Journal of Infectious Diseases and Patient Care

Review Article

WRJIDPC-25-010

Prevalence and Risk Factors Associated with Geohelminth Infections Among Pre-School Aged Children Attending Kabutare District hospital in Rwanda

Patrick Nemeyimana[1]*, Jean Paul Tuyisenge[1], Jacques Karekezi[2], Dany Kanobana[2], Clemence Tumukunde[2], Pascal Kayiranga[2], Ella Larissa Ndoricyimpaye[2], Ruhumuriza Anselme[2], Bisanukiuri Evergiste[3], Iraguha Alain[3], Turatsinze Benon[3], Karenzi Valens[3], Shema Eliah[3], Nshimiyimana Charles[3] and Uwumuremyi Fabrice[3]

[1]University of Rwanda-Legacy Clinics Pathology Department-Medical Informatics Innovates Ltd., Kigali, Rwanda
[2]University of Rwanda, Kigali, Rwanda
[3]Quality and Accreditation at Legacy clinics, Rwanda

***Correspondence:** Patrick Nemeyimana, University of Rwanda-Legacy Clinics Pathology Department-Medical Informatics Innovates Ltd., Kigali, Rwanda, E-mail: nemeyepatrick2015@gmail.com; DOI: https://doi.org/10.56147/jidpc.2.1.10

Citation: Nemeyimana P, Tuyisenge JP, Karekezi J, Kanobana D, Tumukunde C, et al. (2025) Prevalence and Risk Factors Associated with Geohelminth Infections Among Pre-School Aged Children Attending Kabutare District hospital in Rwanda. J Infect Dis & Pati Care 2: 10.

Abstract

Geohelminthiasis remain a major public health problem, in tropical and sub-tropical regions. Though infections are prevalent among all age groups, the World Health Organization recommended strategies to control those infections and now pre-school aged children are involved. This study aimed at determining the prevalence of *Geohelminths* and associated risk factors among pre-school aged children attending Kabutare District hospital.

A cross-sectional study was conducted at Kabutare district hospital. The pre-school aged children were selected by convenience sampling method and invited to participate in the study. Formal-ether concentration technique was employed for parasitological analysis of stool samples and structured questionnaire survey was used to gather the information related to the factors.

Total of 308 pre-school aged children were recruited. The study showed that 24.4% of children were infected with one or more species of *Geohelminths*. *A. lumbricoides* was the most prevalent soil-transmitted helminth (12.0%), followed by *T. trichiura* (6.5%), hookworm (2.6%) and co-infection of *A. lumbricoides* and Hookworm (3.2).

Geohelminths were a public health problem among pre-school aged children in the study area necessitating deworming and developing measures to control morbidities associated with STH. Besides, the existing health education program should also be strengthened to prevent re-infection in the pre-school aged children.

Keywords: *Geohelminthiasis*; Public health problem; 308 pre-school aged children; Infections

Received date: January 11, 2025; **Accepted date:** January 15, 2025; **Published date:** February 10, 2025

Introduction

Definitions of key terms pertinent to the study

Geohelminths: They are also called Soil-Transmitted Helminths (STH). Those are a group of parasites that are transmitted through soil contaminated with faecal materials and lead to diseases described as *Geohelminthiasis* or soil-transmitted helminthiasis [1].

Infection: Invasion of a host organism by a microorganism, proliferation of the invading organism and host reaction [2].

Parasite: Unicellular or metazoan organisms living in or on an organism of another species (host) on the expense of the host [3].

Prevalence: Statistical concept referring to the number of cases of a disease, which are present in a particular population at a given period [4].

Risk factors: Variables which are related to increased risk of infection or disease [5].

Background

Geohelminths or Soil-Transmitted Helminths (STHs) are a group of parasites that are transmitted through soil contaminated with faecal materials and lead to diseases described as *Geohelminthiasis* or soil-transmitted helminthiasis. *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms, *Necator americanus* and *Ancylostoma duodenale* are important parasites associated with geo-helminthiasis [1]. The disease burden is found to be concentrated in the poorest communities with higher morbidity and predisposing factors are related to poverty hence taken as neglected tropical diseases [6].

The global atlas of Helminth Infections Estimates in 2010 indicates that >1.7 billion people were affected by geohelminth parasites. The recent worldwide estimation of *Geohelminthic* infections shows that more than 1.5 billion are infected with the highest distribution in sub-Saharan Africa, America, China and Asia. Over 568 million are School-Aged Children (SAC) and over 267 million are Preschool-Aged Children (PSAC) who live in the areas where these parasites are mostly transmitted need treatment and preventive interventions [7].

In Africa, many studies have been conducted in estimating prevalence but varies according to the region, groups of people such as SAC and population zone of poor facilities at high risks and it was found that infection increases with age as children become independent [8]. In Uganda, the reported prevalence in PSAC at Hoima was 26.5% higher than reported in Dschang (Cameroun), Butajiri (Ethiopia) and Wonji Shoa sugar estate of Ethiopia with 19.7, 23.3 and 24.3% overall prevalence respectively [9].

In Rwanda available data indicates that soil-transmitted helminthic infections continue to appear as endemic despite there exist control programs attributed by the country and the prevalence in PSAC is most of the time neglected in epidemiological studies [10]. By 2008, a national survey involving over 8000 SAC sampled across 30 districts recorded that 66% of individuals were infected with geohelminth parasites. Currently, according to Ruberanziza et al. the reported prevalence of soil-transmitted helminth in Rwanda based on a 2014 Kato-Katz survey of 9226 Rwandan school children, it was found that *A. lumbricoides* was the most prevalent geohelminth parasite (37%) followed by *T. trichiura* (23%) and hookworm at lower prevalence (5%) [3]. Geographical variation in observed prevalence for *A. lumbricoides* and *T. trichiura* showed concordant patterns with Northern, Western and the Southwestern parts of the country were highly affected. However, hookworm's prevalence was low across the country. The transmission of STHs continues to occur in Huye district and it has been mapped as a highly affected area with high prevalent of *A. lumbricoides* in SAC [3].

Problem statement

Geohelminths contribute to *Geohelminthiasis* worldwide with high prevalence in sub-Saharan Africa including Rwanda [11]. The public health burden of *Geohelminths* has been consistently underrated in PSAC as it was found that they contribute to the observed heavy burden of SAC [8]. As indicated by Ruberanziza et al. these infections are still highly prevalent in SAC in Rwanda [3]. They may continue to have a significant relation to different complications if no control and prevention measures taken in PSAC. In 2016, the baseline prevalence of geohelminth infections was 45.2% and the target was to reduce the infections to 35% in 2020 and then less than 20% in 2024 [12].

In Rwanda, the control strategies of STHs are by mass treatment where the entire population of an area is given antihelminthic medicines at regular intervals irrespective of individual infections status by Albendazole and Mebendazole. Deworming is combined with another approach such as the improvement of water access, sanitation including improved latrines and faecal sludge management and hygienic practices like handwashing habits, nails trimming and wearing shoes for the long-term *Geohelminthic* infections control and elimination [13]. These control measures against *Geohelminthic* infections are implemented, but SAC are highly targeted leaving behind PSAC [5]. This can be attributed to little knowledge of the magnitude of *Geohelminthic* infections and the influencing factors in PSAC. However, studies show that *Geohelminths* are also significantly prevalent in PSAC.

