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Prevalence of soil-transmitted helminth infections and factors associated with anemia, stunting, and underweight among primary school children in Hai District, north-eastern Tanzania

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Abstract

Background: Soil-transmitted helminth infections, undernutrition, and anemia are common and serious public health problems among school-age children in low- and middle-income countries, especially in sub-Saharan Africa. However, there is limited information on the prevalence and factors associated with STHs and their morbidities among primary school children in Tanzania. The study was carried out to determine the prevalence and factors associated with STHs and their morbidities among primary school children in Hai District, Tanzania.

Methods: Cross-sectional analytical design was used to collect data from 339 children aged 7-14 years using a structured questionnaire, portable stadiometer for anthropometric measurements HemoCue photometer to determine the concentration of haemoglobin in blood. The stool samples were processed using the formol-ether concentration technique and Kato-Katz techniques. Microscopic examination of stool was carried out to detect helminth ova. Univariate and multivariate logistic regression analysis were employed to assess the association between the outcomes and various socio-demographic and nutritional factors.

Results: Only *Trichuris trichiura* infection was observed with a prevalence of 0.6%. The prevalence of underweight, stunting, and anemia was 9.1%, 19.5%, and 2.4%, respectively. While age, locality (ward), were associated with stunting ($p \leq 0.01$), the STHs were significantly associated with underweight (OR=3.39; p=0.032).

Conclusions: The prevalence of STHs in the study area was less than 2%, the WHO 2030 NTD Roadmap global target for STHs. Morbidities such as anemia, stunting, and underweight were common among primary school children in the study area. Age, locality (ward), and school were associated with stunting, while STHs were significantly associated with underweight. The findings of this study suggest that preventive chemotherapy has been effective in reducing STHs in the area, and call for other interventions to overcome the multifactorial causes and consequences of the observed morbidities among the primary school children.

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Introduction

Soil-Transmitted Helminth (STH) infections are among the most common and widespread parasitic diseases affecting humans, especially in Low- and Middle-Income Countries (LMICs) with poor sanitation and hygiene conditions [1]. STHs are caused by different species of intestinal worms, such as roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*), and hookworms (*Necator americanus and Ancylostoma duodenale*), that are transmitted by eggs or larvae present in human faeces that contaminate the soil [1]. Soil-Transmitted Helminth (STH) infections cause different health problems, including malnutrition, anemia resulting from blood loss, impaired development, and abdominal symptoms. Severe, chronic infections can lead to intestinal obstruction and decreased school performance due to impaired cognitive development [2].

According to the World Health Organization (2021) [1], approximately 1.5 billion people (24% of the world's population) are infected with STHs, with the highest prevalence reported from sub-Saharan Africa, China, South America, and Asia. Among the infected population, over 260 million Preschool-Age Children (PSC), 654 million School-Age Children (SAC), 108 million adolescent girls, and 138.8 million pregnant and lactating women live in areas where these parasites are intensively transmitted and need treatment and preventive interventions [1]. STHs are particularly harmful for children, as they can impair their physical growth, mental development, school performance, and future productivity [3].

The main strategy for controlling STHs is preventive chemotherapy. It involves the large-scale and periodic distribution of anthelmintic drugs (mainly albendazole or mebendazole) to at-risk populations, especially PSC and SAC, to reduce the worm burden and prevent morbidity [4].

However, preventive chemotherapy alone is not sufficient to eliminate STHs as a public health problem. Preventive chemotherapy does not address the underlying causes of transmission and re-infections, such as poor Water, Sanitation, and Hygiene (WASH); inadequate dietary intake and diversity; low health education and awareness; and co-infections with other Neglected Tropical Diseases (NTDs) [4]. Therefore, an integrated approach that combines preventive chemotherapy with other interventions is recommended to achieve sustainable and long-term impact on STHs and their associated outcomes [5]. Such interventions include improving WASH, promoting health education and behaviour change, enhancing food security and dietary diversity, and integrating STHs control with other NTD control programs.

Tanzania is one of the endemic countries for STHs in sub-Saharan Africa, with an estimated national prevalence of 8.4% among PSC and SAC in 2016 [6] despite several rounds of MDA with albendazole. However, there is considerable geographical variation in the prevalence and intensity of STHs across different regions and Districts in Tanzania, depending on local environmental, socio-economic, and epidemiological factors [7]. Most previous studies have focused on SAC enrolled in school-based deworming programs. However, it remains important to study STHs among primary school children because prevalence and intensity can change over time due to various factors such as environmental conditions and hygiene practices. Additionally, it is valuable to explore the interactions and relationships between STHs and other health conditions, shedding light on potential co-infection patterns and co-morbidities. Finally, assessing the efficacy of interventions helps in designing more effective public health strategies. Besides STHs, undernutrition and anemia are also significant public health issues among the primary school children in Tanzania.

