.89	23.20 ± 3.92	0.39	−2.57 (0.012)
11–15	155	33.71 ± 6.96	33.78 ± 6.96	0.07	−0.63 (0.529)
Sex					
Female	120	30.04 ± 8.16	30.29 ± 7.96	0.25	−2.04 (0.043)
Male	115	29.92 ± 7.84	30.04 ± 7.86	0.12	−0.84 (0.400)
Mean BAZ ± SD	235	−1.37 ± 1.29	−1.29 ± 1.33	0.08	−2.35 (0.019)
Age (years)					
5–10	80	−1.08 ± 1.22	−0.91 ± 1.23	0.17	−2.57 (0.012)
11–15	155	−1.52 ± 1.31	−1.49 ± 1.34	0.03	−0.75 (0.453)
Sex					
Female	120	−1.18 ± 1.10	−1.07 ± 1.08	0.11	−2.68 (0.008)
Male	115	−1.57 ± 1.44	−1.53 ± 1.51	0.04	−0.83 (0.410)
Mean WAZ ± SD	235	−1.32 ± 0.99	−1.19 ± 1.00	0.13	−2.78 (0.006)
Sex					
Female	80	−1.45 ± 0.90	−1.29 ± 0.85	0.16	−3.02 (0.004)
Male	155	−1.14 ± 1.10	−1.06 ± 1.18	0.08	−0.97 (0.340)
Prevalence of underweight	235	77 (32.5)	66 (27.8)	4.7	4.84 (0.027)
Age (years)					
5–10	80	28 (34.5)	20 (24.7)	9.8	8.00 (0.004)
11–15	155	49 (31.4)	46 (29.5)	1.9	0.53 (0.467)
Sex					
Female	120	28 (23.1)	21 (17.4)	5.7	3.77 (0.052)
Male	115	49 (42.2)	45 (38.8)	3.4	1.33 (0.248)

CI = −0.07, −0.01). The mean changes in weight after treatment were also marginally significantly decreased with an increase in the age of the children (β = −0.07, 95% CI = 0.15, 0.00) in the multivariate linear regression model adjusted for sex and status of helminth infection (intensity and number of species) before treatment. However, sex, intensity and multiplicity of helminth infection were not significantly associated with mean changes in weight and BAZ after treatment in the multivariate regression model.

Discussion

The present study showed a significant association of intestinal helminth infection with undernutrition. Helminth-infected children were particularly more susceptible to low body mass. This is consistent with similar previous studies [6,7,9], which reported a high prevalence of undernutrition among helminth-infected children. Helminths can cause anorexia, vomiting, diarrhea and luminal obstruction, thereby causing reduced food intake and nutrient absorption from ingested foods [17]. Helminths can also compete for nutrients with the host or lead to loss of the nutrients (e.g., iron) in the host's blood [4].

The association of helminth and underweight was strong in the case of hookworm infection. A strong reduction in the means of the *z*-scores for body mass index-for-age and weight-for-age was observed in children infected with hookworm. Foo [18] also observed significant deficits in the weight and height of children infected with hookworm. This could be mainly due to the biology of the parasite. Hookworms cause heavy blood loss (up to 0.26 ml of blood daily) [2,19], leading to iron-deficiency anemia. Hookworm infection can also impair fat digestion and cell-mediated immunity and cause anorexia and diarrhea, among others [4,20]. *A. lumbricoides* and *S. mansoni* infections also tended to be associated with low body mass. However, this association was not statistically significant. In contrast, others have reported a significant association of underweight with *A. lumbricoides* [7,9] and *S. mansoni* infections [21,22]. The relatively small number of children infected with *A. lumbricoides* alone and *S. mansoni* alone and the high prevalence of light intensity of these infections might explain the absence of a significant association in the present study.

In the current study, underweight showed a significant association with sex and age even after controlling for the effects of helminths, in that males and children aged 5—10 years were more susceptible. An increase in age among children was significantly associated with a reduction in the prevalence of underweight. This is in agreement with previous observations [7,9]. Given a comparable moderately severe helminth infection in children aged 5—10 years and in children aged 11—15 years, the observation of a higher prevalence of undernutrition among the lower aged children appears to support the possibility of an inflammatory response effect of helminths on host nutrition [23]. During their earlier infections with helminths, lower aged children may produce proinflammatory mediators such as IL-1, IL-6, and TNF-α, which can impair nutrient metabolism and appetite [24,25]. Hence, even moderately severe helminth infections may lead to a greater prevalence of underweight in young children [23]. On the other hand, the greater prevalence of underweight among males than females, though both groups showed similar prevalence and intensity of helminth infections, might be related to the genetic character of males or their mobile behavior, which could expose them to a greater energy loss.

In the current study, the prevalence of underweight was comparable among children with different intensities of helminth infection. The mean z-scores of height-for-age, weight-for-age and body mass index-for-age were less correlated with egg counts. The low prevalence of a heavy intensity (only 1 child with *S. mansoni*) infection among the current study participants could have hidden any statistical difference in the mean egg intensity between helminth-infected, malnourished children and helminth-infected, well-nourished children, or a significant correlation between anthropometric indicators and egg counts.

