UJMR, Vol. 10 No. 1, June, 2025, pp. 39 - 55 E-ISSN: 2814 – 1822; P-ISSN: 2616 – 0668

https://doi.org/10.47430/ujmr.25101.005

Received: 6th January, 2025 Accepted: 11th March, 2025

Soil-transmitted Helminth (STH) Infections in Northern Nigeria between 2000-2022: A Review

Adamu Rabiu[1,2], Nor Azwady Abd Aziz[1], Muskhazli Mustafa[1] & Shamarina Shohaimi[1]

[1]Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2]Department of Biology, School of Secondary Education (Sciences), Federal College of Education (Technical) Bichi, Kano, 703101 Kano State, Nigeria

Corresponding Author: rabiuadamu15@gmail.com / gs60901@student.upm.edu.my

Phone: +234 806 029 9611/ +234 802 060 6068

Abstract

Soil-transmitted helminth (STH) infections, caused by parasitic nematodes, are a significant public health concern in many parts of the world, including Nigeria. This review aims to comprehensively analyze the available studies and research trends on STH infections among children aged 0 - 17 years in northern Nigeria. The review focuses on studies on the prevalence and risk factors related to STH infections from year 2000 - 2022 in this specific region and emphasizes the urgent need for effective control measures to mitigate the burden of these infections. The population involved 25 studies (92.6%) on School Age Children (SAC) and 2 studies (7.4%) on Pre-School Age Children (PSAC). A total of 8 514 children examined, 4 384 (51.5%) males and 4 130 (48.5%) females. Children from rural areas were 5 165 (60.7%) while 3 349 (39.3%) children were from urban areas. Sample size ranges from 100 - 620. Formol-ether concentration was employed as stool examination technique by 22 (74.1%) studies, while 4 (14.8%) and 3 (11.1%) used Kato-Katz and Direct smear methods respectively. The overall pool prevalence estimates (PPE) for STH infections were 3 160 (37.1%, 95% CI: 36.5-37.7). PPE for males 1 880 (59.5%, 95% CI: 58.6-60.1) was higher than for females 1 280 (40.5%, 95% CI: 54.2-55.3). Children from rural areas had the highest PPE 1 955 (37.9%) OR 1.26 (95% CI: 0.32-3.73) p=0.02, while children from urban areas had 3 160 (35.9%) OR 1.15 (95% CI: 0.62-5.02) p=0.01. There was no significant association between STH infections and community settings among SAC and PSAC. The most common PPEs by species identified was Ascaris lumbricoides 1 022 (32.3%, 95% CI: 31.7-32.9), hookworm 931 (29.5%, 95% CI: 28.9 - 30.1) and the least; Trichuris trichjura 356 (11.3%, 95% CI: 10.7 - 11.9). Children between 10 - 15 years had highest prevalence (48.6%), and 0 - 9 years had the least prevalence (23.5%) by age groups. Four common risk factors were identified: walking barefooted 6 (22.2%) OR 1.16 (95% CI: 1.53 - 6.42) p-0.44, drinking untreated water 12 (44.4%) OR 1.66 (95% CI: 1.30 - 19.49) p=0.53, open field or bush defecation 8 (29.6) OR 3.41 (95% CI: 1.94 - 9.32) p=0.72 and eating unwashed fruits or vegetable 1 (3.7) OR 2.01 (95% CI: 1.32 - 4.51) p=0.54. The research underscores the need for enhanced surveillance, improved sanitation, and comprehensive sustainable interventions to reduce the prevalence and morbidity associated with STH infections in northern Nigeria.

Keywords: Children, Northern Nigeria, prevalence, risk factors, Soil-Transmitted Helminths

INTRODUCTION

Soil-transmitted helminth infections, including those caused by roundworms (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), and hookworms (*Ancylostoma duodenale* and *Necator americanus*), affect millions of people worldwide (World Health Organization, 2022), particularly in low-resource settings (Hailegebriel *et al.*, 2020) Nigeria, the most populous country in Africa, with its diverse geographical and socioeconomic characteristics, is heavily burdened by these infections (Yahaya *et al.*, 2015; Abdulhadi, 2017; Dahal *et al.*, 2019) Soil-transmitted helminths (STH) are spread principally through contact with feces of infected people and penetration of hookworm larvae which thrive in warm and moist soil of most tropical and subtropical countries (Bethony *et al.*, 2006). These helminthes are collectively referred to as geohelminths and usually co-infect their host (Ojha *et al.*, 2014).

These geohelminthes are identified using their respective ova (Bhumbla, 2018) The developmental stages of the nematodes causing STH are partly in the soil and in vertebrate host(s) (Loukouri *et al*., 2019) Soil-transmitted helminths may impact on the mental health of children as well as bring about malnutrition leading to growth retardation (Karagiannis-Voules *et al*., 2015) However, there is a paucity of comprehensive literature reviews focusing specifically about STH infections in the northern region of the country. This review aims to provide an in-depth analysis of the prevalence and risk factors associated with STH infections in northern Nigeria to bridge knowledge gap by systematically examining relevant studies conducted in this area.

METHODOLOGY

Search Strategy

A systematic literature search using a predefined search strategy was conducted in 11 electronic databases (Annual Review, Cambridge Core, CABI, Elsevier Scopus, Nature, Oxford Academic, PubMed, Google Scholar, Science Direct, Royal Society and World Scientific). The following were used as keywords in the search: ("Soil-transmitted helminths" OR "*Ascaris lumbricoides*" OR "*Trichuris trichiura*" OR "*Ancylostoma duodenale*" OR "*Necator americanus*" OR "Roundworm" OR "Whipworm" OR "Hookworm"), AND ("prevalence"), OR ("risk factors") AND ("children") AND ("northern Nigeria"). Studies published in English from January 2000 to September 2022 were considered for inclusion. The systematic review and selection of relevant literature were conducted according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines. Prevalence data from the surveyed States categorized under study area locations were analyzed. PICO elements were considered as the search strategies; thus, Population (northern Nigeria), Exposure (Soil-transmitted helminthiasis), Comparison (urban and rural area), and Outcome (prevalence, risk factors, and authors recommendations). Original laboratory-based studies and field studies with clearly stated location, sample sizes ($n \geq 100$), and number of positive samples were considered for inclusion. Searches were restricted to northern regions; the north-central, north-east and north-west states of Nigeria. This review focused on prevalence, population and outcome because all screened articles were observational studies.

Study Area

Nigeria is situated in the West African region and lies between longitudes 3 degrees and 14 degrees and latitudes 4 degrees and 14 degrees. It has a land mass of 923,768 sq.km with a population of over 200 million people which covers a surface area of 923 768 km^2 in the sub-Saharan African region (Adeleye *et al*., 2023) It has two distinct seasons; the rainy season which runs from March to November in the southern region and May to October in the northern region as well as the dry season which runs from December to February in the south and November to April in the North (Adewole & Serifat, 2015) Nigeria is divided into six geopolitical zones (Figure 1), each of which has multiple states (Chinweuba *et al*., 2014; Monyei *et al*., 2023) These are the Northcentral (Plateau, Niger, Kwara, Nasarawa, Abuja, Kogi, Benue States), Northeast (Taraba, Bauchi, Gombe, Adamawa, Borno, Yobe States), Northwest (Kaduna, Zamfara, Katsina, Kano, Sokoto, Jigawa, Kebbi States), Southeast (Abia, Imo, Anambra, Ebonyi, Enugu State), South-South (Edo, Akwa Ibom, Rivers, Bayelsa, Cross River, Delta States) and Southwest (Oyo, Osun, Ogun, Lagos, Ekiti, Ondo States) geopolitical zones.

Inclusion Criteria and Exclusion Criteria

Studies screened for relevance based on inclusion requirement stated and duplicates were removed. Detailed abstract reviewed for eligibility and presence of the outcome of interest on the following conditions:

Studies were included if they:

i. Focused on soil-transmitted helminth infections in northern Nigeria.
ii. Published in English.
iii. Assessed the prevalence, population, gender, age group and risk factors of STH infections.
iv. Sample size and number of positive cases clearly stated.
v. Presented original research findings.
vi. Reported STH infections in Nigerian children.
vii. Published in national and international reputable peer-reviewed journal.

Studies were excluded if they:

i. Were conducted outside the geographical scope of northern Nigeria
ii. Primarily targeted non-soil-transmitted helminth infections.
iii. Reported STH infections in other animals.
iv. Were systematic reviews, or meta-analyses.
v. Were case reports, letters, editorials, or conference abstracts.