Undernutrition refers to a state of inadequate nutrition caused by insufficient intake or utilization of energy or nutrients, which can present as underweight (low weight-for-age), stunting (low height-for-age), or wasting (low weight-for-height) in children. Anemia is a condition where the number or quality of red blood cells or haemoglobin falls below the normal range for age and sex. It can result from various causes, including iron deficiency, inflammation, malaria, or other infections. Both undernutrition and anemia can have serious effects on children's health, growth, development, and survival [8].

According to the Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) 2015-16 [9], the national prevalence of underweight, stunting, and wasting among children under five years old was 8.4%, 13.7%, and 3.6%, respectively [6]. The national prevalence of anemia among children under five years old was 14.8%, with 2.5% having severe anemia (MoHCDGEC, 2019) [6]. However, there is also considerable geographical variation in the prevalence and factors of undernutrition and anemia among children across different regions and Districts in Tanzania, depending on the local environmental, socio-economic, and epidemiological factors [10]. Moreover, there is limited information on the prevalence and factors of undernutrition and anemia among SAC in Tanzania compared to PSC. This is because most of the previous studies have focused on PSC who are enrolled in various nutrition programmes. The SAC are also at high risk of morbidity due to undernutrition and anemia. Furthermore, there is evidence that STHs, undernutrition, and anemia are interrelated and synergistic conditions that can affect each other's occurrence and severity among children [11]. The STHs can cause or worsen undernutrition and anemia by causing malabsorption, intestinal inflammation, blood loss, and reduced appetite [2].

Undernutrition and anemia can increase the susceptibility and intensity of STHs by impairing the immune system and reducing the resistance to worm invasion and multiplication [2]. Therefore, it is essential to understand the prevalence and factors of STHs, undernutrition, and anemia among children, as well as their interactions and impacts on each other. The present study was aimed at determining the prevalence of STHs and factors associated with underweight, stunting, and anemia among primary school children in Hai District, Kilimanjaro, Tanzania. Additionally, they assessed the association between STHs and underweight, and the association between STHs and anemia among the primary school children.

Materials and methods

Study design and setting

A cross-sectional analytical study was conducted in May 2023 to assess the prevalence of STHs, underweight, stunting, and anemia; and the factors associated with these outcomes among primary school children in Hai District, northeastern Tanzania.

The Hai District is one of the seven districts of the Kilimanjaro region of Tanzania, located at 3°24'30.24"S 37°10'7.32". It has 10 wards which cover an area of 1,217 km^2, located at an altitude of 1,388 meters above sea level (Figure 1). According to the 2012 census, the district had a total population of 210,533 people. There are three climatic seasons in the area: long rainy season, short rainy season, and dry season. The main economic activity of people in the study area is agriculture, where agricultural practices vary between its highland and lowland zones, with coffee and bananas dominating the wetter highlands, and maize and beans grown in the drier lowlands.

The study area was selected because the prevailing socio-economic activities are conducive to the transmission of STHs. The projected population from 2012, the total School Aged Children (SAC) for the Hai District Council was 50, 136 and the number of Primary Schools is 132 [12]. According to Mgongo et al., 2017 [13], living in the Hai District was among the factors that were associated with child undernutrition.

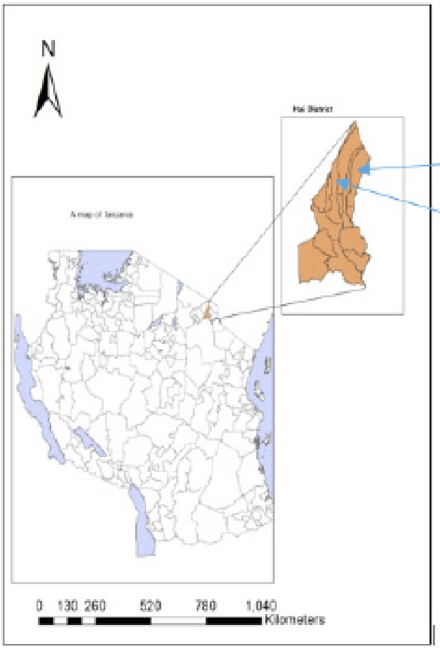

Figure 1: Map of Tanzania showing the location of Hai District, where the study was carried out.

Study population

The study population consisted of primary school children aged 7–14 years from two wards, Machame East and Masama East, and three primary schools.

Inclusion and exclusion criteria

Children were eligible if they were 7–14 years old, had lived in the study area for at least three months, and were present at school on the day of data collection. In addition, informed consent had to be obtained from the parents or guardians.

Children who had received anti-helminthic medication within two weeks prior to the study, and those who were seriously ill and absent from school, were excluded from the study.

Sampling and sample size estimation

Stage one sampling: At the ward level, two wards were randomly selected using simple random sampling through the balloting method, namely, Machame East and Masama East. A list of all primary schools in the selected wards was from the District Education Officer and a total of three primary schools were randomly selected; two from Machame East and one from Masama East.

