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RESEARCH ARTICLE

Identifying risk factors for soil-transmitted helminths among indigenous communities in Simalungun, North Sumatra

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ABSTRACT

Soil-transmitted helminths (STH) are among the most common parasitic infections associated with neglected tropical diseases (NTDs), particularly in regions with poor sanitation and hygiene. The prevalence of STH is disproportionately high in middle- to low-income countries due to inadequate infrastructure and hygiene practices. This study aimed to identify risk factors associated with STH infections among native communities in the rural Simalungun District, North Sumatra, Indonesia. A cross-sectional study was conducted among 592 native Simalungun Bataknese individuals living and working in 14 villages across the district. Participants were interviewed regarding sanitation, hygiene practices, and demographic factors, while fecal samples were collected for parasitological examination using the direct smear and Kato-Katz methods. All laboratory analyses were conducted at the Parasitology Laboratory, Faculty of Medicine, Universitas Sumatera Utara, and interpreted by a parasitologist. Statistical analysis was performed using chi-square tests and multivariate logistic regression to identify significant risk factors for STH infection. The overall STH prevalence was 14.5% (86/592 participants), with identified species including *Trichuris trichiura* (33.7%), hookworm (31.4%), *Ascaris lumbricoides* (11.6%), and mixed infections (23.3%). Multivariate analysis revealed two significant risk factors for STH infection: consumption of uncooked drinking water (AOR 2.05, 95% CI 1.10–3.81, p=0.000) and not using a toilet with a septic tank (AOR 2.38, 95% CI 1.46–3.87). These findings highlight the critical role of sanitation and water safety in reducing STH transmission. Improving access to safe drinking water and proper sanitation facilities is essential for controlling STH infections in rural communities.

Keywords: Neglected-tropical diseases (NTD); helminthiasis; parasite.

INTRODUCTION

Soil-transmitted helminths (STH) remain a significant public health challenge in middle- to low-income countries, classified as neglected tropical diseases (NTDs). STH infections rank among the most prevalent NTDs globally, affecting approximately 1.5 billion people or 24% of the world's population. These infections are caused by several helminth species, including *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms (*Ancylostoma duodenale* and *Necator americanus*). Transmission occurs through fertilized eggs ingestion (e.g., *A. lumbricoides* and *T. trichiura*) or skin penetration by infective larvae (hookworms). Once inside the gastrointestinal tract, these parasites cause local tissue invasion, triggering immune responses and chronic infections that lead to malnutrition, anemia, and impaired growth and development, particularly in children and young adults (van Lieshout & Yazdanbakhsh, 2013; Mitra & Mawson, 2017; Hotez & Lo, 2020).

In Indonesia, STH remains highly prevalent, with more than 20% of the population infected with *A. lumbricoides* and 12% with *T. trichiura*. The burden of STH is closely linked to poor hygiene and inadequate sanitation infrastructure, which facilitate parasite transmission. Control strategies for STH rely primarily on improving hygiene and sanitation alongside mass drug administration (MDA) of deworming medications. Studies have shown that enhanced sanitation infrastructure plays a crucial role in reducing STH prevalence by limiting environmental contamination with parasite eggs and larvae. However, in many rural communities, particularly those with low socio-economic status and limited education, hygiene and sanitation practices remain neglected, contributing to the persistence of STH infections (Campbell *et al.*, 2014; Vaz Nery *et al.*, 2019).

Simalungun District, located in North Sumatra, Indonesia, is a predominantly rural region with a population of approximately one million. Despite improvements in human development indicators, with a Human Development Index (HDI) score of 73.77 in 2022 (above the national average of 70) and an economic growth rate of 3.70% (Damanik *et al.*, 2022), STH infections remain a concern. Since STH is a poverty-related disease, improving socio-economic conditions and sanitation infrastructure is expected to contribute to a declining prevalence of STH infections (Sanchez *et al.*, 2016).

Given these circumstances, this study aimed to assess the current risk factors associated with STH prevalence in the native rural communities of Simalungun District, particularly in recent socio-economic growth. Understanding these risk factors is essential for developing targeted interventions to reduce STH infections in the region further.

MATERIAL AND METHODS

Study design, location, and sample collection

This cross-sectional study used a point-time approach to evaluate risk factors associated with STH positivity. The study was conducted in rural areas of Simalungun District, North Sumatra Province, Indonesia, involving native Bataknese people from 14 villages within the district (02°36′05′′–03°18′14′′ N, 98°32′03′′–99°35′03′′ E). Simalungun District is located 150 km from Medan, the provincial capital, and is classified as a rural mountainous region with a humid climate supporting STH transmission and development (Figure 1). The required sample size was determined using the standard formula for cross-sectional studies; n= $(1.96)^2pq/d^2$. Based on this calculation, a total of 605 participants were initially targeted. Sample selection was conducted using a cluster sampling method, with study invitations distributed across 14 villages in the district. Of those invited, 592 individuals (97.9%) attended the sampling process and provided informed consent to participate in the study.

