ADDIS ABABA UNIVERSITY
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STUDY OF THE ASSOCIATION OF SOIL-TRANSMITTED HELMINTHIASIS WITH MALNUTRITION AND ANEMIA AMONG SCHOOL CHILDREN, DEBUB ACHEFER DISTRICT, NORTHWEST ETHIOPIA

BY
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Study of the Association of Soil-Transmitted Helminthiasis with Malnutrition and Anemia among School Children, Debub Achefer District, Northwest Ethiopia

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List of abbreviations and acronyms

AAU	Addis Ababa University
ACC/SCN	Administrative Committee on Coordination/ Sub-Committee on Nutrition
ANOVA	Analysis of variance
BMI-for-age	Body mass index for age
CDC	Center for disease control
DALYs	Disability Adjusted Life Years
DHS	Demographic and Health Survey
EDHS	Ethiopian demographic and health survey
Epg	Eggs per gram
HAZ	Height for age Z score
Hb	Hemoglobin
IDA	Iron Deficiency Anemia
masl	Meter above sea level
MCV	Mean Cell Volume
NCHS	National Center for Health Statistics
NTDs	Neglected Tropical Diseases
PEM	Protein energy malnutrition
SPSS	Statistical package for social sciences
STH	Soil-transmitted helminths
UNICEF	**U**nited Nations Children’s Fund
WAZ	Weight- for- age Z-score
WHZ	Weight for height Z-score

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Abstract

Soil-transmitted helminth (STH) infections are the major public health problems in many developing countries including Ethiopia. STHs are one of the major factors that cause malnutrition and anemia. This study was aimed to investigate the associations of intestinal STHs with malnutrition and anemia among school children. A cross-sectional study was carried out and 384 schoolchildren were chosen using stratified sampling technique enrolled in the study, Debub Achefer District, Northwest Ethiopia from February to March, 2010. Structured questionnaires were administered to gather relevant information on demographic and socioeconomic data. Stool samples were processed for microscopic examinations using Kato-Katz method. Weight and height were taken using a digital portable weighing calibrated SECA scale with a sliding headpiece. Epi Info version 6 software was employed to evaluate anthropometric parameters. The NCHS growth chart reference was used to estimate the prevalence of underweight/thinness among 9-14 years school children. Hemoglobin was determined using Hemocue HB 201 analyzer. Data were analyzed using SPSS statistical software version 15. Binary logistic regression analysis (OR) was used to determine association of STH with malnutrition and anemia, whereas Pearson chi-square test was applied to compare proportions. The overall point prevalence of STH infection in the study area was 54.9%, single, double, and triple infections being 45.8%, 8.6%, and 0.5%, respectively. The prevalence of hookworm, *Ascaris lumbricoides*, *Trichuris trichiura*, *Enterobius vermicularis*, and *Hymenolepis nana* infections were 46.9%, 13.8%, 2.3%, 1%, and 0.5%, respectively. The prevalence of malnutrition in terms of stunting, underweight and wasting were 12.2%, 30.7% and 17.9%, respectively. The overall prevalence of anemia was 17.2%. The findings showed that there was no statistically significant association between STH infections and malnutrition ($P>0.05$). However, there was significant association between STH infections and anemia ($P<0.05$). The present study showed that STH infections, malnutrition, and anemia were highly prevalent. Hookworm infections were considered as the main causes of anemia among schoolchildren in the study area. Nevertheless, no association was observed between STH infections and malnutrition. Mass drug administration is recommended for STHs together with school feeding programs, health education on proper personal and environmental hygiene practices.

Key words/phrases: Anemia, Debub Achefer District, Ethiopia, Malnutrition, School children, STH

1. Introduction

Helminths are parasitic worms, which infect humans (Maizels and Yazdanbakhsh, 2003), and mainly found in two phyla, Platyhelminths and Nematoda (Hotez *et al*., 2008). Helminth infections affect over one quarter of the world's population (Bethony *et al.*, 2006; Brooker *et al*., 2006), of which 300 million suffer from associated severe morbidity and about 400 millions of which are school-age children (Rodriguez-Morales *et al*., 2005). More than 150 million school-age children are severely affected by intestinal parasitic worms (Jukes *et al.*, 2008).

Soil-transmitted helminths (STHs) refer to a group of round worms that are transmitted through contact with fecally contaminated soil (Hotez *et al*., 2008). These are among the most major health problems in many developing countries, especially among children (Parajuli *et al.*, 2009), (Goodman *et al*., 2007; Mukhopadhyay *et al*., 2008). Moreover, it is estimated that there are about 135, 000 deaths per year directly due to STH infections, but the principal public health significance of these infections lies in their chronic effects (WHO, 2002).

Malnutrition refers to the cellular imbalance between the supply of nutrients and the body's need for them to ensure specific functions of the body for growth, maintenance, and other functions (Fauci and Longo, 2008). Each nutrient deficient disease is characterized by an imbalance at the cellular level. Energy-providing macro-nutrients (protein, fat, and carbohydrate), micro-nutrients (vitamins and minerals), and water are required for good health (Fauci and Longo, 2008). Many children in developing countries suffer from poor nutrition and are the most important risk factor for illness and death (WHO, 2000). It is estimated to account for over half of children's deaths annually in developing countries (Pelletier and Frongillo, 2003). Malnutrition covers a broad spectrum of illness, including undernutrition, specific nutrient deficiencies and over nutrition, (WHO, 2000).Several factors influence the risk of malnutrition. It may result from unbalanced diet, digestive difficulties, absorption problems and other medical conditions (Westergren *et al.*, 2009).

Anemia is defined as a health condition in which the hemoglobin (Hb) content of the blood is lower than the normal cutoff levels established by World Health Organization. Hb is the substance in red blood cells that carries oxygen to the cells of the body system (WHO, 2001; Freire *et al.,* 2003). Anemia is an indicator of both poor nutrition and health problem worldwide, especially in developing (WHO, 2008). Over one third of the women and children in developing countries are affected by anemia (WHO/UNICEF/UNU, 2003). It is common in young children (vulnerable groups) because of exposures to poor nutrition and high prevalence of parasitic infections (ACC/SCN, 2000). It was reported that as many as 80% of the children in developing countries will be anemic at some point by the age of 18 years (Ramzan *et al.,* 2009). Anemia is common among children in Ethiopia; more than half are anemic (EDHS, 2005).

Therefore, STH infections, malnutrition and anemia among schoolchildren are not only health problems, but also pose considerable problem to socio-economic development in developing countries like Ethiopia. Hence, it is necessary to determine the magnitude of STH infections, malnutrition, and anemia among schoolchildren to generate data that would guide control programs.

1.1 Soil-transmitted helminths (STHs)

STHs are among the most common intestinal parasites (Rodriguez-Morales *et al*., 2005; Mehraj *et al.,* 2008). The three major STH infections are roundworms (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), and hookworms (*Ancylostoma duodenale* and *Necator americanus*) (Awasthi *et al*., 2003; Hotez *et al*., 2008; Ibidapo and Okwa, 2008; Zonta *et al*., 2009).

1.1.1 Global prevalence of STH infections

The global prevalence and intensity of STH infections in humans show considerable variations in distribution and in seasonal occurrence due to geographical, climatic factors, or socio-cultural (WHO, 1980; Kunwar *et al.,* 2006). The prevalence of parasitic infections was found to be high in the lower altitudes of the world. These infections are widespread in its distribution in underdeveloped countries. Infection rates tend to be high in regions with high temperature (warm climates) (Stephenson and Holland, 1987). Soil-transmitted helminths (STHs) are widespread in underdeveloped countries.

A study estimated that *Ascaris lumbricoides* infects 1,221 million people, *Trichuris trichiura* 795 million, and hookworms infect 740 million (Brooker *et al*., 2006). Approximately, 85% of the Neglected Tropical Diseases (NTDs) burden results from STH infections (Hotez and Kamath, 2009). Moreover, it has been estimated that STH infections account for 12% of the total disease burden and about 20% of disability adjusted life years (DALYs) lost due to communicable diseases in children, globally (Awasthi *et al*., 2003).

Recently, it has been reported that one third of sub-Saharan Africa's population is affected by one or more STH infections (Hotez and Kamath, 2009), and these infections are considered as first causes of disease burdens among children and estimated to account for 11.3% of the total burden of disease in children aged 5-14 years, making it the most common cause of morbidity in this age group (World Bank, 1993).

1.1.2 STH infections in Ethiopia

Intestinal parasitic infections cause serious public health problem in Ethiopia. In this country, a number of surveys have shown that STHs are prevalent in varying magnitudes (Tedla and Jemaneh, 1985; Erko and Medhin, 2003).Similarly, Belyhun *et al.* (2010) reported that, the prevalence and distribution of helminth infection varies by place and with age in Ethiopia. World Health Organization's also indicated that the prevalence of helminth infections in Ethiopia ranges from 31-57.8% (WHO, 2003 as cited in Borkow and Bentiwich, 2004).

As in other developing countries, high prevalence of STH infection is attributable to factors associated with low socio-economic status. Such factors include poor personal hygiene and environmental sanitation, with low household income, overcrowding and lack of clean water supplies for most parts of the country. For instance, Ethiopia has one of the lowest quality drinking water supply and latrine coverage in the world. As comparison by 2000, Ethiopia had only 12% latrine coverage while Kenya had 87% (Kumie and Ali, 2005 as cited by Mengistu *et al.,* 2007).

1.1.3 STH infections and factors for their transmission

The adult parasite stages inhabit some part of the host intestine (*A. lumbricoides* and hookworm in the small intestine; *T. trichiura* in the colon), reproduce sexually and produce eggs, which are passed in human feces and deposited in the external environment. Adult worms survive for several years and produce large numbers of eggs after 4 – 6 weeks. Eggs can remain viable in the soil for several months (*A. lumbricoides* and *T. trichiura*) and larvae several weeks (hookworms), dependent on prevailing environmental conditions (Brooker *et al.,* 2006).

Infection occurs through accidental ingestion of eggs or penetration of the skin by infective stages of STHs. The transmission of ascariasis and trichuriasis are by the fecal - oral route of infected food or water ingestion. Similarly, enterobiasis, and hymenolepidiasis are also transmitted through ingestion of fecally contaminated food or water with infective stages of egg of the worm. The transmission of hookworm infections and strongyloidiasis involves filariform larval penetration of any parts of the skin exposed to contacts with contaminated soil or water (Asaolu and Ofoezie, 2003). But, the larvae of *Ancylostoma duodenale* is acquired by both skin penetration and ingestion of contaminated water/food, whereas the larvae of *Necator americanus* are acquired exclusively by skin penetration (WHO, 1990).

Soil type favorable for the development of larvae of *Necator americanus* is sandy clay soil, while for the larvae of *Ancylostoma duodenale* is sandy loam soil. Ascaris eggs development requires hard clay soil (Kloos and Tesfayohanis, 1993). In general, most of the parasites having an environmental phase have specific requirements but they have also a high possibility of adapting themselves to different environmental conditions (WHO, 1980).

The poor handling of personal hygiene and environmental sanitation, use of human excreta as fertilizers, lack of shoes, low household income, overcrowding living style, and limited access to clean water are the major causes that favor intestinal worm infections (Bhargava, 2001; MOH, 2004; Wordermann *et al.*, 2006; Mengistu *et al.*, 2007; Ostan *et al*., 2007; Gamboa *et al.*, 2009; Niyyati *et al*., 2009).

1.1.4 Impact of STH infections

The impact of intestinal parasitic infections depends on different factors including type of parasitic species, intensity of infection, nature of interaction between the parasite species and concurrent infections, the nutritional and immunological status of the host, socioeconomic factors (Wordermann *et al.*, 2006; Liabsuetrakul, 2009), and demographic factors (Cook *et al*., 2009). For instance, the morbidity of STH infections is most commonly associated with heavy worm load/intensity (Crompton and Nesheim, 2002; Ostan *et al*., 2007).

The long time negative effects of STH infections often result in malnutrition, anemia, growth retardation, poor cognitive performance, increases school absenteeism, exacerbation of other infectious agents, impairment of vaccination and reduction of economic development (Stephenson *et al.,* 2000b; Fleming *et al.,* 2006 ; Markus and Fincham, 2007; Van Riet *et al*., 2007; Lim *et al*.,2009).

Intensity of infection was estimated indirectly by counting the mean number of eggs per gram of faeces (epg) (Fleming *et al*. 2006; Brooker *et al*. 2007), and categorized using thresholds recommended by the World Health Organization. Accordingly it is indicated for hookworm infections to be light (1 – 1999 epg), moderate (2000 – 3999 epg), and heavy infection ≥ 4000 epg), for *Ascaris lumbricoides* (light, 1 - 4999 epg, Moderate (5000 - 49,999 epg and heavy infection≥ 50,000 epg), for *Trichuris trichiura* (light, 1 - 999 epg, moderate, 1000 – 9999 epg and heavy, ≥ 10,000 epg). On the other hand, WHO indicated that high prevalence for STH infections refer to (≥ 70 %,), Moderate prevalence (≥ 50% but < 70%), and Low prevalence and low intensity (< 50%) (WHO, 2002).