Therefore, this study is intended to show the magnitude of the burden of geo-helminthic infections among PSAC in Huye district, Southern province of Rwanda and their relation to demographic factors of preschoolers, the water source of preschoolers, latrine usage, hygienic behaviours and practice, parental hygienic behaviours, rural/urban areas and over crowdedness, parental job occupation and educational level.

Objectives

Main objective

To determine and document the magnitude of geo-helminthic infections among pre-school aged children attending Kabutare district hospital and assessment of the possible risk factors.

Specific objectives

- To report the overall prevalence of geo-helminthic infections in preschool-aged children attending Kabutare district hospital.
- To identify possible risk factors associated with geo-helminthic infections in preschool-aged children at Kabutare district hospital.

Research question

- What is the prevalence of *Geohelminthic* infections among in preschool-aged children attending Kabutare

Journal of Infectious Diseases and Patient Care

district hospital?

- What are the risk factors associated with *Geohelminthic* infections in preschool-aged children attending Kabutare district hospital?

The significance of study

This study documents the burden and risk factors of soil-transmitted helminths among preschool-aged children in Huye district, Southern province of Rwanda, the latter being currently neglected in terms of epidemiological studies. The study may help the Rwanda Ministry of Health, Huye district leaders and other health sector stakeholders to identify the ways of tailoring control measures and targeted interventions to protect this risky group of PSAC.

Literature Review

This chapter contains a theoretical literature including; introduction, epidemiology, transmission and risk factors of *Geohelminthic* infections.

Introduction to geohelminth infections in PSAC

Geohelminth infections are the most common parasitic infections worldwide. Most commonly they are found in tropical and subtropical regions of the developing countries where poverty and unhygienic practices prevail [14]. Part of *Geohelminths* development takes place outside of the human body in soil. The infection occurs when an individual gets in contact with parasite eggs or larvae in contaminated soil. Many infected individuals are asymptomatic depending on the intensity of infection [11].

The mode of transmission of geohelminth infections, it was found that *Ascaris lumbricoides* and *Trichuris trichiura* follow a modified direct transmission [15]. Their eggs are passed in the stool and then undergo stages of development to become infective in soil. The development and transmission of these *Geohelminths* indicate that soil, food and water might be contaminated with the infective eggs and then eventually ingested [16]. The prevalent sanitary conditions of the locality favour the spread of the parasites. The poor hygienic practices such as drinking contaminated water from the public tap and hand-dug well water sources, using open-pit latrine and some attitudes such as to defecate on open fields, not washing hands with soaps after defecation, picking objects from the ground and playing on the soil of the PSAC and SAC predispose children to the risk of contaminating their hands with infective stages of *Ascaris lumbricoides* and *Trichuris trichiura* [17].

For hookworm infections, the transmission is by penetrating the skin [15]. The eggs of hookworm are passed in faeces into the soil, hatch into larvae and then undergo further development into filariform larvae (infective stage). So poor hygienic practice such as defecating on the open fields and environmental conditions like warm and moist climates favour the transmission in PSAC and SAC. Besides, the attitude of not wearing sandals while playing in the soil predispose children to the active penetration of infective hookworm larvae in the soil [17].

The morbidity caused by *Geohelminths* includes malnutrition, anaemia, malabsorption disorders, intestinal obstruction, dysentery, rectal prolapse, respiratory complications and poor weight gain in PSAC [18]. Poor weight gain during *Geohelminthic* infections is caused by the adult helminth worms residing in the intestines. This interferes with the host's nutrition status and can induce damage to the intestinal mucosa, resulting in the host's reduced ability to extract and absorb nutrients from food [18].

Apart from acute clinical disease, chronic heavy *Geohelminthiasis* can lead to insidious and debilitating diseases, especially in PSAC and women of child-bearing age [19]. In addition to their health effects, an intestinal helminth infection impairs cognition in PSAC and hinders economic development [20]. Infections can be primarily caused by the absence of safe drinking water, lack of hygienic behaviour, improper sanitation, poor faecal disposal systems, poverty and a wide dispersion of parasites within human communities.

Epidemiology of geohelminth infections

Soil-transmitted helminths are distributed worldwide. The incidence of *Geohelminthic* infections, particularly among poor human populations living in low- and middle-income countries, continues to be a major public health concern [7]. The prevalence of *Geohelminthic* infections has remained at a similar level over the past 50 years [21]. *Geohelminths* usually co-infect the host. Recent global estimates indicate that approximately 3.5 billion people are infected with one or more of the most common of these nematode parasites **Figure 1** [22].

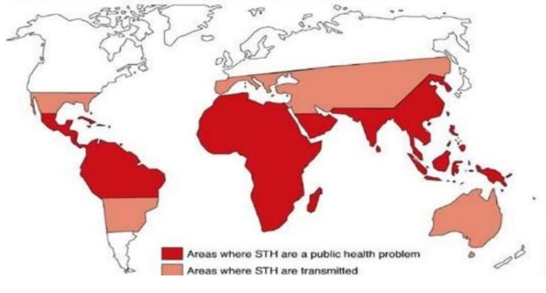

Figure 1: The epidemiological distribution of *Geohelminthic* infections.

From the survey of 2003, *A. lumbricoides* global prevalence was 1.2 billion of which more than 50% cases were seen in China, *T. trichiura* prevalence was 795 million and hookworm was estimated to be 740 with high numbers in china and Sub-Saharan Africa contributing nearly 50% of hookworm [23]. Another survey by Pullan et al. revealed the prevalence of 819 million, 464 million and 439 million rates of *A. lumbricoides*, *T. trichiura* and Hookworm infections respectively of which 50% of the cases seen in South Asia and Sub-Saharan Africa [6].

From recent surveys in Rwanda, soil-transmitted helminthic infections were found to affect more SAC. The obtained data for geographical distribution of STHs reviewed through countrywide mapping the overall prevalence of any STHs was 65.8% with 38.6% for *A. lumbricoides*, hookworm 31.6% and 27% for *T. trichiura* [24]. The national mapping in 2008 revealed the higher prevalence of *A. lumbricoides* and *T. trichiura* in Western and Northwestern part of the country whereas higher prevalence of hookworm was found in the East of the country [10]. STH infections are more prevalent in SAC, from the contribution of the higher burden of *Geohelminthic* infection in PSAC which is sometimes neglected, in rural areas compared to urban areas where sanitation and resources are limited. By comparing geographical distribution in urban to rural areas in Rwanda 2014, the prevalence in rural areas was 38% over 13% in urban areas [25].

Risk factors of geohelminth infections in PSAC

Demographic factors: Children may be exposed to geohelminth infections within first 5 years of life irrespective to their gender (sex). A study conducted by Ojja et al. in Hoima district (Uganda) showed that the age had a significant association with STH infections (Pearson chi-square test: p=0.002), as it was found that PSAC with 5 years old were 1.2 times more likely to be infected than those aged 1–2 years [9]. This stated age was fitted in the age group found in the study conducted in the Ogun state (Nigeria) where geohelminth infections were higher among PSAC within 0–60-month age category and children within 60-72-month category. Also, Shumbej et al. documented that children within the age group of 36-47 months were 2.5 times more likely to get infected with STH than those within the age group of 12-23 months.