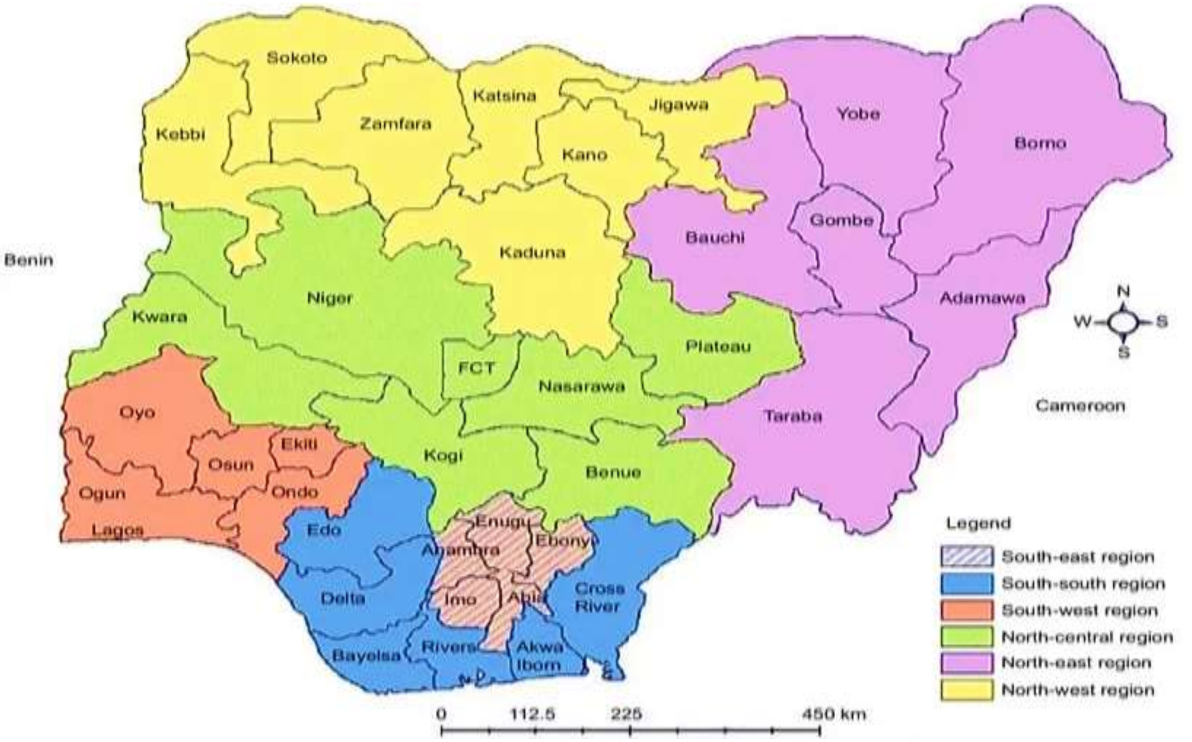
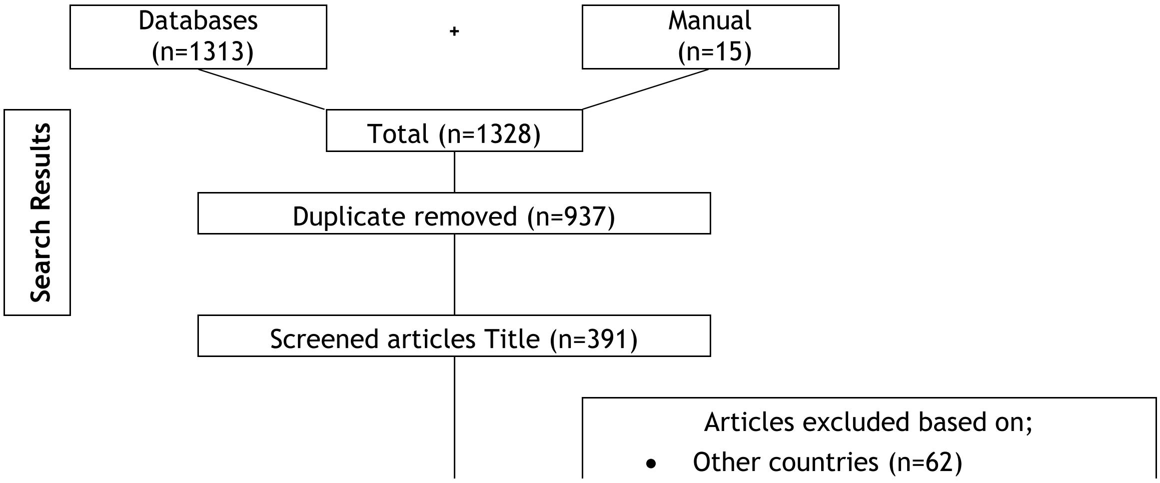


Figure 1: Nigeria geopolitical zones; South-West (SW), South-East (SE), North-West (NW), North-East (NE), North-Central (NC) and South-South (SS).

Data Extraction and Synthesis
Data extraction and synthesis were conducted to analyze the location, prevalence rates, methodology, and risk factors pertaining to STH infections in northern Nigeria. Selected articles were organized by study characteristics (author, year, methodology), study population, and sample sizes. The extracted data were synthesized thematically and presented using charts and tables. The prevalence of each STH in the study area was determined by dividing the total number of study participants by the number of STH-positive subjects. A 95 percent confidence interval (CI) was employed for assessing the overall prevalence. Mean differences are significant at 95% C.I., ($p < 0.05$) alpha value.

RESULTS AND DISCUSSION

Study Selection
The refined search yielded a total of 1313 studies that reported STH infection among children in northern Nigeria available in selected online databases (Table 1), and 15 studies retrieved manually. Mendeley reference manager version 2.103.0 was used for screening the downloaded articles.



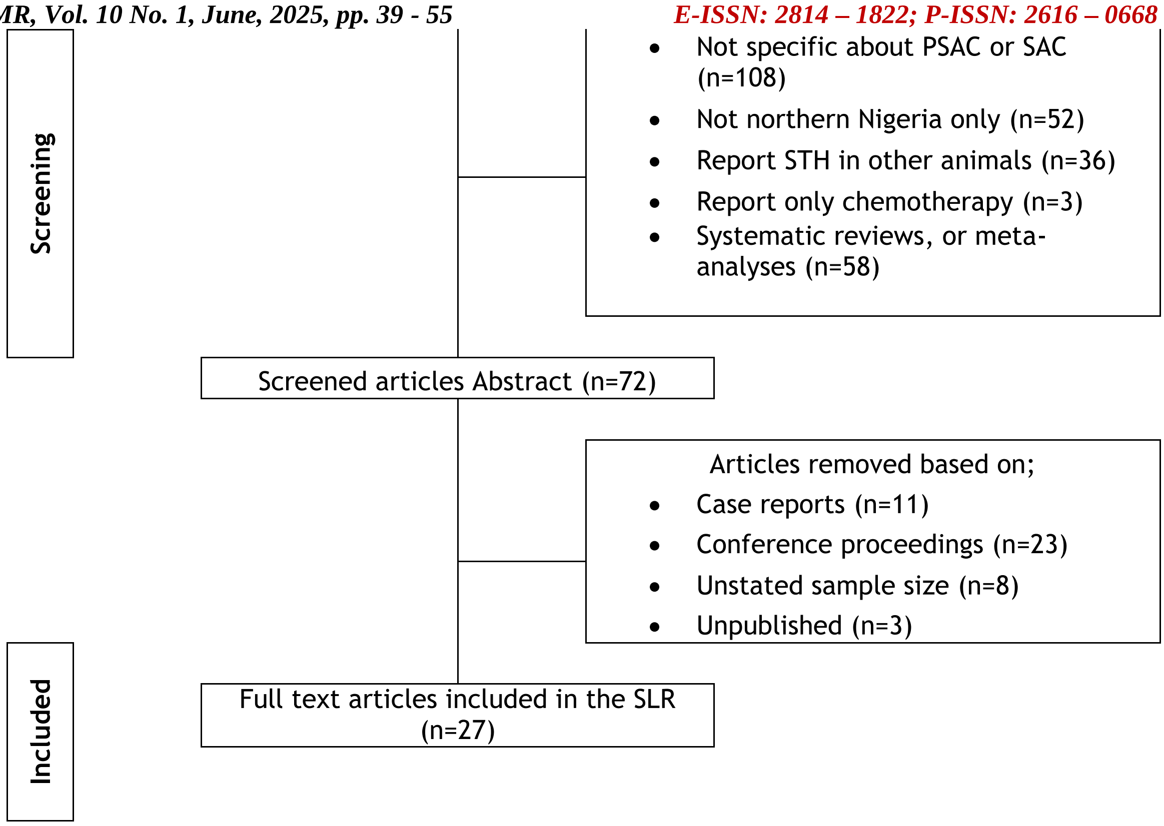


Figure 2: Flow diagram of screened document for inclusion in the review on STH in northern Nigeria.

Table 1: Databases Search Result

Database	Initial Search Results	2000 - 2022 Publications	2000 - 2022 Refined Results
Annual Review	12	12	12
Cambridge Core	47	44	41
CABI	243	157	127
Elsevier Scopus	36	23	23
Google Scholar	5,471	1101	801
Nature	5	5	5
Oxford Academic	9	4	4
PubMed Central	698	329	229
Royal Society	8	6	6
Science Direct	45	33	33
Scopus	37	24	24
World Scientific	19	11	9
Total	= 6,630	1,749	1,313

A total of 937 articles were removed due to duplications, 36 articles were excluded for referring to other animals, 58 systematic reviews or meta-analyses studies were excluded, and 45 articles were excluded based on abstract, 8 articles with unstated numbers of positive samples and sample sizes (Figure 2). Twenty-seven articles were selected for this literature review.

Pooled Prevalence Distribution of STH infections in northern Nigeria

Table 2 summarizes the population and study area of STH infections reported in different regions of northern Nigeria. Twenty-five (92.6%) studies were reported among school-aged children, while 2 (7.4%) of the studies were reported among pre-school-aged children. The prevalence of STH infections among eligible studies ranged between 6.0 and 96.1%. Sixteen (59.3%) studies were conducted in rural areas, and 11 (40.7) were carried out in urban areas.

Pooled prevalence estimates (PPE) for STH infections are presented in Table 3. The included studies reported prevalence rates ranging from 2.7% and 76.1%, with significant regional variations. The sample sizes ranged between 100 – 620, with 5,165 (60-7%) children from rural areas and 3,349 (39.3%) children from urban areas. Formol-ether concentration was a commonly used technique for stool examination by 20 (74.1%) studies, 4 (14.8%) studies used Kato-Katz, and 3 (11.1%) applied Direct smear method. A total of 3,160 of the 8,514 northern Nigerian children examined during the period under review were infected with one or more species of STHs, yielding an overall PPE of 37.1% (95% CI: 32.4–39.5).

