

Jurnal Info Kesehatan

Vol. 21, No. 3, September 2023, pp. 508-516

P-ISSN 0216-504X, E-ISSN 2620-536X

DOI: [10.31965/infokes.Vol21Iss3.1362](https://doi.org/10.31965/infokes.Vol21Iss3.1362)

Journal homepage: <http://jurnal.poltekkeskupang.ac.id/index.php/infokes>



RESEARCH

Open Access

Community and School-Based Surveys of Soil-Transmitted Helminth Infections on Samosir Island, Indonesia

Ivan Elisabeth Purba^{1a*}, Viero Irennius Girsang^{2b}, Amila^{2c}, Ester Saripati Harianja^{2d}, Yunita Purba^{3e}, Toni Wandra^{1f}, Christine M. Budke^{4g}

¹ Directorate of Postgraduate, Sari Mutiara Indonesia University, Medan, North Sumatra, Indonesia

² Faculty of Pharmacy and Health Science, Sari Mutiara Indonesia University, Medan, North Sumatra, Indonesia

³ Faculty of Vocational Education, Sari Mutiara Indonesia University, Medan, North Sumatra, Indonesia

⁴ Department of Veterinary Integrative Biosciences, School of Veterinary Medicine & Biomedical Sciences, Texas A & M University, College Station, Texas, USA

^a Email address: poerba.ivanelis@gmail.com

^b Email address: viertogirsang@gmail.com

^c Email address: mila_difa@yahoo.co.id

^d Email address: esterharianja25@gmail.com

^e Email address: yunitapurba1956@gmail.com

^f Email address: tony_wdr2009@yahoo.com

^g Email address: cbudke@cvm.tamu.edu

Received: 24 September 2023 Revised: 30 September 2023 Accepted: 30 September 2023

Abstract

Soil-transmitted helminth (STH) infections are common in tropical and sub-tropical regions where they can have substantial local public health impacts. This study aimed to evaluate the prevalence of STH infection in the community and children aged 6 to 11 years attending government-run schools in the Simanindo sub-district of Samosir Island. In total, 314 individuals in the community and 187 children aged 6 to 11 years attending government schools were invited to provide a fecal sample. All fecal samples were examined microscopically using the Kato-Katz technique. The prevalence of STH infection in the community was 46.8% (147/314). Infections were caused by *Ascaris lumbricoides* (n=52), followed by *Trichuris trichiura* (n=48), and hookworms (n=26). The prevalence of STH infection in school-age children was 4.8% in 2023. All infections in this cohort were due to *T. trichiura*. Even though the MDA program effectively controls *A. lumbricoides* and hookworm infections in school children, the problem of controlling *T. trichiura* infection remains. Therefore, selective treatment after fecal sample examination is needed to prevent *T. trichiura* infection and the potential for infection-associated anemia. Health education focusing on personal hygiene and environmental sanitation is still important for preventing STH infections. The suggestion is a new community-based survey with random sampling is necessary to ensure the present prevalence of STH in the community.

Keywords: Soil-Transmitted Helminth Infection, Community, School-Age Children, Samosir, Indonesia.

***Corresponding Author:**

Ivan Elisabeth Purba

Directorate of Postgraduate, Sari Mutiara Indonesia University, Medan, North Sumatra, Indonesia

Email: poerba.ivanelis@gmail.com



©The Author(s) 2023. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated.

1. INTRODUCTION

Soil-transmitted helminths (STHs) can infect humans through the ingestion of eggs or skin penetration by the larvae (Awasthi et al., 2003; CDC, 2023). The species of STHs that most commonly infect humans are *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and *Ancylostoma duodenale* or *Necator americanus* (hookworms) (WHO, 2020; WHO, 2023a; Kapti et al., 2021). While *A. lumbricoides* and hookworms inhabit the small intestine, *T. trichiura* resides in the cecum and ascending colon. Adult female worms produce thousands of eggs expelled with feces and can contaminate the environment when defecation occurs outdoors. STH transmission of STHs can occur in several ways, including ingesting eggs on unwashed vegetables and in contaminated water, and ingesting eggs in soil through poor hand hygiene (Sutisna et al., 2023). The highest infection prevalence of *A. lumbricoides* and *T. trichiura* is usually found in school-age children, while hookworms are more common in adults (Gordon et al., 2017).