In a study conducted by Ojja et al. the prevalence of STH infections was significantly higher in boys than in girls [9]. There was a significant sex difference in the prevalence of Hookworm infection (p=0.004), but insignificant sex difference was observed in the prevalence of *A. lumbricoides* and *T. trichiura* infections (p=0.298 and p=0.657). Moreover, Tekalign et al. reported that males were 1.67 times more often get an infection than females. But studies conducted to geohelminth infections in Dschang (Cameroon) and Butajiri (Ethiopia) showed indifference between gender groups [26].

Water source of preschoolers: Drinking water from unprotected sources was found to be associated with STH infections in PSAC. A large number of preschoolers were found to obtain their daily water from both public tap and hand-dug well water sources, this enhanced the better morbidity as those children are exposed to contaminated water. In a study conducted to Kenyan schoolchildren, Freeman et al. reported that improved water source supply as a factor was more strongly related to lower infection of STHs (p=0.83). Moreover, in a study conducted among Rural Community of Southwest Ethiopia by Tekalign et al. reported that the infections of STHs were found to be 1.9 times in people drinking untreated water compared to the people who drink treated water [26]. The indifference trends were reported by Menzies et al. in a study conducted in the children of the first 3 years of life in the tropics [27].

Latrine usage of preschoolers: Many preschoolers were found to use open-pit latrine and some of them defecated on open fields. The study conducted by Omitola et al. where only 97 provided the adequate stool samples for microscopic examination, the majority of the 72.2% were found to use open-pit latrine and 19.6% of them were found to defecate on open fields, thus increasing the susceptibility to STH infections in PSAC (p=0.099 and p=0.120 respectively) [28]. Also, among those that use toilet facilities, 78.4% of them were found to share with another member of their household or community and it was related to the STH infections in PSAC (p=0.513). In the study done by Pasaribu et al. showed that improved latrines and faecal sludge management decreased the risk of infection [15].

Hygienic behaviours and practice of preschoolers: It is found that the PSAC who don't wash their hands with soap before eating and after defecating and those who don't trim their nails are at high risk of being infected with *Geohelminths*. In the study conducted in Preschool Children Living in Farmland North Sumatera, Indonesia, Novianty et al. reported that washing hands before eating or after defecation and nail trimming habit of children have a significant association with prevalence of STH infections in PSAC (p=0.003 and p=0.007) [29]. Moreover, in the Ogun state (Nigeria), Omitola et al. showed that playing on soil, picking objects on soil and eating uncooked food and lack of sandals when playing on soil were found to be associated with a high prevalence of STH infections in PSAC, with p-value of 0.052, 0.133 and 0.003 respectively [28]. Shumbej et al. also showed that children who had no regular practices of washing their hands before a meal were 3 times more likely to be infected with STHs than those who had regular practices (p=0.001) [30].

Another study conducted to SAC living in an agricultural area of North Sumatera (Indonesia) by Pasaribu et al. documented that approximately 62.39% of children played with soil/dirt every day and only 50% of them regularly washed their hands after those activities [15]. Most of the children wore shoes/slippers when going outside (87.82%) and used a latrine for defecation (85.04%). So, they found that playing without wearing sandals in contaminated soil, not washing hands and nails trimming have been shown to increase the risk of STH infections 7.53 times (p<0.001 on each), while hand washing habits and latrine usage decreased the risk of STH infections 0.16 times each.

Parental hygienic behaviors: One of the factors for geohelminth infections in PSAC is poor hygiene of mother or caregiver. Novianty et al. reported that hand washing habit of mother/caregiver, eating uncooked food and nail trimming habit of mother/caregiver have a significant association with the incidence of STH infections in PSAC (p value of 0.004, 0.016 and 0.018, respectively) [29]. The children from mother/caregiver who did not do hand washing, have a habit of eating uncooked food in the family and have the habit of not trimming nails possess the high probability of getting STH infections at a rate of 5.3 times, 4.0 times and 3.5 times compared to the children from the opposed group, respectively. Slightly difference in trends were also reported by Menzies et al. in study conducted in the children of first 3 years of life in the tropics and by Shiferaw et al. in study conducted in pregnant women at Anbesame health center, Northwest Ethiopia [27].

Rural/urban areas and over crowdness: A child's playground and a densely populated home environment may lead to the transmission and spread of the diseases of *Geohelminths*. This is because, in densely populated area, the poor environmental sanitation such as improper faeces disposal and use of night soil has been reported to be predominant. Therefore, this improves STHs prevalent among PSAC. In the study done by Menzies et al. reported that people who lived in rural areas have had the increased risk of infections of the STHs compared to those who resided in the urban areas and the household overcrowding was associated with first infections after the 1st year of life [27]. The previous studies were done in PSAC and SAC in rural Southwest China, in Butajira (Ethiopia) and in PSAC in southern rural Lao People's Democratic Republic, have identified similar factors as being associated with risk of STH infections.

Moreover, Traub et al. 2014 showed that individuals living in households with more than six members were 2.0 times, 1.6 times and 1.7 times more likely to be infected with *Ascaris lumbricoides* (p=0.0041), *Trichuris trichiura* (p=0.0561) and hookworm (p=0.0338) than individuals living in households with six or fewer members, respectively [31]. Ostan et al. and Maia et al. also reported that increased number of household members from eight members or more in the family and the overcrowded conditions are associated with a higher frequency of geohelminth infections and may lead to increased risk of intra-family transmission [32,33]. This is in contradiction to the work of Quihui et al. which observed that family size had no significant effect on the rate of parasitic infections [34].

Parental job occupation: It was also found that parental activities affect the children infection rate of *Geohelminths*. In the study conducted by Anuar et al. more than 60% of the population in Negritos and Senois villages were categorized under low household incomes family (RM500) and this has shown the increased risk of being infected with *Geohelminths* [35]. Moreover, Novianty et al. reported that the majority of PSAC infected with *Geohelminths*, most of their fathers' occupations were in the vegetable farming category, 86.7%, as well as their mothers' occupation, 86.7% [29]. In the study conducted to PSAC in Elberton Municipality (Kenya), Mokua et al. reported that father's job occupation showed significant differences (P=0.001562) and mother's occupation did not show a significant difference (p=0.033393) in PSAC STH infections. Parental job occupation has been also reported to influence STH prevalence in children in Peninsular Malaysia and in South-Eastern Nigeria [36].

Parental education: The parents with low educational level were also found to be associated with an increased risk of geohelminth infections across the first 5 years of the life of their children. Shumbej et al. showed that children within the age group of 36-47 months (33%) whose mother or guardian had no formal education (37.8%) had a significantly high prevalence of 23.3% of the STHs (p=0.001) [30]. In the study conducted in Three Orang Asli tribes in Peninsular Malaysia by Anuar et al. reported that low level of mother's education and father's education is a major factor associated with STH infections (p=0.004 and p=0.015 respectively) [35]. Furthermore, the same trends were found in the studies done by Shakya et al. and Quihui et al., 2006 from Nepal and Mexico, that children of illiterate and basic education fathers and mothers were often infected by STHs than the literate ones respectively [34,37]. It was also revealed that better-educated parents had the lower association of intestinal parasitic infections in children as previously reported by Nematian et al. and Wamani et al., 2004 with children from Iran and Uganda [38].