Ascaris lumbricoides had the highest PPE of 1,022; 32.3% (95% CI: 31.5–33.9) while Hookworms and *Trichuris trichiura* recorded PPEs of 931; 29.6% (95% CI: 29.0-30.2) and 356; 11.3% (95% CI: 10.7-11.9) respectively (Table 4). Out of 9.384 (51.5%) males and 4,130 (48.5) females examined (Table 5), males had the highest infection rate PPE of 1,880; 59.5% (95% CI: 58.1- 60.1) and females had 1,280; 20.5% (95% CI: 19.1-21.1). The studies used varieties of age intervals; consistent age-group intervals were 3, 4 and 5 (75.8%). Age highest PPE of 88.0% was recorded between 6 – 17 years, and least PPE of 0.0% was recorded in older children between the ages 16 -20 years. (Table 6).

Risk factors of STH infections in Northern Nigeria

Table 7 presents the identified risk factors associated with STH infections in northern Nigeria. Common risk factors include, Drinking untreated water 12 (44.4%); OR 1.66 (95% CI: 1.30 - 19.49) p=0.53, Open field or Bush defecation 8 (29.6%); OR 3.41 (95% CI: 1.94 - 9.32) p=0.72.

Table 2: Study Area and Population of STH infections in northern Nigeria

AUTHORS	YEAR	STUDY AREA	POPULATION
Sule *et al.*	2019	Dawakin Kudu, Kano*	School-aged Children
Abdulhamid *et al.*	2019	Katsina Metro, Katsina	Pre-School Children
Lawal *et al*	2022	Batagarawa, Katsina*	School-aged Children
Abubakar *et al.*	2011	Yamaltu, Gombe*	School-aged Children
Abdulazeez *et al.*	2019	Kano Metropolis, Kano	Pre-School Children
Galamaji *et al.*	2018	Jega, Kebbi*	School-aged Children
Abednego *et al.*	2019	Dadin Kowa, Jos*	School-aged Children
Nwalorzie *et al.*	2015	Gwagwalada, Abuja	School-aged Children
Babatunde *et al.*	2013	Moro, Kwara*	School-aged Children
Oloyede et ai.	2017	Ifelodun, Kwara*	School-aged Children
Ikpe *et al.*	2020	Guma, Benue*	School-aged Children
Obeta *et al.*	2019	Jos, Plateau	School-aged Children
Atta *et al.*	2018	Samaru, Zaria Kaduna	School-aged Children
Attahiru et al.	2017	Dukku, Gombe*	School-aged Children
Saddiqa *et al.*	2020	Yana, Shira Bauchi*	School-aged Children
Amaechi *et al.*	2019	Ilorin, Kwara	School-aged Children
Eniola *et al.*	2019	Lafia, Nasarawa	School-aged Children
Salwa *et al.*	2018	Kura, Bebeji, Gwarzo, Shanono and Minjibir*	School-aged Children
Maikenti *et al.*	2020	Auta-balefi, Karu Nasarawa*	School-aged Children
Shitta *et al*	2017	Lokoja, Kogi	School-aged Children
Tofa *et al.*	2018	Dawakin Kudu, Kano*	School-aged Children
Nasiru *et al.*	2017	Dutsin Ma, Katsina*	School-aged Children
Abdullahi *et al.*	2015	Birnin Kudu, Jigawa	Qur'anic School
Adamu *et al.*	2022	Bauchi Metropolis, Bauchi	School-aged Children
Oriakpono *et al.*	2015	Noman, Adamawa*	School-aged Children
Nasiru *et al.*	2000	Bosso, Niger*	School-aged Children
Halima *et al.*	2017	Laddoga, Kaduna*	School-aged Children
		Rural Area* 16 (59.3) Urban Area 11 (40.7)	School-aged Children 25 (92.6) Pre-School Children 2 (7.4)

Walking barefooted 6(22.2%); OR 1.16 (95% CI: 1.53 - 6.42) p=0.44 and eating unwashed fruits and/or vegetables 1 (3.7%); OR 2.01 (95% CI: 1.32 - 4.51) p=0.54. School Health Services recommended in all primary and Secondary schools 7 (25.9), Regular deworming and provision of portable drinking water is needed 6 (22.2), Sanitation and improved personal hygiene, regular health education and portable drinking water and implementation of sustainable intervention measures were the common recommendations made by the authors. The findings of this systematic review highlight the significant burden of STH infections in northern Nigeria (Yahaya *et al.*, 2015; Taiwo *et al.*, 2019; Funso-Aina *et al.*, 2020) The prevalence rates varied across different regions, emphasizing the need for region-specific interventions (Adamu & Abdulkadir, 2017; Yusuf *et al.*, 2018)Twenty-five (92.6%) studies were reported among SAC while 2 (7.4%) of the studies were reported among PSAC. The prevalence of STH infections among eligible studies ranged between 6.0 and 96.1%. The finding is, however, within the range of 52.4–65.8% reported from other sub-Saharan African countries (Karagiannis-Voules *et al.*, 2015). Study 2016 revealed a 36.4% decline in the prevalence of STH infections within a period of twenty-four years in India (Sardar *et al.*, 2016a) STH studies in Nigeria have been focused mostly on children (preschool and school-age) (69%) than adults (31%), and mostly in rural (68.9%) than urban areas (31.1%) (Taiwo *et al.*, 2019) Kumar *et al.* 2000 review 18 articles in Malaysia, the overall prevalence of STH was in range 7.56 to 78.27% (Nisha *et al.*, 2020) Oluwatobiloba in Nigeria review STH articles between 2006 - 2015 revealed that prevalence of intestinal helminth in the country has not declined since the 1970s (Funso-Aina *et al.*, 2020).

Table 3: Pooled Prevalence Distribution of STH Infections in Northern Nigeria

AUTHORS	LOCATION	METHOD	SAMPLE SIZE	PREVALENCE (%)
Sule *et al.*, 2019	Rural	Formol-ether	214	46 (21.5)
Abdulhamid *et al.*, 2019	Urban	Formol-ether	302	182 (60.3)
Lawal *et al.*, 2022	Rural	Formol-ether	320	189 (59.1)
Abubakar *et al.*, 2011	Rural	Direct smear	310	34 (11.0)
Abdulazeez *et al.*, 2019	Urban	Formol-ether	620	17 (2.7)
Galamaji *et al.*, 2018	Rural	Formol-ether	200	43 (21.5)
Abednego *et al.*, 2019	Rural	Formol-ether	136	58 (42.6)
Nwalorzie *et al.*, 2015	Urban	Kato - Katz	220	161 (73.2)
Babatunde *et al.*, 2013	Rural	Formol-ether	413	171 (41.9)
Oloyede *et al.*, 2017	Rural	Kato - Katz	160	10 (6.3)
Ikpe *et al.*, 2020	Rural	Kato - Katz	443	219 (49.4)
Obeta *et al.*, 2019	Urban	Direct smear	200	46 (24.0)
Atta *et al.*, 2018	Urban	Formol-ether	100	30 (30.0)
Attahiru et al., 2017	Rural	Formol-ether	300	47 (15.7)
Saddiqa *et al.*, 2020	Rural	Formol-ether	132	50 (37.9)
Amaechi *et al.*, 2019	Urban	Kato - Katz	508	206 (40.6)
Eniola *et al.*, 2019	Urban	Formol-ether	200	67 (33.5)
Salwa *et al.*, 2018	Rural	Formol-ether	551	181 (33.0)
Maikenti *et al.*, 2020	Rural	Formol-ether	288	130 (45.1)
Shitta *et al.*, 2017	Urban	Formol-ether	254	148 (58.3)
Tofa *et al.*, 2018	Rural	Formol-ether	560	426 (76.1)
Nasiru *et al.*, 2017	Rural	Formol-ether	252	160 (63.5)
Abdullahi *et al.*, 2015	Urban	Formol-ether	383	210 (54.8)
Adamu *et al.*, 2022	Urban	Direct smear	562	158 (28.1)
Oriakpono *et al.*, 2015	Rural	Formol-ether	296	27 (9.1)
Nasiru *et al.*, 2000	Rural	Formol-ether	250	115 (46.0)
Halima *et al.*, 2017	Rural	Formol-ether	340	49 (14.4)

	Rural Area 16 (59.3) Urban Area 11 (40.7)	Formol-ether 20(74.1) Kato-Katz 4(14.8) Direct smear 3(11.1)	Rural Area 5,165 (60.7) Urban Area 3,349 (39.3) Total 8,514	Rural Area 1,955 (37.9) Urban Area 1,205 (35.9) Total 3,160 (37.1)

More than half of the studies were conducted in rural community settings 16 (59.3%) and 11 (40.7) were carried out in urban areas. The sample sizes ranged between 100 – 620, with an overall total of 5,165 (60-7%) children from rural areas and 3,349 (39.3%) children from urban areas. This is consistent with other studies (Ohiolei *et al.*, 2017; Hailegebriel *et al.*, 2020;) The prevalence of STH was higher in the rural population compared to the urban (Bhumbla, 2018; Santosh K. A., 2012) population, which is most likely on account of behaviors found in rural children such as defecation in open fields (Samuel, 2015), poor hygiene practices, such as having untrimmed fingernails, dirt under the nails, and lack of footwear (Yahaya *et al.*, 2015; Taiwo *et al.*, 2019) Several studies in Ethiopia also revealed that intestinal parasite infections are widely distributed with higher prevalence rates in rural community (Fauziah *et al.*, 2022).(World Health Organization, 2021)