STH infections are common in the tropical and sub-tropical regions (WHO, 2017; Molla and Mamo, 2018; Hotez et al., 2014; Steventon et al., 2012) and disproportionately impact residents with poor sanitation and hygiene practices (Gordon et al., 2017; WHO, 2023b; Sato et al., 2018; Steibaum et al., 2016; Strunz et al., 2014; Blum & Hotez, 2018; Starr & Montgomery, 2011). A high prevalence of STH infection has been reported in regions of Asia, Sub-Saharan Africa, and Latin America, with up to one billion people affected globally (Maleki et al., 2020; Taghipour et al., 2022; Badri et al., 2022). In Indonesia, it is estimated that around 195 million people, including 13 million children under the age of 6 years and 37 million children aged 6 to 12 years, live in areas endemic for STH infections (Tan et al., 2014; Sutisna et al., 2023). In children, STH infections, especially *A. lumbricoides* and *T. trichiura*, continue to pose a significant public health problem (Kapti et al., 2023).

Samosir Island is located in Lake Toba and is considered an important location for international tourism by the Indonesia government (Kementerian Pariwisata dan Ekonomi Kreatif/Badan Pariwisata dan Ekonomi Kreatif, 2023). Therefore, implementing local control programs for communicable diseases, including STH infections, is important to support public health and tourism. Current control programs for STH in Indonesia include health education, disease surveillance, risk factors control, patient management, and MDA, to decrease the prevalence of STHs to < 10% at the districts-level (Kementerian Kesehatan Republik Indonesia, 2017).

This study aimed to evaluate the prevalence of STH infection in the community and in children aged 6 to 11 years attending government-run schools in the Simanindo sub-district of Samosir Island.

2. RESEARCH METHOD

Samosir Island has nine subdistricts (Fig. 1), with a 2021 population of 137,696. The local temperature ranges from 22.0 to 35.0°C, with 39% to 100% humidity (BPS Kabupaten Samosir, 2022). This study consisted of a community-based survey conducted in September 2015 and an elementary school-based survey conducted in May 2023. Both surveys took place in the Simanindo sub-district, which had a population of 23,039 in 2021. Simanindo is predominately rural, with a small tourist industry (Wandra et al., 2020). A full description of the community-based study has been previously described in Wandra, (2020). Briefly, surveys were conducted in two selected villages based on the recommendations of the Samosir District Health Office and the local health center. Fecal samples were collected from a convenience sample of 314 villagers aged 2 to 80 years.

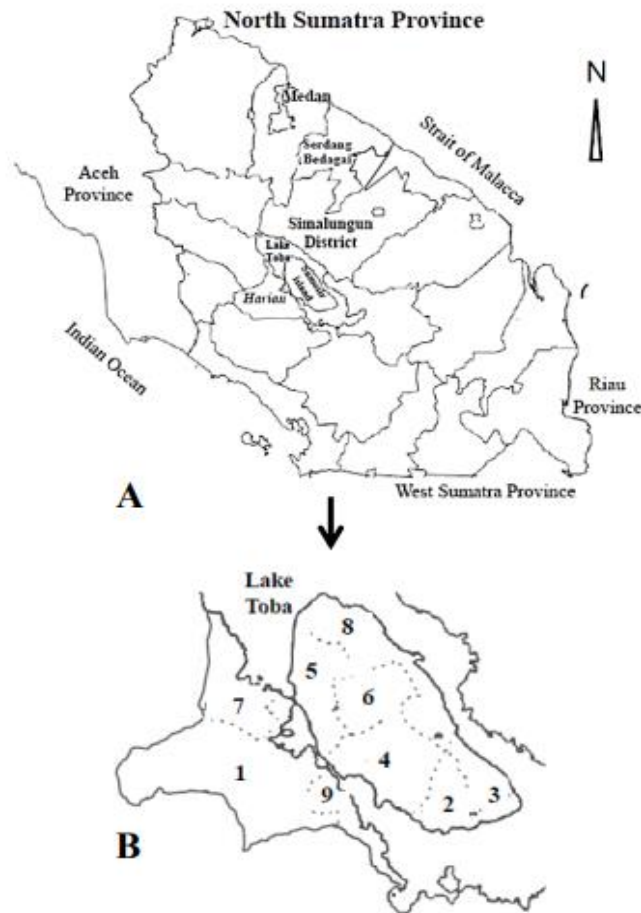


Figure 1. Samosir Island and nine districts in North Sumatra.