Stunting was the most frequently observed form of undernutrition among the study participants; however, the prevalence was not associated with age, sex or intestinal helminth infection. Children aged 5—10 years and 11—15 years, males and females and infected and uninfected children were all equally vulnerable to stunting. In contrast, previous studies reported high prevalences of stunting in boys and in children infected with helminths [6,7,9]. Stunting is chronic and thus signifies the long-term nutritional status of the host. In contrast, helminth infections in the current study participants might have been acute, affecting their weight more than their height.

Unexpectedly, the prevalence of undernutrition was slightly lower among children infected with two or three intestinal helminth species than in children with only one intestinal helminth species. Other reports have also documented an insignificant difference in the nutritional status between individuals infected with three or one intestinal helminth species [11]. However, another similar study showed exacerbation of malnutrition in individuals co-infected with two different intestinal helminth species, compared to children infected with one intestinal helminth species [11]. In the present study, the intensity of helminth infection was primarily light, except in one child who was heavily infected with *S. mansoni*. In addition, hookworm showed a significant association with undernutrition independently, and most of the infections due to a single helminth species in the current study participants were attributed to hookworm. In contrast, *S. mansoni* and *A. lumbricoides* infections did not show a significant association with undernutrition among the current study participants when considered independently or together.

The present study showed a significant improvement in the weights of helminth-infected schoolchildren after treatment with a single dose of antihelminthics. Helminth-infected schoolchildren at baseline survey gained 0.18 kg in weight, and the means of WAZ and BAZ increased by 0.13 and 0.08, respectively, four weeks after treatment with a single dose of antihelminthic drugs. Although the magnitudes of the changes are inconsistent, similar previous studies documented a significant increase in the weight and the weight-for-age values after antihelminthic treatment [19,26—28].

The variation of the magnitude of the weights reported in previous studies could be attributed to differences in the study design (length of follow up periods, placebo or no treatment as a control group), nature of the study population (children or adults), the types and doses of drugs used for treatment, endemicity of the area or type and intensity of helminth infection. Most previous studies included follow-ups ranging from 6 months to 6 years, thus it is more probable that other related factors might have affected the results [19,27]. Thus, the significant improvement in weight that can be observed immediately after treatment may not be maintained after 6 month [19,27]. In addition, in areas where helminth infections are highly prevalent, individuals might be re-infected after treatment, prior to evaluation of any changes. In addition, in cases of infection with helminths of low intensity and species that have a modest impact on nutritional status, effects during the baseline survey might not be significant, thereby showing negligible changes after treatment. The drug types and doses used for treating helminth infection can also affect the cure rates and egg reduction rates, thereby affecting the magnitude of changes in nutritional status.

In contrast with most similar previous studies [19,26—28], the current study participants did not include a placebo-treated group to compare changes against the drug-treated groups. However, in contrast to previous studies [19,26—28], the duration between the baseline exam and the final exam in the current study was only four weeks. In addition, iron folates or other nutrient supplementary foods were not given to the treated groups during the study periods. Thus, it is likely that the changes could be due to treatment rather than season. On the other hand, comparison of the changes in the placebo group and the drug-treated group might not be conclusive, as the cases in both groups cannot be completely identical in terms of gender, age, genetic factors, healthy status, types, prevalence and intensity of helminths before treatment. Thus, for long-term follow up studies, placebos could be important, but the appropriate selection of control groups and the management of environmental constraints could be factors in making correct inferences about the effect of treatment on the nutritional status.

As the current data are based on a cross-sectional survey, depicting information on the temporal relationship between helminth infection and undernutrition might not be plausible. However, it is likely that the malnutrition observed in the present study might have been due to helminth infection. Significant changes in the nutritional status of infected children without giving any additional supplementary foods, such as iron folates, within four weeks after treatment could be evidence for this. In addition, underweight indicates a short-term nutritional status that can be caused from acute infection or starvation [29]. Acute starvation was not evident in the area, and other acute infections are also not expected, as the children appeared to be healthy at the time of the survey. Although the study population was more homogenous in terms of socioeconomic and other related factors, some minor variations might have existed in relation to educational and economic status, water and sanitation among the community. These factors can be associated with nutritional status and helminth infection [30,31]. However, these factors were not considered when analyzing the data. In addition, the lack of a placebo-treated group for making comparisons with the drug-treated group and the short periods of follow up limited further interpretation of the findings. These factors represent the limitations of the current study.

Conclusions

Helminth-infected male children in the age group of 5—10 years were more vulnerable to malnutrition, which decreased four weeks after treatment. Thus, deworming children living in the area might be important to improve their nutritional status.

Competing interests

The authors declare that they have no competing interests.

Authors' contribution

AD and BE conceived and designed the study; AD collected and analyzed the data and drafted the manuscript; both authors commented on the paper and approved the final manuscript.

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