Table 4: Pooled Prevalence of STH Parasites Distribution in northern Nigeria

AUTHORS AND YEAR OF PUBLICATION	EXAMINED No.	PARASITE IDENTIFIED Hookworm No. (%)	*A. lumbricoides* No. (%)	*T. trichiura* No. (%)
Sule *et al.*, 2019	214	31 (14.5%)	15 (7.0)	0(0.0)
Abdulhamid *et al.*, 2019	302	37 (20.4)	144 (79.1)	10 (5.5)
Lawal *et al.*, 2022	320	55 (29.1)	84 (44.7)	50 (26.2)
Abubakar *et al.*, 2011	310	2 (5.0)	14 (41.2)	18 (52.9)
Abdulazeez *et al.*, 2019	620	4 (23.5)	12(70.5)	1 (6.0)
Galamaji *et al.*, 2018	200	34 (61.8)	18 (32.7)	3 (5.5)
Abednego *et al.*, 2019	136	3 (5.1)	15 (25.7)	6 (10.3)
Nwalorzie *et al.*, 2015	220	46 (28.6)	66 (40.9)	25 (15.5)
Babatunde *et al.*, 2013	413	63 (36.8)	46 (26.9)	33 (19.3)
Oloyede *et al.*, 2017	160	0 (0.0)	10 (6.3)	0 (0.0)
Ikpe *et al.*, 2020	443	121 (55.3)	98 (44.7)	0 (0.0)
Obeta *et al.*, 2019	200	14 (7.0)	20 (10.0)	9 (4.5)
Atta *et al.*, 2018	100	13 (43.3)	7 (23.3)	2 (6.7)
Attahiru et al., 2017	300	8 (17.0)	27 (57.4)	12 (25.5)
Saddiqa *et al.*, 2020	132	24 (18.1)	14 (10.6)	9 (6.8)
Amaechi *et al.*, 2019	508	62 (30.1)	78 (37.9)	10 (4.9)
Eniola *et al.*, 2019	200	16 (23.9)	26 (13.0)	15 (22.4)
Salwa *et al.*, 2018	551	28 (15.4)	14 (8.0)	0 (0.0)
Maikenti *et al.*, 2020	288	40 (30.8)	33 (25.4)	0 (0.0)
Shitta *et al.*, 2017	254	27 (18.2)	0 (0.0)	36 (24.3)
Tofa *et al.*, 2018	560	142 (25.4)	48 (8.6)	17 (3.0)
Nasiru *et al.*, 2017	252	33 (13.2)	54 (21.4)	12 (4.8)
Abdullahi *et al.*, 2015	383	51 (24.3)	62 (29.5)	14 (6.7)
Adamu *et al.*, 2022	562	22 (13.9)	61 (38.6)	43 (27.2)
Oriakpono *et al.*, 2015	296	10 (3.4)	6 (2.0)	11 (3.7)
Nasiru *et al.*, 2000	250	22 (0.09)	41 (16.4)	16 (0.07)
Halima *et al.*, 2017	340	23 (46.9)	9 (18.4)	4 (8.2)
	Total =8,514	**931 (29.5)**	**1,022 (32.3)**	**356 (11.3)**

Parasitic infections were determined mainly using Formol-ether concentration technique 20 (74.1%) and Kato-Katz 4 (14.8%). FECT was more successful in detecting light infections (World Health Organization, 2022) and has the advantages of detecting other intestinal parasites and preservation of fecal samples (Santosh, 2012; Bhumbla, 2018); it has become the method of choice, formal ether concentration method is considered to be better compared to the others (Allen & Ridley, 1970; Fitriani *et al*., 2018; Suwansaksri *et al*., 2002).

Table 5: Gender-specific Pooled Prevalence of STH Infections in Northern Nigeria

Authors and Year of Publication	Number Examined			Number Infected		
	Male No. (%)	Female No. (%)	Total	Male No. (%)	Female No. (%)	Total
Sule *et al*., 2019	154 (72.0)	60 (28.0)	214	33 (71.7)	13 (28.3)	46 (21.5)
Abdulhamid *et al*., 2019	144 (47.7)	158 (52.3)	302	76 (41.8)	106 (58.2)	182 (60.3)
Lawal *et al*., 2022	213 (66.6)	107 (33,4)	320	127 (67.2)	62 (32.8)	189 (59.1)
Abubakar *et al*., 2011	170 (54.5))	140 (45.5)	310	13 (38.2)	21 (61.8)	34 (11.0)
Abdulazeez *et al*., 2019	330 (53.2)	290 (46.8)	620	11 (64.7)	6 (35.3)	17 (2.7)
Galamaji *et al*., 2018	100 (50.0)	100 (50.0)	200	31 (72.1)	12 (27.9)	43 (21.5)
Abednego *et al*., 2019	61 (44.9)	75 (55.1)	136	32 (52.5)	26 (34.5)	58 (42.6)
Nwalorzie *et al*., 2015	109 (49.5)	111 (50.5)	220	67 (41.6)	94 (58.4)	161 (73.2)
Babatunde *et al*., 2013	197 (47.7)	216 (52.3)	413	84 (49.1)	87 (50.9)	171 (41.9)
Oloyede *et al*., 2017	85 (53.1)	75 (46.9)	160	6 (60.0)	4 (40.0)	10 (6.3)
Ikpe *et al*., 2020	271 (61.2)	172 (38.8)	443	141 (52.0)	78 (45.3)	219 (49.4)
Obeta *et al*., 2019	84 (42.0)	116 (58.0)	200	20 (10.0)	26 (13.0)	46 (24.0)
Atta *et al*., 2018	54 (54.0)	46 (46.0)	100	19 (63.3)	11 (36.7)	30 (30.0)
Attahiru et al., 2017	150 (50.0)	150 (50.0)	300	26 (55.3)	21 (44.7)	47 (15.7)
Saddiqa *et al*., 2020	87 (65.9)	45 (34.1)	132	35 (40.2)	15 (33.3)	50 (37.9)
Amaechi *et al*., 2019	259 (60.0)	249 (40.0)	508	115 (44.4)	91 (36.5)	206 (40.6)
Eniola *et al*., 2019	80 (40.0)	120 (60.0)	200	29 (43.3)	38 (56.7)	67 (33.5)
Salwa *et al*., 2018	340 (61.7)	211 (38.3)	551	99 (54.7)	82 (45.3)	181 (33.0)
Maikenti *et al*., 2020	143 (49.7)	145 (50.3)	288	73 (51.0)	57 (39.3)	130 (45.1)
Shitta *et al*., 2017	146 (57.5)	108 (42.5)	254	96 (37.8)	52 (20.5)	148 58.3)
Tofa *et al*., 2018	357 (63.8)	203 (36.2)	560	267 (62.7)	159 (37.3)	426 76.1)
Nasiru *et al*., 2017	146 (57.9)	106 (42.1)	252	98 (61.2)	62 (38.8)	160 (63.5)
Abdullahi *et al*., 2015	0 (0.0)	383 (100.0)	383	210 (100.0)	0 (0.0)	210 (54.8)
Adamu *et al*., 2022	281 (50.0)	281 (50.0)	562	82 (51.9)	76 (48.1)	158 (28.1)
Oriakpono *et al*., 2015	138 (46.6)	158 (53.4)	296	14 (51.9)	13 (48.1)	27 (9.1)
Nasiru *et al*., 2000	135 (54.0)	115 (46.0)	250	55 (47.8)	60 (52.1)	115 (46.0)
Halima *et al*., 2017	150 (44.1)	190 (55.9)	340	21 (42.9)	28 (57.1)	49 (14.4)
	4,384 (51.5)	4,130 (48.5)	8,514	1,880 (59.5)	1,280 (40.5)	3,160 (37.1)

In this study, 3,160 of the 8,514 northern Nigerian children examined during the period under review were infected with one or more species of STHs, yielding an overall PPE of 37.1% (95% CI: 32.4–39.5). The overall pooled prevalence estimate observed in the present study is higher than the 24.1% (Hailegebriel *et al.*, 2020) and 25.4% (Sardar *et al.*, 2016b) reported in Ethiopia and India, respectively. The northern zones have the worst spread and highest average prevalence for all helminthiases (Funso-Aina *et al.*, 2020). Karshima in Nigeria reported a higher PPE of 54.8%, a total of 46 338 children (Male = 23 374 and Female = 22 964) in the 70 eligible studies (Karshima, 2018). In 2022, Nisa Fauziah *et al*. studied 17 articles in review related to STH infection in stunted children; PPE ranged from 12.5% to 56.5% (Fauziah *et al.*, 2022).