Table 1. Number of elementary schools, school children, and fecal samples examined in the Simanindo sub-district of Samosir island

Elementary school	A*/B	Number of school children*	No. of the fecal sample examined	No. of positive STH (%)
Government-run (public) schools	28/7	2543	187	9/187 (4.8)
Private	2/0	316	--	--
Total	30/7	2859	187	9/187 (4.8)

A: No. of elementary school, B: No. of elementary school surveyed
 *BPS-SSR, 2022

Table 1 shows that Simanindo has 30 elementary schools, including 28 government-run (public) schools and 2 private schools. As of 2022, 2859 children 6 to 11 years of age attended these schools, with 2543 children attending government-run schools and 316 children attending private schools (BPS Kabupaten Samosir, 2022). The school-based survey was carried out in seven randomly selected government-run elementary schools in seven villages, representing 25% of the government-run schools in the sub-district. All students in the first, second, and third grades (representing children 6-11 years of age) (n=187) were invited to provide a fecal sample.

After obtaining informed consent, each child's parent or guardian was asked to complete a questionnaire on possible risk factors for STH infection. The questionnaire was adapted from

a survey previously used by the Indonesian Ministry of Health (Kementerian Kesehatan Republik Indonesia, 2017).

The school-based survey was approved by The National Research and Innovation Agency, Republic of Indonesia (No. 025, dated 30 March 2023). All fecal samples were examined microscopically using the Kato-Katz technique and all individuals diagnosed with *A. lumbricoides* and/or hookworm infections were treated with albendazole (400 mg) for one day. Individuals diagnosed with *T. trichiura* infection were treated with albendazole (400 mg) for three consecutive days. STH infection prevalence was defined as the number of participants with an STH infection divided by the total number of fecal samples x 100. STH infection prevalence was compared between populations and sub-groups using Pearson's chi-square or Fisher's exact test as appropriate. A *p*-value < 0.05 was considered statistically significant. Data analysis was conducted using SPSS v.21 (IBM).

3. RESULTS AND DISCUSSION

Table 2. Prevalence and cause of STH infection on the community and school children in the Simanindo sub-district of Samosir Island

Infesting parasite	Prevalence (%)		p-value
	Community 2015 (n=314)*	School children 2023 (n=187)	
STH infection	46.8 (147/314)	4.8 (9/187)	<0.0001
<i>A. lumbricoides</i> (Al)	35.4 (52/147)	0.0 (0/9)	0.0231
<i>T. trichiura</i> (Tt)	32.7 (48/147)	100(9/9)	<0.0001
Hookworms (HW)	17.7 (26/147)	0.0 (0/9)	0.1847
Al+Tt	6.8 (10/147)	0.0 (0/9)	0.5419
Al+Hw	6.1 (9/147)	0.0 (0/9)	0.5772
Tt+Hw	1.4 (2/147)	0.0 (0/9)	0.8876
Al+Tt+Hw	0.0 (0/147)	0.0 (0/9)	--

*Wandra et al., 2020

Table 2 shows that the prevalence of STH infections in the community-based study was 46.8% (147/314). Infections were caused by *A. lumbricoides* (35.4%, 52/147), followed by *T. trichiura* (32.7%, 48/147), hookworms (17.7%, 26/147), *A. lumbricoides* + *T. trichiura* (6.8%, 10/147), *A. lumbricoides* + hookworms (6.1%, 9/147), and *T. trichiura* + hookworms (1.4%, 2/147) (data previously published in Wandra et al., (2020). The prevalence of STH infections in the school-based study was lower (4.8%, 9/187) compared to the prevalence found across all age groups in the community (46.8%) (*p* < 0.0001) (Table 1, 2).