1.1.5 Signs and Symptoms of STH infections

Parasitic infections can live within the intestines for years without causing any symptoms. When they do, they show the following clinical manifestations/discomforts. These include: abdominal pain, colics, nausea, vomiting, coughing, diarrhea, weight loss, anorexia, abdominal distention or bloating, feeling tired, dysentery (loose stools containing blood and mucus), rash or itching around the rectum or vulva, passing a worm in a stool, sometimes mentally related disorders and anemia (Niyyati *et al.,* 2009).

1.1.6 Intervention mechanisms of STH infections

The major intervention mechanisms used to control and prevent intestinal helminthic infections and their detrimental effects involve: anthelmintic drug treatment, personal hygiene and environmental sanitation, supply of quality water, socioeconomic improvement and health education (WHO, 1987a; Aimpun and Hshieh, 2004; Ulukanligil, and Seyrek, 2004; Belizario *et al.*, 2008). Drugs recommended by WHO for reducing morbidity due to soil transmitted helminthiasis are albendazole, levamisole, mebendazole, and pyrantel (WHO, 2002). Mass treatment is a short-dated measure for STH control (Boia *et al.,* 2006). This implies that without a change in defecation habits, periodic deworming cannot attain a stable reduction in transmission (Aimpun and Hshieh, 2004). However, treatment should be targeted only to high risk groups so as to prevent the emergence of drug resistance (Awasthi *et al*., 2003). The reduction in adult worm burden has been considered as the gold standard for vaccine development; however, currently there is no available vaccine for human STH infections control.

1.2 Malnutrition

Malnutrition generally implies undernutrition and refers to all deviations from adequate and optimal nutritional status in infants, children and adults. Lack of adequate food and nutrient intakes as well as recurrent infections is often the underlying causes of malnutrition in infants and children (Shetty, 2006). Nutrients are substances that must be supplied by the diet to the body cells (Brooker *et al.*, 2006).

Malnutrition arises from inadequacy of specific nutrients or from inappropriate combinations or proportions of diets. For example, goiter, scurvy, anemia and xerophthalmia are forms of malnutrition caused by deficiency of iodine, vitamin C, iron and vitamin A, respectively. On the other hand, it can be caused by excess nutrient utilization (Shetty, 2006). The required amount of the essential nutrients differs by age and physiologic state. Growth, strenuous physical activity, pregnancy, and lactation increase needs for energy and several essential nutrients. Energy needs rise during pregnancy, due to the demands of fetal growth, and during lactation, because of the increased energy required for milk production (Fauci and Longo, 2008).

Estimations on the amount of food eaten are used to assess the adequacy of dietary macronutrients (energy, protein and fat) and micronutrient (vitamins and minerals) intake (Shetty, 2006). If the food intake matches with the requirements for both macronutrients and micronutrients, an individual is known as well nourished, and if not considered as malnourished.

In many developing countries, protein-energy malnutrition (PEM) is the foremost nutritional deficiency, whereas iron deficiency is ranked second. PEM is a complex nutritional disorder of multifactorial causality, often classified according to severity. Except in famine conditions, sever PEM is generally restricted to infants and very young children (per-school children), however, mild-to-moderate PEM is also found among school age children (Pollitt, 1990). Similarly, malnutrition is reported as common manifestations of children younger than five years of age (Rai *et al*., 2002). Severe malnutrition, typified by wasting, edema or both, occurs almost exclusively in children (Shetty, 2006).

Causes of under-nutrition include inadequate food intake, incorrect feeding practices, infection or a combination of these factors. Nutritional deficiencies are the causes for poor school enrolment, absenteeism, early drop-out, and weaknesses in physical and intellectual performance in primary school children (Pollitt, 1990; Brooker *et al.*, 2006).

Nutritional status assessment is the interpretation of information concerning nutrient utilization. It involves multiple dimensions, including documentation of dietary intake, anthropometric measurements, biochemical measurements of blood and urine, clinical examination, and health history (Fauci and Longo, 2008). Anthropometry is the most universally applicable method available to assess, the size, proportion and composition of human body (WHO, 1995). As a result, most studies on nutritional status use anthropometric measurements for the assessment of nutritional status of an individual (Jelliffe, 1989). This measurement provides information on body muscle mass and fat reserves. The most practically used body growth measurements (major nutritional status indicators) in the definition of PEM are weight-for-age, height-for-age and weight-for-height (EDHS, 2005).

However, inheritance may have a negative effect for accuracy of data interpretations gathered from anthropometric parameters. In fact, it is known that both genetics and environmental factors influence the growth and development of an individual. However, optimum environmental conditions are required for full expression of genetic potential (Rao *et al.*, 2003). Similarly, economic improvements favor better expression of genetic potential for physical growth of an individual (Fauci and Longo, 2008). Studies in different countries of the world have reported that the growth pattern of normal children is similar, but later deviations may occur due to environmental factors (nutrition and infection) than genetic factors (Gerien, 1998). The common anthropometric parameters are underweight, stunting and wasting.

Underweight, weight-for-age is a composite index of height-for-age (stunting) and weight-for-height (wasting). It takes in to account both acute (present) and chronic malnutrition (EDHS, 2005). It is a sign of current undernutrition. It is recommended as the indicator to assess changes in the magnitude of malnutrition over time. If the weight deficit is severing, life may be endangered. Weight-for-height is not a particularly sensitive nutritional indicator in adolescence, when there is a marked increase in growth velocity (Pollitt, 1990). Therefore, BMI-for-age captures changes in the weight-height relation with age and used for school children and adolescents up to the age of 20 years to determine nutritional status (Flegal *et al.*, 2002). This implies that for children, the distribution of BMI varies with age.

Stunting is an indicator of past growth failure**,** which is a sign of poor nutritional history. It is associated with a number of long-term factors including chronic insufficient protein and energy intake, frequent infection, sustained inappropriate feeding practices and poverty. In children, over 2 years of age, the effects of these long-term factors may not be reversible. It does not vary according to recent dietary intake. This index is an indicator of linear growth retardation and cumulative growth deficits.

Wasting indicates current or acute malnutrition resulting from failure to gain weight or actual weight loss. Wasting indicates recent weight loss. Wasting in individual children and population groups can change rapidly and shows marked seasonal patterns associated with changes in food availability or disease prevalence to which it is very sensitive (Bruce, 2001).

For diagnosis, clinicians emphasize various features of childhood malnutrition for the differential diagnosis of kwashiorkor and marasmus. Marasmic-kwashiorkor is also characterized with severe wasting in the presence of edema (Pollitt, 1990; Muller and Krawinkel, 2005). Other than weight deficit, edema must be present and is the only characteristic for the diagnosis of kwashiorkor.

The WHO cut-offs points for different malnutrition include Z-scores < -1 Z-score, < -2 Z-score, and < -3 Z-score for mild, moderate, and severe malnutrition classifications respectively (Bruce, 2001). It is used in this study. The most commonly used cutoff with Z-scores is -2 standard deviations, irrespective of the indicator used. This means children with a Z-score for underweight, stunting or wasting, below -2 SD are considered malnourished (WHO, 1998)

There are international standards used as references in nutritional assessment. Children whose height-for-age, weight-for-height and weight-for-age Z scores of each below minus two standard deviations (-2SD) from the median of the reference populations are considered as short (stunted),which are chronically malnourished, thin (wasted), which are acutely malnourished and underweight, respectively. Moreover, among children whose Z scores are below minus three standard deviations (-3SD) from the mean are considered as severely stunted, wasted and underweight, respectively (WHO, 1995; Gibson, 1990; EDHS, 2005).

The Z-score or standard deviation unit (SD) is defined as the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population. Z-scores are more commonly used by the international nutrition community because they offer two major advantages (WHO, 1998).

For the control of malnutrition, synergistic interventions mechanisms are needed since it has many causes. A variety of actions are needed, including agricultural and micronutrient interventions, the provision of safe drinking water and sanitation, education and support for better diets, special attention to gender issues and vulnerable groups such as pregnant women and young children, and quality of health services (Muller and Krawinkel, 2005), by increasing their consumption of fortified foods (Kraemer and Zimmermann, 2007).

1.3 Malnutrition and STHs infections

Malnutrition is the most widespread public health problem in the world. Malnutrition promotes infection and infection leads to malnutrition (Koski and Scott, 2001). The relationship between malnutrition and infection is complex, and both interact synergistically with each other to worsen the health conditions of the risk groups (WHO, 1992a). This combination is the leading cause of death among young children in developing countries. In developing countries, it is reported that approximately 183 million children are underweight-for-age, 67 million are underweight-for-height (wasted), and 226 million are low height-for-age (stunted) (Jones *et al.*, 2003).

Malnutrition depends on determinants such as socioeconomic and physical environment in which an individual lives (Ostan *et al.*, 2007; Jardim- Botelho *et al.*, 2008). Multiple species infections may have an additive impact on nutrition, especially in childhood (Pullan and Brooker, 2008). Malnutrition and worm infections usually occur in the same geographical areas and often in the same individuals (Stephenson, 1994). Good nutritional status is required to maintain maximum resistance to infection and the ability to recover from these infections (WHO, 1992a; FAO, 1992). The pre-existing malnutrition lowers the host resistance for infection by depression of cellular and humoral immunity. This is probably due to their impact on PEM (Stephenson, 1994). However, host immunity seems to limit intensity and severity of infections, but there is no permanent protective immunity against re-infections (Kloos and Tesfayohanis, 1993).

The negative effects of intestinal parasitic infections on nutritional status are very common with highest intensity in school age children (WHO, 1997). This is possible through directly by affecting the ability of the host to gain nutriture from diets (Koski and Scott, 2001). This includes a variety of pathophysiological responses in the gastrointestinal tract such as vomiting, diarrhea, malabsorption, and anorexia. For example, food intake reduction, digestion impairment, malabsorption, and poor growth rate are frequently observed in children suffering from ascariasis and trichuriasis. Ascariasis reduces the body's ability to use protein and to absorb fat, which worsens PEM. It also exacerbates vitamin A deficiency and milk intolerance (Crompton and Nesheim, 2002).

A study conducted in Brazil showed a significant associations between stunting with *Ascaris lumbricoides* and *Trichuris trichiura* infections among pre-school and school children, whereas low body mass was significantly associated with hookworm infections among adults and the elderly (Jardim-Botelho *et al.*, 2008). Another study by Jukes *et al.* (2008) have shown the existence of associations between worm infection and under-nutrition, iron deficiency anemia, stunted growth, poor school attendance and poor performance in cognition tests. Moreover, a cross-sectional survey, in Turkey, among shantytown school children reported the common occurrence of undernutrition with high prevalence of stunting, anemia and helminthic infections (Ulukanligil, and Seyrek, 2004).

Similarly, a cross-sectional study among school children, conducted in Babile town, Eastern Ethiopia, reported that children with stunted growth had higher infection rate of *Hymenolepis nana* than children who are properly nourished (Tadesse, 2005). A study by Belizario *et al*. (2008) demonstrated the impact of worm burden on nutritional status of an individual. It is also reported that strongyloidiasis causes diarrhea and malnutrition in sub-Saharan Africa (Hotez and Kamath, 2009). Moreover, the findings of a retrospective study among young age (5-15 years of age), showed that the correlation of severe malnutrition with increased rates of gastrointestinal parasitic infections in the Palajunoj Valley of Guatemala (Cook *et al*., 2009).

On the contrary, studies in Bolivia children, reported the lack of statistically significant associations between helminth infections and anthropometric measures of nutritional status (Tanner *et al.,* 2009). Similarly, a study among school children were reported the lack of association between malnutrition and intestinal parasites in Gonder, Northwest Ethiopia (Worku *et al.,* 2009).

Different types of helminth infections may affect growth in different ways. For instance, the nutritional status of the host may be impaired by the increased nutrient demands of the parasite itself or by specific actions of the parasite. For example, blocking of the absorbing surfaces of the mucosal wall by adult *Ascaris lumbricoides*, and blood loss by hookworm infections affects human life (Jardim-Botelho *et al*., 2008). The high prevalence of severe ascariasis and trichuriasis in children may lead to micronutrient deficiency (iron deficiency anemia, vitamin A deficiency) and protein-energy malnutrition (Al-Mekhlafi *et al.,* 2006). Consequently, anemia in children is associated with stunting, wasting, poor cognitive abilities and impaired immune system (Muhangi *et al.,* 2007).

Intestinal helminthic infections are manifested mainly by nutritional disturbance (Crompton and Nesheim, 2002), having their deleterious effects at different phases during the human life cycle. For instance, intense STH infections can contribute to malnutrition and iron-deficiency anemia, and adversely affect the physical and mental growth in childhood (Brooker *et al.,* 2006). Therefore, intestinal nematode infections exacerbate nutritional problems.

1.4 Anemia

Anemia is a reduction of the total amount of red blood cell (RBC) count, packed cell volume, or hemoglobin concentration below normal, and consequently a decrease in oxygen-carrying capacity and delivery to tissue. Anemia is not a diagnosis in itself but is rather a sign of an underlying disease process.

Worldwide, more than 2 billion peoples are anemic (WHO, 1992b; WHO, 2001; Casey *et al*., 2009). It is estimated that the highest proportions of individuals affected by anemia are found in

Africa (Haida and Pobocik, 2009). In developing countries, over half of all children and pregnant women are anemic (Crompton, 2000). For example, preschool children in Africa have some of the highest rates of anemia accounting for nearly 56% in the world (United Nations, 1991).