Ascaris lumbricoides had the highest PPE of 1,022; (32.3%, 95% CI: 31.5–33.9) while Hookworms and *Trichuris trichiura* recorded PPEs of 931; (29.6%, 95% CI: 29.0–30.2) and 356; (11.3%, 95% CI: 10.7–11.9) respectively. This result agrees with previous findings of a greater *Ascaris lumbricoides* risk in peri-urban rather than rural regions and two hookworm species *Ancylostoma duodenale* and *Necator americanus* are endemic in South America (Chammartin *et al.*, 2013), but their distribution, infection prevalence, and regional burden are poorly understood. The prevalence data in Nigeria showed a reduction in *Ascaris lumbricoides* and *Trichuris trichiura* infections, while infections with hookworm showed an irregular pattern with no significant differences (Imam *et al.*, 2019). The prevalence of *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Trichuris trichiura* in India was in the range between 0.4 to 71.87%, 0.14 to 42%, and 0.3 to 29.57%, respectively (Jayaram *et al.*, 2021). This relative difference in prevalence of the three STHs is observed similarly across all regions of all countries and has been persistent even before independent review studies. The current study also suggests that Ascaris lumbricoides are the highest in northern Nigeria; this can be attributed to the ownership of domestic animals and improper hand-washing practices, especially after defecating. In contrast, another study showed a decreasing trend in prevalence for *A. lumbricoides*, and *T. trichiura* (6·6%, and 4·4%) among school-aged children from 2000 onwards in sub-Saharan Africa (Sartorius *et al.*, 2020).

Table 6: High and Least Pooled Prevalence by Age of STH Infections in Northern Nigeria

Authors and Year of Publication	Examined No. (%)	Infected No. (%)	Highest Age-group (%)	Least Age-group (%)
Sule *et al.*, 2019	214	46 (21.5)	10 – 13 (52.2)	14 -16 (8.7)
Abdulhamid *et al.*, 2019	302	182 (60.3)	4 - 5 (82.7)	1 -3 (41.4)
Lawal *et al.*, 2022	320	189 (59.1)	8 - 10 (59.1)	5 - 7 (59.0)
Abubakar *et al.*, 2011	310	34 (11.0)	10 - 14 (14.3)	5 - 9 (8.9)
Abdulazeez *et al.*, 2019	620	17 (2.7)	12 - 14 (54.8)	4 -6 (27.6)
Galamaji *et al.*, 2018	200	43 (21.5)	5 - 7 (25.7)	8 - 10 (23.3)
Abednego *et al.*, 2019	136	58 (42.6)	7 - 9 (61.7)	13 - 15 (23.5)
Nwalorzie *et al.*, 2015	220	161 (73.2)	6 - 10 (54.7)	1 - 5 (6.8)
Babatunde *et al.*, 2013	413	171 (41.9)	15 - 20 (47.1)	10 - 14 (39.6)
Oloyede *et al.*, 2017	160	10 (6.3)	11 - 15 (50.0)	16 - 20 (0.0)
Ikpe *et al.*, 2020	443	219 (49.4)	10 - 13 (62.7)	6 - 9 (3.7)
Obeta *et al.*, 2019	200	46 (24.0)	6 - 10 (10.5)	1 - 5 (4.5)
Atta *et al.*, 2018	100	30 (30.0)	10 - 13 (62 7)	6 - 9 (0.1)
Attahiru et al., 2017	300	47 (15.7)	5 - 7 (63.8)	8 - 12 (36.2)
Saddiqa *et al.*, 2020	132	50 (37.9)	7 - 10 (38.7)	4 - 6 (36.8)
Amaechi *et al.*, 2019	508	206 (40.6)	5 - 7 (52.2)	14 - 16 (28.2)
Eniola *et al.*, 2019	200	67 (33.5)	42.6 (5 - 7)	14 - 16 (25.5)
Salwa *et al.*, 2018	551	181 (33.0)	6 - 17 (88.0)	1 - 5 (75.0)
Maikenti *et al.*, 2020	288	130 (45.1)	11 - 16 (48.3)	5 - 10 (22.2)
Shitta *et al.*, 2017	254	148 58.3)	0 (0.0)	0.(0.0)
Tofa *et al.*, 2018	560	426 76.1)	12 - 14 (38.0)	6 - 8 (15.7)
Nasiru *et al.*, 2017	252	160 (63.5)	7 - 9 (66.7)	13 - 15 (35.7)
Abdullahi *et al.*, 2015	383	210 (54.8)	11 - 15 (60.2)	26 - 30 (31.8)
Adamu *et al.*, 2022	562	158 (28.1)	10 - 14 (56.2)	5 - 9 (3.7)
Oriakpono *et al.*, 2015	296	27 (9.1)	14 - 20 (10.7)	21 - 25 (0.0)
Nasiru *et al.*, 2000	250	115 (46.0)	8 - 10 (53.5_	10 - 12 (40.0)
Halima *et al.*, 2017	340	49 (14.4)	10 - 15 (55.1)	5 - 9 (44.9)
	8,514	**3,160 (37.1)**	**48.6**	**23.5**

Ascaris lumbricoides had the highest PPE of 1,022 (32.3%, 95% CI: 31.5-33.9), while Hookworms and *Trichuris trichiura* recorded PPEs of 931; (29.6%, 95% CI: 29.0-30.2) and 356; (11.3%, 95% CI: 10.7-11.9) respectively (Figure 3). This result agrees with previous findings of a greater *Ascaris lumbricoides* risk in peri-urban rather than rural regions and two hookworm species *Ancylostoma duodenale* and *Necator americanus* are endemic in South America (Chammartin *et al.*, 2013), but their distribution, infection prevalence, and regional burden are poorly understood.

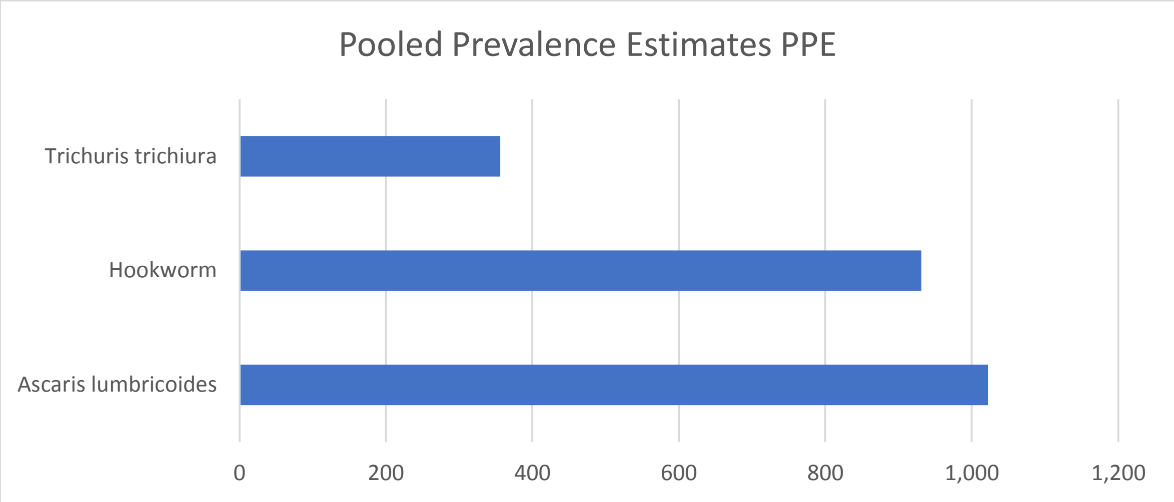


Figure 3: Pooled Prevalence Estimates (PPE)

Table 7: Risk factors of STH Infections in northern Nigeria

Authors and Year of Publication	Common Risk Factor	OR (95% C.I)	p-value
Sule *et al.*, 2019	Walking barefooted	1.03 (2.36 - 7.21)	0.95
Abdulhamid *et al.*, 2019	Walking barefooted	0.57 (0.30 - 1.11)	0.09
Lawal *et al.*, 2022	Drinking untreated water	1.21 (0.64 - 3.49)	0.68
Abubakar *et al.*, 2011	Open field or Bush defecation	0.01 (0.57 - 2.81)	0.97
Abdulazeez *et al.*, 2019	Eating unwashed fruits or vegetable	2.01 (1.32 - 4.51)	0.54
Galamaji *et al.*, 2018	Open field or Bush defecation	9.56 (4.12 - 22.21)	0.73
Abednego *et al.*, 2019	Open field or Bush defecation	3.21 (0.42 - 5.31)	0.01
Nwalorzie *et al.*, 2015	Walking barefooted	0,62 (1.13 - 16.7)	0.42
Babatunde *et al.*, 2013	Drinking untreated water	3.49 (0.37 = 15.9)	0.17
Oloyede *et al.*, 2017	Drinking untreated water	2.55 (1.54 - 12.6)	0.96
Ikpe *et al.*, 2020	Drinking untreated water	1.23 (0.61 - 7.22)	0.56
Obeta *et al.*, 2019	Drinking untreated water	2.71 (1.23 - 4.25)	0.62
Atta *et al.*, 2018	Open field or Bush defecation	1.65 (2.43 - 10.28)	0.76
Attahiru et al., 2017	Drinking untreated water	0.26 (2.41 - 13.5)	0.56
Saddiqa *et al.*, 2020	Drinking untreated water	1.17 (0.54 - 9.11)	0.09
Amaechi *et al.*, 2019	Drinking untreated water	2.32 (0.57 - 3.33)	0.36
Eniola *et al.*, 2019	Drinking untreated water	1.46 (0.74 - 3.91)	0.98
Salwa *et al.*, 2018	Walking barefooted	2.14 (2.61 - 5.09)	0.12
Maikenti *et al.*, 2020	Drinking untreated water	0.32 (1.02 - 4.51)	0.09
Shitta *et al.*, 2017	Walking barefooted	2.01 (1.32 - 4.51)	0.57
Tofa *et al.*, 2018	Open field or Bush defecation	4.71 (3.84 - 16.2)	0.98
Nasiru *et al.*, 2017	Open field or Bush defecation	2.32 (1.32 - 5.71)	0.55
Abdullahi *et al.*, 2015	Open field or Bush defecation	3.64 (2.41 - 8.54)	0.86
Adamu *et al.*, 2022	Drinking untreated water	1.65 (3.71 - 5.69)	0.75
Oriakpono *et al.*, 2015	Walking barefooted	0.61 (1.45 - 3.89)	0.51
Nasiru *et al.*, 2000	Open field or Bush defecation	2.21 (0.42 - 3.51)	0.92
Halima *et al.*, 2017	Drinking untreated water	1.51 (2.24 - 7.29)	0.57
		1.67 (1.52 - 9.88)	**0.56**