Table 3. Prevalence of STH infections in children 11 years of age and younger in the community (2015) and in school children 6 to 11 years of age (2023) in the Simanindo sub-district of Samosir Island

Infesting parasite	Prevalence (%)		p-value
	Community (≤ 11 year old)	School children (≤ 11 year old)	
<i>T. trichiura</i> (Tt)	16.9 (27/160)	4.8 (9/187)	0.0002
Hookworms (Hw)	0.6 (1/160)	0.0 (0/187)	--
Al+Tt	5.6 (9/160)	0.0 (0/187)	--
Al + Hw	3.1 (5/160)	0.0 (0/187)	--
Tt + Hw	0.0 (0/160)	0.0 (0/187)	--

Table 3 shows that all STH infections in the school-based study were due to *T. trichiura*, with 5 cases in first graders (age group = 6 years) and 4 cases in second and third graders (age group = 7 - 11 years). There was a significant difference in the prevalence of trichuriasis in the school-based study (4.8%, 9/187) and the prevalence of trichuriasis in participants less than 11 years of age (91% of whom were less than 6 years of age) in the community study (16.9%, 27/160) ($p=0.0002$).

Table 4. Prevalence of STH infections in the community and school children by sex in the Simanindo sub-district of Samosir Island

Infecting parasite	Prevalence (%)					
	Community		p-value	School children		p-value
	Male	Female		Male	Female	
STH infection	70.6 (60/85)	38.0 (87/229)	<0.0001	4.2 (4/95)	5.4 (5/92)	0.4798
<i>A. lumbricoides</i> (Al)	18.3(11/60)	47.1(41/87)	0.0003	0.0 (0/4)	0.0 (0/5)	--
<i>T. trichiura</i> (Tt)	58.3 (35/60)	14.9 (13/87)	<0.0001	100(4/4)	100(5/5)	--
Hookworms (Hw)	8.3 (5/60)	24.1 (21/87)	0.0136	0.0 (0/4)	0.0 (0/5)	--
Al+Tt	10.0 (6/60)	4.6 (4/87)	0.3175	0.0 (0/4)	0.0 (0/5)	--
Al + Hw	3.3 (2/60)	8.0 (7/87)	0.3103	--	--	--
Tt + Hw	1.7(1/60)	1.1(1/87)	0.6514	--	--	--

Table 4 shows that of the participants in the community-based study, 85 (27.1%) were male and 229 (72.9%) were female. There was a higher prevalence of STH infections in males (70.6%, 60/85) than in females (38.0%, 87/229) ($p < 0.0001$). The most common single parasite infection in males was *T. trichiura* (58.3%, 35/60), followed by *A. lumbricoides* (18.3%, 11/60), and hookworms (8.3%, 5/60). In contrast, in females, the most common single parasite infection was *A. lumbricoides* (47.1%, 41/87), followed by hookworms (24.1%, 21/87), and *T. trichiura* (14.9%, 13/87). In the school-based study, 95 (50.8%) of the participants were male, and 92 (49.2%) were female. There was no statistically significant difference in STH infection prevalence between males (4.2%, 4/95) and females (5.4%, 5/92) ($p=0.4798$).

Table 5. Response to a questionnaire administered to parents or adult members of a student's household regarding possible risk factors for STH infection in the Simanindo sub-district of Samosir Island, 2023 (n=187).

Household sanitary facilities	n*	%
Source of drinking water at home		
Sufficient (1)	60/165	36.4
Insufficient (2)	105/165	63.6
Drinking water at home		
Boiled water	151/167	90.4
Un-boiled water	16/167	9.6
Having toilet facilities		
Yes	143/159	89.9
No	16/159	10.1

*Some questions have fewer responses due to participants being unwilling to answer.

(1) Commercial water/water pipes.

(2) Borholes/open well (n=27), natural pond (n=34), rainwater (n=8), lake (n=36)

Table 5 show that the most common source of drinking water in the home was commercially supplied pipes (36.4%; 60/165). In addition, 90.4% (151/167) indicated that the family drank boiled water, and 89.9% (143/159) had a household toilet.

