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Helminth Infection among Children Living in an Urban Area in Tropical Countries: A Systematic Review

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Abstract

BACKGROUND: Neglected tropical diseases are a group of preventable and treatable diseases, in which soil-transmitted helminth (STH) infections are among the most common infections worldwide.

AIM: Most affected are the children and this review aims to identify the prevalence, risk factors, and impact of STH in an urban area.

METHODS: This review was guiding using preferred reporting items for systematic reviews and meta-analyses review protocol incorporating the research question of "What is the prevalence, risk factors, and impact of Helminth infection among urban children in tropical countries?" The databases used in this review include SCOPUS, WEB OF SCIENCE, OVID MEDLINE, and PUBMED. The articles used include observational and interventional studies conducted among children aged 18 years and less from 2010 to 2020. The main outcome measure was risk factors of STH infection seen in urban children include social backgrounds, sanitation, and policy.

RESULTS: From the initial 973 articles found in the database searching, only 13 articles selected for qualitative synthesis after exclusion and screening for eligibility done. The overall prevalence of helminth infection among urban children ranges from 4.8% to 48.9%. The associated factor that influences helminth infection among children living in an urban area are age, male more common than female, low socioeconomic status, low parents' education level, living in an urban slum or crowded area, low water quality and sanitation practice, and poor hygiene practice. The deworming tablets consumption acts as protective factors for helminth infections. The medium hemoglobin value was significantly lower in helminth-infected children compared to uninfected children and the stunting, underweight as well as moderate acute malnutrition were attributable to helminth infections.

CONCLUSION: The prevalence and intensity of helminthiasis were heterogeneous among urban areas of developing countries; however, the endemicity is still high. Further efforts including healthy policies, continuous national deworming programs, and multi-sectorial partnership are required to reduce the prevalence of helminthiasis in the urban area.

Introduction

Neglected tropical diseases (NTDs) are a group of preventable and treatable parasitic, viral, and bacterial diseases that result in substantial illness for more than 1 billion people globally [1]. The worldwide statistic shows more than 1.5 million people, accounting to almost a quarter of the world's population, are infected with soil-transmitted helminth (STH) infections. Most infections are highly distributed in tropical and subtropical areas, with the greatest numbers occurring in sub-Saharan Africa, the Americas, China, and East Asia [2]. In addition, the global burden of STH infection was estimated at 1.9 million disability-adjusted life years [3], [4].

STH infection has become the concern among the poorest and most deprived communities. The main species that infect people are the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*), and hookworms (*Necator americanus* and *Ancylostoma duodenale*) [2]. They are transmitted by eggs present in human faces which, in turn, contaminate the surrounding soil areas. The route of transmission is through fecal-oral or skin penetration when in mature form [2], [5]. Although STH infection has been frequently related to the rural area, the prevalence in the urban setting is appallingly high reaching up to 55% [4].

The impairment of normal developmental milestones is tremendous in STH infected children. The disability not only affects the children school attendance, but also disrupts the productivity of family, particularly worsening in the unstable economic countries [1]. The previous literature noted that the STH infection sequelae such as stunting, wasting, anemia, and hypersensitivity were common, that could lead to mortality without early intervention [1], [4], [6], [7].

The Global NTD programs conducted through regional collaboration of the World Health Organization (WHO) member state countries, aimed to improve the existing NTD intervention such as the mass drug administration campaigns [1]. The WHO recommended preventive chemotherapy with Albendazole or Mebendazole to at least 75% of school age children in the endemic countries. However, the sustainability of the effort was incapacitated by limitation of global financial support, drug donation capacity of pharmaceutical companies and exclusively targeting school-age children to the need of treatment as compared to other age groups like the preschool-age children [8]. Nonetheless, countries with high STH endemicity were expected to reach the effective treatment coverage target as outlined in the Sustainable Development Goal 3, aimed on ending the NTDs by 2030 [9].

The continuous increase in treatment coverage and operational challenges related to preventive chemotherapy strategies are important to control the spread of the disease in the rural area [9]. However, the progressive rise of STH among the urban dwellers shall not be overlooked by the stakeholders. Several studies showed the prevalence of STH in the urban settings ranges from more than 10% to <50%, indicating the lack of control activities and health programs of the population [10], [11]. Therefore, this review aims to identify the prevalence, risk factors and impact of helminth infection among urban children in the tropical region.

Methods

The review protocol - preferred reporting items for systematic reviews and meta-analysis (PRISMA)

This systematic review was conducted based on the PRISMA guideline.

Formulation of research questions

The review question was developed based on the population, phenomena of interest and context concept [12]. The population is children under 18 years old who live in urban or suburban area, phenomena of interest is helminth infection and the context is prevalence, risk factors, and impact of helminth.

Information sources

A systematic and structured electronic search was conducted from the four primary databases, including Scopus, Web of Science, Ovid Medline, and PubMed. The literature search was conducted using specific keywords and identified medical search heading terms for PubMed. The keywords used to search the related articles are shown in Appendix A.

Systematic searching strategies

In total, the four databases identified 973 potentially relevant articles for screening. The title of all articles was screened to find any duplicates and 62 records were removed during this stage, while 911 records were screen based on the inclusion criteria and exclusion criteria. The inclusion criteria were: (a) Articles that were published within 10 years from 2010 to 2020, (b) full article journal, (c) studies that were published in the English language, and (d) observational and interventional studies related to the helminth's infection among children in the urban area. Title and abstract that were not an original article such as conference abstracts, book chapter, reports, systematic reviews, and meta-analysis were therefore excluded from the study. Based on these criteria, a total of 487 records were excluded from the study. After exclusion, the remaining 424 records were assessed for relevance articles by three authors based on the title's abstracts. A total of 42 full articles that were potentially eligible based on their title or abstract were retrieved in full and assessed independently for eligibility and relevance. Disagreement about the eligibility of reports was resolved in discussion among the four authors. Finally, a total of 13 articles included in the qualitative synthesis analysis, as shown in Appendix B.