The prevalence data in Nigeria showed a reduction in *Ascaris lumbricoides* and *Trichuris trichiura* infections, while infections with hookworm showed an irregular pattern with no significant differences (Imam *et al*., 2019). The prevalence of *Ascaris lumbricoides*, *Ancylostoma duodenale* and *Trichuris trichiura* in India was in the range between 0.4 to 71.87%, 0.14 to 42% and 0.3 to 29.57%, respectively (Jayaram *et al*., 2021) This relative difference in the prevalence of the three STHs is observed similarly across all regions of all countries and has been persistent even prior to independent review studies. The current study also suggests the prevalence of *Ascaris lumbricoides* as the highest in northern Nigeria; this can be attributed to ownership of domestic animals and improper hand-washing practices, especially after defecating. In contrast, another study showed a decreasing trend in prevalence for *A. lumbricoides*, and *T. trichiura* (6·6%, and 4·4%) among school-aged children from 2000 onwards in sub-Saharan Africa (Sartorius *et al*., 2020). Out of 9.384 (51.5%), males had the highest infection rate PPE of 1,880 (59.5%, 95% CI: 58.1-60.1), and females had 1,280 (20.5%, 95% CI: 19.1–21.1). Gender distribution is not a confounding factor in STH infections, as both sexes are equally susceptible. Data from the reviewed literatures show more than one-third of the Ethiopian SAC were infected with STH, a close margin and insignificant gender difference between in Southwest and Northcentral regions (Samuel, 2015; Leta *et al*., 2020).

The studies used a variety of age intervals; consistent age-group intervals were 3, 4, and 5 (75.8%). Age-highest PPE of 88.0% was recorded between 6 – 17 years, and the lowest PPE of 0.0% was recorded in older children between the ages of 16 -20 years. Additionally, two studies reported that older children were more likely to be parasitized with STH than their younger counterparts(Abe *et al*., 2019; Dawaki *et al*., 2019) Children aged 5–14 years are known to carry the heaviest burden of soil-transmitted helminthiasis, this is in line with the findings of the association of high STH infections with children aged 2-5 years in northern Nigeria (Shuaibu *et al*., 2018; Taiwo *et al*., 2019) Age group of 4-10 years is the high-risk group and most STH infected children (Ishaku *et al*., 2020). The identified risk factors associated with STH infections in northern Nigeria include drinking untreated water 12 (44.4%); OR 1.66 (95% CI: 1.30 - 19.49) p=0.53, open field or bush defecation 8 (29.6%); OR 3.41 (95% CI: 1.94 - 9.32) p=0.72, walking barefooted 6(22.2%); OR 1.16 (95% CI: 1.53 - 6.42) p=0.44 Not wearing shoes can increase the risk of infection with STH that penetrates the skin to infect humans (Brahmantya *et al*., 2020; Khan *et al*., 2022) Eating unwashed fruits and/or vegetable 1 (3.7%); OR 2.01 (95% CI: 1.32 - 4.51) p=0.54. Consumption of raw vegetables is known to increase the risk of exposure to STH eggs if they are not appropriately cleaned due to the possibility of contamination of STH eggs from the soil (Kiiti *et al*., 2020). The most recent study examining risk factors for STH in Honduras showed that the number of children in the household with a recent history of diarrhea was associated with ascariasis caused by improper hygiene (Sanchez *et al*., 2014). Patterns of soil-transmitted helminth infection in sub-Saharan Africa have changed, and the prevalence of infection has declined substantially in this millennium, probably due to socioeconomic development and large-scale deworming programs (Mackinnon *et al*., 2019).

Table 8: Authors Recommendations on STH Infections in northern Nigeria

Authors and Year of Publication	Recommendation
Sule *et al.*, 2019	School Health Services recommended in all primary and Secondary schools
Abdulhamid *et al.*, 2019	School Health Services recommended in all primary and Secondary schools
Lawal *et al.*, 2022	Regular deworming and provision of portable drinking water is needed
Abubakar *et al.*, 2011	School Health Services recommended in all primary and Secondary schools
Abdulazeez *et al.*, 2019	Regular health education and portable drinking water
Galamaji *et al.*, 2018	Sustainable intervention measures should be implemented
Abednego *et al.*, 2019	Regular health education and portable drinking water
Nwalorzie *et al.*, 2015	Regular health education and portable drinking water
Babatunde *et al.*, 2013	Regular health education and portable drinking water
Oloyede *et al.*, 2017	Regular health education and portable drinking water
Ikpe *et al.*, 2020	Regular deworming and provision of portable drinking water is needed
Obeta *et al.*, 2019	Sustainable intervention measures should be implemented
Atta *et al.*, 2018	School Health Services recommended in all primary and Secondary schools
Attahiru et al., 2017	Sanitation and improved personal hygiene should be encouraged
Saddiqa *et al.*, 2020	School Health Services recommended in all primary and Secondary schools
Amaechi *et al.*, 2019	School Health Services recommended in all primary and Secondary schools
Eniola *et al.*, 2019	Sanitation and improved personal hygiene should be encouraged
Salwa *et al.*, 2018	Sanitation and improved personal hygiene should be encouraged
Maikenti *et al.*, 2020	Regular health education and portable drinking water
Shitta *et al.*, 2017	School Health Services recommended in all primary and Secondary schools
Tofa *et al.*, 2018	Regular deworming and provision of portable drinking water is needed
Nasiru *et al.*, 2017	Sanitation and improved personal hygiene should be encouraged
Abdullahi *et al.*, 2015	Regular deworming and provision of portable drinking water is needed
Adamu *et al.*, 2022	Sanitation and improved personal hygiene should be encouraged
Oriakpono *et al.*, 2015	Sanitation and improved personal hygiene should be encouraged
Nasiru *et al.*, 2000	Regular deworming and provision of portable drinking water is needed
Halima *et al.*, 2017	Regular deworming and provision of portable drinking water is needed
Summary	School Health Services recommended in all primary and Secondary schools 7 (25.9) Regular deworming and provision of portable drinking water is needed 6 (22.2) Regular health education and portable drinking water 6 (22.2) Sustainable intervention measures should be implemented 2 (7.4) Sanitation and improved personal hygiene should be encouraged 6 (22.2)_

CONCLUSION

STH infections are highly prevalent and well distributed across Nigeria and within community settings. This systematic literature review comprehensively reviews soil-transmitted helminth infections in Northern Nigeria. The findings underscore the urgent need for improved surveillance, targeted interventions, and enhanced healthcare infrastructure to control and manage STH infections in this region.

The data presented in this review can serve as a valuable resource for policymakers, healthcare professionals, and researchers working towards the eradication of STH infections in northern Nigeria. Furthermore, the identified research gaps call for further studies to enhance our understanding of the epidemiology and control of STH infections in northern Nigeria. Additional research is warranted to address existing gaps, such as the impact of STH infections on maternal and child health, the efficacy of different control measures, and the economic burden of these infections.

Recommendations

School Health Services are recommended in all primary and Secondary schools; furthermore, regular deworming and provision of portable drinking water, sanitation and improved personal hygiene, regular health education and potable drinking water, as well as the implementation of sustainable intervention measures were the common recommendations made by the authors in the analysed studies, towards the control of STH.

REFERENCES

Abdulazeez Imam, Farouk, Z. L., Hassan-Hanga, F., & Ihesiulor, U. G. (2019). A comparative cross-sectional study of prevalence and intensity of soil-transmitted helminthic infection between healthy and severe acutely malnourished pre-school aged children in Kano, Northern Nigeria. *BMC Infectious Diseases, 19*(1). **[Crossref]**

Abdulhadi, B. J. (2017). Survey on Prevalence of Intestinal Parasites Associated With Some Primary School Aged Children in Dutsinma Area, Katsina State, Nigeria. *MOJ Biology and Medicine*, 2(2). **[Crossref]**

Abdulhamid, A., & Sani, A. (2019). Prevalence and risk factors associated with helminthic infections among pre-school children in Katsina Metropolis, Katsina State, Nigeria. *International Journal of Zoology and Applied Biosciences, 4*(3), 126–133. **[Crossref]**

Abdullahi, Y., & Idris, A. (2015). Prevalence of intestinal parasitic helminths from fingernails of "Almajiris" in Birnin Kudu Local Government Area, Jigawa State, Nigeria. *International Journal of Tropical Disease & Health, 8*(2), 66-74. **[Crossref]**

Abe, E. M., Echeta, O. C., Ombugadu, A., Ajah, L., Aimankhu, P. O., & Oluwole, A. S. (2019). Helminthiasis among school-age children and hygiene conditions of selected schools in Lafia, Nasarawa State, Nigeria. *Tropical Medicine and Infectious Disease*, *4*(3). **[Crossref]**

Abednego Samuel, D., Francis, E., Francis, J., & Wamtas, F. (2019). Soil-transmitted helminths and associated risk factors among elementary school pupils in Dadin Kowa, Jos. *Nigerian Medical Journal, 60*(4), 181. **[Crossref]**

Abubakar, J., Muhammad, A., & Karatu, D. I. (2011). Prevalence of soil-transmitted helminths among school children in Yamaltu, Gombe, Gombe State Nigeria. *Gombe Medical Journal, 45*, 51.