DISCUSSION

Risk factors previously linked to STH infections on Samosir Island include inadequate toilets, poor hand hygiene prior to eating, poor hand hygiene after defecation, and drinking unfiltered water (Yulfi et al., 2016). The prevalence of STH infections in children in elementary school was lower (4.8%) than in the community (46.8%), including all age groups ($p < 0.0001$). While only *T. trichiura* was found in children (aged 6-11 years) in the school-based study, other STH species were identified in the greater community. This finding is likely due to the impact of MDA that is performed in elementary schools on Samosir Island, with this practice now in place for more than 10 years (Kementerian Kesehatan Republik Indonesia, 2012; Kementerian Kesehatan Republik Indonesia, 2017). When evaluating infection prevalence in children 11 years of age or younger in the community study, the vast majority (91.0%, 147/160) were less than 6 years of age and, therefore, ineligible to participate in the MDA program.

The national MDA program aimed at elementary school children includes administration of a single dose of albendazole (400 mg) two times a year if the local prevalence is greater than 50%, one time a year if the local prevalence (20-50%), and selectively if the local prevalence is less than 20% (Kementerian Kesehatan Republik Indonesia, 2017). A single dose of albendazole can effectively control *A. lumbricoides* and hookworm (Moser et al., 2017; Montresor et al., 2020; WHO, 2023b). However, a three-dose albendazole regimen has been recommended to control *T. trichiura* (Namwanje et al., 2011; Tee et al., 2022). This need was illustrated in a 2006 study of students aged 9 to 15 years, where 59.6% of students were positive for *T. trichiura* eggs two weeks after the single-dose MDA protocol (Wandra et al., 2020).

In the community, males had a higher prevalence of STH infections (70.6%) than females (38.0%) ($p < 0.05$). However, hookworm infection was lower in males (8.3%) than in females (24.1%), which may be due to females (> 15 years of age) spending more time working in the fields and often doing so barefoot (Wandra et al., 2020). In contrast, there was no significant difference in STH infection prevalence between males (4.2%) and females (4.5%) in the school-based study, likely due to the impact of the MDA program.

Our study did have some limitations. Since participant selection was not random, we cannot exclude the possibility of bias in our sample population. However, we assumed that there has not been a substantial change in STH infection prevalence in the community since 2015. Although the MDA program has been active in schools for over a decade, an MDA program for other age groups is still unavailable in Indonesia.

4. CONCLUSION

The prevalence of STH infection in the community was 46.8% (147/314). Infections were caused by *Ascaris lumbricoides* (n=52), followed by *Trichuris trichiura* (n=48), and hookworms (n=26). The prevalence of STH infection in school-age children was 4.8% in 2023. All infections in this cohort were due to *T. trichiura*. Even though the MDA program effectively controls *A. lumbricoides* and hookworm infections in school children, the problem of controlling *T. trichiura* infection remains. Therefore, selective treatment after fecal sample examination is needed to prevent *T. trichiura* infection and the potential for infection-associated anemia. Health education focusing on personal hygiene and environmental sanitation is still important for preventing STH infections. The suggestion is a new community-based survey with random sampling is necessary to ensure the present prevalence of STH in the community.

ACKNOWLEDGEMENTS

We sincerely thank personnel from the National Research and Innovation Agency Republic of Indonesia, the Samosir district health office and the health center in Simanindo. We would also like to thank the heads and teachers of seven elementary schools in Simanindo and researchers from Sari Mutiara Indonesia University, who have contributed to this study.