Methodology

Study area

The study was conducted at Kabutare district hospital, located in Ngoma sector Huye district of the southern province of Rwanda.

Study design

The cross-sectional study design was used in this project as the outcomes and exposures were measured at the same time in the targeted population. Here the participant was tested for the presence of *Geohelminthic* infection at the same time as a structured questionnaire was used in assessing risk factors.

Study population

This study included all PSAC who live in Huye district attending Kabutare district hospital whose parents consented to participate in this study.

Study sample (sample size)

A total number of 308 (80.2%) of participants were recruited at Kabutare district hospital. The initial sample size was 384 and it was calculated using the following formula to get sample size in our target population according to the formula of prevalence [39].

$$n=\frac{z^2 * p(1-p)}{d^2}$$ Where,

N: Is sample size,

Z: Is statistic for the level of confidence, 1.96 on 95% confident interval,

P: Is the prevalence. According to the previous prevalence studies in Rwanda, there is no prevalence of geohelminth infections among preschool-aged children. Then the proportion of 50% is used to calculate the sample size with unknown previous studies in the area.

Therefore, p to be used is equivalent to 0.5

D: Precision, if 5% is equivalent to 0.05.

Journal of Infectious Diseases and Patient Care

From the formula, sample size=$\frac{(1.96)^2 x0.5(1-0.5)}{(0.05)^2} = 384$

Inclusion criteria and exclusion criteria

Inclusion criteria

Children aged between 12 and 59 months who have not been recently dewormed, visiting the laboratory of Kabutare District hospital, whose parents or legal guardians signed the written consent were included in this study.

Exclusion criteria

Children aged between 12 and 59 months who received anti-*Geohelminthic* drugs within one month before data collection were excluded from the study. The samples taken from PSAC which were found to be insufficiency and contaminated were also rejected in this study.

Sampling strategy

Convenient sampling was the sampling method where the Preschool-Aged Children (PSAC) visiting Kabutare DH in time of the study were included in our study. The duration of the study was 6 weeks, from 14th December 2020 to 22nd January 2021.

Data collection methods and procedures

Parents/guardians of children who accepted to participate in our study signed the informed consent form. The parents of children were explained about the data collection procedures and were given the structured questionnaire to obtain the information about demographic and risk factors associated with the geohelminth infections. The structured questionnaires were prepared in English and translated to Kinyarwanda language.

After signing the informed consent and completing the questionnaire survey, the parents/guardians of children who agreed to participate in the study were provided with the appropriate labelled plastic containers for fresh stool sample collection and instructed to bring approximately 5 grams of their own children stool samples. The samples collected were examined at Kabutare DH primarily with physical examinations where faecal specimens were assessed for the features like consistency, bloody diarrhoea and mucus and whether insufficiency or contaminated by urine, dirt, water or other body secretions. This was followed by detection and identification of *Geohelminths* by two laboratory scientists under low power objective lenses microscope, using direct saline techniques within 30 minutes of stool collection.

After the completion of the direct stool examination, each sample was examined in the same laboratory of Kabutare DH within the same day for quantitative examination of *Ascaris lumbricoides*, *Trichuris trichiura* and Hookworm under low power objective lenses microscope by using formal-ether concentration techniques.

Reliability and validity

This method of data collection and examination has been validated in several published studies targeting SAC and PSAC; example Ojja et al. in Uganda [9]. The number of pre-school aged children used in this study was calculated by using a standard formula to represent the whole population. The samples taken from the selected children were analyzed under a microscope by 2 analysts to control each other with the guidance of written protocols which describe aim, principle, specimen, reagents, procedures, interpretations, recording and reporting the obtained results.

Data analysis

The prevalence results of this study were analyzed by using Statistical Packages for Social Sciences software (SPSS IBM Version 21 and Microsoft Excel); the results were calculated and presented as a percentage by using Tables and graphs. Data obtained were first subjected to descriptive statistics including frequencies and cross-tabulations, followed by Pearson chi-square analysis to test for variables that were significantly associated with geohelminth infections among the surveyed PSAC. Factors that showed some significant relationship (P values <0.05) with geohelminth infections were selected as potential risk factors into our models.

Limitations of the study

Problems

Finding stool of young children was a hinder to us to collect so many children as expected and some of them were unwillingly to give samples.

Limitations

The study was conducted in a short period and the number of PSAC attending Kabutare DH were very few due to the consequences of Covid-19 pandemic. The later became an obstacle to maximize our sample size.

Ethical consideration

Data were collected after obtaining ethical clearance from Institutional Review Board of College of Medicine and Health Sciences (IRB of CMHS), University of Rwanda (UR) and a letter from General Director of Kabutare District hospital for researching the institution. The participants were informed about the purpose of the study and the data were collected from consenting individuals (appendix 2). Also, the participant's confidentiality was guaranteed by the use of codes on behalf of the participants' names. The information gathered during this study remained confidential. Only the researchers were allowed to access the study data and information. Infected children found, were reported to the Kabutare DH for more follow up.

Results

Introduction

To determine the prevalence of geohelminth infections and associated risk factors, the study participants of three hundred and eight (308) were recruited at Kabutare district hospital from Huye district in the Southern province of Rwanda. The findings on the prevalence of geohelminth infections and associated factors were analyzed and presented using tables and figures.

Prevalence of geohelminth infections in PSAC

From 308 participants, 75 participants were tested positive by using formal-ether concentration technique **(Table 1)**. The results from this study showed that *Geohelminths* were prevalent at 24.4% with 12.0% of *A. lumbricoides*, 6.5% of *T. trichiura*, 2.6% of hookworm and 3.2% of co-infection of *A. lumbricoides* and Hookworm **(Figure 2)**.

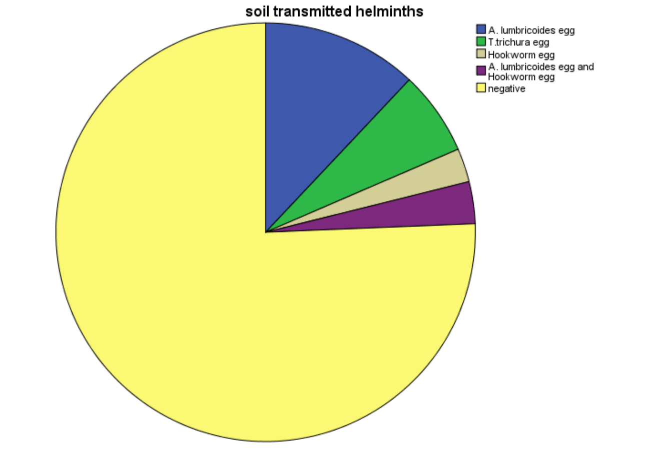

Figure 2: Prevalence of *Geohelminth* infections.