Adamu, I., & Sule, H. (2022). Soil transmitted helminths among some primary school pupils in Dawakin Kudu Local Government Area, Kano State, Nigeria. *FUDMA Journal of Microbiology, 2*(2). researchgate.net

Adeleye, Q. A., Ahmed, P. A., Babaniyi, I. B., Oniyangi, O., Mukhtar-Yola, M., Adelayo, A. Y., Wey, Y. O., Ononiwu, U. N., Sanni, U. A., Adeleye, B. B., Adeleye, B. B., & Audu, L. I. (2023). Identifying Challenges in Implementing Child Rights Instruments in Nigeria: A Nationwide Survey of Knowledge, Perception, and Practice of Child Rights among Doctors and Nurses. *Annals of African Medicine*, *22*(2), 189-203. **[Crossref]**

Adewole, O. O., & Serifat, F. (2015). *Modelling Rainfall Series in the Geo-Political Zones of Nigeria*. *5*(2). www.iiste.org

Allen, A. V., & Ridley, D. S. (1970). Further observations on the formol-ether concentration technique for faecal parasites. *Journal of Clinical Pathology*, *23*(6), 545-546. **[Crossref]**

Amaechi, E., Edungbola, L. E., Nyamngee, A., Ikpi, R. T., & Taiwo, O. O. (2019). Soil-transmitted nematode infections in school children in a peri-urban area, North Central Nigeria. *Sri Lankan Journal of Biology, 4*(2), 1-12. **[Crossref]**

Atta, H. I., Isah, U., & Amadi, K. U. (2018). Prevalence of soil-transmitted helminths in children attending public primary schools in Samaru, Zaria, Nigeria. *FUW Trends in Science &*

Technology Journal, *4*(1). researchgate.net

Attahiru Adamu, & Bashir Abdulkadir. (2017). Common Intestinal Helminthes Associated With Nursery and Primary School Pupils in Dukku Town. *UMYU Journal of Microbiology Research (UJMR)*, *2*(1), 28–35. [Crossref]

Babatunde, S. K., Adedayo, M. R., Ajiboye, A. E., Sunday, O. A., & Nimat, A. (2013). Soil-transmitted helminth infections among school children in rural communities of Moro Local Government Area, Kwara State, Nigeria. *African Journal of Microbiology Research, 7*(45), 5148-5153. [Crossref]

Bethony, J. M., Cools, P., Albonico, M., Ame, S., Angebault, C., Ayana, M., Behnke, J. M., Cringoli, G., Dana, D., Vlaminck, J., & Vercruysse, J. (2006). Identifying thresholds to classify moderate-to-heavy soil-transmitted helminth intensity infections for FECPAKG2, McMaster, Mini-FLOTAC, and qPCR. *PLoS Neglected Tropical Diseases, 14*(7), 1-20. [Crossref]

Bhumbla, U. (2018). Stool Examination. In *Workbook for Practical Microbiology* (pp. 142–142). Jaypee Brothers Medical Publishers (P) Ltd. [Crossref]

Brahmantya, I. B. Y., Iqra, H. H. P., Hartawan, I. G. N. B. R. M., Anjani, I. A. W., Sudarmaja, I. M., & Ryalino, C. (2020). Risk factors and prevalence of soil-transmitted helminth infections. *Open Access Macedonian Journal of Medical Sciences*, *8*, 521–524. [Crossref]

Chammartin, F., Scholte, R. G. C., Guimarães, L. H., Tanner, M., Utzinger, J., & Vounatsou, P. (2013). Soil-transmitted helminth infection in South America: A systematic review and geostatistical meta-analysis. *The Lancet Infectious Diseases*, *13*(6), 507–518. [Crossref]

Chinweuba, T., Sunday, C., & Charles, J. (2014). *Patterns of Inequality in Human Development Across Nigeria's Six Geopolitical Zones*. *4*(8). www.iiste.org

Dahal, A., Francis, E., Francis, J., & Wamtas, F. (2019). Soil-transmitted helminths and associated risk factors among elementary school pupils in Dadin Kowa, Jos. *Nigerian Medical Journal*, *60*(4), 181. [Crossref]

Dawaki, S., Al-Mekhlafi, H. M., & Ithoi, I. (2019). The burden and epidemiology of polyparasitism among rural communities in Kano State, Nigeria. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *113*(4), 169–182. [Crossref]

Eniola, M., Echeta, O. C., Ombugadu, A., Ajah, L., Aimankhu, P. O., & Oluwole, A. S. (2019). Helminthiasis among school-age children and hygiene conditions of selected schools in Lafia, Nasarawa State, Nigeria. *Tropical Medicine and Infectious Disease*, *4*(3). [Crossref]

Fauziah, N., Ar-Rizqi, M. A., Hana, S., Patahuddin, N. M., & Diptyanusa, A. (2022). Stunting as a Risk Factor of Soil-Transmitted Helminthiasis in Children: A Literature Review. In *Interdisciplinary Perspectives on Infectious Diseases* (Vol. 2022). Hindawi Limited. [Crossref]

Fitriani, C. L., Panggabean, M., & Pasaribu, A. P. (2018). The accuracy of formol-ether concentration in diagnosing soiltransmitted helminths in elementary school 27 Peusangan in Bireuen. *IOP Conference Series: Earth and Environmental Science*, *125*(1). [Crossref]

Funso-Aina, O. I., Chineke, H. N., & Adogu, P. O. (2020). A Review of Prevalence and Pattern of Intestinal Parasites in Nigeria (2006-2015). *European Journal of Medical and Health Sciences*, *2*(1). [Crossref]

Galamaji, M. M., Aisha, A., Hafsat, A. L., & Victor, O. B. (2018). Epidemiological study of soil-transmitted helminthic among primary school pupils in Jega, Kebbi State, Nigeria. *South Asian Journal of Parasitology*, *1*(4), 1-7. [Crossref]

Hailegebriel, T., Nibret, E., & Munshea, A. (2020). Prevalence of Soil-Transmitted Helminth Infection Among School-Aged Children of Ethiopia: A Systematic Review and Meta-Analysis. *Infectious Diseases: Research and Treatment*, *13*, 117863372096281. [Crossref]

Halima, B.-M., Mamman, A., Suleiman, H., Olayinka, A., Musa, A., & Musa, K. (2017). Prevalence and pattern of parasitic infestations among nomadic Fulani children in a grazing reserve in Northwestern Nigeria. *Annals of Tropical Medicine and Public Health*, *10*(6), 1799. [Crossref]

Ikpe, R. T., Taiwo, O. O., Edungbola, L. D., Nyamngee, A., & Amaechi, E. C. (2020). Concurrent intestinal schistosomiasis and soil-transmitted nematode infections in primary school children, Benue State, North Central Nigeria. [Crossref]

Imam, A., Farouk, Z. L., Hassan-Hanga, F., & Ihesiulor, U. G. (2019). A comparative cross-sectional study of prevalence and intensity of soil-transmitted helminthic infection between healthy and severe acutely malnourished pre-school aged children in Kano, Northern Nigeria. *BMC Infectious Diseases*, *19*(1). [Crossref]

Ishaku, M. J., Onyeacho, C. P., & Koggie, A. Z. (2020). Prevalence of Gastrointestinal Helminth Parasites among School Children Attending Two Community Schools in Auta Balefi, Karu, Nasarawa State. *Annual Research & Review in Biology*, 96-106. [Crossref]

Jayaram, S., Saya, G. K., Rajkumari, N., Ulaganeethi, R., Roy, P. K., & Mathavaswami, V. (2021). Prevalence of intestinal parasitic infection and its associated factors among children in Puducherry, South India: a community-based study. *Journal of Parasitic Diseases*. [Crossref]

Karagiannis-Voules, D. A., Biedermann, P., Ekpo, U. F., Garba, A., Langer, E., Mathieu, E., Midzi, N., Mwinzi, P., Polderman, A. M., Raso, G., Sacko, M., Talla, I., Tchuenté, L. A. T., Touré, S., Winkler, M. S., Utzinger, J., & Vounatsou, P. (2015). Spatial and temporal distribution of soil-transmitted helminth infection in sub-Saharan Africa: A systematic review and geostatistical meta-analysis. *The Lancet Infectious Diseases*, *15*(1), 74-84. [Crossref]

Karshima, S. N. (2018). Prevalence and distribution of soil-transmitted helminth infections in Nigerian children: A systematic review and meta-analysis. In *Infectious Diseases of Poverty* (Vol. 7, Issue 1). BioMed Central Ltd. [Crossref]

Khan, W., Rahman, H., Rafiq, N., Kabir, M., Ahmed, M. S., & Escalante, P. D. L. R. (2022). Risk factors associated with intestinal pathogenic parasites in schoolchildren. *Saudi Journal of Biological Sciences*. [Crossref]

Kiiti, R. W., Omukunda, E. N., & Korir, J. C. (2020). Risk Factors Associated with Helminthic Intestinal Infection in Lurambi Subcounty, Kakamega, Kenya. *Journal of Parasitology Research, 2020.* [Crossref]

Lawal, A., Abba, A. M., Omenesa, R. L., Suleiman, M. J., & Murtala, U. M. (2022). Impact of soil-transmitted helminths (STHs) on nutritional and anemia status in school-aged children in Batagarawa Local Government Area, Katsina State, Nigeria. *UMYU Scientifica, 1*(1), 67-74. [Crossref]