Stage two sampling: The pupils from each of the three selected schools were stratified by their classes, from Class One to Class Seven. The number of school children selected from each class was determined by the probability proportional to size (PPS method). An attempt was made to sample equal numbers of boys and girls from each class, aiming for a 1:1 ratio where feasible.

Sample size estimation

The Cochran formula below was used to calculate the sample size [14]

$$N = \frac{Z^2\ P\ (1 - P)}{\varepsilon^2}$$

Whereby N = Sample size

Z^2 = confidence interval (95%=1.96)

P = prevalence of Northern-Western Tanzania is 29% (Eltantawy *et al.*, 2021) [15]

ε^2= marginal error (5%)

$$N = \frac{(1.96)^2 \times 0.29(1 - 0.29)}{(0.05)^2} = 316$$

The calculated sample size was 316.

After adjusting for 10% non-response, the final sample size was 348.

At each school, eligible pupils who were present on the data collection day were recruited until the allocated sample size was reached. Ultimately, 110 pupils were selected from Makeresho Primary School, 122 pupils from Seleufundi Primary School, and 107 pupils from Ngira Primary School.

Dependent and independent variables

In this study, dependent variables were Soil-Transmitted Helminth (STH) infections, anemia, underweight, and stunting, while independent variables were age in years, sex, parents' occupation, residence, meal consumption frequency, and types of food consumed.

Data collection tools

Different tools were used for data collection, including a structured questionnaire, stadiometer, calibrated digital weighing machine, and the HemoCue® analyzer. The information contained in the questionnaire includes socio-demographic characteristics of the pupils, food consumption at home and school, the number of meals one consumes at home per day, and the type of meal one consumes either at home or at school.

Data collection methods

A structured questionnaire with closed-ended questions was administered by trained interviewers to collect information on each pupil in the Swahili (national) language, and their responses were recorded by ticking the appropriate boxes provided. The English language version of the questionnaire has been attached as an additional file (Additional file 1). The pupils were also asked about gastrointestinal symptoms in the past three months, including diarrhea (with or without abdominal pain) and dysentery.

Stool sample collection, processing, and microscopic examination

Objectives of the study were explained to the school teachers and pupils, a day before the collection of stool samples. The next day, pupils whose parents/guardians signed informed consent forms and who provided assent to participate in the study were provided with stool containers for stool sample collection. They were also provided with clean wooden applicator sticks. The containers were labeled, clean, and leak-proof. Each pupil was requested to bring his /her sizeable stool sample (one sample). The stool samples were stored in a plastic bag in a cool box and transported to the medical laboratory, where the samples were preserved/frozen at -80°C until the day of processing.

Each stool sample was processed using the formal-ether concentration technique followed by microscopic examination. However, a duplicate of the smears was prepared for quality control. If a sample tested positive, it was further processed using the Kato-Katz technique, and a thick smear was prepared from a stool sample that tested positive following standard protocol, using a 41.7 mg template.

The eggs of each parasite on the slides were counted, and the number was multiplied by 24 to estimate the infection intensity. The procedure for sample collection, processing and microscopic examination was carried out by an experienced laboratory technologist to detect ova of the STHs according to WHO guidelines [16,17]. The intensity level of STHs was determined according to WHO intensity classes (light, moderate, and heavy intensity) [18,19].

Anthropometric measurements.

The heights of participants were measured once using a calibrated portable stadiometer, and their weight was measured using a SECA digital scale (SECA GmbH & Co. KG, Hamburg, Germany. The participants were asked to remove shoes and heavy headwear before standing on the base plate. Then, they were asked to stand up straight with heels together, back against the vertical rod, and line of sight straight ahead. Before taking the reading, the headpiece was lowered until it rested firmly on top of the head. The height was read where the sliding headpiece intersected with the measuring rod. The weight of each participant was taken during the morning hours. The calibrated digital scale was placed on the floor, and turned on. One it read "0.0", the participants, one by one were asked to gently step on the center of the digital scale. The weight was read when the display stabilized. The anthropometric measurements were taken by two trained research assistants. The resulting height and weight measurements were compared to a class population of the same age group to calculate height-for-age z scores and BMI-for-age z scores.

These anthropometric indices were calculated using the new World Health Organization Child Growth Standards [18,20]. The World Health Organization (WHO) Child Growth Standards define underweight in children as a low weight-for-age that falls below -2 Standard Deviations (SD) of the WHO *Child growth standards* median [19,21]. Any child with Height-for-Age Z scores (HAZ) and BMI-for-age z scores (BMIAZ) below or equal to -2 standard deviation (-2SD) was classified as stunted and wasted, respectively. Children with HAZ and BMIAZ below or equal to -3 Standard Deviation (-3 SD) were classified as severely stunted and severely wasted, respectively [22].