The etiology of anemia varies from countries to country and includes deficiencies of essential nutrients such as micronutrients (e.g., iron, vitamin A, vitamin C, folate, riboflavin, and vitamin B12), physical injuries (e.g., hemorrhages, abnormal menstrual bleeding), genetic abnormalities (e.g., thalassemia, sickle-celled anemia), parasitic infections (e.g., hookworms and malaria), systemic infections (e.g., malaria, HIV, tuberculosis), and cancer (Pollitt, 1990; Gilgen *et al.*,2001; Haidar and Pobcik, 2009). However, the relative contribution of different etiologic factors to anemia in a population is often difficult to single out.

Among the multiple causes of anemia, iron deficiency appears to be by far the single most frequent cause, accounting for at least 50% of the cases of children and women of reproductive age in developing countries (WHO/UNICEF/UNU, 2003). Anemia is the most common manifestation of disease observed in the tropics. Iron-deficiency anemia affects about 1.3 billion people, with the highest prevalence and morbidity in young children and pregnant women (Gillespie *et al.*, 1991). About 3.8 billion people all over the world have been estimated to have iron deficiency anemia (WHO, 1998). Although iron deficiency is the most common cause of anemia, among these groups, other nutrient deficiencies (folate and vitamin B12), can also contribute to anemia. Iron deficiency is the commonest nutritional deficiency in the developing and developed countries (Yip, 1994). An individual can be iron deficient without being anemic, but iron deficiency anemia (IDA) without depletion of iron stores cannot occur (Pollitt, 1990).

Intestinal helminthic infections exist widely with micronutrient deficiencies (Steketee, 2003). In developing countries, anemia is considered as a priority nutritional problem. Consequently, these infections could be associated with the development of anemia among children, pregnant and lactating women (Rodriguez-Morales *et al.*, 2005). On the other hand, children and pregnant women need high amount of iron due to the nature of their physiology (Viteri, 1994). Moreover, iron requirements are high during periods of rapid growth, which occur in the fetus, children less than 2 years old, preschool and school-age children, and adolescents (Freire *et al.*, 2003).

In Ethiopia, IDA is not only due to low dietary iron intake, but also with other nutrient deficiencies and non-nutritional factors such as parasitic infections (Haida and Pobocik, 2009). Fernandez-Banares *et al*. (2009) also reported that the most frequent etiology of anemia is the combination of iron and vitamin B12 deficiency. In addition, other nutrient deficiencies such as vitamin A, B-6, and B-12, riboflavin, and folic acid have been associated with the occurrence of anemia (Van Broek and Letsky, 2000).

The specific hemoglobin cutoff points recommended by the World Health Organization for anemia are determined by taking into account factors like age, gender, altitude and genetic background of the individuals. The cut-off points used to define anemia in school children, from 6-11 and 12-14 years are if Hb is less than 11.5 and 12g/dl, respectively. Moreover, severe anemia is defined when hemoglobin concentration is less than 7g/dl as recommended by WHO. The different stages of anemia and values used in demographic and health surveys, for children aged from 5-11 years are (mild, 10-11.4, and moderate, 7.0-9.9), and for children 12-14 years old (mild, 10-11.9, and moderate, 7.0-9.9) (WHO/UNICEF/UNU, 2001). Such hemoglobin measure can be used to assess anemia (Brooker *et al*., 2006).

IDA impairs cognitive performance, causes poor physical growth, delays psychomotor development and productivity, reduces appetite, leads to low birth weight, hypoxia, compromises immune system and increases morbidity (Pollitt, 1990; World Bank, 1993; Crompton, 2000; Bobonis *et al*., 2004). Moreover, iron deficiencies early in life are thought to potentially inhibit the function of neurotransmitters, compromising brain function and may also lead to severe anemia (Stoltzfus *et al.*, 1997). These over all impacts lead to a decrease in work capacity and fitness of individuals. However, it is hypothesized that iron supplementation could improve both physical and cognitive developments of school children (Bobonis *et al*., 2004).

The signs and symptoms of anemia are non-specific and difficult to detect. However, findings suggest that chronic anemia includes irritability, pallor (usually not seen until hemoglobin levels are less than 7g/dl), glossitis, a systolic murmur, and growth delay. Children with acute anemia often present more dramatically with clinical findings including jaundice (yellow skin), tachypnoea, tachycardia, splenomegaly, haematuria and congestive heart failure (Haidar and pobcik, 2009; Ramzan *et al*., 2009).

Iron intervention is the core of anemia control programs. The four basic approaches to the prevention of iron deficiency anemia are supplementation with medicinal iron, education and associated measures to increase dietary intake, the control of infection and the fortification of the staple food with iron (Al-Mekhlafi *et al.,* 2008; Ramzan *et al.,* 2009). The multi-causal etiology of anemia calls for an integrated multi-sectoral approach comprehend addressing major nutritional (iron and other nutrients) and non-nutritional causal factors (parasites, systemic infections), particularly in settings where presentably causes other than iron deficiency are likely to play an important role (Stoltzfus, 2001). Moreover, periodic mass deworming of communities at high risk of helminth infections (De Silva, 2003), reduces anemia by storing iron and improves growth in children. Therefore, iron supplementation should be included with anthelminthic therapy in neglected tropical disease treatment programmes (Stoltzfus *et al.,* 1997).

1.5 Anemia and STH infections

There are few studies investigating the relative contribution of different parasitic infections to anemia among schoolchildren (Koukounari *et al*., 2008). The extent to which anemia occurs due to parasitic infections will depend on host iron status, the infecting species, the intensity, and duration of infections (WHO, 2003). However, it is suggested that many Neglected Tropical Diseases (NTDs) cause anemia either directly through blood loss or indirectly through bone marrow suppression, inflammation, hypersplenism, haemolysis, or anorexia (Friedman *et al.,* 2005; Stephenson *et al.,* 2000a). Anemia is a frequent finding in most digestive diseases which cause malabsorption (Fernandez-Banares *et al*., 2009). Both hookworm and *T. trichiura* infections have been most suggested to contribute to IDA in developing countries (WHO, 2002).

Hookworm infections occur in almost half of Sub-Saharan Africa’s poorest people, including 40–50 million school-aged children and 7 million pregnant women in whom it is a leading cause of anemia, and undernutrition (Hotez and Kamath, 2009). Basically, IDA and poor iron status are the hallmarks of hookworm disease, and is well known worldwide (Oski, 1993; Crompton and Nesheim, 2002).

Hookworms contribute to IDA by actively feeding on blood from the capillaries and arterioles in the intestinal mucosa, causing further gastrointestinal hemorrhage, loss of serum proteins, and intestinal inflammation (Olsen *et al*., 1998). Blood loss occurs when the worms use the cutting apparatus to attach themselves to the wall of intestinal mucosa, and contract their muscular esophagi to create negative pressure, which sucks a plug of tissue into their buccal capsules (Hotez *et al.,* 2004).The digestive enzymes of the hookworms help to rupture blood capillaries both mechanically and chemically (Hotez and Pritchard, 1995). Moreover, they release anticoagulant compounds into the blood stream, which makes the blood leaking out continues (Stanssens *et al*., 1996; Hotez and Cerami, 1983). Therefore, the amount of blood loss in hookworm infections is strongly and linearly correlated with worm load /fecal egg counts (Muhangi *et al.,* 2007). For example, for each of 1000epg of infection intensity, the average blood loss in stool was found to be 0.825ml/g (Crompton, 2000). Depending on the status of the host iron content, 40 to 160 hookworm burdens may be associated with low Hb level (Bundy *et al.,* 1995). Moreover, infections with *A. duodenale* cause greater blood loss than with *N. americanus* does (Stolzfus *et al.,* 1997).

Views differ regarding the effects of worm infections on anemia. A cross-sectional study among schoolchildren in Southeast of Lake Langano, Ethiopia, showed the absence of associations between hookworm infections and haematocrit values in the study subjects (Legesse and Erko, 2004). Moreover, a similarly study showed the lack of associations between intestinal parasitic infections and anemia (Haida and Pobocik, 2009). However, these studies imply the need to investigate the actual effect of deworming on iron status in hookworm endemic communities. In contrast, other studies among schoolchildren living in areas where hookworm infections are endemic were showed 25%–73% occurrences of mild to severe anemia (Stoltzfus *et al.*, 1997). Additionally, hookworm infections were investigated to induce deficiencies of iron, energy, protein, folate and zinc (Rodriguez-Morales *et al*., 2005).

Heavy infections with *Trichuris trichiura* have been reported to cause IDA (Ramdath *et al*., 1995). Trichuriasis often occurs concurrently with hookworm infections and so may accelerate the onset of IDA (WHO, 2002). Although blood loss can be a feature of *T. trichiura* infection, it is less prominent than in hookworm infections. However, there are both direct and indirect mechanisms in trichuriasis which is responsible for anemia. The direct mechanism is via bleeding in the large bowel, with Trichuriasis Dysentery Syndrome (TDS) or rectal prolapse. The indirect mechanism is systemic. This occurs likely with elevated levels of tumor necrosis factor alpha (TNF-α), which reduces appetite, and thus food (iron) intake (Stephenson *et al.*, 2000b). This could occur in any child and the effects may produce, or aggravate pre-existing anemia.

T. trichiura does not ingest erythrocytes, but at the point of intestinal insertion of the worm, it leads to blood loss (hemorrhage) with stool, and causes further chronic mucosal inflammation and ulceration among children (Cooper *et al.*, 1992; Van den Broek and Letsky, 2000). This in turn contributes to iron loss and lead to life-threatening anemia (Crompton and Nesheim, 2002). In agreement with this, a cross-sectional study among aboriginal schoolchildren in Malaysia showed that severe trichuriasis was found to be associated with low Hb level (Al-Mekhlafi *et al.*, 2008). Muhangi *et al.* (2007) also reported that individuals infected with heavy *T. trichiura* infections have a higher prevalence of anemia (Hb <11 g / (d1) than uninfected controls.

*Ascaris lumbri*co*ides* infection is widely considered to significantly impair childhood nutrition. It impairs fat digestion, lactose digestion, affects absorption of vitamin A, Iodine, and proteins (Stephenson and Holland, 1987; Crompton, 1994), and reduces food intake .However, this infection does not affect iron absorption, but it may aggravate anemia resulting from malnutrition (Islek *et al.*, 1993). Prior studies have also linked ascariasis with nutritional anemia. For example, vitamin A deficiency entirely causes IDA. Moreover, children with high intensity of *A. lumbricoides* infection are at high risk of intestinal obstruction, while adults may experience a range of acute complications when the adult worm migrates from the lumen of the small intestine to the lungs (WHO, 2002).

1.6 Statement of the problem

Lack of current reports on the prevalence of intestinal helminth parasites, nutritional status and hemoglobin level in different areas of the country may limit the rate at which decisions are made for intervention measures against these effects by concerned bodies such as National Government and International Organizations (Brooker *et al*., 2006). In Ethiopia, even though many studies have been carried out on malnutrition in children, there are limited studies that have shown the relationship of STHs with anemia and nutritional status (Worku *et al*., 2009). Therefore, there is a need to carry out further studies on the prevalence of intestinal parasites and its associated health impact on high risk groups of the society in this country. Such information is required to guide policy makers in deciding on type of strategies and frequency of mass drug administration in controlling worms.

In Debub Achefer District, Northwest Ethiopia, there are no previous studies which show the associations between malnutrition and anemia with intestinal helminth infections among school children. However, according to clinical reports of the Health Center in this District, worm infections are currently listed as the second reason why people visit health facilities. Therefore, the present study was undertaken to investigate the association of STHs with malnutrition and anemia in Debub Achefer District school children as part of the community.

1.7 Research hypothesis

This study hypothesized that soil-transmitted helminth infections are not associated with malnutrition and anemia among primary school children in Debub Achefer District, Northwest Ethiopia.

2. Objectives

2.1 General objective

The overall objective of this study is to investigate the associations of intestinal STHs with malnutrition and anemia among school children in Debub Achefer District, Northwest Ethiopia.

2.2 Specific objectives

- To determine the prevalence of STHs among school children in Debub Achefer District, Northwest Ethiopia.
- To identify risk factors for STH infections in the study area
- To assess the nutritional status of the school children
- To determine hemoglobin level and prevalence of anemia among school children
- To assess the associations of STH infections with malnutrition and anemia among school children

3. Materials and Methods

3.1 The study area

The study was conducted at Durbate Health Center, Debub Achefer District, Amhara National Regional State, Ethiopia. Debub Achefer District is located about 503 Km from Addis Ababa to Northwest. It is situated in Western Gojjam Zone between Dangila and Bahir Dar towns.

According to the information obtained from the District Planning and Economic Development Department (2008/2009), the District is estimated to cover an area of 1,183.05 Square Kilometers (sq.kms). Twenty kebele's are found in the District, of which 18 Kebele's are rural and 2 kebele's are urban settings of Durbate town. The town covers an area of about 3.35 sq.kms of the total land area. The District is bordered by Mechia District to the East, Awi zone to the West, North Achefer District to the North, Awi zone and Mechia District to the South (Fig.4).

According to the information obtained from the District Planning and Economic Development Department, the total population in the year 2009 is estimated to at 189,343 (96,254 males and 93,089 females). A total of 171,846 people live in rural area (88,473 males and 83,373 females). The rest 17,497 people live in urban (7781 males and 9716 females). The dominant ethnic group in the District is Amhara.