Four authors assessed the articles using the appraisal tool, namely, mixed methods appraisal tool (MMAT) Version 2018. This appraisal tool able to assess the quality of different study designs include qualitative, quantitative, and mixed methods studies [13].

Based on MMAT classification, all 13 final articles included in this review fall into the quantitative non-randomized study design category. The score was given as 20% for Yes, 10% for can't tell, and 0% for No. Eight studies were given the highest score of 100% [6], [14], [15], [16], [17], [18], [19], [20], four studies were given 80% score [21], [22], [23], [24], and one study was given a score of 70% [7]. One author in the team cross-checked the findings of the evaluation. Disagreements about the quality appraisal were resolved in discussion.

Four authors went through all articles and individually reviewed the 13 articles. Data were extracted to a data extraction form and organize into a standard Microsoft Excel 2019 spreadsheet. The data and information collected included: (1) authors, (2) year of publication (3) country, (4) study design (5) objective, (6) methodology and study tools, and (7) sample size and findings from the publication that answer the review question which is prevalence, risk factor, and impact of helminth infection among urban children. A discussion was conducted to identify relevant common themes.

Information obtained from the analyzed articles were grouped accordingly into nine main themes for risk factors and three themes for the impact of Helminth.

Results

Background of selected articles

A total of 13 studies were included in this systematic review (Appendix C). Descriptive summary of included studies concerning publication year, study location and setting are shown in Appendix D All eligible studies were conducted in various WHO geographical region with the majority of from the African Region. All of the studies included were conducted in a tropical country. Majority of the studies was conducted from 2010 to 2014. The study setting for all of the studies included was the subnational level. Most of the study designs were cross sectionals (11 studies) and one each case controls and cohort, respectively. Majority of the studies involves the school-aged (6–12 years old), with three studies involving the preschooler age group (2–5 years old) and two studies involve the adolescent age group (13–18 years old).

Prevalence, the themes, and sub-themes

The overall prevalence of helminth infection among urban children ranges from 4.8 to 48.9%. Five studies reported that the most typical infections were *T. trichiura* [6], [15], [17], [18], [22]. Meanwhile, five studies [7], [14], [16], [20] reported *A. lumbricoides* and two studies reported hookworm as the most common intestinal infection among urban children [22], [24]. Said *et al*. reported *Schistosoma* spp. as the most common intestinal infection [19]. The prevalence of helminth infection among urban children was summarized in Appendix E.

Based on thematic analysis, three main themes were identified as risk factors for Helminth infection among urban children, namely, social background, sanitation, and policy. As shown in Appendix C, the sub-themes under social background were age (4 studies), sex (5 studies), low socioeconomic status (2 studies), live in urban slum or overcrowded places (2 studies), and parent’s education level (1 studies). The sub-themes under sanitation include water and sanitation (5 studies) and poor hygiene (5 studies). Meanwhile, deworming program (3 studies) and polyparasitism (1 study) were categorized under the policy theme. For the impact of helminth infection among urban children, there were three main themes identified, namely, anemia (2 studies), malnutrition (2 studies) and hypersensitivity reaction (1 study).

A total of eight studies reported on a social background as risk factors for helminth infection among urban children. Four studies identified age as a risk factor related to intestinal helminth infection [15], [17], [23], [24]. Three studies reported males to represent a higher infection rate than females [6], [15], [23], while two studies reported the higher infection were among females [17], [24]. The low socioeconomic status was significant risk factors for infection with helminths [6], [16]. Besides, living in an urban slum or crowded area [14], [24] and parents’ education level [21] also were found to be a risk factor for helminth infection among urban children.

Low water quality and sanitation practice [16], [18] such as defecate in the open field [14], [21], and having septic tank toilet in the house [19] found to be associated factors in the presence of helminth infection among children. Besides, poor hygiene practice such as eating raw vegetable and undercooked food and habitually eating food that has fallen also associated with helminth infection [14], [15], [16], [20], [21]. In addition, deworming tablets’ consumption acts as protective factors for helminth infections [6], [14]. In term of duration of deworming, Lwanga *et al*. found that children who were last de-wormed more than 6 months to the time of research were twice more likely to be infected with Helminths than those last de-wormed <6 months [22].

For the impact of helminth infections, Said *et al*. found that the medium Hb value was significantly lower in helminth-infected children compared to uninfected children [19]. The morbidity imposed by helminth infections such as anemia remains a challenge and cannot be overcome by preventive chemotherapy alone [15]. One study revealed that stunting, underweight and moderate acute malnutrition was attributable to helminth infections [22]. Besides, Lander *et al*. reported that among 20% of preschoolers classified as undernourished or moderately undernourished, nearly one-third presented with an intestinal parasitic infection, notably *A. lumbricoides* and *T. trichiura* [6]. Finally, Obeng *et al*. reported that Trichuris was positively associated with cockroach skin prick test [7].

Discussion

The presence of STH infections in tropical and subtropical countries remains a major public health concern with its prevalence ranging between 13% and 48% [6], [15], [19], [23]. Even though many studies examined the high prevalence of STH infection in a rural area, there is still a significant proportion of the urban and peri-urban dwellers having similar disease [11], [25], [26]. Substantial efforts by the health authorities to eliminate STH infection have overlooked certain group of population potential as the source of dissemination and persistence [11].

Majority of the study reported highest STH infection among the male of school-going age children, living in urban poor area [26], [27], [28]. The infection is most commonly seen in the younger age group because they are more prone into direct contact with the dirt during playing in the playground and seldom use of shoes [15], [16], [28]. Despite gender being described in numerous studies as having an association with STH infection, it must be interpreted in a cautious manner as a direct risk factor due to the characteristic variations that can be attributed to the composition of sample size in each study setting [16], [29], [30], [31]. In fact, in certain endemic areas, children were exposed to similar risk factors that the susceptibility does not differ between opposite genders.