Determination of hemoglobin levels.

Blood samples were collected by the finger-prick method using disposable lancets, and a sample of blood (about 100 µl) was collected and used to measure capillary Hemoglobin (Hb) in a calibrated HemoCue photometer (HemoCue AB, Angelholm, Sweden). However, the first and second drops wiped awa to avoid contamination with tissue fluid, so the third drop was used. Two Eurotrol HemoTrol® liquid controls were used to provide measures of normal (level 2) and low (level 1), hematological parameters using the HemoCue® Hb system. The HemoCue® Hb photometer was factory calibrated, and the Quality Control checks was done every week of testing. The liquid controls were also tested every week of testing.

For quality assurance, duplicate readings were obtained per sample. Blood collection and measurement of hemoglobin levels were done by trained and experienced laboratory technicians. Anemia was defined as Hb levels <11 g/dL, while Hb levels of <7 g/dL, 7.0-9.9 g/dL, and 10.0-10.9 g/dL were classified as severe anemia, moderate anemia, and mild anemia, respectively [23].

Data management and analysis

The questionnaires were checked daily in the field for missing questionnaires. Double entry of data was done, followed by an accuracy check to minimize errors.

The data were entered into an Excel spreadsheet, cleaned, and exported to SPSS version 20 (IBM Corp., Armonk, NY, USA) for analysis. Continuous and categorical data were summarized using descriptive statistics, reported as mean and class deviation for continuous variables; frequencies and proportions for categorical variables. Logistic regression analysis was employed to assess the association between the independent variables and the dependent variables. Variables showing a potential association with dependent variables ($p<0.05$) were included in a multivariate logistic regression model, where all significant variables were included. The association was expressed through Crude Odds Ratio (COR) and Adjusted Odds Ratio (AOR) after controlling for confounders. A p-value of less than 0.05 at 95% confidence was considered statistically significant.

Results

Response rate

In this cross-sectional study, the sample size was 348 pupils including a 10% of the non-response. Out of these, 339 participants completed the survey by responding to the questionnaire, providing anthropometric data, giving a stool sample, and a blood sample, resulting in a response rate of 97.4%.

Socio-demographic characteristics of the participants

Socio-demographic characteristics of the participants are summarized in Table 1. Children were aged between 7 and 14 years, with a mean age of 10.29 (±2). The sample was almost equally distributed by sex, with 50.1% males and 49.9% females. The majority of the children (68.4%) came from Masama East ward, while the rest (31.6%) came from Machame East ward.

The proportions of children from each of the three schools were almost equal.The sample was also divided by class level, with 45.7% of children up to class 4 and 54.3% of children from class 5 to 7. Most of the fathers (78.2%) and mothers (64%) were employed.

More than half of the children (54.9%) reported taking at least three meals per day, which was considered class, while the others (45.1%) had irregular or uncertain meal patterns. Less than half of Children (44.8%) knew a balanced diet, while the majority (55.2%) did not.

Table 1: Socio-demographic characteristics of the primary school children (N=339).

Variable	n	%
Age		
Mean (SD)	10.29 (±2)	
7-10	178	52.5
11-14	161	47.5
Sex		
Male	170	50.1
Female	169	49.9
Ward		
Masama East	232	68.4
Machame East	107	31.6
Name of school		
Makeresho Primary School	110	32.4
Seleufundi Primary school	122	36
Ngira Primay School	107	31.6
Child's class		
Up to standard 4	155	45.7
Class 5 to 7	184	54.3
Fathers' occupation		
Unemployed	74	21.8
Employed	265	78.2
Mothers' occupation		
Employed	217	64
Unemployed	122	36
Number of meals taken per day		
Class (at least 3 meals)	186	54.9
Irregular (1, 2, or uncertain)	153	45.1
Knowledge on a balanced diet		
No	187	55.2
Yes	152	44.8

Prevalence and intensity of STHs among primary school children in Hai District

Out of the 339 children who were examined for STHs, only 4 children (0.6%) were found to be positive for *Trichuris trichiura* infections. Out of these, 3 children were females (75%), while 1 child was male (25%). Three children out of 4 were aged 7-10 years (75%), while 1 child (25%) was aged 7-14 years. Of the infected children, 3 children were from Machame East ward (75%), attending Seleufundi Primary School, and 1 child (25%) was from Masama East ward, attending Ngira Primary School. Nobody from Makeresho Primary School was infected with STHs. Of the 4 children who were infected with *Trichuris trichura*, 2 of them (50%) had light intensity, and the remaining 2 children (50%) had high intensity.

Prevalence and factors associated with underweight among primary school Hai District

The prevalence of underweight among the children was 9.1% children. Table 2 summarizes the factors that were associated with underweight among the children. Children who attended Seleufundi or Ngira Primary Schools had lower odds of being underweight than those who attended Makeresho Primary School (OR=0.26 and 0.36, respectively; p=0.01). Children who had irregular or uncertain meal patterns had higher odds of being underweight compared to the children who had at least three meals per day (OR=1.54; p=0.17).