REFERENCES

- Awasthi, S., Bundy, D. A., & Savioli, L. (2003). Helminthic infections. *BMJ*, 327(7412), 431-433. <https://doi.org/10.1136/bmj.327.7412.431>
- Badri, M., Olfatifar, M., Wandra, T., Budke, C. M., Mahmoudi, R., Abdoli, A., ... & Eslahi, A. V. (2022). The prevalence of human trichuriasis in Asia: a systematic review and meta-analysis. *Parasitology Research*, 121(1), 1-10. <https://doi.org/10.1007/s00436-021-07365-8>
- Blum, A. J., & Hotez, P. J. (2018). Global “worming”: Climate change and its projected general impact on human helminth infections. *PLoS Neglected Tropical Diseases*, 12(7), e0006370. <https://doi.org/10.1371/journal.pntd.0006370>
- BPS Kabupaten Samosir. (2022). *Kabupaten Samosir dalam Angka*. BPS Kabupaten Samosir.
- CDC. (2023). *Helminths, Soil-Transmitted CDC Yellow Book 2024*. Centers for Disease Control and Prevention. Retrieved from <https://wwwnc.cdc.gov/travel/yellowbook/2024/infections-diseases/helminths-soil-transmitted>
- Gordon, C. A., Kurscheid, J., Jones, M. K., Gray, D. J., & McManus, D. P. (2017). Soil-transmitted helminths in tropical Australia and Asia. *Tropical medicine and infectious disease*, 2(4), 56. <https://doi.org/10.3390/tropicalmed2040056>
- Hotez, P. J., Alvarado, M., Basáñez, M. G., Bolliger, I., Bourne, R., Boussinesq, M., ... & Naghavi, M. (2014). The global burden of disease study 2010: interpretation and implications for the neglected tropical diseases. *PLoS neglected tropical diseases*, 8(7), e2865. <https://doi.org/10.1371/journal.pntd.0002865>
- Kapti, N., Sutisna, P., & Widjana, D. P. (2021). Prevalence and Reinfection of *Ascaris lumbricoides* and *Trichuris trichiura* among Elementary School Children in Rural Villages of Bali. *J Trop Dis*, 9, 283.
- Kementerian Kesehatan Republik Indonesia. (2012). *Pedoman Pengendalian Kecacingan*. Jakarta: Kementerian Kesehatan Republik Indonesia.
- Kementerian Kesehatan Republik Indonesia. (2017). *Peraturan Menteri Kesehatan Nomor 15 Tahun 2017 tentang Penanggulangan Cacingan*. Jakarta: Kementerian Kesehatan Republik Indonesia.
- Kementerian Pariwisata dan Ekonomi Kreatif/Badan Pariwisata dan Ekonomi Kreatif. (2023). *Peraturan Menteri Pariwisata dan Ekonomi Kreatif/Kepala Badan Pariwisata dan Ekonomi Kreatif Republik Indonesia Nomor 1 Tahun 2023 tentang Petunjuk Teknis Penggunaan Dana Alokasi Khusus Nonfisik Bidang Pariwisata*. Jakarta: Kementerian Pariwisata dan Ekonomi Kreatif/Badan Pariwisata dan Ekonomi Kreatif.
- Maleki, B., Dalimi, A., Majidiani, H., Badri, M., Gorgipour, M., & Khorshidi, A. (2020). Parasitic infections of wild boars (*Sus scrofa*) in Iran: a literature review. *Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders)*, 20(5), 585-597. <https://doi.org/10.2174/1871526519666190716121824>