The occurrence of STH infection within the school-aged children has been linked to the parental low socioeconomic background [11]. Underlying the socioeconomic pressure and low job opportunities, people migrate from rural to urban areas for better needs. Extensive population growth coupled with high living cost in the urban limits the affordability for housing scheme and thus increases number of the slum area. Staying in an overcrowded area, lack of access to sanitation facilities and proper drinking water sources were the most important factors contributing to the persistence of STH in the population [11], [27], [31], [32]. Besides that, failure to detect early and limited access to proper treatment may lead to serious consequences of the children including malnutrition, stunting, and developmental delay [16], [28], [29].

Lack of personal hygiene has been longed identified as a source of STH infection particularly to the younger age children [29], [33]. The previous studies revealed <10% of caregivers washed their hands before feeding children, approximately 50% parents lack of trimming nails habit and some had habit of eating unwashed raw food [26], [30], [34]. Studies in Sri Lanka reported a high prevalence of STH infection among children who consumed unwashed fruit [15]. Collectively, the attitude and personal hygiene determine the recurrent STH infection within the community. Health education or promotion regarding knowledge on the importance of practicing good hygiene habit should focus the parents where early education begins at the household level.

This review revealed that prophylactic deworming was also a determinant factor on helminth infection among children staying in urban localities, as deworming was seen as a protective factor in reducing the prevalence [6], [14], [22]. The policy on periodical deworming regulated by many tropical countries as recommended by the WHO to minimize and sustain the severity and to protect at-risk populations against worm infection, however, findings on the effectiveness vary [2], [35], [36]. Moreover, in this review, polyparasitism was seen as no exception even in children living in urban area whereby, they were being infected with more than one species of helminths or co-infected with other parasites such as protozoa [23]. Polyparasitism signify the lack in sanitary-hygienic habit, which potentially cause high susceptibility to other infections and higher impacts on morbidity [4], [37].

In addition to determining risk factors on STH prevalence, other outcome evaluated in this review included impacts caused by the infection; anemia, malnutrition, and allergy [6], [7], [19], [22]. The impacts found among STH infected children living in urban localities were not dissimilar than those in rural, given that the types of helminths found were not immensely different. There is association of children with intestinal helminth infection with anemia as it interferes iron stores therefore induces iron deficiency [38], [39]. Helminth infections are also associated with malnutrition for it contributes to increased nutritional loss by decreasing appetite, persistent vomiting, diarrhea, or blood loss [40]. While helminth infection has a negative association with allergies, the impact tends to differ by species of helminth and age of infection. The dynamic relationship between helminths and allergies is still inadequately understood up to current date [41], [42]. They are few recommendations for future research. The WHO guidelines emphasizing control and eventual elimination of STH infection which include preventive deworming chemotherapy aimed at “at-risk” populations, should be applied by all endemic countries. Studies have shown improvements in nutritional status and hemoglobin levels in children after deworming [43], [44], [45]. Efforts on STH infection control should be included in the national agenda, providing sustainable intervention strategies that are more focused and targeted. Surveillance and continuous monitoring of the available programs are in fact necessary to look on the effectiveness and room of improvements. Health and hygiene education aiming on the behavioral modification to reduce transmission and provision of adequate sanitation are likewise crucial, especially among children as good habits need to be trained from young age. The attempt on focusing to improved water, hygiene, and sanitation consist of a multi-pronged approach that involves community water resource management, encouraging local bodies and private organizations to increase capacity to procure clean drinking water, encourage hand hygiene and provision of proper latrines. Better awareness of hygiene practices, improved sanitation, and a more frequent supply of piped water will help to further reduce these parasitic infections, thus improving the overall quality of health status endemic parts of the world. There are few limitations of this systematic review. First, most of the studies included in the systematic review were cross-sectional, thus unable to elicit plausible relationship of existing helminths infection and the risk factors. Second, despite the high prevalence of helminth infections among the peri-urban and urban area concluded from the analysis of the studies, majority were conducted in African region, hence the findings cannot be generalized to other tropical countries due to different socio-economic backgrounds. Third, the inconsistent pattern of helminths identification across all studies may underestimate the prevalence of STH infections particularly in the urban area.

Conclusion

While the prevalence and intensity of helminthiasis were heterogeneous among urban areas of developing countries, the endemicity is still high. Healthy policies and continuous national deworming programs targeting the urban poor schoolchildren are required in the tropical countries. Multi-sectorial partnership to help improves the waste management system in the overcrowded and urban slum area, warrants further attention from the local authorities to break the chain of persistent infection.

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Author Contributions

All authors contributed to the design and implementation of the research, analysis of the results, and writing of the manuscript.