Children who were infected with STHShad higher odds of being underweight than those who were not infected (OR=3.39; p=0.32), although this was based on a very small sample size (n=4).

Prevalence and factors associated with stunting among primary school children in Hai District

The prevalence of stunting among the children was 19.5% children. Table 3 summarizes the factors associated with stunting among the children. Children who were aged 11-14 years had higher odds of being stunted than those who were aged 7-10 years (OR=2.9; p<0.001). Children who came from Masama East ward had higher odds of being stunted than those who came from Machame East ward (OR=3; p=0.01). Children who attended Makeresho Primary school had higher odds of being stunted than those who attended Ngira Primary school (OR=3; p=0.01). Children who attended Seleufundi Primary school also had higher odds of being stunted than those who attended Ngira Primary school, but this was only significant in the crude model (OR=2.4; p=0.024) and not in the adjusted model (OR=2.1; p=0.07). None of the other factors, such as sex, child's class, parents' occupation, number of meals taken per day, knowledge of a balanced diet, and presence of Soil-Transmitted Helminth (STH) infections, were significantly associated with stunting.

Table 2: Factors associated with underweight among primary school children in Hai District (N=339).

Characteristic	N	Underweight, n (%)	Crude OR (95% CI)	p-value
Age				
Mean(SD)	10.29 (±2)			
7-10	178	14(7.9)	1	
11-14	161	17(10.6)	1.38 (0.66 - 2.91)	0.25
Sex				
Male	170	15 (8.8)	1	
Female	169	16 (9.5)	1.08 (0.52 - 2.26)	0.49
Ward				
Masama East	232	24 (10.3)	1	
Machame East	107	7 (6.5)	0.61 (0.25 - 1.45)	0.18

Name of school				
Makeresho Primary School	110	18 (16.4)	1	
Seleufundi Primary School SSSchoolPrimary school	122	6 (4.9)	0.26 (0.10 - 0.69)	
Ngira Primay School	107	7 (6.5)	0.36 (0.14 - 0.89)	0.01
Child's class				
Up to standard 4	155	12 (7.7)	1	
Class 5 to 7	184	19 (10.3)	1.37 (0.64 - 2.92)	0.26
Fathers occupation				
Employed	265	22 (8.3)	1	
Unemployed	74	9 (12.2)	1.52 (0.67 - 3.48)	0.21
Mothers occupation				
Employed	217	23 (10.6)	1	
Unemployed	122	8 (6.6)	0.59 (0.26 - 1.38)	0.15
Number of meals taken per day				
Standard (at least 3 meals)	186	14 (7.5)	1	
Irregular (1, 3, or uncertain)	153	17 (11.1)	1.54 (0.73 - 3.23)	0.17
Knowledge on balanced diet				
No	187	18 (9.6)	1	
Yes	152	13 (8.6)	0.88 (0.42 - 1.86)	0.44
Presence of STH				
No	335	30 (9)	1	
Yes	4	1 (25)	3.39 (0.34 - 33.6)	0.32

OR: Odds ratio; CI: Confidence interval; SD: Standard deviation.

Table 3: Factors associated with underweight among primary school children in Hai District (N=339).

Characteristic	N	Stunted, n (%)	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age						
Mean(SD)	10.29 (±2)					
7-10	178	21 (11.8)	1		1	
11-14	161	45 (28.0)	2.9 (1.6 - 5.1)	< 0.001	2.9 (1.6 -5.2)	0
Sex						
Male	170	39 (22.9)	1.5 (0.9-2.7)	0.107		
Female	169	27 (16)	1			
Ward						
Masama East	232	55 (23.7)	2.7 (1.3-5.4)	0.005	3 (1.4 - 6.3)	0.01
Machame East	107	11 (10.3)	1			
Name of school						
Makeresho Primary School	110	31 (25.4)	2.9 (14 -6.3)	0.004	3 (1.4 -6.3)	0.01
Seleufundi Primary School	122	24 (21.8)	2.4 (1.37-5.26)	0.024	2.1 (0.9-4.6)	0.07
Ngira Primary School	107	11 (10.3)	1		1	
Child's class						
Up to standard 4	155	23 (14.8)	1			
Class 5 to 7	184	43 (23.4)	1.75 (1.01-3.1)	0.844		
Fathers occupation						
Employed	265	51 (19.2)	1			
Unemployed	74	15 (20.3)	1.07 (0.6 - 2.0)	0.48		
Mothers occupation						
Employed	217	46 (21.2)	1			
Unemployed	122	20 (16.4)	0.73 (0.4 - 1.3)	0.18		
Number of meals taken per day						
Standard (at least 3 meals)	186	35 (18.8)	1			
Irregular (1, 3, or uncertain)	153	31 (20.3)	1.1 (0.64 - 1.9)	0.42		

Knowledge on balanced diet						
No	187	33 (17.6)	1			
Yes	152	33 (21.7)	1.29 (0.8 - 2.2)	0.21		
Presence of STH						
No	335	65 (19.4)	1			
Yes	4	1 (25)	1.39 (0.1-13.5)	0.58		

OR: Odds ratio; CI: Confidence interval

Table 4: Factors associated with anemia among primary school children in Hai District (N=339).