The altitude of the District ranges from 1500masl – 2500masl. The mean annual temperature ranges from 25^0C - 29^0C and the mean annual rainfall ranges from 1400 mm – 1594 mm. Like most parts of the country, the District has three distinct agro-ecological zones; 'Dega'-1.1sq.km (0.09%), 'Woinadega'-851.63 sg.km (71.97%), and 'Kola'-330.601sq.km (27.94%) (Debub Achefer District information center, 2008/2009). The dominant soil type of the District is brown and black loam soil.

The majority of the populations of the District are engaged in mixed agricultural activities. The residents earn their living as farmers, merchants, daily laborers, and governmental employees. The dominant crops grown are maize, millet, and 'teff'. Cattle, Goats, sheep and poultry are the major animals reared by most farmers. And the staple food was teff. The inhabitants of the District use stream water, river water, wells or pool water, standing pipe water, communal and private tap water as a source of drinking and for laundering.

In the District, the total student population of the schools surveyed was 1875 (600 from Abchikeli and 1275 from Ayalew Mekonnen).

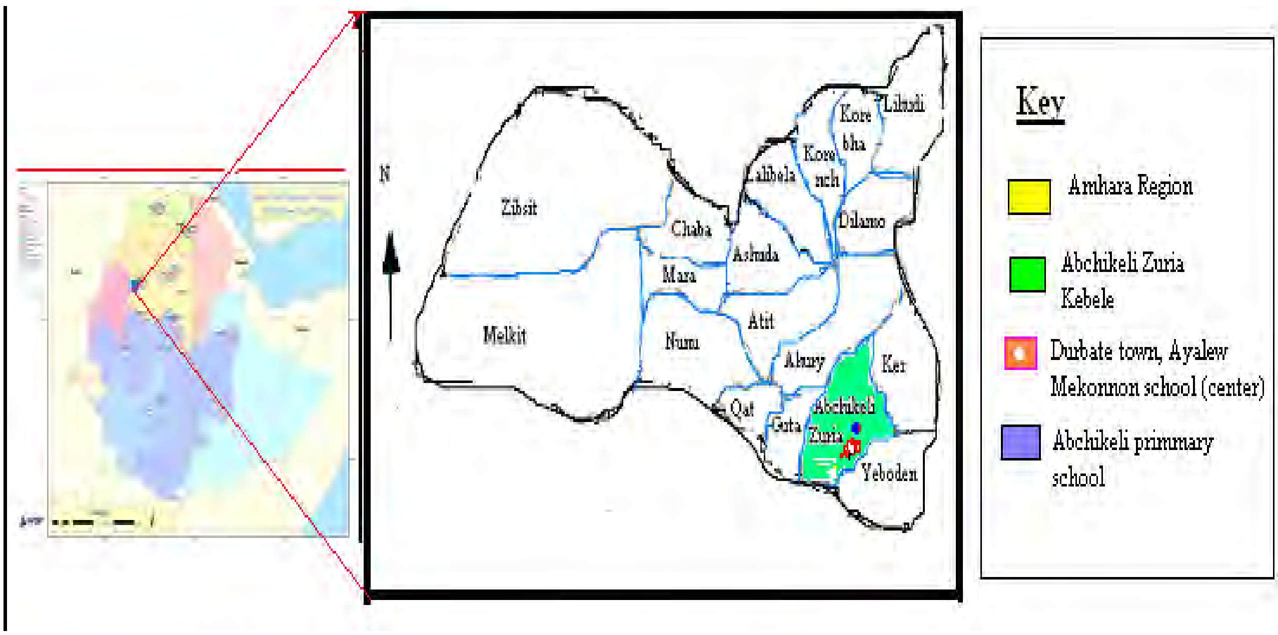

Figure 1. Map of Debub Achefer District, Northwest Ethiopia (source: Debub Achefer District information center, 2008/2009

3.2 The study population

The study population consisted of 403 school children enrolled in Abchikeli and Ayalew Mekonen primary schools. 256 children were selected from Abchikeli (108 males and 148 females) while 147 from Ayalew Mekonnen (73 males and 74 females). Abchikeli primary school is located at the periphery of the town Durbate nearly at a distance of 1km from the center to the North, where as Ayalew Mekonnen located at the center of the town. Age records were obtained from master list or roster for each school. Months from the registration list were rounded to the nearest complete years.

3.3 The study design and sampling techniques

The study design was cross-sectional survey and it was conducted from February to March 2010 at Abchikeli Zuria Kebele, in Debub Achefer District, Northwest Ethiopia. The study study participants were school children selected using a multi-stage random sampling technique. The students were first stratified by stratified cluster sampling techniques according to their educational level (grades 1 to 6). Then, a quota was allocated for each grade, each class room, and number of sections. Finally, the school children were selected by random sampling technique using random numbers generated from master's lists (roster) of each section documented for 2009/10 academic year taking as the sample frame. A total of 247 children were selected from Abchikeli, and 137 Ayalew Mekonnen primary schools. All the children from grade 1 to 6, and grade 1 to 3 were involved and selected from Abchikeli and Ayalew M. schools, respectively

Before the commencement of the study, a clear explanation about the objectives of the study and their involvement (consent) was given to headmaster, teachers and school children. Then, only those children who volunteered to participate in the study were included. Children who were not eligible for the study were excluded from the study.

3.4 Sample size determination

The sample size was estimated using the following statistical formula (Daniel, 1995):.

$$n = \frac{Z^2 P (1-P)}{d^2}$$

Where: n= sample required

Z= 95% confidence interval (1.96)

D= margin of error (5%)

P= prevalence rate.

Since the overall prevalence rate (p) of intestinal parasites was not known for the study area, prevalence was taken to be 50%. Hence, the required sample size was 384.

To compensate missing arising from the likelihood of non compliance, 5% of the sample size was added to the initially estimated sample size (384). Hence, this addition of contingency (5% of 384), gave 19. As a result, 403 school children were chosen to participate in the study.

3.5 Data collection

3. 5. 1 Structured questionnaires

A pre-tested standardized questionnaire based on known risk factors was developed. These questionnaires were constructed in English and translated into Amharic. Then, the children were interviewed in their mother tongues, Amharic. These standardized and coded questionnaires with a few open-ended questions were used to gather relevant general information on demographic and socioeconomic data on the children and their parents in the study area. The questionnaires were administered and observations on physical situations were recorded by an oriented health assistant for each child in the school setting.

3. 5. 2. Physical examination

The study participants were examined physically for variables such as the presence or absence of clean clothing, hygienic conditions, wearing shoes, edema, and for any more body abnormalities by the nurse. The observations were recorded in the recording format.

3. 5. 3 Stool collection and examination

The school children were provided with small plastic sheets and clean wooden applicator stick. They were then informed to bring sizable stool sample of their own. The stool samples were then processed for microscopic examination using Kato-Katz method (WHO, 1991).

Briefly, portion of the fecal specimen was taken by clean wooden spatula and forced through the nylon screen to separate fecal materials from the large debris. The screened fecal material was transferred to the template which was laid flat centrally on a microscope slide. The template hole was completely filled with screened fecal material and leveled to the surface of the template. The cellophane square which was soaked in malachite green-glycerin solution was placed over the fecal specimen. The specimen was made to spread evenly under the cellophane tape by pressing it with another glass slide (prepared for this purpose).

The prepared Kato-Katz slides were examined systematically under the middle (10X) and high power (40X) objectives of the microscope for STH ova by experienced laboratory technician at Durbate town Health Center laboratory setting. Moreover, negative samples were re-examined on the same day at the same time by another laboratory technician and the researcher. Eggs counted for each species of STHs were recorded and later converted into eggs per gram of stool (EPG) multiplied by a factor of 24. Infection intensity (light, moderate, and high) was classified as described by World Health Organizations criteria (WHO, 2002).

3. 5. 4. Anthropometric measurements

Body size and growth were assessed through height and weight measurements. Weight and height were taken using a digital portable weighing calibrated SECA scale by trained Health assistant at Durbate town Health Center laboratory setting to determine the nutritional status of each child. The school children were weighed wearing lightly clothed / with school uniforms, without shoes and with empty pockets. The calibrated SECA balance scale has intervals/ sensitivity of 0.1kg with and a capacity of 130 kg; height was measured to the nearest 0.1 cm precision and length up to 2 meters using the same device that has a scale and a sliding head piece. Weighing scale was calibrated to the zero before taking every measurement. To reduce intra-individual errors, weight and height were measured twice by different persons and the mean value was used for the analysis.

Anthropometric index/ nutritional indicators of Z-scores for height-for-age (HA) or stunting, weight-for-age (WAZ),or underweight and weight-for-height(WHZ) or wasting were calculated as indicators of growth status of the children using anthropometry software(Epi Info) in accordance with the recommendations of World Health Organizations (WHO, 1995),on the basis of the reference data of National Center for Health and Statistics. Since wasting for those children with age of 9-14 years cannot be evaluated through Epi Info 3.5.1, hence BMI-for-age percentiles in reference with tables of 5^{th} percentiles of NCHS was used to evaluate wasting (loss of weight).

The age of each child was recorded from the school master's list since birth identity card was not available for each of the study subjects. Height-for–age, weight-for-age and weight-for- height denote stunting, underweight and wasting, respectively. All the data were transformed and expressed in Z-scores and calculated using SPSS version 15 statistical packages. The mean Z scores were calculated. Under nutrition was defined for a child, who had less than-2 z-scores (-2SD) from the NCHS median reference population values. This was used as cut-off points for determination of malnourishment.

3. 5. 5. Hemoglobin Determination

Hemoglobin analysis was carried out using Hemocue haemoglobin spectrophotometer (Hemocue HB 201 analyzer). The blood sample was collected by finger pricking after rubbing the finger tip with sterile cotton (immersed in alcohol), and pricking it with a sterile disposable lancet at Durbate Health Center laboratory setting.

A drop of blood was allowed to enter the optical window of the microcuvette through capillary action. The microcuvette was placed into the cuvette holder for photometric determination of hemoglobin level. Then, the concentration of hemoglobin level was quantitatively determined and read in g/dl. School children with hemoglobin levels lower than 11.5g/dl and 12g/dl were considered as anemic for age ranges of 6-11 and 12-14 years (WHO, 2001).

3. 5. 6. Quality control for examinations

During data collection, all the activities of the work was carefully monitored and supervised. First, meeting was made with the laboratory technicians and nurses to discuss the need for quality data.

Before information was gathered using questionnaires, pre-test or pilot study was made and the necessary adjustment was made. The questionnaires filled by the school teachers and headmasters were checked and any deviations and inconsistencies were corrected as soon as possible. Demographic records of students were cross checked from the school's master list against completed questionnaires.

The Kato slides were examined microscopically (40X) by the technician and, all negative and positive slides were immediately (within one hour) observed by another senior technician, and the researcher in this laboratory. Furthermore, 10% of the total fecal specimen (384) was re-checked in the laboratory at Aklilu Lemma Institute of Pathobiology, Addis Ababa University, by a senior technician after three weeks of its preparation. However, there was no discrepancy on the stool examination results between the first test at Durbate and the quality control test at Addis Ababa University.

Each Hemocue photometer was checked for calibration every morning before use. In addition, hemoglobin levels of 100 participants of the total sample size (384) were measured with Hematocrit analyzer machine in parallel with Hemocue machine. The comparison between two methods was not show significant variations. The weight scales were checked at the beginning of each working day against a standard of six kilo-gram stone which was kept for this purpose until the end of the study.

3.2 Data analysis

The data was computerized using Excel 2007, cleaned and checked against original document before analysis. Data entry for anthropometric indices was done using the Epi Info version 6 calculating software programme. All statistical analyses were performed using SPSS for windows version 15 statistical package. Descriptive statistical tests were applied to indicate the prevalence of STH infections, anemia and nutritional status as percentages and proportions. To test the null hypothesis, inferential statistical analyses of comparisons between two categorical variables was carried out using Pearson chi-square (x^2) test verifying the relationship between independent factors and the outcome variables. Binary logistic regression analysis (Odds ratios, OR) was used to determine association of STH with malnutrition and anemia. The 95% CI was used to show the accuracy of data analysis. Probabilities less than 5% ($P < 0.05$) for null hypothesis testing were considered statistically significant.

3.7 Ethical considerations

The project obtained clearance from the Ethical Clearance Committee of Biology Department, Addis Ababa University. Permission to conduct the study was also obtained from Debub Achefer District Health Officers, Educational Authorities and School Principals. The objective of the study was explained to the teachers and school principals. It was also explained to the study participants and the sample was collected from assented children. At the end of the study, all children who had STH infections were treated with mebendazole, 100mg, orally twice a day for three days, which was obtained from Aklilu Lemma Institute of Pathobiology, Addis Ababa University, free of charge. Finally, health education on nutrition, personal hygiene and environmental sanitation were also given for the school children and school staff by the researcher.

4. Results

A total of 384 were included in this study. The median age of the children was 10.0 years. Out of 384, 63.5 %(244) were from rural, while the rest were from peri-urban settings. Gender wise, 44.5% (171) were males and 55.5% (213) were females.