References

1. Centre for Disease Control and Prevention. Neglected Transmitted Disease; 2020. Available from: https://www.cdc.gov/globalhealth/ntd [Last accessed on 2022 May 25].
2. World Health Organization. Soil-Transmitted Helminth Infections. Geneva: World Health Organization; 2020. Available from: https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections [Last accessed on 2020 Dec 24].
3. Freeman MC, Akogun O, Belizario V Jr., Brooker SJ, Gyorkos TW, Imtiaz R, *et al*. Challenges and opportunities for control and elimination of soil-transmitted helminth infection beyond 2020. PLoS Negl Trop Dis. 2019;13(4):e0007201. https://doi.org/10.1371/journal.pntd.0007201
   PMid:30973872
4. Mekonnen Z, Suleman S, Biruksew A, Tefera T, Chelkeba L. Intestinal polyparasitism with special emphasis to soil-transmitted helminths among residents around Gilgel Gibe Dam, Southwest Ethiopia: A community based survey. BMC Public Health. 2016;16(1):1185. https://doi.org/10.1186/s12889-016-3859-2
5. Shumbej T, Menu S, Girum T, Bekele F, Gebru T, Worku M, *et al*. Impact of annual preventive mass chemotherapy for soil-transmitted helminths among primary school children in an endemic area of Gurage zone: A prospective cross-sectional study. Res Rep Trop Med. 2019;10:109-18. https://doi.org/10.2147/RRTM.S208473
   PMid:31308788
6. Lander RL, Lander AG, Houghton L, Williams SM, Costa-Ribeiro H, Barreto DL, *et al*. Factors influencing growth and intestinal parasitic infections in preschoolers attending philanthropic daycare centers in Salvador, Northeast region of Brazil. Cad Saúde Pública. 2012;28(11):2177-88. https://doi.org/10.1590/S0102-311X2012001100017
   PMid:23147959
7. Obeng BB, Amoah AS, Larbi IA, de Souza DK, Uh HW, Fernández-Rivas M, *et al*. Schistosome infection is negatively associated with mite atopy, but not wheeze and asthma in Ghanaian schoolchildren. Clin Exp Allergy. 2014;44(7):965-75. https://doi.org/10.1111/cea.12307
   PMid:24641664
8. Barry MA, Simon GG, Mistry N, Hotez PJ. Global trends in neglected tropical disease control and elimination: Impact on child health. Arch Dis Child. 2013;98(8):635-41. https://doi.org/10.1136/archdischild-2012-302338
   PMid:23793132
9. Marocco C, Tediosi F, Bangert M, Mupfasoni D, Montresor A. Estimated need for anthelminthic medicines to control soil-transmitted helminthiases in school-aged children, 2020-2030. Infect Dis Poverty. 2020;9(1):48. https://doi.org/10.1186/s40249-020-00656-9
   PMid:32381061
10. Eze P, Agu UJ, Aniebo CL, Agu SA, Lawani LO. Perception and attitudinal factors contributing to periodic deworming of preschool children in an urban slum, Nigeria. BMC Public Health. 2020;20(1):1839. https://doi.org/10.1186/s12889-020-09958-x
    PMid:33261596
11. Sahimin N, Abd Khalil NS, Lewis JW, Mohd Zain SN. Post-era mass drug administration: An update on intestinal parasitic infections in urban poor communities in Peninsular Malaysia. Trop Biomed. 2020;37(2):363-71.
    PMid:33612805
12. Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Healthc. 2015;13(3):179-87. https://doi.org/10.1097/XEB.0000000000000062
    PMid:26262565
13. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, *et al*. The mixed methods appraisal tool (Mmat) version 2018 for information professionals and researchers. Educ Inform. 2018;34(4):285-91.
14. Kattula D, Sarkar R, Ajjampur SS, Minz S, Levecke B, Muliyi J, *et al*. Prevalence & risk factors for soil transmitted helminth infection among school children in South India. Indian J Med Res. 2014;139(1):76-82.
    PMid:24604041
15. Knopp S, Mohammed KA, Stothard JR, Khamis IS, Rollinson D, Marti H, *et al*. Patterns and risk factors of helminthiasis and anemia in a rural and a peri-urban community in Zanzibar, in the context of helminth control programs. PLoS Negl Trop Dis.

2010;4(5):e681. https://doi.org/10.1371/journal.pntd.0000681

PMid:20485491

16. Mbuh JV, Ntonifor NH, Ojong J. The epidemiology of soil-transmitted helminth and protozoan infections in South-West Cameroon. J Helminthol. 2012;86(1):30-7. https://doi.org/10.1017/S0022149X1000091X

PMid:21281528

17. Odiere MR, Opisa S, Odhiambo G, Jura WG, Ayisi JM, Karanja DM, *et al*. Geographical distribution of schistosomiasis and soil-transmitted helminths among school children in informal settlements in Kisumu City, Western Kenya. Parasitology. 2011;138(12):1569-77. https://doi.org/10.1017/S003118201100059X

PMid:21679486

18. Rosewell A, Robleto G, Rodriguez G, Barragne-Bigot P, Amador JJ, Aldighieri S. Soil-transmitted helminth infection and urbanization in 880 primary school Children in Nicaragua, 2005. Trop Doct. 2010;40(3):141-3. https://doi.org/10.1258/td.2010.090425

PMid:20555043

19. Said K, Hella J, Knopp S, Nassoro T, Shija N, Aziz F, *et al*. Schistosoma, other helminth infections, and associated risk factors in preschool-aged children in urban Tanzania. PLoS Negl Trop Dis. 2017;11(11):e0006017. https://doi.org/10.1371/journal.pntd.0006017

PMid:29108003

20. Staudacher O, Heimer J, Steiner F, Kayonga Y, Havugimana JM, Ignatius R, *et al*. Soil-transmitted helminths in Southern highland Rwanda: Associated factors and effectiveness of school-based preventive chemotherapy. Trop Med Int Health. 2014;19(7):812-24. https://doi.org/10.1111/tmi.12321

PMid:24750543

21. Abera B, Alem G, Yimer M, Herrador Z. Epidemiology of soil-transmitted helminths, *Schistosoma mansoni*, and haematocrit values among schoolchildren in Ethiopia. J Infect Dev Ctries. 2013;7(3):253-60. https://doi.org/10.3855/jidc.2539

PMid:23493004

22. Lwanga F, Kirunda BE, Orach CG. Intestinal helminth infections and nutritional status of children attending primary schools in Wakiso District, Central Uganda. Int J Environ Res Public Health. 2012;9(8):2910-21. https://doi.org/10.3390/ijerph9082910

PMid:23066405

23. Muñoz-Antoli C, Gozalbo M, Pavón A, Pérez P, Toledo R, Esteban JG. Enteroparasites in preschool children on the pacific region of Nicaragua. Am J Trop Med Hyg. 2018;98(2):570-5. https://doi.org/10.4269/ajtmh.17-0551