Characteristic	N	Anemia, n (%)	Crude OR (95% CI)	p-value
Age				
Mean(SD)	10.29 (±2)			
7-10	178	5 (2.8)	1	
11-14	161	3 (1.9)	0.66 (0.15 - 2.79)	0.42
Sex				
Male	170	6 (3.5)	1	0.14
Female	169	2 (1.2)	0.33 (0.07 - 1.65)	
Ward				
Masama East	232	5 (2.2)	1	
Machame East	107	3 (2.8)	1.31(0.31-5.58)	0.715
Name of school				
Makeresho Primary School Sschool	110	1 (0.9)	1	
Seleufundi Primary School	122	4 (3.3)	3.7 (0.41 - 33.57)	0.25
Ngira Primay School	107	3 (2.8)	3.1 (0.32 - 30.71)	0.33
Child's class				
Up to class 4	155	6 (2.3)	1	
Class 5 to 7	184	2 (2.7)	1.19(0.23-6.07)	0.826
Fathers occupation				
Employed	265	6 (2.3)	1	
Unemployed	74	2 (2.7)	1.2(0.24-6.07)	0.55
Mothers occupation				
Employed	217	6 (2.8)	1	
Unemployed	122	2 (1.6)	0.58(0.11-2.95)	0.52
Number of meals taken per day				
Standard (at least 3 meals)	186	2 (1.1)	1	
Irregular (1, 3, or uncertain)	153	6 (3.9)	3.76(0.78 - 18.88)	0.09
Knowledge on balanced diet				
No	187	5 (2.7)	1	
Yes	152	3 (2.0)	0.73(0.17 - 3.12)	0.48
Presence of STH				
NoOR: Odds ratio; CI: Confidence interval.	335	7(2.1)	1	
Yes	4	1(25)	15.62	0.09

Prevalence and factors associated with anemia among primary school children in Hai District

The prevalence of anemia among the children was 2.4%. Table 4 summarizes factors associated with anemia among the children. Children who had irregular or uncertain meal patterns had higher odds of being anemic than those who had at least three meals per day (OR=3.76; p=0.09). Children who were infected with STHs had higher odds of being anemic than those who were not infected (OR=15.62; p=0.09), however, this was based on a very small sample size (n=4).

Discussion

The present study investigated the burden of Soil-Transmitted Helminth infections (STHs) and factors associated with anemia, stunting, and underweight among primary school children in Hai District, north-eastern Tanzania. Only *Trichuris trichiura* infection was observed with a prevalence of 0.6%. The prevalence of underweight, stunting, and anemia was 9.1%, 19.5%, and 2.4% respectively. While age, locality (ward), and school were associated with stunting, the STHs were significantly associated with underweight.

Annual mass drug administration with albendazole focused on school childrenrepresents the main control approach against STHs in Tanzania as per World Health Organization has developed a plan for eliminating STHS and schistosome infections by 2020 [24], through the Mass Drug Administration (MDA) to at-risk populations mainly school-aged children(5 to 14 years old) [19,25]. Other interventions include improvement of the water supply [26]. These interventions have led to a steady decline in STHs, especially from 2009 to 2012 [26]. For more than a decade, School-based Mass Drug Administration (MDA) has been the main strategy for the prevention and control of Soil Transmitted Helminths (STH) infections in Tanzania. However, some studies, including that of Jones et al. (2025) [27], have reported sustained transmission of STHs after MDA programs and other interventions that have been in place. The present study was carried out to determine the prevalence and factors associated with an increased risk of STHs among SAC and PSC in Hai District in Kilimanjaro Region, north-east Tanzania, after several years of MDA distribution with Albendazole among SAC and PSC, following the national guidelines.

The prevalence of STHs in this study was 0.6%, which is far lower than the national average of 8.4% reported by the Tanzania Ministry of Health, Community Development, Gender, Elderly and Children(MoHCDGEC) in 2016 [28].

This could be attributed to the high coverage of preventive chemotherapy for STHs in Hai District, which reached 95% in 2016, Kilimanjaro Regional Health Management Team (RHMT 2016 [29]. The low prevalence of STHs could also be explained by the high altitude of the Hai District (1400-2000 m above sea level), which is unfavorable for the survival and development of STHSeggs and larvae [30]. It could also be explained by yearly MDA prevention of STHSin PSC [24].