4.1 Questionnaire surveys

The results of the questionnaire surveys for socio-demographic, socio-economic and physical examinations of the school children were presented in Tables 1, 2 and 3. Table 1 shows the socio-demographic characteristics of the study participants. From a total of 384 study participants, 63.5% were from rural and 36.5% were from peri-urban settings. The proportion of male and female participants was 44.5% and 55.5%, respectively. Almost all the study participants were from Amhara ethnic group (98.4%), and the majority of the respondents were Christian (95.3%), whereas 4.7% were Muslims. The illiteracy rates were 52.6% (fathers), and 62.8% (mothers). 93.5% of the fathers were farmers and 94.3% of the mothers were housewife, the rest earn their living as merchants, government employee, and daily laborers. There was no statistically significant associations of STH infections with gender (P=0.994), religion (P=0.666), ethnicity (P=0.387), father occupation (P=0.638), mother occupation (P=0.645), and father education (P=0.411) (Table 1).

The number of children in the age groups of 10 to 14 constituted about 54.4% of the study population, whereas children in the age group 6 to 9 years constituted 45.6%. The majority of participants' family size ranges from 1 to 3 (53.9%), followed by family size of 4 to 6 (32%). STH infections varied significantly with residence, age groups, family size and mothers' education (P<0.05). As the age of the children increased, STH prevalence increased (P=0.000).

Table 1. Association of socio-demographic characteristics with STHs among the school children (N= 384) in Abchikeli and Ayalew Mekonnen Elementary schools , Debub Achefer District, Northwest Ethiopia, February to March, 2010

Socio-demographic variables	Total n (%)	STH positive n(%)	negative n (%)	x^2	P-value
Gender					
Male	171(44.5)	94(55)	77(45)	0.000	0.994
Female	213(55.5)	117(54.9)	96(45.1)		
Residence					
Rural	244(63.5)	159(65.2)	85 (34.8)	28.216	0.000
Urban	140(36.5)	52(37.1)	88(62.9)		
Father Occupation					
Farmer	359(93.5)	199(55.4)	160(44.6)		
Merchant	17(4.4)	8(47.1)	9(52.9)		
Government employee	7(1.8)	3(42.9)	4 (57.1)	1.695	0.638
Daily labourer	1(0.3)	1 (100)	0		
Mother Occupation					
House wife	362(94.3)	201(55.5)	161(44.5)		
Merchant	15(3.9)	7(46.7)	8(53.3)		
Government employee	7(1.8)	3 (42.9)	4 (57.1)	0.878	0.645
Daily labourer	0	0	0		
Father education					
Illiterate	202(52.6)	115(56.9)	87 (43.1)	0.677	0.411
Literate	182(47.4)	96(52.7)	86(47.3)		
Mother Education					
Illiterate	241(62.8)	143(59.3)	98 (40.7)	5.034	0.025
Literate	143(37.2)	68(47.6)	75(52.4)		
Age groups					
6-9 years of age	175(45.6)	76(43.4)	99(56.8)		
10-14 years of age	209(54.4)	135(64.6)	74 (35.4)	17.235	0.000
Family size					
1 to 3	207(53.9)	97(46.9)	110(53.1)		
4 t0 6	123(32.0)	82(66.7)	41(33.3)	12.699	0.002
> 7	54(14.1)	32(59.3)	22(40.7)		

As shown in Table 2, 34.1% of the study participants used tap water, 38.5% protected spring/well water, 25.5% unprotected spring/well water, and 1.8% river water. A total of 96.1% of 384 participants were pouring out water from the container by immersing the can, whereas only 3.9% did by inclining the container. Only 5.5% of participants had cemented house floor, 39.3% had latrine, 36.7% had electricity, 44% had radio, 21.9% had TV, 97.1% had their own house, and 10.7% eat raw vegetables, while remaining percentages / proportions/ lack for each of the respective items (Table 2). Out of 39.3% respondents, 88% used the latrine frequently, 6% used sometimes, and 6% never used even if it was available. From the total sample population, 22.4% of the participants wore shoe always. Interestingly, 94% of the respondents washed their hands before eating. Regarding waste disposal, 93.5% of the families threw the waste into open field, 6% burnt and 0.5% put into the pit.

Table 2. Association of socio-economic characteristics with STHs among the school children (N= 384) in Abchikeli and Ayalew Mekonnen Elementary schools , Debub Achefer District, Northwest Ethiopia, February to March, 2010

Socio-economic variables	Total n (%)	STH positive n(%)	STH negative n(%)	x^2	p-value
Water source					
Tap/pipe	131(34.1)	45(34.4)	86 (65.6)		
Protected spring/well	148(38.5)	92 (62.2)	56(37.8)		
Unprotected spring/well	98(25.5)	69(70.4)	29(29.6)		
River	7(1.8)	5(71.4)	2(28.6)	35.791	0.000
Water pour					
Inclining container	15(3.9)	7(46.7)	8(53.3)		
Immersing can	369(96.1)	204(55.3)	165(44.7)	0.432	0.511
House floor condition					
Earthen	363(94.5)	204(56.2)	159(43.8)		
Cement	21(5.5)	7(33.3)	14 (66.7)	4.192	0.041
House ownership					
Owned	373(97.1)	204(54.7)	169(45.3)		
Rented	11(2.9)	7(63.6)	4 (36.4)	0.345	0.557
Latrine					
Yes	151(39.3)	54(35.8)	97(64.2)		
No	233(60.7)	157(67.4)	76 (32.6)	37.00	0.000
Latrine use habit(n=151)					
Always	133(88)	49(36.8)	84(63.2)		
Sometimes	9(6)	2(22.2)	7(77.8)		
Never use	9(6)	3(33.3)	6(66.7)	0.809	0.667
shoe wearing habit					
always	86(22.4)	24(27.9)	62(72.1)		
Sometimes/not at all	298(77.6)	187(62.8)	111(37.3)	32.733	0.000
Availability of Radio					
Yes	169(44)	72(42.6)	97(57.4)		
No	215(56)	139(64.7)	76(35.3)	18.580	0.000
Hand washing habit					
Yes	361(94)	191(52.9)	170(47.1)		
No	23(6)	20(87)	3(13)	10.126	0.001

Continued from table 2

Raw vegetables eating					
Yes	41(10.7)	27(87)	14(34)		
No	343(89.3)	184(53.6)	159(46.4)	2.205	0.138
House waste disposal habit					
Open field	359(93.5)	202(56.3)	157(43.7)		
Burning	23(6)	9(39.1)	14(60.9)		
Waste pit	2(0.5)	0	2 (100)	5.016	0.081

Table 3 shows the results from physical examinations. Observations on wearing shoes revealed that 58.3% of the participants wore shoes. Interestingly, only 21.9% of the participants had dirt in finger nails. Few cases of conjunctiva pallor (1%) and pedal edema (0.5%) were recorded. There was an association between the presences of dirt in finger nails with STH prevalence ($P < 0.05$).

Table 3. Physical examinations among primary school among the school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, and February to March, 2010

Physical examinations	Total n (%)	STH		x^2	p-value
		positive n(%)	negative n (%)		
Observations for wearing shoes					
Yes	224(58.3)	110(49.1)	114(50.9)		
No	160(41.7)	101(63.1)	59(36.9)	7.409	0.006
Dirt in finger nails					
Yes	84(21.9)	59(70.2)	25(29.8)		
No	300(78.1)	152(50.7)	148(49.3)	10.154	0.001
Conjunctiva pallor					
Yes	4(1)	2(50)	2(50)		
No	380(99)	209(55)	171(45)	0.040	NS
Facial/pedal edema					
Yes	2(0.5)	2(100)	0		
No	382(99.5)	209(54.7)	173(45.3)	1.648	NS

NS= not statistically comparable

Table 4 shows the results of multiple logistic regression analysis. For instance, the risk of infection with STH parasite was high for subjects who regularly not wear shoe and those without toilet facilities (*P*< 0.05). This is to mean that, school children who did not wear shoe were exposed about 4 times more than those who had it regularly. Similarly, being younger (6-9) was found to be about 2.4 times more exposing for STH infection than older children (10-14) years.

Table 4. Bivariate logistic regression analysis showing the impact of selected risk factors/ variables on STH prevalence among the school children (N= 384) in Abchikeli and Ayalew Mekonnen Elementary schools , Debub Achefer District, Northwest Ethiopia, February to March, 2010

Variables	Total (n=384)	STH Positive n(%)	STH Negative n(%)	Crude OR	95%CI
Residence					
Rural	244(63.5)	159(65.2)	85(34.8)	3.166	2.055-4.878
Urban	140(36.5)	52(37.1)	88(62.9)	1	
Mother education					
Illiterate	241(62.8)	143(59.3)	98(40.7)	1.609	1.061-2.442
Literate	143(37.2)	68(47.6)	75(52.4)	1	
Age groups					
6-9	175(45.6)	76(43.4)	99(56.6)	2.376	1.574-3.588
10-14	209(54.4)	135(64.6)	74(35.4)	1	
Family size					
1 -3	207(53.9)	97(46.5)	110(53.1)	1	
4-6	123(32)	82(66.7)	41(33.3)	0.727	0.376-1.407
>7	54(14.1)	32(59.3)	22(40.7)	1.649	0.898-3.028
Water source					
pipe	131(34.1)	45(34.4)	86(65.6)	1	
Protected	148(38.5)	92(62.2)	56(37.8)	1.051	0.193-5.730
Unprotected spring	98(25.5)	69(70.4)	29(29.6)	1.522	0.286-8.109
River	7(1.8)	5(71.4)	2(28.6)	4.778	0.891-25.61
House floor					
Earthen	363(94.5)	204(56.2)	159(43.8)	2.566	1.012-6.508
cement	21(5.5)	7(33.3)	14(66.6)	1	
Latrine					
yes	151(39.3)	54(35.8)	97(64.2)	1	
no	233(60.7)	157(67.4)	76(32.6)	3.711	2.411-5.710
Shoes wearing habit					
Always	86(22.4)	24(27.9)	62(72.1)	1	
Sometimes/never use	298(77.6)	187(62.7)	111(37.2)	4.352	2.571-7.368
Hand washing … eating					
yes	361(94)	191(52.9)	170(47.1)	1	
no	23(6)	20(86.9)	3(13.1)	5.934	1.733-20.32

Continued from table 4

Availability of Radio					
yes	169(44)	72(42.6)	97(57.4)	1	
no	215(56)	139(64.6)	76(35.3)	2.464	1.629 - 3.727
Dirt in finger nails					
Yes	84(21.9)	59(70.2)	25(29.8)	2.298	1.367-3.864
No	300(78.1)	152(50.7)	148(49.3)	1	
Observations for shoes					
Yes	224(58.3)	110(49.1)	114(50.9)	1	
No	160(41.7)	101(63.1)	59(36.9)	1.774	1.172-2.685

4.2 Stool examination results

The prevalence of STH infections for Abchikeli and Ayalew Mekonnen school children is shown in figure 2. The overall STH infection prevalence of both genders in Abchikeli was 65.2%, while in Ayalew it was 36.5%. The prevalence of STH infections in boys and girls from Abchikeli was 64.1% and 66%, respectively, whereas, in Ayalew it was 41.2%, and 31.9% for boys and girls, respectively.

The five species of STHs that were encountered during stool examination were hookworm species, *Ascaris lumbricoides*, *Trichuris trichiura*, *Enterobius vermicularis*, and *Hymenolepis nana,* with an overall prevalence of 54.9 % (211 out of 384) in the study area. The predominant helminth infection was hookworm infection with the prevalence of 46.9% (180/384), followed by *Ascaris lumbricoides* 13.8% (53 /384), and *Trichuris trichiura* 2.34% (9 /384) infections. The prevalence of hookworm infections was higher in Abchikeli than in Ayalew. Moreover, the prevalence of ascariasis and trichuriasis was relatively higher in peri-urban school (Ayalew) than in Abchikeli. The prevalence of *Enterobius vermicularis* and Hyminolepis *nana* infections was very low, 1% (4 /384) and 0.5% (2 / 384), respectively. Moreover, both of these infections were found only among Abchikeli school children. *Ascaris lumbricoides* and *Trichuris trichiura* infections were higher in the urban settings than rural populations.