Sample collection and fecal examination

All participants were asked to sign informed consent to be involved in the study after receiving a full explanation; participants below 18 years old were represented by their guardian consent. The interview was conducted with closed questions consisting of seven proposed risk factors regarding hygiene and sanitation. The following day, participants were asked to provide fecal samples in screw-capped plastic containers containing 10% formalin. All fecal preparation was conducted in the Laboratory of Parasitology, Department of Parasitology, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia. The Saline and Kato-Katz technique determined STH positivity in a fecal sample. No quantitative assessment was conducted on all samples; only egg presence was considered positive for STH. Ethical clearance has been obtained from the Ethical Committee for Health Research, Faculty of Medicine, Universitas Sumatera Utara (Certificate Number: 979/KEP/USU/2023). Data was collected following informed consent from participants.

Data Analysis

Data were input in Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 23. The overall prevalence was calculated directly and compared bivariate using chi-square analysis with a confidence interval of 95% (95% CI). Subsequent analysis was carried out using multivariate logistic regression analysis; variables with a p-value below 0.25 underwent further study, and the final output could be considered the significant variables associated with STH prevalence.

RESULTS

A total of 592 native Simalungun Bataknese villagers from 14 subdistricts in the Simalungun District participated in this study. The majority of the participants were in the 31–45-year-old age group (48.0%), and there was a predominance of male participants (60.5%) compared to females (39.5%). Stool examination revealed that 14.5% (n=86) of the study population had active soil-transmitted helminth (STH) infections. Hookworm was the most prevalent infection (4.6%), followed by *Trichuris trichiura* (4.9%) and *Ascaris lumbricoides*