The only type of STHs detected in this study was *Trichuris trichiura*, which had a 50% prevalence of light and high intensity each. No cases of *Ascaris lumbricoides* or hookworm infections were found among Children. This is consistent with previous studies that have reported that *Trichuris trichiura* is more prevalent and persistent than other STHSspecies in high-altitude areas [7].

STHsThe prevalence of underweight in this study was 9.1%, which is similar to the national average of 8.4% reported by the MoHCDGEC in 2016 (MoHCDGEC, 2016) [28]. However, it was lower than the regional average of 13.9% reported by the Kilimanjaro RHMT in 2016 [29], and surprisingly, living in the Hai District was found to be among the factors for underweight under five children [13]. The findings of the present study are based on school children aged 7 to 14 years of age, unlike previous studies [13,28,29] where the participants were under five children. However, children who attended Seleufundi or Ngira Primary Schools had lower odds of being underweight than those who attended Makeresho Primary School, probably due to differences in school feeding programmes among the schools. The results show that none of the factors were significantly associated with underweight. However, some factors showed a trend towards significance, such as the name of the school, the number of meals taken per day, and the presence of STHs.

Children who attended Seleufundi or Ngira Primary Schools had lower odds of being underweight than those who attended Makeresho Primary School. Children who had irregular or uncertain meal patterns had higher odds of being underweight than those who had at least three meals per day. This is in line with previous studies that have shown that inadequate dietary intake is a major risk factor for undernutrition among school-age children [10].

Children who were infected with STHS had higher odds of being underweight than those who were not infected. This is consistent with previous studies that have demonstrated that STHs can cause malabsorption, intestinal inflammation, blood loss, and reduced appetite, leading to undernutrition [8]. The prevalence of stunting in this study was 19.5%, which is higher than the national average of 13.7% reported by the MoHCDGEC in 2016 (MoHCDGEC, 2016) [28]. It was also higher than the regional average of 16.3% reported by the Kilimanjaro RHMT in 2016 [29]. This could be due to the chronic exposure to environmental and biological factors that impair linear growth among children in Hai District. The results show that age, ward, and name of school were significantly associated with stunting, both in the crude and adjusted models. Children who were aged 11-14 years had higher odds of being stunted than those who were aged 7-10 years. This could be due to the cumulative effect of early childhood undernutrition and infections on growth faltering during adolescence [31]. Children who came from Masama East ward had higher odds of being stunted than those who came from Machame East ward. According to previous studies, substantial regional variation in stunting exist in Tanzania [32,33], which can be explained by the agro-ecological differences of the settings. Agro-climatic variation may affect nutritional status through different pathways including by altering the types and timing of food availability [34], and by influencing access to food and its utilization [35].

Children who attended Makeresho Primary Schoolhad higher odds of being stunted than those who attended Ngira Primary School. This could be explained by the differences in school feeding programmes, hygiene practices, and environmental conditions among the schools.

The prevalence of anemia in this study was 2.4%, which is lower than the national average of 14.8% reported by the MoHCDGEC in 2016 (MoHCDGEC, 2016) [28]. It was also lower than the regional average of 11.9% reported by the Kilimanjaro RHMT in 2016 [29]. This could be attributed to the high coverage of iron supplementation and deworming programmes for school-age children in Hai District, which reached 90% and 95%, respectively, in 2016 [29]. The low prevalence of anemia could also be explained by the low prevalence of malaria and STHs, which are major causes of anemia among children in Tanzania [10]. The results show that none of the factors were significantly associated with anemia. However, some factors showed a trend towards significance, such as the number of meals taken per day and the presence of STHs. Children who had irregular or uncertain meal patterns had higher odds of being anaemic than those who had at least three meals per day. This is in agreement with previous studies that have shown that inadequate dietary intake of iron and other micronutrients is a major risk factor for anemia among school-age children [3]. Children who were infected with STHShad higher odds of being anaemic than those who were not infected. This is consistent with previous studies that have indicated that STHs can cause blood loss, inflammation, and reduced iron absorption, leading to anemia [2].

The findings of the present study show that STHs, underweight, stunting, and anemia are common and serious problems among school-age children in the Hai District, Kilimanjaro, Tanzania. They also show that there are significant or marginal differences in the prevalence and factors of these outcomes among the children, depending on their age, ward, name of school, number of meals taken per day, and presence of STHs.

Therefore, it is important to implement effective interventions to prevent and control these outcomes among children, such as improving WASH facilities; promoting health education and behaviour change; enhancing food security and dietary diversity; and integrating STHs control with other NTDs control.These results are consistent with previous studies that have reported similar or higher prevalence and factors of STHs, underweight, stunting, and anemia among school-age children in Tanzania and other sub-Saharan African countries [36]. Moreover, these results show that there are significant or marginal associations between STHs and underweight or anemia among Children.