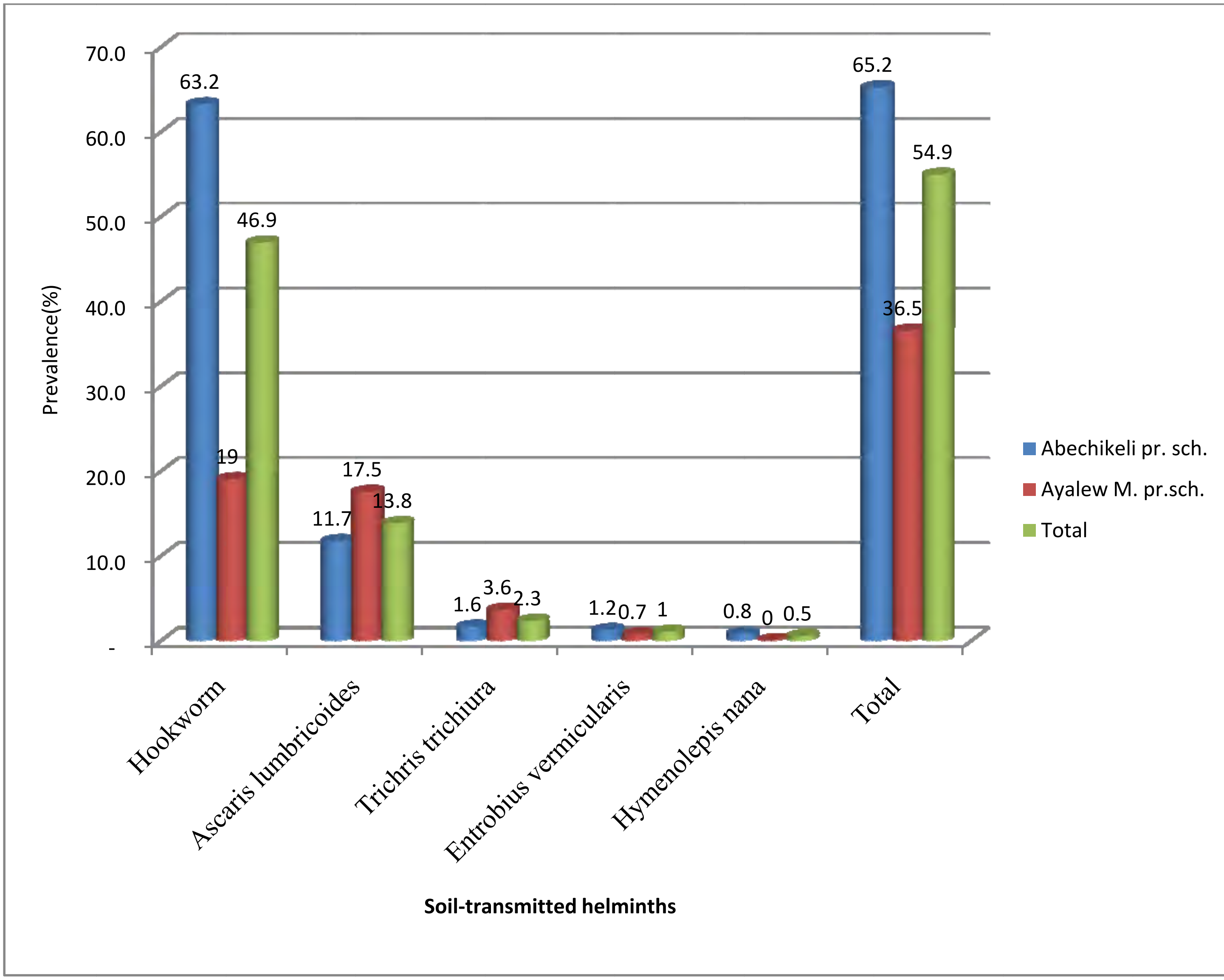

Figure 2. Prevalence of STH infections among school children in Abechikeli and Ayalew M. elementary Schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010.

The overall prevalence of STH infection was 54.9%,while the prevalence of single, double and triple infections were 45.8 %, 8.6 % and 0.5% triple respectively (Table 5). Concerning specific parasite, the prevalence of hookworm, and *Ascaris lumbricoides* infections were 82.4% and 14.8%

respectively. There were no single infections for *Enterobius vermicularis* and *Hymenolepis nana*, but found in mixed infections.

Table 5. Prevalence of single and multiple STH infections among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

STH infections	Total (N= 384) n (%)
Single infections	45.8 (176)
Hookworms species	82.4(145)
Ascaris lumbricoides	14.8(26)
Trichuris trichiura	2.8(5)
Enterobius vermicularis	0
Hymenolepis nana	0
Double	8.6(33)
Triple	0.5(2)
Over all prevalence	54.9(211)

Table 6 presents prevalence of STH infections by age groups. The prevalence of hookworm infection considerably increased with age, 32.6% in 6-9 years age group and 58.9% in 10-14 years age group(P=0.000).

Table 6. Prevalence of STH infections by age groups among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, and February to March, 2010

Age groups (years	Number examined n(%)	STH positive in number (%)					x^2	P-value
		Hw n(%)	Al n(%)	Tt n(%)	Ev n(%)	Hn n(%)		
6-9	175(45.6)	57(32.6)	25(14.3)	4(2.3)	1(0.6)	1(0.6)	17.235	0.000
10-14	209(54.4)	123(58.9)	28(13.4)	5(2.4)	3(1.4)	1(0.5)		
Total	384(100)	180(46.9)	53(13.8)	9(2.3)	4(1)	2(0.5)		

The prevalence of STH infections among males and females were 55% (94/171) and females was 55% (117 /213) (x^2 =0.000, P= 0.994) (Table 7).

Table 7. Prevalence of STH infections by gender among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Gender	Total tested	STH infection		x^2	P-value
		Positive n (%)	Negative n(%)		
Male	171(44.5)	94 (55)	77(45)	0.000	0.994
Female	213 (55.5)	117(55)	96 (45)		
Total	384(100%)	211 (54.9)	173 (45.1)		

4.3 Anthropometric measurements

Two different sets of nutritional indicators were used as recommended by World Health Organizations for 6-8 years of age and from 9 years and above (adolescent) (9-14). Nutritional values below -2 z scores or standard deviations were taken as cut-off points for being malnutrition as recommended by WHO (1995).

In Table 8, the overall prevalence of stunting among age groups 6-8 years was 9.4 % (10/106), of which 14.8% were males and 3.8% were females. There was no severe stunting, but moderate. On the other hand, 20.8% (22/106) of the school children aged 6-8 were underweight, of which 17.3% were females and 24.1% were males. Still sever underweight was rare (3.7%).The extent of wasting was 17.9 % (19/106), of which males and females were 14.8% and19.2%, respectively. There was a significant difference in the prevalence of underweight between males and females (P=0.027), but not for stunting, and wasting.

Table 8. Prevalence of stunting, underweight and wasting status by gender within age groups 6-8 years school children among males and females of school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Gender	Total Examined n(%)	**Height-for-age (Stunting)** Mild (< -1z score)	Moderate (< -2 z score)	Sever (<-3 z score)	Total for moderate	x^2	P-value
Male	54(50.9)	14(25.9)	8(14.8)	0	8(14.8)		
Female	52(49.1)	11(21.2)	2(3.8)	0	2(3.8)	4.614	0.100
Total	106(100)	25(23.6)	10(9.4)	0	10(9.4)		
		Weight-for-age (Underweight)					
Male	54(50.9)	28(51.9)	11(20.4)	2(3.7)	13(24.1)		
Female	52(49.1)	17(32.7)	9(17.3)	0	9(17.3)	9.188	0.027
Total	106(100)	45(42.5)	20(18.9)	2(1.9)	22(20.8)		
		Weight-for-height (wasting)					
Male	54(50.9)	25(46.3)	6(11.1)	2(3.7)	8(14.8)		
Female	52(49.1)	24(46.2)	8(15.4)	2(3.4)	10(19.2)	0.574	0.902
Total	106(100)	49(46.2)	14(13.2)	5(4.7)	19(17.9)		

Table 9 presents prevalence of stunting, underweight, and wasting by age and gender. The prevalence of stunting, underweight and wasting was 9.4%, 20.8%, and 17.9%, respectively. The prevalence of stunting and underweight among males were 14.8 %(8/54), and 24.1 %(13/54), respectively. However, wasting was higher in females (19.2%) 10/52) than in males (16.7 % (9/54).

On the other hand, the prevalence of stunting and underweight among females were 1.9% and 17.3%, respectively.

Table 9. Prevalence of stunting, underweight and wasting within the age group 6-8 years among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Gender	Stunting			
	6 years n (%)	7 years n (%)	8 years n(%)	Total n(%)
Male	-	1(1.9)	7(13)	8(14.8)
Female	0	2(1.9)	0	2(1.9)
Total	0	3(2.8)	7(6.6)	10(9.4)
	Underweight			
Male	-	4(7.4)	9(16.7)	13(24.1)
Female	0	9(17.3)	0	9(17.3)
Total	0	13(12.3)	9(8.5)	22(20.8)
	wasting			
Male	-	1(1.9)	8(14.8)	9(16.7)
Female	0	7(13.50	3(5.8)	10(19.2)
Total	0	8(7.5)	11(10.4)	19(17.9)

Key: '-'no 6 years age male participant

Genders combined, the overall prevalence of stunting within the age group 9-14 years was 13.3%, the respective prevalence among males and females become 17.9% and 9.9 % (Table 10).

Table 10. Prevalence of stunting by gender within age group 9-14 years, among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer, Debub Achefer District, Northwest Ethiopia, and February to March, 2010

Gender	Stunting						
	9 years n(%)	10 years n(%)	11 years n(%)	12 years n(%)	13 years n(%)	14 years n(%)	Total n(%)
Male	3(2.6)	6(5.1)	5(4.3)	5(4.3)	1(0.9)	1(0.9)	21(17.9)
Female	0	4(2.5)	4(2.5)	7(4.3)	1(0.6)	0	16(9.9)
Total	3(1.1)	10(3.6)	9(3.2)	12(4.3)	2(0.7)	1(0.4)	37(13.3)

BMI-for-age under **5th** percentiles was 37.6% (44/117) for males and 32.3% (52/161) for females were found to be under **5th** percentile, which is an indication for being wasted and/or underweight for 9-14 years of age(Table 11). In this age group, a total of 34.5% (96/278) were wasted (thinness), and/or underweight. Moreover, BMI-for-age percentiles of 5th - 85th, and ≥85th were calculated for analyzing the status of normal growth and to assess risks for overweight and/or obesity, respectively. However, there was no any risk for overweight among the study school children.

Table 11. Prevalence of underweight and/or thinness in the age group 9-14 years by gender among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Gender	BMI-for-age < **5th** percentiles (underweight/thinness)						
	9 years n(%)	10 years n(%)	11 years n(%)	12 years n(%)	13 years n(%)	14 years n(%)	Total n(%)
Male	10(8.5)	15(12.8)	5(4.3)	8(6.8)	5(4.3)	1(0.9)	44(37.6)
Female	13(8.1)	17(10.6)	7(4.3)	11(6.8)	4(2.5)	0	52(32.3)
Total	23(8.3)	32(11.5)	12(4.3)	19(6.8)	9(3.2)	1(0.4)	96(34.5)

Figure 3 presents summary of prevalence of malnutrition among school children for both age group of 6-8 and 9-14 years. The respective prevalence of stunting; underweight and wasting were found to be 12.2%, 30.7%, and 17.9%.

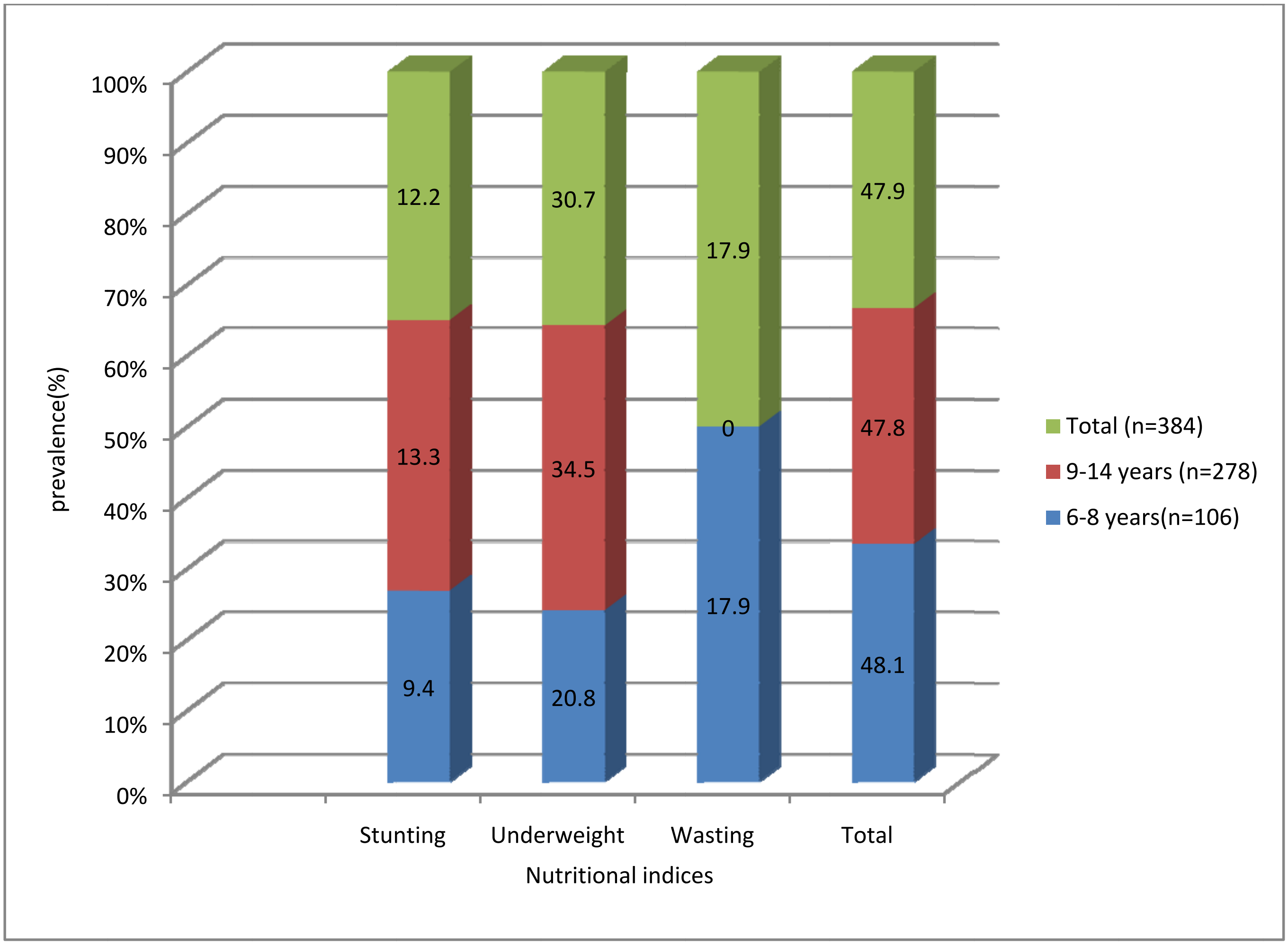

Figure 3. Overall prevalence of stunting, underweight and wasting among school children in Abchikeli and Ayalew Mekonnen Elementary Schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

The prevalence of hookworm infections among school children aged 6-8 years was 24.5% (26/106), while for 9-14 years was 55.4% (Table 12).However, there was no associations between hookworm infection and nutritional indicators ($P > 0.05$).