PMid:29260648

24. Von Huth S, Kofoed PE, Holmskov U. Prevalence and potential risk factors for gastrointestinal parasitic infections in children in Urban Bissau, Guinea-Bissau. Trans R Soc Trop Med Hyg. 2019;113(9):trz032. https://doi.org/10.1093/trstmh/trz032

PMid:31034044

25. Balen J, Raso G, Li YS, Zhao ZY, Yuan LP, Williams GM, *et al*. Risk factors for helminth infections in a rural and a peri-urban setting of the Dongting Lake area, people's republic of China. Int J Parasitol. 2011;41(11):1165-73. https://doi.org/10.1016/j.ijpara.2011.07.006

PMid:21854780

26. Gyang VP, Chuang TW, Liao CW, Lee YL, Akinwale OP, Orok A, *et al*. Intestinal parasitic infections: Current status and associated risk factors among school aged children in an archetypal African urban slum in Nigeria. J Microbiol Immunol Infect. 2019;52(1):106-13. https://doi.org/10.1016/j.jmii.2016.09.005

PMid:28711437

27. Asady A, Ismail S, Jalil MA, Pakeer O. Soil transmitted helminth infection among children admitted to hospital Tengku Ampuan Afzan, Kuantan, Pahang. Int Med J Malaysia. 2019;18(2):107-12. https://doi.org/10.31436/imjm.v18i2.89

28. Van Soelen N, Mandalakas AM, Kirchner HL, Walzl G, Grewal HM, Jacobsen M, *et al*. Effect of *Ascaris Lumbricoides* specific IgE on tuberculin skin test responses in children in a high-burden setting: A cross-sectional community-based study. BMC Infect Dis. 2012;12:211. https://doi.org/10.1186/1471-2334-12-211

29. Darlan DM, Alexandra TS. Tala ZZ. Soil transmitted helminth infections in medan: A cross-sectional study of the correlation between the infection and nutritional status among elementary school children. Family Med Prim Care Rev. 2017;19(2):98-103. https://doi.org/10.5114/fmpcr.2017.67860

30. Indah BP, Indraningrat AA, Arwati H, Dachlan YP. Short communication: Prevalence and risk factors of soil-transmitted helminth infection among farmers in Gelgel Village, Klungkung District, Bali, Indonesia. Biodivers J Biol Divers. 2020;21(4):1535-40. https://doi.org/10.13057/biodiv/d210434

31. Tekalign E, Bajiro M, Ayana M, Tiruneh A, Belay T. Prevalence and intensity of soil-transmitted helminth infection among rural community of Southwest Ethiopia: A community-based study. Biomed Res Int. 2019;2019:3687873. https://doi.org/10.1155/2019/36878732

PMid:31915688

32. Belyhun Y, Medhin G, Amberbir A, Erko B, Hanlon C, Alem A, *et al*. Prevalence and risk factors for soil-transmitted helminth infection in mothers and their infants in Butajira, Ethiopia: A population based study. BMC Public Health. 2010;10:21. https://doi.org/10.1186/1471-2458-10-21

PMid:20085635

33. Anuar TS, Salleh FM, Moktar N. Soil-Transmitted helminth infections and associated risk factors in three Orang asli tribes in Peninsular Malaysia. Sci Rep. 2014;4:410. https://doi.org/10.1038/srep04101

PMid:24525479

34. Novianty S, Dimyati Y, Pasaribu S, Pasaribu AP. Risk factors for soil-transmitted helminthiasis in preschool children living in Farmland, North Sumatera, Indonesia. J Trop Med. 2018;2018:6706413. https://doi.org/10.1155/2018/6706413

PMid:29849666

35. Abraham D, Kaliappan SP, Walson JL, Rao Ajjampur SS. Intervention strategies to reduce the burden of soil-transmitted helminths in India. Indian J Med Res. 2018;147(6):533-44. https://doi.org/10.4103/ijmr.IJMR_881_18

PMid:30168484

36. Arta Suryantari SA, Satyarsa AB, Hartawan GN, Parastuta KY, Sudarmaja IM. Prevalence, intensity and risk factors of soil transmitted helminths infections among elementary school students in Ngis village, Karangasem district, Bali. Indones J Trop Infect Dis. 2019;7(6):137. https://doi.org/10.20473/ijtid.v7i6.9952

37. Steinmann P, Utzinger J, Du ZW, Zhou XN. Multiparasitism. A neglected reality on global, regional and local scale. Adv Parasitol. 2010;73:21-50. https://doi.org/10.1016/S0065-308X(10)73002-5

PMid:20627138

38. Molla E, Mamo H. Soil-transmitted helminth infections, anemia and undernutrition among schoolchildren in Yirgacheffee, South Ethiopia. BMC Res Notes. 2018;11(1):585. https://doi.org/10.1186/s13104-018-3679-9

PMid:30103797

39. Osazuwa F, Ayo OM, Imade P. A significant association between intestinal helminth infection and anaemia burden in children in rural communities of Edo state, Nigeria. N Am J Med Sci. 2011;3(1):30-4. https://doi.org/10.4297/najms.2011.330

PMid:22540060

40. De Gier B, Ponce MC, Van De Bor M, Doak CM, Polman K. Helminth infections and micronutrients in school-age children: A systematic review and meta-analysis. Am J Clin Nutr. 2014;99(6):1499-509. https://doi.org/10.3945/ajcn.113.069955

PMid:24740209

41. Cruz AA, Cooper PJ, Figueiredo CA, Alcantara-Neves NM, Rodrigues LC, Barreto ML. Global issues in allergy and immunology: Parasitic infections and allergy. J Allergy Clin Immunol. 2017;140(5):1217-28. https://doi.org/10.1016/j.jaci.2017.09.005