The associations indicate that STHs may have a direct or indirect impact on the nutritional status and haemoglobin level of Children. STHs may directly affect the nutritional status and haemoglobin level of Childrenby causing malabsorption, intestinal inflammation, blood loss, and reduced appetite [8]. STHs may also indirectly affect the nutritional status and haemoglobin level of Childrenby influencing their dietary intake, hygiene practices, health-seeking behaviour, and access to health services [10]. Therefore, it is important to assess the magnitude and direction of these effects and their implications for developing and evaluating integrated interventions to prevent and control STHs, underweight, stunting, and anemia among children. Integrated control approaches combining extended preventive chemotherapy, improvement of WASH, public health education, vector control, integration to the peripheral health system, and improved socio-economic living conditions are required to sustain the gains and move forward elimination of the STHs as a public health problem. There is also a need for promoting behavior change, enhancing food security and dietary diversity, and integrating STHs control with other NTDs control.

Limitations of the study

This study has several methodological limitations that warrant consideration. The classification of anaemia was based on the World Health Organization (WHO) 2011 haemoglobin cut-offs, which apply a single threshold of 11.0 g/dL for children in the studied age group. However, the updated WHO 2024 guidelines recommend higher, age- and sex-specific thresholds. The use of the earlier cut-offs may therefore have led to an underestimation of the true prevalence of anaemia in this population.

Hemoglobin concentrations were not initially adjusted for altitude, despite the study being conducted in a highland setting where physiological adaptation to reduced oxygen pressure can elevate haemoglobin levels. The absence of altitude correction may have further contributed to underestimating anaemia prevalence. While these limitations may affect the absolute estimates of anaemia prevalence, they do not change the study's central finding that STHs alone does not fully explain the burden of anaemia in this population. Nonetheless, future studies should incorporate updated haemoglobin thresholds and altitude adjustments from the outset to improve accuracy and comparability.

Furthermore, only one fecal sample was collected instead of three consecutive time samples due to the time constraints. This might have underestimated the actual prevalence of the STHs infections. The study relied on self-reported data in attempting the questionnaire, which may be subject to recall bias and socio-desirability bias. Lastly, following time limitation and and inadeqate resources, the study was carried out in two wards only which may not represent the Hai Distcrict with a total of ten wards.

Conclusions

The findings of the present study show that the prevalence of STHs (*Trichuris trichiura*) in the study area was less than 2%, the WHO 2030 NTD Roadmap global target for STHs. Such low level of transmission has been reported elsewhere in southern Tanzania in Iringa District Council, suggesting that Preventive Chemotherapy interventions have effectively reduced these infections in the target populations. However, underweight, stunting, and anemia are common and remain a serious health problem among school-age children in the study area. Age, locality (ward), and school were associated with stunting, while s *Trichuris trichiura* infections were significantly associated with underweight. The findings of this study call for other interventionsincluding iron supplementation programmes, health and hygiene education, to address the multifactorial causes and consequences of the morbidities among the children. The study also provides evidence-based recommendations for policymakers, practitioners, researchers, and stakeholders involved in STHs control and child health promotion in Tanzania.

Abbreviations: BMI: Body Mass Index; BMIAZ: BMI-for-age Z scores; CI: Confidence Interval; EPG: Eggs per Gram; HAZ: Height-for-age Z scores; MIS: Malaria Indicator Survey; MoHCDGEC: Ministry of Health, Community Development, Gender, Elderly, and Children; NTDs: Neglected Tropical Diseases; OR: Odds Ratio; PSC: Preschool-age Children; RHMT: Regional Health Management Team; SAC: School-Age Children; SD: Standard Deviation; SPSS: Statistical Package for the Social Sciences; STHs: Soil Transmitted Helminth Infections; TDHS: Tanzania Demographic Health Survey; WASH: Water, Sanitation, and Hygiene; WHO: World Health Organization.

Declarations

Ethics approval and consent to participate: The present was conducted in accordance with the Declaration of Helsinki. Ethical approval for the study was obtained from the KCMC University Research Ethics Review Committee (KURERC) (Ethical clearance certificate No. UG 12/2023). Prior to study initiation, Kiswahili translated informed consent was obtained from the parents or guardians (children's primary caregivers) for the children to participate in the study and the children provided their assent to participate in the study. Confidentiality was maintained where participants were assigned unique identification numbers instead of their names. The authors declare that they have no competing interests.

Availability of data and materials: The raw data supporting the conclusions of this article will be made available by the authors on request.

Competing interests: All authors declare that they do not have competing interests.

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Authors' contributions: JM, MK, and TM conceived and designed the study. MK supervised the Data collection.

MK, MM, FF, and VM performed data collection. JM analyzed the data and wrote the first draft. VM and TM provided a critical revision of the manuscript. JM, MK, MM, FF, VM, and TM read and approved the submitted manuscript.

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