Table 12. Comparison of categorical nutritional parameters with stool positive and negative tests for hookworm infections within the age group 6-8 and 9-14 years among school children, Debub Achefer, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Nutritional indicators	Number	Hookworm infections: Infected %(n)	Hookworm infections: Not infected %(n)	OR(95%CI)	x^2	P- value
For 6-8 age groups	106	26(24.5%)	80 (75.5%)			
Stunting						
Yes	10	3	7	0.735 (0.176 - 3.076)	0.179	0.673
No	96	23	73			
Underweight						
Yes	22	3	19	2.388 (0.645 - 8.839)	1.779	0.182
No	84	23	61			
Wasting						
Yes	19	1	18	7.258 (0.919 -13.319)	2.641	0.101
No	87	25	62			
For 9-14 age groups	278	154(55.4)	124(44.6)			
Stunting						
Yes	37	22	15	2.691 (0.951-7.615)	0.285	0.593
No	241	132	109			
Underweight/thinness						
Yes(<5^{th} …)	96	54	42	0.372 (0.131- 1.052)	0.043	0.835
No(>5^{th} …)	182	100	82			

5^{th}…. = 5^{th} percentiles

4.4 Hemoglobin level

As shown in Table 13, the overall prevalence of anemia was found to be 17.2%, mild, moderate, and severe being 13.8%, 2.9%, and 0.5%, respectively.

Table 13. Prevalence of anemia by age groups among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Age/year category	Status of anemia						x^2 test	P-value
	Total examined No(%)	Sever No(%)	Moderate No(%)	Mild No(%)	Total anemic No(%)	Normal No(%)		
6 to 11	305(79.4)	1(0.3%)	7(2.3%)	40(13.1%)	48(15.7%)	257(84.3)		
12 to 14	79(20.6)	1(1.3%)	4(5.1%)	13(16.5%)	18(22.9)	61(77.2%)	3.193	0.526
Total	384(100)	2(0.5%)	11(2.9%)	53(13.8)	66(17.2%)	318(82.8)		

The prevalence of anemia in females was 18.8% (40/213), and 15.2% (26/171) among males. Severe anemia was lowest in both genders (Table 14). However, there were no statistically significant differences between males and females for the prevalence of anemia (P = 0.715).

Table 14. Prevalence of anemia by gender among school children, in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Sex	Total examined n(%)	Status of anemia				x^2	P-value
		Sever	Moderate	Mild	Total anemia		
Males	171(44.5%)	1(0.6)	6(3.5)	19(11.1)	26(15.2)		
Female	213(55.6%)	1(0.5)	5(2.3)	34(16)	40(18.8)	2.113	0.715
Total	383(100)	2(0.5)	11(2.9)	53(13.8)	66(17.2)		

The total prevalence of anemia associated with STH infections among school children was 15.4% (59/384) (Table 15). Only 1.8% of anemia was caused by non-STH infections. Hookworm infection constitutes 57.6% (38/145) of anemia and is the main predictor for the reduction of hemoglobin level among the school children in the current study.

Table 15. Associations between STH infections and anemia (hemoglobin level) among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

STH infections	Number Examined N=384	Anemia		OR(95%CI)	x^2	P-value
		Present N=66 n(%)	Absent N=318 n(%)			
Single infections						
yes	176(45.5)	39(59.1)	137(43.1)	1.908	5.642	0.018
No	208(54.2)	27(15.4)	181(56.9)	(1.114 - 3.270)		
Hookworms						
yes	145(37.8)	38(57.6)	107(33.6)	10.654	7.820	0.005
No	31(8.1)	1(1.5)	30(9.4)	(1.404 - 80.835)		
A. lumbricoides						
yes	26(6.8)	0	26(8.2)	NS	-	-
No	150(39.1)	39(59.1)	111(34.9)			
T. trichiura						
yes	5(1.3)	1(1.5)	4(1.3)	1.143	0.014	0.906
No	171(44.5)	38(57.6)	133(41.8)	(0.1254 -10.531)		
Double infection						
yes	33(8.6)	19(28.9)	14(4.4)	8.778	41.375	0.001
No	351(91.4)	47(71.2)	304(95.6)	(4.123 – 18.688)		
Triple infections						
yes	2(0.5)	1(1.5)	1(0.3)	4.877	1.521	0.218
No	382(99.4)	65(97.9)	317(99.7)	(0.301-78.9760)		
Total positive cases	211(54.9)	59(15.4)	152(39.6)			

NS= not statistically comparable

As illustrated in Table 16, Light infection for hookworms was accounted for 44 % (169/384), for *A. Lumbricoides,* 13.8% (53/384), and for *T. trichiura* 2.1% (8/384). Heavy infections were only observed for hookworms (1%). The highest egg count for hookworm was 4368 epg, while the least count was 24 eggs per gram. Hookworm infections showed significant associations (P< 0.05) with anemia at all levels of intensity.

Table 16. Associations between anemia and classes of intensity for major STH infections among school children in Abchikeli and Ayalew Mekonnen Elementary schools, Debub Achefer District, Northwest Ethiopia, February to March, 2010

Categories of intensity (epg)	Total number (%) of eggs	Anemic cases		x^2	P-value
		Anemic	Non-anemic		
Hookworm species					
Light (1-1,999)	169(44)	51(30.2)	118(69.8)	5.294	0.021
Moderate(2,000-3,999)	7(1.8)	4(57.1)	3(42.9)	2.071	0.03
Heavy(≥4,000)	4(1)	3(75)	1(25)	3.428	0.04
Ascaris lumbricoides					
Light(1-4,999)	53(13.8)	17(32.1)	36(67.9)	3.575	0.062
Moderate(5,000-49,999)	0	0	0	0	NS
Heavy(≥50,000)	0	0	0	0	NS
Trichuris trichiura					
Light(1-999)	8(2.1)	2(25)	6(75)	2.250	0.134
Moderate(1,000-9,999)	1(0.3)	1(100)	0	2.250	0.134
Heavy(≥10,000)	0	0	0	0	NS

epg = eggs per gram of feces, NS= not statistically comparable

5. Discussion

Knowledge about the extent of helminth infections in a given community is also a prerequisite for planning and evaluating intervention programs. The present study was conducted to investigate the associations of STH infections with malnutrition and hemoglobin level among schoolchildren (6-14 years) in Debub Achefer District, Northwest Ethiopia. The overall prevalence of any STH infection was 54.9% among school children. This was similar to prevalence of infection (55.6%) reported among school children Gondar, Northwest Ethiopia (Worku *et al*., 2009). Similar infection rate was also reported in another study conducted in Alaba Kulito Woreda, Southern Ethiopia (Degarege *et al.*, 2009).

On the other hand, the prevalence of intestinal helminth infections observed in the present study was higher than the prevalence (27.2%) reported from Babile area in eastern Ethiopia (Tadesse, 2005). Higher prevalence of helminth infection in the present study could be explained by a number of factors. In the present study area, only 34.1% of the study participants used piped water and 39.3% of school children had access to latrine facilities, where as the proportions using piped water and latrine facilities in Babile area were 99.6% and 84%, respectively. In addition, 95.7% of the school children in Babile town had shoes while only 52% of the children had shoes in the present study area.

Study from the low lands of Ethiopia reported that the highest prevalence of hookworm infections was 60-80 % (Tedla and Jemaneh, 1985). Other studies conducted in different parts of Ethiopia reported prevalence of hookworm infection ranging from 4.3% to 25.5% (Alie *et al.*, 1999; Tadesse, 2005; Worku *et al.*, 2009). The prevalence of hookworm infection reported in the present study was 46.6%. These variations indicate that infection rates depend on such factors as local personal hygienic and sanitary conditions, ecology and geography, among other factors.

Malnutrition is a considerable health problem with prevalence ranges of 4 - 46% in developing countries (Thomas *et al.*, 2001). In the present study, the prevalence of stunting observed among school children was 12.2%, which was relatively lower compared to previous findings in Attat area (48.3%) in Ethiopia (Birmeka, 2007). The prevalence of malnutrition observed among school children in Tanzania was 42.5% (Lwambo *et al.,* 2000) while a prevalence of 40.2% was observed among school children in Malaysia (Zulkifli *et al.,* 2000). Since stunting is a type of chronic malnutrition which begins in childhood, this difference might be attributable to difference in breastfeeding of an infant with breast milk.

The prevalence of underweight in the present study (30.7%) was lower than the prevalence of underweight (36%) reported from Southern Ethiopia (Birmeka, 2007). On the other hand, it was higher than the prevalence reported for Malaysian school children (25.7%) (Zulkifli *et al.,* 2000). The variations may be probably due to differences in nutrition and types of staple food the communities live upon.

In the present study, the prevalence of wasting and underweight were found to be higher than those of both the regional and the national rates, where wasting was 6.5% both nationally and regionally, and underweight was 29.7% regionally, but 20.8% nationally (FMOH, 2005). The higher rates of acute malnutrition in the present study may be due to inadequate dietary intake, cultural, religious, or other factors associated with low socio-economic development such as differences by place of residence and mother's education (EDHS, 2005).

Improvement in the growth of children following antihelminthic treatment indicates that malnutrition is associated with parasitic infections. A study in Mexican (Quihui-Cota *et al.*, 2004), Thailand (Egger, 1990), Brazil (Tsuyuoka *et al.*, 1999), and in Malaysia (Al-Mekhlafi, *et al.,* 2005) demonstrated the associations between intestinal parasitic infections and nutritional indicators among schoolchildren. This is in agreement with previous reports from Gondar (Worku *et al*., 2009). However, malnutrition did not show any statistical significant association with STH in the present study. This difference could be due to difference in socio-demographic and socio-economic status of the community.

Hookworms have long been recognized as an important cause of iron deficiency anemia (Stephenson *et al.,* 1994; Crompton, 2000). The current study also showed significant association of anemia with STH infections, particularly with hookworm infections. This observation is in agreement with the earlier studies done in other parts of Ethiopia (Birmeka, 2007; Woldeyes, 2007; Tsegaye *et al.,* 1999), Malawi (Verhoeff *et al.*, 1998), and in USA (Hawdon and Hotez, 1996).

Studies conducted in Kenya (Latham *et al.,* 1983) and Egypt (Curtale *et al*. 1998) reported that anemia is associated with hookworm infections at all level of intensity. Similarly, the present study showed that light, moderate and heavy intensity of hookworm infections have statistically significant associations with anemia. Bates *et al.* (2007) also reported that heavy and light infections of hookworms showed very strong relationships with anemia.

Contrary to the present observation, Haidar and Pobocik (2009) reported the absence of significant association between hookworm infections and anemia although prevalence of anemia was slightly higher among women aged 15 to 49 years. Similarly, a study among schoolchildren in Southeast of Lake Langano, Ethiopia, showed the absence of associations between hookworm infections and haematocrit values (Legesse and Erko, 2004). Moreover, studies in Panama also failed to demonstrate associations between hookworm infections and anemia at lower intensities (Robertson *et al.,* 1992).The possible explanations for the observed discrepancy between these findings could be variations in the duration of infection, and differences in nutritional intake.

6. Limitations of the study

Seasonal variations were not considered for STH and malnutrition surveys. Age determination was also difficult as there were no birth certification cards for each child.

Taking a single stool examination will sometimes miss very light infections since egg excretion is variable from day to day. In addition, both finance and time constraints prevented detailed studies of the proposed work.

7. Conclusion and recommendations

The results of this study show high prevalence of hookworm infections, malnutrition and anemia among schoolchildren in Debub Achefer Ddistrict, northwest Ethiopia. No association was observed between STH infection and acute malnutrition in the present study as malnutrition is a multifactorial problem. Hence, detailed studies are required to investigate the association of helminth infection and malnutrition.

High prevalence of hookworm infection in the present study calls for mass drug administration to reduce the prevalence of infection and anemia to below the level of public health importance. Complementation of the deworming program with non-disease specific measures such as health education on personal hygiene and environmental sanitation is also recommended to maintain the impact of deworming.