Leta, G. T., Mekete, K., Wuletaw, Y., Gebretsadik, A., Sime, H., Mekasha, S., Woyessa, A., Shafi, O., Vercruysse, J., Grimes, J. E. T., Harrison, W., & Fenwick, A. (2020). National mapping of soil-transmitted helminth and schistosome infections in Ethiopia. *Parasites and Vectors*, *13*(1). [Crossref]

Loukouri, A., Méité, A., Kouadio, O. K., Djè, N. N., Trayé-Bi, G., Koudou, B. G., & N'Goran, E. K. (2019). Prevalence, Intensity of Soil-Transmitted Helminths, and Factors Associated with Infection: Importance in Control Program with Ivermectin and Albendazole in Eastern Côte d'Ivoire. *Journal of Tropical Medicine, 2019*. [Crossref]

Mackinnon, E., Ayah, R., Taylor, R., Owor, M., Ssempebwa, J., Olago, L. D., Kubalako, R., Dia, A. T., Gaye, C., C. Campos, L., C. Campos, L., & Fottrell, E. (2019). 21st century research in urban WASH and health in sub-Saharan Africa: methods and outcomes in transition. *International Journal of Environmental Health Research*, *29*(4), 457-478. [Crossref]

Maikenti, J., Onyeacho, C. P., & Koggie, A. Z. (2020). Prevalence of gastrointestinal helminth parasites among school children attending two community schools in Auta Balefi, Karu, Nasarawa State. *Annual Research & Review in Biology, 35*(2), 96-106. [Crossref]

Monyei, F. E., Onyekwelu, P. N., Emmanuel, I. E., & Taiwo, O. S. (2023). Linking Safety Net Schemes and Poverty Alleviation in Nigeria. *International Journal of Community and Social Development*, *5*(2), 187-202. [Crossref]

Nasiru, A., Ige, A. O., Otone, B., & Abubakar, M. (2017). Prevalence of intestinal helminths among primary school children in Bosso, North Central Nigeria. *International Journal of Biomedical and Advance Research, 473*(12). www.ssjournals.com

Nasiru, M., Fana, S. A., Enimien, J. O., & Emmanuel, B. W. (2000). Intestinal helminthic infection in Numan (Northeast Nigeria). *International Journal of Progressive Sciences and Technologies (IJPSAT), 1*(1). http://ijpsat.ijsht-journals.org

Nisha, M., Aiman, M., Asyhira, N., Syafiq, H., Atiqah, N., Kumarasamy, V., Tan, M. P., & Davamani, F. (2020). Risk factors associated with soil transmitted helminth (STH) infection in two indigenous communities in Malaysia. *Tropical Biomedicine*, *37*(2), 379-388.

Nwalorzie, C., Nyenakazi, S., Ogwu, S., & Okafor, A. (2015). Predictors of intestinal helminthic infections among school children in Gwagwalada, Abuja, Nigeria. *Nigerian Journal of Medicine, 24*(3), 233-241. **[Crossref]**

Obeta, M. U., Omenesa, R. L., Lote-Nwaru, J. R. I., & Ibrahim, A. S. (2019). Prevalence and distribution of soil-transmitted helminths among children attending Township Primary School, Jos, Plateau State, Nigeria. *London Journal of Medical and Health Research*. http://creativecommons.org/licenses/by/4.0/

Ohiolei, J. A., Isaac, C., & Omorodion, O. A. (2017). A review of soil transmitted helminthiasis in Nigeria. In *Asian Pacific Journal of Tropical Disease* (Vol. 7, Issue 12, pp. 841–848). Editorial Office of Asian Pacific Journal of Tropical Disease. **[Crossref]**

Ojha, R., Kharel, G., Shing, Y. K., Jamarkattel, S., Yadav, J. K., Vyas, H., Poudyal, D., & Sah, R. (2014). The dangers of mass drug administration of albendazole in Nepal, a neurocysticercosis-endemic region. *Tropical Diseases, Travel Medicine and Vaccines, 6*(1). **[Crossref]**

Oloyede, S. B., Akinleye, A. A., Agunbiade, T. B., Adeyemo, O. A., Bakare, O. E., & Adeyeba, O. A. (2017). Survey of intestinal schistosomiasis and soil-transmitted helminthiasis among pupils in Ifelodun, Kwara State, Nigeria. *Journal of Bio-Innovation, 6*(1). www.jbino.com

Oriakpono, J., Fana, S. A., Enimien, J. O., & Emmanuel, B. W. (2015). Intestinal helminthic infection in Numan (Northeast Nigeria). *International Journal of Progressive Sciences and Technologies (IJPSAT), 1*(1). http://ijpsat.ijsht-journals.org

Saddiqa, M., Abubakar, M. B., Hassan, I., & Aliyu, U. (2020). Prevalence of soil-transmitted helminths among primary school children in Yana, Bauchi State, Nigeria. *Bima Journal of Science and Technology, 3*(2). **[Crossref]**

Salwa, D., Al-Mekhlafi, H. M., & Ithoi, I. (2019). The burden and epidemiology of polyparasitism among rural communities in Kano State, Nigeria. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 113*(4), 169-182. **[Crossref]**

Samuel, F. (2015). Status of Soil-Transmitted Helminths Infection in Ethiopia. *American Journal of Health Research, 3*(3), 170. **[Crossref]**

Sanchez, A. L., Gabrie, J. A., Rueda, M. M., Mejia, R. E., Bottazzi, M. E., & Canales, M. (2014). A Scoping Review and Prevalence Analysis of Soil-Transmitted Helminth Infections in Honduras. In *PLoS Neglected Tropical Diseases* (Vol. 8, Issue 1, p. 17). Public Library of Science. **[Crossref]**

Santosh K. A. (2012). *Microbiological Stool Examination: Overview*. researchgate.net

Sardar, A. D., Patel, V., & Venkatesh, S. (2016a). *Prevalence of Soil-Transmitted Helminthic Infection in India in Current Scenario: A Systematic Review*. researchgate.net

Sardar, A. D., Patel, V., & Venkatesh, S. (2016b). *Prevalence of Soil-Transmitted Helminthic Infection in India in Current Scenario: A Systematic Review*. researchgate.net

Sartorius, B., Cano, J., Tusting, L. S., Pullan, R. L., Marczak, L. B., Miller-Petrie, M. K., Hay, S. I., Sartorius, B., Cano, J., Simpson, H., Tusting, L. S., Marczak, L. B., Miller-Petrie, M. K., Kinvi, B., Zoure, H., Mwinzi, P., Hay, S. I., Rebollo, M., & Pullan, R. L. (2020). *Prevalence and intensity of soil-transmitted helminth infections of children in sub-Saharan Africa, 2000-18: a geospatial analysis*. **[Crossref]**

Shitta, K. B., Audu, H. O., & Usman, A. Y. (2018). Prevalence of geohelminthes in school children in some parts of Lokoja, Kogi State, North-Central Nigeria. *Bayero Journal of Pure and Applied Sciences, 10*(1), 151. **[Crossref]**

Shuaibu, I., Umar, Y. A., & Chanding, A. Y. (2018). Prevalence and Associated Risk Factors of Gastro – Intestinal Parasites among Primary School Pupils in Ilorin East Local Government Area, Kwara State, Nigeria. *Researchers World : Journal of Arts, Science and Commerce, IX*(4), 137. **[Crossref]**

Sule, H., & Adamu, I. A. (2019). Soil transmitted helminths among some primary school pupils in Dawakin Kudu Local Government Area, Kano State, Nigeria. *FUDMA Journal of Microbiology, 2*(2). researchgate.net

Suwansaksri, J., Nithiuthai, S., Wiwanitkit, V., Soogarun, S., & Palatho, P. (2002). *THE FORMOL-ETHER CONCENTRATION TECHNIQUE FOR INTESTINAL PARASITES:*

COMPARING 0.1 N SODIUM HYDROXIDE WITH NORMAL SALINE PREPARATIONS (Vol. 33, Issue 3).

Taiwo, O. O., Edungbola, L. E., Nyamngee, A., Ikpi, R. T., & Amaechi, E. C. (2019). Soil-transmitted nematode infections in school children in a peri-urban area, North Central Nigeria. *Sri Lankan Journal of Biology*, *4*(2), 1–12. **[Crossref]**

Tofa, D. Y., Sulaiman, S., & Umar, S. S. (2018). Helminth infection among pupils of seven primary schools in Tamburawa, Dawakin-Kudu Local Government, Kano State, Nigeria. *International Journal of Advanced Academic Research | Arts, 4*(4).

World Health Organization (2021). *World Health Organization Report Part Title: Core data elements Report Title: Digital Adaptation Kit for Antenatal Care Report Subtitle: Operational requirements for implementing WHO recommendations in digital systems Report Author(s): World Health Organization*.

World Health Organization. (2022). *World Health Organization Report Part Title: Health interventions and recommendations Report Title: Digital Adaptation Kit for Antenatal Care Report Subtitle: Operational requirements for implementing WHO recommendations in digital systems Report Author(s): World Health Organization*.

Yahaya, A., Tyav, Y., & Idris, A. (2015). Prevalence of Intestinal Parasitic Helminths from Fingernails of "Almajiris" in Birnin Kudu Local Government Area, Jigawa State, Nigeria. *International Journal of TROPICAL DISEASE & Health*, *8*(2), 66–74. **[Crossref]**

Yusuf, T. D., Sulaiman, S., & Umar, S. S. (2018). Helminthes Infection Among Pupils of Seven Primary Schools In Tamburawa, Dawakin-Kudu Local Government, Kano State Nigeria. \. In *International Journal of Advanced Academic Research | Arts* (Vol. 4, Issue 4).