PMid:29108604

42. Maizels RM. Regulation of immunity and allergy by helminth parasites. Allergy. 2020;75(3):524-34. https://doi.org/10.1111/all.13944

PMid:31187881

43. Ahmed A, Al-Mekhlafi HM, Al-Adhroey AH, Ithoi I, Abdulsalam AM, Surin J. The nutritional impacts of soil-transmitted helminths infections among Orang asli schoolchildren in rural Malaysia. Parasit Vectors. 2012;5(1):119. https://doi.org/10.1186/1756-3305-5-119

PMid:22704549

44. Girum T, Wasie A. The effect of deworming school children on anemia prevalence: A systematic review and meta-analysis. Open Nurs J. 2018;12(1):155-61. https://doi.org/10.2174/1874434601812010155

PMid:30197721

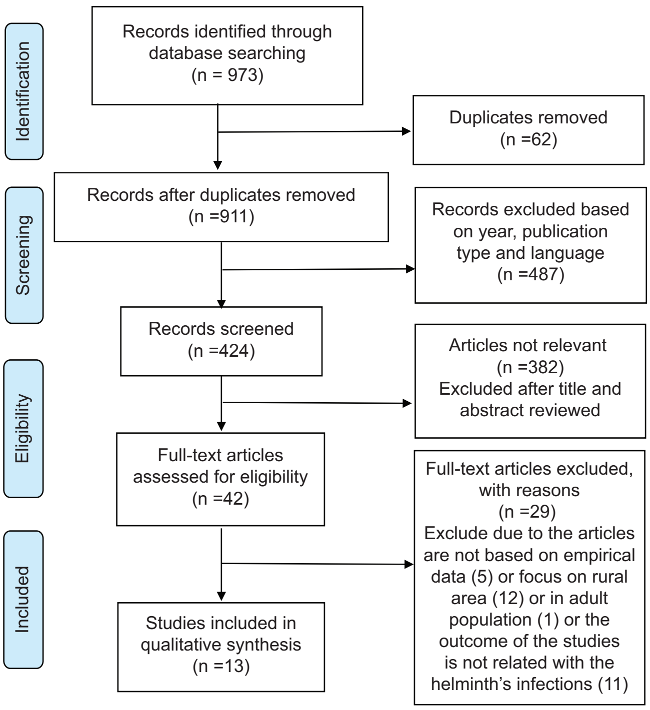
45. Sungkar S, Ridwan AS, Kusumowidagdo G. The effect of deworming using triple-dose albendazole on nutritional status of children in Perobatang village, Southwest Sumba, Indonesia. J Parasitol Res. 2017;2017:5476739. https://doi.org/10.1155/2017/5476739

PMid:29250439

Appendix

Appendix A: Keywords search used in the screening process

Database	Search string
Scopus	TIT-ABS-KEY((“urban*” OR “cit*” OR “non-rural” OR “metropolitan*” OR “urban population*”) AND (“child*” OR “kid*” OR “pupil*” OR “toddler*” OR “student*” OR “primary school*” OR “preschool child*”) AND (“epidemiology” OR “prevalence*” OR “occur*” OR “inciden*”) AND (“risk factor*” OR “factor*” OR “exposure*” OR “determinant*” OR “infection risk*” OR “personal hygiene” OR “social status*”) AND (“helminth infection*” OR “roundworm* infection*”))
Web of Science	TS = ([“urban*” OR “cit*” OR “non-rural” OR “metropolitan*” OR “urban population*”] AND [“child*” OR “kid*” OR “pupil*” OR “toddler*” OR “student*” OR “primary school*” OR “preschool child*”] AND [“epidemiology” OR “prevalence*” OR “occur*” OR “inciden*”] AND [“risk factor*” OR “factor*” OR “exposure*” OR “determinant*” OR “infection risk*” OR “personal hygiene” OR “social status*”] AND [“helminth infection*” OR “roundworm* infection*”])
Ovid Medline and PubMed	([“urban*” OR “cit*” OR “non-rural” OR “metropolitan*” OR “urban population*”] AND [“child*” OR “kid*” OR “pupil*” OR “toddler*” OR “student*” OR “primary school*” OR “preschool child*”] AND [“epidemiology” OR “prevalence*” OR “occur*” OR “inciden*”] AND [“risk factor*” OR “factor*” OR “exposure*” OR “determinant*” OR “infection risk*” OR “personal hygiene” OR “social status*”] AND [“helminth infection*” OR “roundworm* infection*”])