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9. Appendices

Annex 1. Structured questionnaires

ADDIS ABABA UNIVERSITY
FACULTY OF SCINCE
GRADUATE STUDIES

This is a **questionnaire** set to gather information on the study subjects (students) among primary schools children in Debub Achefer District, Northwest Ethiopia.

Instruction: First tell interviewee that you are going to ask him/ her question about himself/herself and his/her family. Then, request him/her to correctly respond to the questions. Please write clearly (to be filled by field assistant).

Name of interviewer________________ ________________ Sign ______ Date ____________

Part 1: Student's school record and **socio-demographic** information

1. Student's name __________________________Age (to the nearest year)____Sex ___Grade and section _____Student's code_____________ School code ___________
2. Residence : a) Rural b)Urban ______________
3. Ethnic group_______ 4. Religion ____________

Part 2: Student's **scioeconomic** aspect

4. What is your mother occupation? a) House wife b) Merchant c) Government employee d) Private employee e) daily laborer f) Others _____
5. What is your father's occupation? a) Farmer b) Merchant c) Government employee d)daily laborer e) private employee f) Others ---------
6. What is your mother education level?
   a) Unable to read/write (Illiterate) b) Able to read /write (Literate)
7. Do your parents have radio? a) yes b) no
8. What is the number of your family? a) 1 b) 2 c) 3 d) 4 e)5 f) 6 g) 7 h) 7 i) >7
9. What is your father's education level?
   a) Unable to read/write (Illiterate) b) Able to read /write (Literate)
10. Do your parents have television a) yes b) no
11. Whose property is the house in which you live?

a) Our own   b) Rented house

12. Of what material is your house floor made?

a) Cement b) Earthen c) other (specify) _______________

13. From where do you get your drinking water? a) from tap b) from protected/ cleaned spring /well c) from unprotected stream/well/ d) from river

14. How do you pour or take out water from the container?

a) Inclining the water container b) Immersing can

15. Do your parents have latrine? a) yes b) no

16. How often the families use the latrine? a) always b) sometimes c) never use

17. How does family dispose your house waste? a) Burning b) into waste pit c) Open field

18. Do you always wash your hands before you eat? a) Yes b) no

19. Do you eat raw vegetables? a) yes b) no

20. Do you always wear shoes? a) yes b)No

21. Do you always wear shoes? 1. yes 2.No

Part 3: **Medical history**, **diseases and symptoms i**nterview questionnaire to be filled by health assistant/ a nurse **interviewer.**

22. **Observation**, usually inspect the student against the questions below

a) Conjunctiva/nail bed pallor? 1. Yes 2. No

b) Dirt in finger nails? 1. Yes 2. No

c) Facial/ pedal edema? 1. Yes 2. No

d) Wearing shoes? 1. Yes 2. No

e) Other gross abnormalities _________________________

Annex 2. CDC growth charts for boys and girls from 2 to 20 years developed by NCHS (modified in 2000).

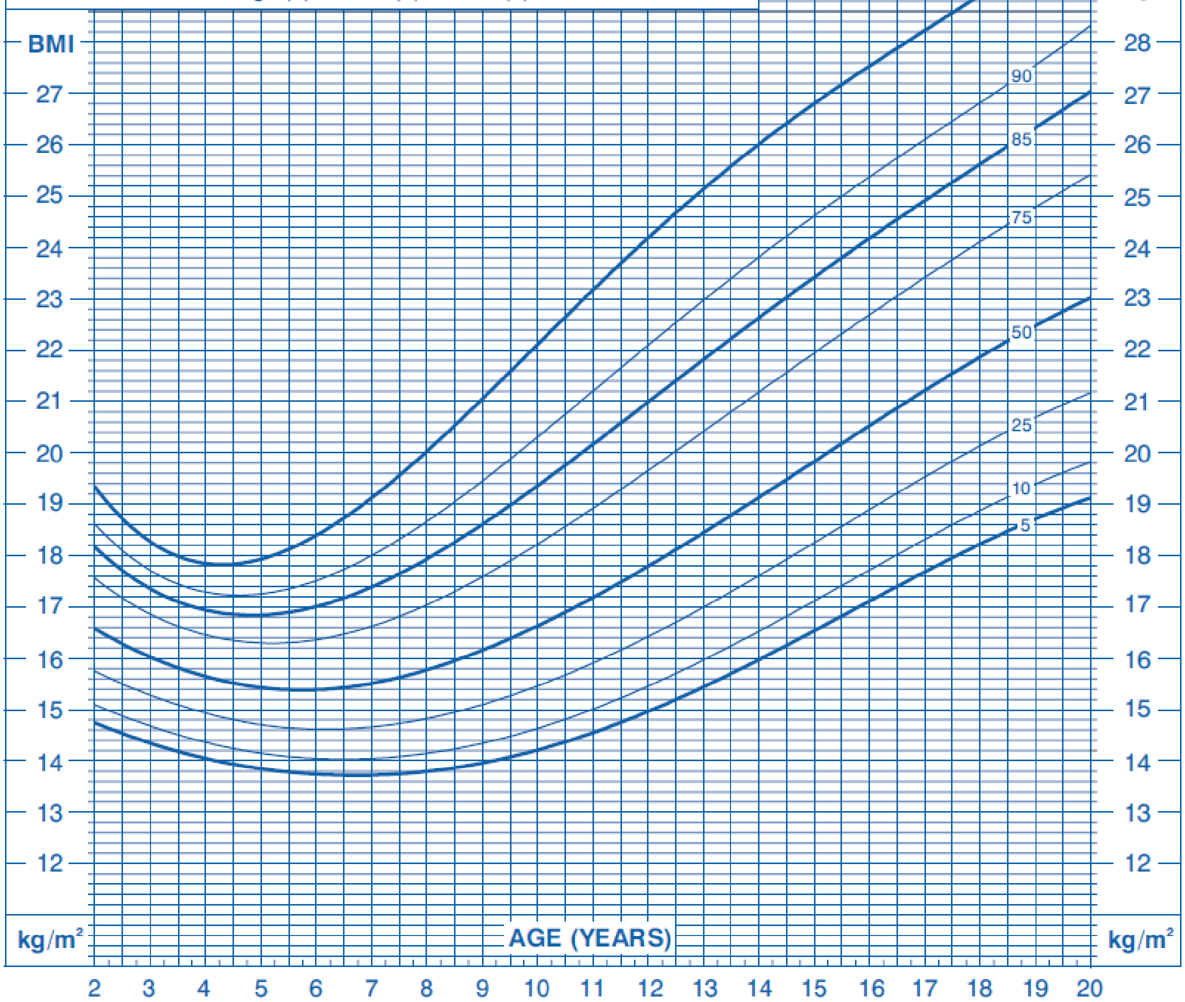
2 to 20 years: Boys
Body mass index-for-age percentiles

NAME ______________________

RECORD # ____________

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI**: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

CDC SAFER · HEALTHIER · PEOPLE™

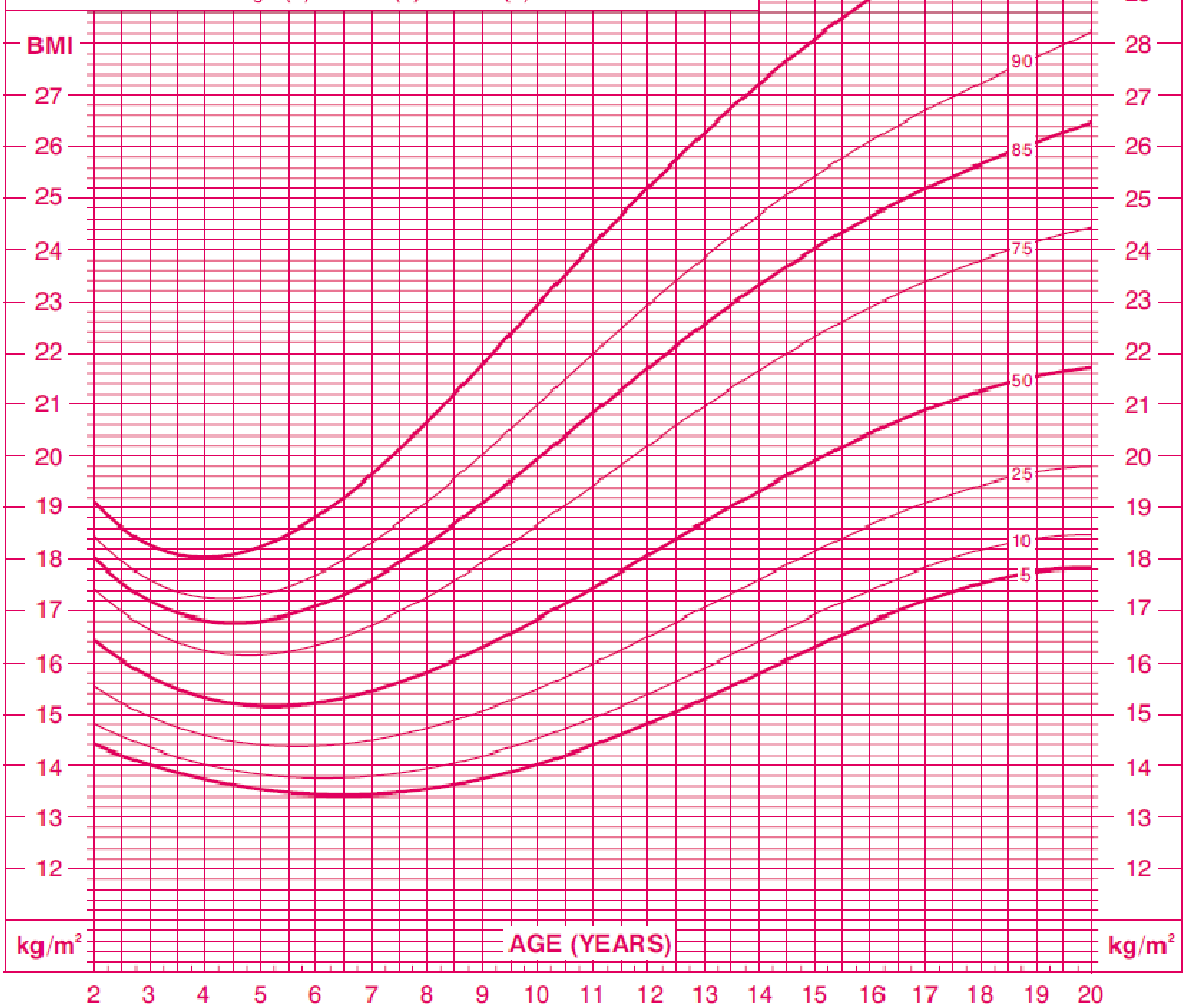
2 to 20 years: Girls
Body mass index-for-age percentiles

NAME ______________________

RECORD # ____________

Date	Age	Weight	Stature	BMI*	Comments

***To Calculate BMI**: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

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Annex 3.Values calculated from CDC/NCHS growth chart for age groups starting from 9 and above years used as reference to determine wasting and/or underweight by considering BMI-for-age percentiles

Boys(2 to 20 years)		
Age/years	5th percentiles	85th percentiles
9	14	18.6
10	14.2	19.4
11	14.4	20.2
12	15.0	21.0
13	15.4	21.8
14	16	22.4
Girls (2 to 20 years)		
Age/years	5th percentiles	85th percentiles
9	13.7	19.1
10	14.1	20
11	14.4	20.8
12	14.8	21.8
13	15.3	22.5
14	15.8	23.4

Annex 4. Distribution of study participants selected from Abchikeli and Ayalew Mekonnen primary school children, Debub Achefer District, February-March, 2010(N=384)

Grade level	Abchikeli	Ayalew M.	Total n(%)
One	44(11.5)	52(13.5)	96 (25)
Two	40(10.4)	56(14.60	96(25)
Three	58(15.1)	29(7.6)	87(22.7)
Four	42(10.9)	0	42(10.9)
Five	26(6.8)	0	26(6.8)
Six	37(9.6)	0	37(9.6)
Total	247(64.3%)	137(35.7%	384(100%)

Annex 5. Written Consent Form

You are invited to participate in a study of malnutrition and anemia associated with intestinal geohelminths in your area. The study is going to be conducted by Ato Tilahun Alelign from the Graduate school of science faculty, Addis Ababa University. I am currently a postgraduate student of Biomedical Science in the Department of Biology. I would like to obtain stool sample, a drop of blood sample from finger and need to measure your body weight and height. There is no any health related risk in participating. When you or your children are found positive for intestinal helminthiasis and anemia, you will receive standard drugs free of charge. The information in your records is strictly confidential.

Your participation in this study is completely voluntary and you can refuse to participate or free to withdraw yourself from the study at any time. Refusal to participate will not result in loss of medical care provided or any other benefits. Do you understand what has been said to you? If not, you have the right to get proper explanation.

I am informed to my satisfaction the purpose of this study nature of laboratory investigation. I am also aware of my right to opt out of the study at any time during the course of the study without having to give reasons for doing so.

This consent form has been readout to me in my own language, and I understand the content and I am voluntarily consent to participate in the study.

Study Code No __________Study area_______________________________________

Name_______________________________Signature_____________Date___________

Wittiness

Name______________________________ Signature _________ Date__________

Investigator

Name __________________________________ Signature __________ Date _________

Figure 4. Picture showing anthropometric measurements