Risk factors of *Geohelminth* infections in PSAC

Socio-demographic factors associated with Geohelminth infections in the PSAC

The participants (PSAC) were aged from 12 to 59 months. The age-group distribution of children showed that majority (66.9%) were in the age group of 12-36 months. Most of the children (88.6%) and (86.4%) were with female guardians and had family size of less than five of the households respectively. Moreover, the age-group distribution of guardians showed that majority (62.0%) were in age group of 30-45 years. The children's mothers and fathers had secondary and primary education were (43.2%) and (34.4%) respectively. Children with mothers and fathers engaged in farming as the job occupation were found to be (33.4%) and (45.5%) respectively **(Table 1)**.

Children within the age group of 37-59 months whose mothers as guardians and those whose guardians aged more than 46 years (P<0.001 on each) had significantly higher prevalence of the STHs, showing that infection rate increases as children continues to grow **(Table 1)**. Prevalence of the STH infections was also significantly higher in children with more than five members of the households respective to their attendance in this study (P<0.001). Moreover, children whose mothers did farming as a job occupation and with no formal education had higher significance of STH infections with 60% and 61.3% respectively, whereas children whose fathers also did farming as job occupation and with only primary education showed significantly higher of prevalence of the STHs 74.7% and 41.3% respectively (P<0.001) as shown in **Table 1**.

Table 1: Geohelminth infections in relation to socio-demographic factors of the PSAC.

Variables		Geohelminth infection		Infection status		P-value
		Positive n (%)	Negative n (%)	Infected *n* (%)	Examined *n* (%)	
Sex of PSAC	Male	33 (44)	99 (42.5)	33(25)	132 (42.9)	
	Female	42 (56)	134 (57.5)	42(23.9)	176 (57.1)	0.754
Age in months of PSAC	13485	29 (38.6)	177 (75.9)	29(14)	206 (66.9)	
	27-59	46 (61.4)	56 (24.1)	46(45)	102 (33.1)	<0.001
Sex of guardian (parent)	Male	13 (17.3)	22 (9.4)	13(37.2)	35 (11.4)	
	Female	62 (82.7)	211 (90.6)	62(22.7)	273 (88.6)	0.001
Age of guardian in years	Less than 30	17 (22.7)	68 (29.2)	17(20)	85 (27.6)	
	30-45	26 (34.7)	165 (70.8)	26(13.6)	191 (62.0)	
	Above 46	32 (42.6)	0 (0)	32(100)	32 (10.4)	<0.001
Family size	Below 5	44 (58.7)	222 (95.3)	44(16.6)	266 (86.4)	
	Above 5	31 (41.3)	11 (4.7)	31(73.8)	42 (13.6)	<0.001
Father job occupation	Formal employment	0 (0)	24 (10.3)	0(0)	24 (7.8)	
	Self employed	3 (4)	71(30.5)	3(4)	74 (24.0)	
	Casual workers	7 (9.3)	54 (23.2)	7(11.5)	61 (19.8)	
	Farmer	56 (74.7)	84 (36)	56(40)	140 (45.5)	
	Others	9 (12)	0 (0)	9(100)	9 (2.9)	<0.001
Mother job occupation	Formal employment	0 (0)	16 (6.9)	0(0)	16 (5.2)	
	Self employed	3 (4)	60 (25.7)	3(4.8)	63 (20.5)	<0.001

Journal of Infectious Diseases and Patient Care

	Casual workers	12 (16)	80 (34.3)	12(13)	92 (29.9)	
	Farmer	45 (60)	58 (24.9)	45(43.7)	103 (33.4)	
	Others	15 (20)	19 (8.2)	15(44.1)	34 (11.0)	
Father education	No education	29 (38.7)	18 (7.7)	29(61.7)	47 (15.3)	
	Primary	31 (41.3)	75(32.2)	31(29.2)	106 (34.4)	
	Secondary	10 (13.3)	88 (37.8)	10(10.2)	98 (31.8)	
	University	5 (6.7)	52 (22.3)	5(8.8)	57 (18.5)	<0.001
Mother education	No education	46 (61.3)	7 (3)	46(86.8)	53 (17.2)	
	Primary	12 (16)	89 (38.2)	12(11.9)	101 (32.8)	
	Secondary	12 (16)	121 (52)	12(9)	133 (43.2)	
	University	5 (6.7)	16 (8.8)	5(23.8)	21 (6.8)	<0.001

Water, sanitation and hygiene factors associated with Geohelminth infection among the PSAC

On water sources to drink by the preschoolers; in 75 PSAC infected with STHs, 80% of them were found to use public tap water, while 13.3% and 6.7% were found to use hand dug wells and home treated water respectively, indicating a significance (p<0.001). Prevalence of the STH infections was also significantly higher in children with infrequently wearing shoes (76%) and those frequently playing in the soil (88%). Similarly, significantly higher prevalence of STHs infection was observed in children with untrimmed fingernails (82.7%) **(Table 2)**.

Moreover, STH infection was significantly associated with lack of hand washing habit after defecation in those children (70.7%) and those who do not wash their hands before eating (70.7%). Children who used open pit latrine and those who defecate on open fields showed significantly higher prevalence of STHs infection (58.7%). In addition, eating uncooked food increased children's odds for STH infection (81.3%) as compared to those didn't eat uncooked food **(Table 2)**.

The children with parents having house water sources showed low infection rate of STHs (14.7%). Moreover, the odds of STHs were also more significant in children with parents who infrequently trimmed their nails and those who didn't wash their hands before feeding their children and after defecation (66.7%, 62.7% and 70.7% respectively). The odds of STH infection were also high in children living rural areas (82.7%) compared to those who live in urban areas **(Table 2)**.

Table 2: Water, sanitation and hygiene factors associated with *Geohelminth* infection among the PSAC.

Variables		Geohelminth infection		Infection status		P-value
		Positive n (%)	Negative n (%)	Infected *n* (%)	Examined *n* (%)	
Source of water to drink	Public tap water	60 (80)	196 (84.1)	60 (23.4)	256 (83.1)	
	Hand-dug well	10 (13.3)	11 (4.7)	10 (47.6)	21 (6.8)	
	Home treated water	5 (6.7)	26 (11.2)	5 (16.1)	31 (10.1)	<0.001
Habit of playing in soil	Yes	66 (88)	120 (51.5)	66 (35.5)	186 (60.4)	
	No	9 (12)	113 (48.5)	9 (7.4)	122 (39.6)	<0.001
Washing hand with soap and water before eating	Yes	22 (29.3)	148 (63.5)	22 (12.9)	170 (55.2)	
	No	53 (70.7)	85 (36.5)	53 (38.4)	138 (44.8)	<0.001
Habit of eating uncooked food	Yes	61 (81.3)	108 (46.4)	61 (36.1)	169 (54.9)	
	No	14 (18.7)	125 (53.6)	14 (10.1)	139 (45.1)	<0.001
Habit of walking with barefoot	Yes	57 (76)	116 (49.8)	57 (32.9)	173 (56.2)	
	No	18 (24)	117 (50.2)	18 (13.3)	135 (43.8)	<0.001
Habit of nails trimming regularly	Yes	13 (17.3)	131 (56.2)	13 (9.1)	144 (46.7)	
	No	62 (82.7)	102 (43.8)	62 (37.8)	164 (53.3)	<0.001
Latrine usage	Yes	44 (58.7)	175 (75.1)	44 (20.1)	219 (71.1)	
	No	31 (41.3)	58 (24.9)	31 (34.8)	89 (28.9)	0.002
Type of latrines	Open pit latrine	44 (58.7)	147 (63.1)	44 (23.1)	191 (62.0)	
	Flushing latrine	0 (0)	30 (12.9)	0 (0)	30 (9.7)	
	None	31 (41.3)	56 (24)	31 (35.6)	87 (28.3)	0.001
No latrine	Yes	31 (41.3)	56 (24)	31 (35.6)	87 (28.3)	0.025