Appendix B: Flow diagram for the study

Appendix C: Summary of information derived from final articles

S. No.	Author, year	Country	Study design	Sample size n, range of age	Prevalence	Risk factors and/or impacts
1.	Odiere *et al*. 2011 [17]	Kenya	Cross-sectional	n = 1308 Age 10–18 years	One or more helminth 34% • *S. mansoni* 21% • *S. haematobium* 3.6% One or more soil-transmitted helminth 16.2% • Hookworms 6.1% • *Ascaris lumbricoides* 4.9% • *Trichuris trichiura* 7.7% Ascaris-Trichuris was the most common STH co-infection observed in children. Among all the helminths surveyed, *S. mansoni* had the highest prevalence across all ages.	1) Age Logistic regression revealed a significant relationship between host age and being infected with *S. mansoni* (p < 0.0001), *S. haematobium* (p = 0.002) and hookworm (p = 0.048) within the 10–17 year age bracket. *S. mansoni*- Prevalence increased from 13·3% among children aged 10 years to peak at 33·3% among children aged 16 years before declining. *S. haematobium* and hookworm- steadily increased from 0% among children aged 10 years to peak at 13.3% and 14.3% among children aged 17 years. 2) Sex Females were more than twice as likely to be infected with *S. haematobium* than males (OR = 2.11; 95% CI: 1.15–3.88)
2.	Von Huth *et al*. [24]	Republic of Guinea-Bissau	Cohort	Final n = 1274 (Cohort 1 = 566, cohort 2 = 708) Age 2–15 years	Prevalence of helminth infection in cohort 1 is 13.8% and cohort 2 is 9.6%, p = 0.021 • Hookworms, cohort 1 10.1%, cohort 2, 5.9% • *Ascaris lumbricoides*, cohort 1 0%, cohort 2, 0.1% • *Trichuris trichiura*, cohort 1 0%, cohort 2, 0.1% Positive helminth samples were mainly due to hookworm (73.1% of all samples were positive for helminths in cohort I and 61.8% of all samples were positive for helminths in cohort II)	1) Sex Female children in cohort II were found to have marginally higher odds of infection with hookworm (OR 1.90, P = 0.049). 2) Age The odds of hookworm infection increased in the older age group (8–15 years) (OR 3.11, p < 0.001 in cohort I; OR 4.56, p < 0.001 in cohort II) 3) Sharing a house with ≥ four children In cohort I, sharing a house with four or more children increased the odds of hookworm infection (AOR 2.48, p = 0.032)
3.	Obeng *et al*. 2014 [7]	Ghana	Cross-sectional	N = 2331 participants were recruited from 8 rural (n = 1347), 3 urban-low (n = 564) and 2 urban-high (n = 420) schools.	Hookworm 5/137 (3.7%) *Ascaris* spp. 7/86 (8.1%) *Trichuris* spp. 8/27 (29.6%) *Schistosoma* spp. 19/131 (14.5%) Any intestinal helminth 18/230 (7.8%) Any helminth 36/319 (11.2%)	Trichuris was positively associated with cockroach skin prick test (AOR = 3.73; 95% CI 1.22–11.41; p = 0.021)
4.	Staudacher *et al*. 2014 [20]	Rwanda, Germany	Cross-sectional	N = 622 (rural, 301; urban, 321)	STH infection was present in 38% of rural and in 13% of urban schoolchildren. Prevalence of *Ascaris lumbricoides* in urban school is 11.8% and *Trichuris trichiura* is 1.6%.	In multivariate analysis of urban children, the odds of STH infection were increased with pig ownership (AOR, 8.04; 95% CI,1.6–39.9; p = 0.01)
5.	Abera *et al*. 2013 [21]	Ethiopia	Cross-sectional	N = 791 (rural 394; urban 397)	The overall prevalence of intestinal helminths was 51.5% (rural = 68.3%, urban = 36.2%). *Hymenolepis nana* was higher in urban schools (p = 0.0001) compared to rural school. Among eight species of intestinal helminths isolated in urban school children, *Ascaris lumbricoides* was the most common (13%), followed by hookworm (11.8%), *Hymenolepis nana* (10.6%) and *Schistosoma mansoni* (2%)	Significant positive associations were found in the presence of intestinal helminths infection in children who defecated in open fields (OR 3.4; 95% CI 2.4–4.8) and poor hygiene practices, such as having dirt under the nails (OR 1.6; 95% CI 1.2–2.2). Moreover, the education level of a child's mother had a positive association with intestinal helminths infection; i.e., the prevalence of intestinal helminths was lower in children whose mothers had high levels of education.
6.	Lander *et al*. 2012 [6]	Salvador, Northeast Region of Brazil	Cross-sectional	n = 376 Age 3–6 years	The overall prevalence of intestinal helminths was 17.8%. The most common helminth species found were *T. trichiura* (12%) and A. lumbricoides (10.5%) Prevalence of hookworm infestation was very low (0.9%)	The logistic regression analysis showed that being male (AOR,2.34; 95% CI,1.14; 4.82; p = 0.021) and from a family with extremely low socioeconomic (AOR.2.04; 95% CI 1.33, 3.13; p = 0.001) status were significant risk factors for infection with helminths Almost 20% of preschoolers were classified as undernourished or moderately undernourished. Nearly one-third presented with an intestinal parasitic infection, notably A.lumbricoides and *T. trichiura*
7.	Lwanga *et al*. 2012 [22]	Uganda	Cross-sectional	n = 432 Age 6–14 years	The prevalence of helminth infections was 10.9% for hookworm, 3.1% for *Trichuris trichiura*, 1.9% for *Schistosoma mansoni* and 0.2% for *Ascaris lumbricoides*	Children who were last de-wormed more than 6 months to the time of research were twice more likely to be infected (OR 2.03; 95% CI 1.17–3.53, p = 0.007) with helminths than those last de-wormed < 6 months The study revealed that 26.6%, 46% and 10.3% of incidences of stunting, underweight and moderate acute malnutrition respectively were attributable to helminth infection
8.	Munoz-Antoli *et al*. 2018 [23]	Nicaragua	Cross-sectional	n = 1217 Age 6 months–5 years	Helminth prevalence: 13.1%. Most prevalent species- *Trichuris trichiura* (8.2%), *Ascaris lumbricoides* (5.2%)	1) Age Prevalence increased with age (*T. Trichiura* (p < 0.026). 2) Sex For *T. Trichiura*, males are representing a higher infection rate than females (9.9% vs 6.4%). 3) Areas: helminths are more prevalent in urban areas (helminths p < 0.001, *T. trichiura* p < 0.001, lumbricoides p < 0.004). 4) Polyparasitism: this study found that the children are infected with more than 1 species (42.6% poly [helminth+helminth or helminth+protozoa] - vs 24.9% monoparasitism)
9.	Said *et al*. 2017 [19]	Tanzania	Cross-sectional	n = 310 Age 6–59 months (< 5y.o)	Prevalence of *Schistosoma* spp. infection: 15.8% Other helminth species infection: 9.0% (S.stercoralis 5.2%, *E. vermicularis* 1.9%, hookworm 1.9%). dual species helminth infections 1.6%	*Schistosoma* spp. infection was significant among children who live in a house with a septic tank toilet in the household. No difference/association in the distribution of children with helminth infection by age, exposure to TB, higher education of parents/caregivers, tap water at home, better hygiene The medium hemoglobin value was significantly lower in helminth-infected children compared to uninfected

(Contd...)