- Molla, E. and H. Mamo, H. (2018). Soil-transmitted helminth infections, anemia and undernutrition among schoolchildren in Yirgacheffee, South Ethiopia. *BMC Res. Notes*, 11 (585). <https://doi.org/10.1186/s13104-018-3679-9>
- Montresor, A., Mupfasoni, D., Mikhailov, A., Mwinzi, P., Lucianez, A., Jamsheed, M., ... & Gyorkos, T. W. (2020). The global progress of soil-transmitted helminthiasis control in 2020 and World Health Organization targets for 2030. *PLoS neglected tropical diseases*, 14(8), e0008505. <https://doi.org/10.1371/journal.pntd.0008505>
- Moser, W., Schindler, C., & Keiser, J. (2017). Efficacy of recommended drugs against soil transmitted helminths: systematic review and network meta-analysis. *Bmj*, 358. <https://doi.org/10.1136/bmj.j4307>.
- Namwanje, H., Kabatereine, N. B., & Olsen, A. (2011). Efficacy of single and double doses of albendazole and mebendazole alone and in combination in the treatment of *Trichuris trichiura* in school-age children in Uganda. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 105(10), 586-590. <https://doi.org/10.1016/j.trstmh.2011.07.009>
- Sato, M. O., Sato, M., Yanagida, T., Waikagul, J., Pongvongsa, T., Sako, Y., ... & Moji, K. (2018). *Taenia solium*, *Taenia saginata*, *Taenia asiatica*, their hybrids and other helminthic infections occurring in a neglected tropical diseases' highly endemic area in Lao PDR. *PLoS neglected tropical diseases*, 12(2), e0006260. <https://doi.org/10.1371/journal.pntd.0006260>
- Starr, M. C., & Montgomery, S. P. (2011). Soil-transmitted helminthiasis in the United States: a systematic review—1940–2010. *The American journal of tropical medicine and hygiene*, 85(4), 680. <https://doi.org/10.4269/ajtmh.2011.11-0214>
- Steinbaum, L., Njenga, S. M., Kihara, J., Boehm, A. B., Davis, J., Null, C., & Pickering, A. J. (2016). Soil-transmitted helminth eggs are present in soil at multiple locations within households in rural Kenya. *PLoS One*, 11(6), e0157780. <https://doi.org/10.1371/journal.pone.0157780>
- Steventon, A., Bardsley, M., Billings, J., Dixon, J., Doll, H., Hirani, S., ... & Newman, S. (2012). Effect of telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial. *BMJ*, 344. <https://doi.org/10.1136/bmj.e3874>.
- Strunz, E. C., Addiss, D. G., Stocks, M. E., Ogden, S., Utzinger, J., & Freeman, M. C. (2014). Water, sanitation, hygiene, and soil-transmitted helminth infection: a systematic review and meta-analysis. *PLoS medicine*, 11(3), e1001620. <https://doi.org/10.1371/journal.pmed.1001620>
- Sutisna, P., Kapti, N., Sudarmaja, M., Swastika, K., D.P. Widjana, D.P. (2021). Soil-transmitted helminth infection in general population and schoolchildren of Bali: A review. *J. Trop. Dis.* 9 (283), 1–8.
- Taghipour, A., Bahadory, S., Badri, M., Yadegar, B., Mirsamadi, E.S., Mirjalali, H., Zali, M.R. (2022). A systematic review and meta-analysis on the co-infection of *Helicobacter pylori* with intestinal parasites: public health issue or neglected correlation?, *Int. J. Environ. Health Res.* 32 (4), 808-818. <https://doi.org/10.1080/09603123.2020.1798890>.
- Tan, M., Kusriastuti, R., Savioli, L., Hotez, P.J. (2014). Indonesia: an emerging market economy beset by neglected tropical diseases (NTDs), *PLoS Negl. Trop. Dis.* 8 (2), e2449. <https://doi.org/10.1371/journal.pntd.0002449>.
- Tee, M. Z., Lee, S. C., Er, Y. X., Yap, N. J., Ngui, R., Easton, A. V., ... & Lim, Y. A. L. (2022). Efficacy of triple dose albendazole treatment for soil-transmitted helminth infections. *PLoS ONE* 17(8): e0272821. <https://doi.org/10.1371/journal.pone.0272821>
- Wandra, T., Darlan, D.M., Yulfi, H., Purba, I.E., Sato, M.O., Budke, C.M., Ito, A. (2020). Soil-transmitted helminth infections and taeniasis on Samosir Island, Indonesia. *Acta Trop.* 202,105250. <https://doi.org/10.1016/j.actatropica.2019.105250>

WHO. (2017). *Soil-Transmitted Helminth Infections, Fact Sheet*. WHO.

WHO. (2020). *Soil-transmitted helminthiases*. WHO. Retrieved from <https://www.who.int/news-room/facts-in-pictures/detail/soil-transmitted-helminthiases>.

WHO. (2023a). *Soil-transmitted helminth infections*. WHO. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections>.

WHO.(2023b). *Anaemia*. WHO. Retrieved from https://www.who.int/health-topics/anaemia#tab=tab_1, 2023b

Yulfi, H., Darlan, D. M., Wandra, T., Purba, I. E., Purba, Y., Saragih, J. M., & Ito, A. (2016). Intestinal protozoa infections and associated risk factors in rural community of Samosir Island Indonesia. *Advances in Health Sciences Research* 1, 102-107. <https://doi.org/10.2991/phico-16.2017.79>