	No	44 (58.7)	177 (76	44 (19.9)	221 (71.7)	
Habit of washing hands with soap after defecation	Yes	22 (29.3)	100 (42.9	22 (18.1)	122 (39.6)	
	No	53 (70.7)	133 (57.1)	53 (28.5)	186 (60.4)	0.169
House water facilities	Yes	11 (14.7)	72 (30.9)	11 (13.3)	83 (26.9)	
	No	64 (85.3)	161 (69.1)	64 (28.5)	225 (73.1)	0.028
Habit of nails trimming regularly of guardian	Never	24 (32)	149 (63.9)	24 (13.9)	173 (56.2)	
	Sometimes	50 (66.7)	69 (29.6)	50 (42.1)	119 (38.6)	
	Regularly	1 (1.3)	15 (6.5)	1 (6.3)	16 (5.2)	<0.001
Habit of washing hands before feeding children of guardian	Never	23 (30.7)	1 (0.4)	23 (95.8)	2 (7.8)	
	Sometimes	47 (62.7)	144 (61.8)	47 (24.6)	191 (62.0)	<0.001

Discussions

In recent years, the control of Neglected Tropical Diseases (NTDs) has got significant attention by many governments, donors and international agencies. In Rwanda, MDA for the control of STH is in its early stage of implementation. This study found the prevalence of geohelminth infections among PSAC at Kabutare DH located in Huye District in southern province to be 24.4% (in 308 participants, 75 participants tested positively), which could be due to the undeveloped geographical location, ruled in endemic areas. This prevalence is found to be lower than the prevalence reported by Mokua et al. in the PSAC in Elburgon Municipality, Kenya, which was high 86% [36]. Moreover, this prevalence is higher than the prevalence in Tegal City Indonesia reported in 2010 by Altiara, which was 12.3%. In the Ethiopian study done by Shumbej et al. showed STH infection prevalence of 23.3% in PSAC, which is marked to be slightly equal to the one reported in this study [30].

The differences in prevalence and distribution of the STH among the different communities might be due to variation in both host-specific and environmental factors that may affect transmission of STH infections. These factors may include: population heterogeneity, age, genetics, poly-parasitism, time of study, parasitological technique used, personal hygiene practices, climate and altitude among others [36].

A. lumbricoides was found to be most prevalent with 49.33% of the total tested positive, followed by *T. trichiura* infection (26.67) and Hookworm infection (10.67), due to the Huye District, the availability of water to drink in preschoolers were mostly from public tap water and hand-dug wells water sources. This study is in agreement with the study done in India by Rebecca et al. who found that *A. lumbricoides* was most prevalent (38%) and similarly to the study done in Indonesia by Novianty et al. [29]. It is in contrast with the study done in Peninsular Malaysia by Anuar et al. who found that *T. trichiura* infection (57%) is the most abundant in their study followed by (23.8%) *A. lumbricoides* and hookworm (7.4%) [35]. The variation might be due to differences in environmental factors such as climate, topography, surface temperature, altitude, soil type and rainfall which have a great impact on the distribution of STHs [36].

Also, the findings show that among 75 positive participants', n=10 (13.33%) have co-infection, which might be to the lack of knowledge on how STHs spread [40]. These findings are in agreement to the studies done in Ogun State by Omitola et al. and Mokua et al. done in Kenya which show presence of mixed infections with prevalence of 43.3% and 28% respectively, which are higher than that of our study due to the difference in sample sizes [28,36]. However, the study done in Southwest Ethiopia showed that no double infection of STH observed [26]. These differences could be due to the different geographical distribution as well as implementation of different preventive and control measures.

The prevalence of *A. lumbricoides*, *T. trichiura*, Hookworm and coinfection of *A. lumbricoides* and Hookworm in different age groups was reported to be 2.36, 1, 1 and 1.5 times in 37-59 months more than 12-36 months, respectively. Age group of PSAC showed a great significant association with STH infections in this study ($p<0.001$). This phenomenon might reflect age related change in exposure to STHs infection. Though most children do start walking by the age of 13 months, they might not be strong enough to go outdoor and get infected until the age of 2 years. The same results were found and reported by Ojja et al. in Hoima district (Uganda), by Omitola et al. in the study conducted in the Ogun state (Nigeria) and by Shumbej et al. in Butajira Town, south central Ethiopia [9,28,30]. This developmental factor might be the reason for the slightly lower prevalence in those who were 12-23 months of age and an increasing trend thereafter.

The water sources habit to the PSAC shows a significant to the prevalence of geohelminth infections ($P<0.001$). Among 75 positive participants, 70 (93.33%) of them were found to obtain their daily water from both public tap and hand-dug well water sources. 66 (76%) of all tested positive PSAC were infected by both *A. lumbricoides* and *T. trichiura* and there is no reported cases of *A. lumbricoides* and *T. trichiura* in PSAC who use home treated water. These findings were in the same way to the statistical significance ($P<0.05$), in the study done by Omitola et al. in a Periurban Settlement of Ogun State [28]. It is the contrast with the study done by Menzies et al. who reported the different trends and results in the children of first 3 years of life in the tropics [27]. The water sources as a factor might be the reason for the high prevalence in those who used daily water from both public tap and hand-dug well water sources.

Many preschoolers were also found to use open pit latrines 44 (58.66%) and some of them defecated on open fields 31 (41.33%) in all tested positive and these showed strongly association to the geohelminth infections (p=0.001). This study was in agreement with the study conducted by Omitola et al. where only 97 provided the adequate stool samples for microscopic examination and the majority of them 72.2% were found to use open pit latrine and 19.6% of them were found to defecate on open fields, thus increasing the susceptibility to STH infections in PSAC [28]. This was also agreed with the study done by Pasaribu et al. who showed that improved latrines and faecal sludge management decreased the risk of infection [15].

This study also found that the PSAC who don't wash their hands with soap before eating and those who don't trim their nails are at high risk of being infected with *Geohelminths* (p<0.001 and p<0.001, respectively). These results of this study were like the results found in the study conducted in PSAC Living in Farmland North Sumatera, Indonesia, Novianty et al. who reported that washing hands before eating and nails trimming habit of children have a significant association with prevalence of STH infections in PSAC (p=0.003 and p=0.007 respectively) [29]. This highlighted the need for integrated control of STH, *i.e.,* deworming should be backed-up with health education to prevent re-infection. This is because; the only way of re-infection with STH is exposure to the infective stages from contaminated environment as these parasites do not multiply within the human host.