Appendix C: *(Continued)*

S. No.	Author, year	Country	Study design	Sample size n, range of age	Prevalence	Risk factors and/or impacts
10.	Kattula *et al*. 2014 [14]	India	Case-control	n = 3706 Age 6–14 years	Prevalence of STH in urban (Vellore) was 4.8%. Hookworm infestations were more prevalent among rural children (rural: 8.4%, urban: 0.7%, p < 0.001) whereas A. lumbricoides (rural: 0.4%, urban: 3.3%, p < 0.001) and T. trichiura (rural: 0.3%, urban: 2.2%, p < 0.01) were more prevalent among urban children	Residing in a field-hut, open-air defecation, habitually eating food that has fallen on the ground remained independent risk factors for acquiring STH infection and consumption of deworming tablets remained protective
11.	Mbuh *et al*. 2012 [16]	Africa	Cross-sectional	n = 356 Age range between 1 and 30 years old	Prevalence of helminth infections from rural (47.2%) is higher than urban (21%). Prevalence of hookworms, *Ascaris lumbricoides* and Trichuris trichuria among urban children is 9.4%, 21.2% and 6.6% respectively	Sanitation practices and water quality are major contributory factors. High prevalence in the rural related to poverty, poor living and hygiene conditions. Contaminated vegetables are eaten raw, undercooked or unclean increasing the risk of infection
12.	Rosewell *et al*. 2010 [18]	Nicaragua	Cross-sectional	n = 880 Age 6–14 years	46.0% were infected with STH with the most common was T.trichuria (34.7%), followed by A. lumbricoides (20.7%) and hookworm (1.4%). Children in peri-urban schools were most affected by helminthiasis (OR: 3.90)	A decline in the use of improved sanitation. Pharmacological interventions in schools vary between rural and peri-urban areas
13.	Knopp *et al*. 2010 [15]	Tanzania	Cross-sectional	n = 454 Age categorised into 5–11, 12–14, 15–59 and more than 60 years.	The overall prevalence of STH was 73.7% (rural) and 48.9% (peri-urban). The prevalence of helminthiasis infection was highest among the 5–11 age group (>70%) and reduced with increasing age group	Risk factors identified to be associated with *A. lumbricoides* in the rural area are male, younger age group, eating raw vegetables/salad. Risk factors for *T. trichiura* in rural are among the least poor, age whereas in urban are age group and washing hand practice after defecation. The morbidity imposed by helminth infections such as anaemia remains a challenge and cannot be overcome by preventive chemotherapy alone

S. mansoni: Schistosoma mansoni, S. haematobium: Schistosoma haematobium, E. vermicularis: Enterobius vermicularis, A. lumbricoides: Ascaris lumbricoides, T. trichiura: Trichuris trichiura.

Appendix D: Descriptive summary of included studies (n = 13)

Characteristic	Frequencies (%)
WHO geographical region	
AFRO	9 (69.3)
Region of the Americas (PAHO)	3 (23)
SEARO	1 (7.7)
Publication year	
2010–2014	10 (77)
2015–2020	3 (23)
Study setting	
National level	0
Subnational level	13 (100)
Study design	
Cross-sectional	11 (84.6)
Case-control	1 (7.7)
Cohort	1 (7.7)

AFRO: African region, SEARO: South-East Asia region.

Appendix E: Prevalence of helminth infection among urban children

S. No.	Author, year (country)	Overall helminth infection (%)	Hookworms (%)	*Ascaris lumbricoides* (%)	*Trichuris trichiura* (%)	Hymenolepis nana (%)	*Schistosoma* spp (%)
1.	Odiere *et al*. 2011 (Kenya) [17]	34 STH-16.2	6.1	4.9	7.7	-	*Schistosoma mansoni*-21 *Schistosoma* haematobium-3.6
2.	Von Huth *et al*. 2019 (Republic of Guinea-Bissau) [24]	Cohort 1–13.8 Cohort 2–9.6	Cohort 1–10.1 Cohort 2–5.9	Cohort 1–0 Cohort 2–0.1	Cohort 1–0 Cohort 2–0.1	-	-
3.	Obeng *et al*. 2014 (Ghana) [7]		3.7	8.1	Trichuris spp. 29.6	-	14.5
4.	Staudacher *et al*. 2014 (Rwanda, Germany) [20]	STH-13	0	11.8	1.6	-	-
5.	Abera *et al*. 2013 (Ethiopia) [21]	36.2	11.8	13	-	10.6	*Schistosoma mansoni*-2
6.	Lander *et al*. 2012 (Salvador, Northeast Region of Brazil) [6]	17.8	0.9	10.5	12	-	-
7.	Lwanga *et al*. 2012 (Uganda) [22]		10.9	0.2	3.1		*Schistosoma mansoni*-1.9
8.	Munoz-Antoli *et al*. 2018 (Nicaragua) [23]	13.1	-	5.2	8.2	1.9	-
9.	Said *et al*. 2017 (Tanzania) [19]	9	1.9	0.3		-	15.8
10.	Kattula *et al*. 2014 (India) [14]	STH-4.8	0.7	3.3	2.2	-	-
11.	Mbuh *et al*. 2012 (Africa) [16]	21	9.4	21.2	6.6	-	-
12.	Rosewell *et al*. 2010 (Nicaragua) [18]	46	1.4	20.7	34.7	-	-
13.	Knopp *et al*. 2010 (Tanzania) [15]	48.9	-	3.4	16.8	-	*Schistosoma* haematobium-11.7