Moreover, this study showed that playing on soil, eating uncooked food from soil and walking on soil with barefoot were found to be associated with high prevalence of STH infections, mainly hookworm (13.33%) in all tested positive PSAC, (p<0.001 per each one). This result was in agreement with the results reported by Shumbej et al. who also showed that children who had no regular practices of washing their hands were 3 times more likely to be infected with STHs than those who had regular practices (p=0.001) [30]. These findings of this study were also observed in another study conducted to SAC living in an agricultural area of North Sumatera (Indonesia) by Pasaribu et al. who documented that approximately 62.39% of children played with soil/dirt every day and only 50% of them regularly washed their hands after those activities [15]. They also documented that the children who wore shoes/slippers when going outside (87.82%) have low risk of *Geohelminthic* infections. They also found that playing without wearing sandals in contaminated soil, not washing hands and nails trimming have been shown to increase the risk of STH infections 7.53 times (p<0.001 on each), as the one reported in this study.

This study also found that the factors such as is age, gender, habit of nails trimming regularly, habit of washing hands before feeding children, habit of washing hands with soap after defecation and habit of eating uncooked food of parent (guardian) are strongly associated with geohelminth infections in PSAC (0.001, P<0.001 on the rest factors respectively). STH infections are also high in PSAC with guardians having no latrines 2.41 times more than those with latrines (p<0.001). These findings were also declared in the study done by Shumbej et al. in Butajira Town, South-Central Ethiopia and in the study done by Novianty et al. from North Sumatera, Indonesia. On other hand slightly difference in trends of those factors were also reported by Menzies et al. and by Shiferaw et al. at Anbesame health center, from Northwest Ethiopia [27,29,30].

This study also identified that PSAC living in rural areas have high probability like 4.77 times to be infected by *Geohelminths* more than those who live in urban areas (p<0.001). These findings were in the agreement in the study done by Menzies et al. which showed that people who lived in rural areas have had the increased risk of infections of the STHs compared to those who resided in the urban areas [27]. Moreover, this study showed that the PSAC who live with household members above 5 was associated with geohelminth infections at 41.33% (p<0.001). These trends were also observed in the studies done in Rural Southwest China, in Butajira (Ethiopia) and in in southern rural Lao People's Democratic Republic. These results were in contrast with the results of the study done by Quihui et al. [34]. These differences could be due to the different geographical distribution as well as implementation of different preventive and control measures.

Furthermore, this study also found that the fathers' and mothers' activities engaged in farming have the significant effect on the children infection rate of *Geohelminths* 74.66% and 60% respectively (p<0.001 on each). This study was in the agreement to the results reported by Novianty et al. who showed that the majority of PSAC infected with *Geohelminths*, most of their fathers' occupations were in the vegetable farming category, 86.7%, as well as their mothers' occupation, 86.7% [29]. It is in contrast with the study conducted to PSAC in Elberton Municipality (Kenya), Mokua et al. which reported that father's job occupation showed significant differences (P=0.0015) and mother's occupation did not show any significant difference (p=0.033) in PSAC STH infections [36]. However, parental job occupation has been also reported to have an influence in STH prevalence in children in Peninsular Malaysia and in South-Eastern Nigeria.

This study also showed that the low fathers' and mothers' education were strongly associated with geohelminth infections 80% and 77.33% respectively (p<0.001 on each). These trends were also observed in studies done by Shumbej et al. from Butajira Town, South-Central Ethiopia and by Anuar et al. in Three Orang Asli tribes in Peninsular Malaysia [30,35]. Furthermore, the same trends were reported in the studies done by Shakya et al. and Quihui et al. from Nepal and Mexico, that children of illiterate and basic education fathers and mothers were often infected by STHs than the literate ones respectively [34,37]. On other hand it is revealed that better educated parents had lower association of intestinal parasitic infections in children as previously reported by Nematian et al. and Wamani et al., 2004 with children from Iran and Uganda [38].

Conclusion

The prevalence of *Geohelminthic* infections among preschool aged children attending Kabutare DH was 24.4%. The most prevalent parasite was *A. lumbricoides* with 49.33%. Factors like age of children, not washing hands with soaps before eating and defecation, eating uncooked food, walking with barefoot and playing on soil, drinking untreated water, defecating in the open fields, untrimming nails on both children and parents, gender and age of guardians (parents) and parental job occupation and education were strongly associated with the *Geohelminthic* infections (P<0.05).

Recommendations

This study recommends the researchers to conduct further studies on geohelminth infections across the country. Moreover, advanced techniques other than formal-ether concentration technique like Polymerase Chain Reaction (PCR) should be used to improve the chance of getting infectivity rate that formal-ether concentration cannot detect. The study recommends Huye District leaders in charge of health to put much effort in vulgarization of citizen on how geohelminth infections spread and can be prevented. Rwanda Ministry of Health is also recommended to put in place the control measures and implementation of mass drug administration program against geohelminth infections in pre-school aged children. This prevalence also needs Government support for the improvement of sanitation and treatment of local community living in the risk zones.

References

1. WHO, Holmes P (2015) Investing to overcome the global Impact of neglected tropical diseases: Third WHO report on neglected tropical diseases. Geneva, Switzerland: World Health Organization. 161-167. [Google Scholar]

2. Phuphisut O, Yoonuan T, Sanguankiat S, et al. (2014) Triplex polymerase chain reaction assay for detection of major soil-transmitted helminths, *Ascaris lumbricoides*, *Trichuris trichiura*, *Necator americanus*, in fecal samples. Southeast Asian J Trop Med Public Health 45: 267-275. [Google Scholar]

3. Ruberanziza E, et al. (2019) Mapping soil-transmitted helminth parasite infection in Rwanda: Estimating endemicity and identifying at-risk populations. Trop Med Infect Dis 4: 93. [Crossref] [Google Scholar]

4. WHO (2012) Research priorities for helminth infections. World Health Organization. Tech Rep Ser 972: 1-174. [Google Scholar]

5. Greene LE, et al. (2012) Impact of a school-based hygiene promotion and sanitation intervention on pupil hand contamination in Western Kenya: A cluster randomized trial. Am J Trop Med Hyg 87: 385-393. [Crossref] [Google Scholar]

6. Pullan RL, Smith JL, Jasrasaria R, Brooker SJ (2014) Global numbers of infection and disease burden of soil transmitted helminth infections in 2010. Parasit Vectors 7:37. [Crossref] [Google Scholar]

7. WHO (2019) Factsheets. soil transmitted helminth infections.

8. Sacolo-Gwebu H, Chimbari M, Kalinda C (2019) Prevalence and risk factors of schistosomiasis and soil-transmitted helminthiases among preschool aged children (1-5 years) in rural KwaZulu-Natal, South Africa: A cross-sectional study. Infect Dis Poverty 8: 47. [Crossref] [Google Scholar]

9. Ojja M, et al. (2018) Prevalence, intensity and factors associated with soil-transmitted helminths infections among preschool-age children in Hoima district, rural western Uganda. BMC Infect Dis 18: 408. [Crossref] [Google Scholar]

10. Rujeni N, Morona D, Ruberanziza E, et al. (2017) Schistosomiasis and soil-transmitted helminthiasis in Rwanda: An update on their epidemiology and control. Infect Dis Poverty 6: 1-11 [Crossref] [Google Scholar]

11. Hotez PJ, Aksoy S (2017) Ten years of progress in neglected tropical disease control and elimination. PLoS Negl Trop Dis 11: 1-6. [Crossref] [Google Scholar]

12. Ministry of Health (2016) Control measures in reduction of soil transmitted infections: Neglected tropical diseases and other parasitic diseases unit, malaria and other parasitic diseases division, Rwanda Biomedical Center, MOH, Kigali, Rwanda. 4: 93.

13. Campbell SJ et al (2014) Water, Sanitation and Hygiene (WASH): A critical component for sustainable soil-transmitted helminth and schistosomiasis control. PLoS Negl Trop Dis 8: 2651 [Crossref] [Google Scholar]

14. Brooker S, Clements ACA, Bundy DAP (2011) Global epidemiology, ecology and control of soil-transmitted helminth infections. Adv Parasitol 62: 221-261. [Crossref] [Google Scholar]

15. Pasaribu AP, Alam A, Sembiring K, et al. (2019) Prevalence and risk factors of soil-transmitted helminthiasis among school children living in an agricultural area of North Sumatera, Indonesia. BMC Public Health 5: 813-816. [Crossref] [Google Scholar]

16. Roach J (2019) Global numbers of infection and disease burden of soil transmitted helminth infections. Parasite Vectors 7: 37. [Crossref] [Google Scholar]

17. Nmorsi OPG, Isaac C, Aashikpelokhai IS, Ukwandu NCD (2013) Geohelminthiasis among Nigerian preschool age children. Int J Med Med Sci 1: 407-411. [Crossref] [Google Scholar]

18. Bethony J, et al. (2011) Soil transmitted helminthic infections: Ascariasis, trichiuriasis and hookworm. Lancet 367: 1521-1532 [Crossref] [Google Scholar]

19. Ault SK (2012) Intersectoral approaches to neglected diseases. Ann NY Acad Sci 1136: 64-69 [Crossref] [Google Scholar]

20. Singh C, Zargar SA, Masoodi I, Shoukat A, Ahmad B (2010) Predictors of intestinal parasitosis in school children of Kashmir: A prospective study. Trop Gastroenterol 31: 105-107. [Crossref] [Google Scholar]

21. Ojha SC, Jaide C, Jinawath N, Rotjanapan P, Baral P (2014) *Geohelminths*: Public health significance. J Infect Dev Ctries 8: 5-16. [Crossref] [Google Scholar]

22. Subhash CP, Meenachi C, Jharna M (2017) Epidemiology and clinical features of soil transmitted helminths. Trop Parasitol 7: 81-85. [Crossref] [Google Scholar]

23. DeSilva NR, et al. (2013) Soil-transmitted helminth infections: Updating the global picture. Trends Parasitol 19: 547-551.

[Crossref] [Google Scholar]

24. Ministry of Health (2008) Control measures in reduction of soil transmitted infections: Neglected tropical diseases and other parasitic diseases unit, Malaria and other parasitic diseases division, Rwanda Biomedical Center, MOH, Kigali, Rwanda. 6: 31.

25. Staudacher O, et al. (2014) Soil-transmitted helminths in southern highland Rwanda: Associated factors and effectiveness of school-based preventive chemotherapy. Trop Med Int Health 19: 812-824. [Crossref] [Google Scholar]

26. Tekalign E, et al. (2019) Prevalence and intensity of soil-transmitted helminth infection among rural community of Southwest Ethiopia: A community-based study. Biomed Res Int: 1-8. [Crossref] [Google Scholar]

27. Menzies SK, Rodriguez A, Chico M, Sandoval C, Broncano N, Guadalupe I, Cooper PJ (2014) Risk factors for soil-transmitted helminth infections during the first 3 years of life in the tropics: Findings from a birth cohort. PLoS Negl Trop Dis 8: 1-12. [Crossref] [Google Scholar]

28. Omitola OO, et al. (2016) Geohelminth infections and nutritional status of preschool aged children in a periurban settlement of Ogun State. 9. [Crossref] [Google Scholar]

29. Novianty S, et al. (2018) Risk factors for soil-transmitted helminthiasis in preschool children living in farmland North Sumatera, Indonesia. J Trop Med: 1-7. [Crossref] [Google Scholar]

30. Shumbej T, Belay T, Mekonnen Z, Tefera T, Zemene E, et al. (2015) Soil-transmitted helminths and associated factors among pre-school children in Butajira Town, south central Ethiopia: A community-based cross-sectional study. PLoS ONE 10: 1-11. [Crossref] [Google Scholar]

31. Traub RJ, Robertson ID, Irwin P, Mencke N, Thompson RC (2014) The prevalence, intensities and risk factors associated with geohelminth infection in tea growing communities of Assam, India. Trop Med Int Health 9: 688-701. [Crossref] [Google Scholar]

32. Ostan I, et al. (2007) Health inequities: Lower socio-economic conditions and higher incidences of intestinal parasites. BMC Public Health 7: 342-349. [Crossref] [Google Scholar]

33. Maia MM, et al. (2009) Intestinal parasitic infections and associated risk factors among children presenting at outpatient clinics in Manaus, Amazonas state, Brazil. Ann Trop Med Parasitol 103: 583-591. [Crossref] [Google Scholar]

34. Quihui L, et al. (2006) Role of the employment status and education of mothers in the prevalence of intestinal parasitic infections in Mexican rural schoolchildren. BMC Public Health 6: 225-232. [Crossref] [Google Scholar]

35. Anuar TS, Salleh FM, Moktar N (2014) Soil-transmitted helminth infections and associated risk factors in three Orang Asli tribes in Peninsular Malaysia. Sci Rep 4: 4101. [Crossref] [Google Scholar]

36. Mokua DO, Shivairo RS, Muleke C, Mukabane DK, Oswe MO, et al. (2014) Soil transmitted helminths prevalence among pre-school age children in Elburgon Municipality, Kenya. J Biol Agric Healthc 4: 36-41. [Google Scholar]

37. Shakya B, Shrestha S, Madhikarmi NL, Adhikari R (2012) Intestinal parasitic infection among school children. J Nepal Health Res Council 10: 20-23. [Google Scholar]

38. Nematian J, Nematian E, Gholamrezanezhad A, Asgari AA (2004) Prevalence of intestinal parasitic infections and their relation with socio-economic factors and hygienic habits in Tehran primary school students. Acta Trop 92: 179-186. [Crossref] [Google Scholar]

39. Arya R, Antonisamy B (2012) Sample size estimation in prevalence studies. Indian J Pediatr 79: 1482-1488. [Crossref] [Google Scholar]

40. WHO (2015) Assessing the epidemiology of soil-transmitted helminths during a transmission assessment survey in the global programme for the elimination of lymphatic filariasis. Geneva, Switzerland WHO Press. [Google Scholar]