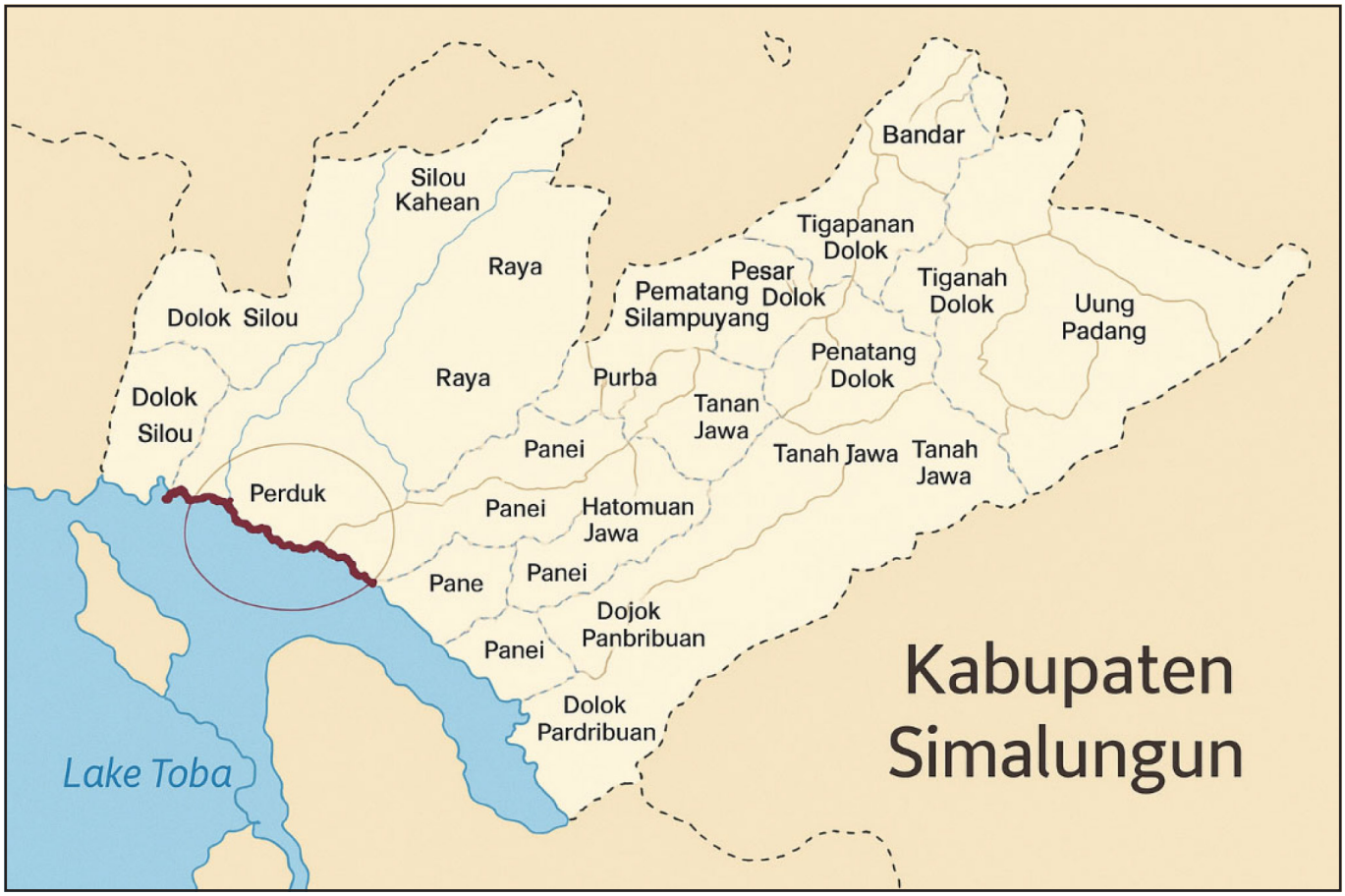

Figure 1. Study Location.

Table 1. Baseline characteristics of the study participants

Characteristics	Participants n (%)
Age (years)	
<15	13 (2.2)
16-30	64 (10.8)
31-45	284 (48.0)
46-60	175 (29.6)
>60	56 (9.5)
Sex	
Male	358 (60.5)
Female	234 (39.5)
STH infection	
Negative	506 (85.5)
Ascaris lumbricoides (Al)	10 (1.7)
Trichuris trichiura (Tt)	29 (4.9)
Hookworms (Hw)	27 (4.6)
Mix Al + Tt	9 (1.5)
Mix Hw + Tt	9 (1.5)
Mix Al + Tt + Hw	2 (0.3)
Total	592

(1.7%). Additionally, 20 individuals (20% of the infected participants) experienced multiple STH infections (Table 1).

Bivariate analysis identified several significant risk factors for STH infection, including male sex (p=0.017), using an open water source (p=0.011), drinking uncooked water (p=0.002), not washing hands before eating (p<0.001), and having a toilet without a septic tank (p<0.001) (Table 2). Further multivariate logistic regression analysis confirmed that consuming uncooked drinking water (AOR = 2.055, 95% CI: 1.106–3.819, p<0.001) and having no septic tank in the toilet (AOR = 2.380, 95% CI: 1.461–3.877, p<0.001) were the most significant independent risk factors for STH infection (Table 3). These findings suggest that poor sanitation and unsafe drinking water play a critical role in STH transmission within this population.

DISCUSSION

The study findings highlighted distinct epidemiological characteristics of STH infections within the Simalungun Bataknese population. Interestingly, Hookworms and *T. trichiura* were the predominant species, which differs from common findings in other endemic regions where *A. lumbricoides* not uncommonly dominates (Naish *et al.*, 2004). The relatively low prevalence of *A. lumbricoides* in this study could be attributed to its typical infection pattern, which is more common in school-aged children rather than the predominantly adult population included in this research. The local epidemiological context in this district likely plays a crucial role in shaping the distribution of STH species, influenced by a combination of population demographics, sanitation and hygiene practices, and prior deworming programs. The adult dominance in this study is an important factor to consider when assessing the exposure risk to STH infection. Adults are more likely to engage in occupational activities that increase their contact with contaminated soil or water sources, which may explain the observed infection pattern (Jiraanankul *et al.*, 2011; Pasaribu *et al.*, 2019). Unlike younger populations, adults may also exhibit different hygiene behaviours and levels of compliance with mass deworming programs, further influencing STH prevalence.

Several key risk factors were significantly associated with STH prevalence in this study. Consuming uncooked drinking water and using toilets without septic tanks were both identified as independent predictors of infection. Participants who consumed uncooked drinking water had a twofold increased risk of STH infection, while those without a proper septic tank had a 2.3 times higher likelihood of infection (Table 3). These findings reinforce the well-established relationship between poor sanitation, water contamination, and the persistence of STH transmission in endemic areas (Montresor *et al.*, 2020). The continued presence of these risk factors suggests that improving water quality and sanitation infrastructure should be prioritized in STH eradication strategies.

Table 2. Bivariate analysis of risk factors associated with STH infection in the study population (n = 592)

Risk factors	STH infection		p-value
	No, n (%)	Yes, n (%)	
Age (years)			
>30	442 (85.8)	73 (14.2)	0.529
≤30	64 (83.1)	13 (16.9)	
Sex			
Male	296 (82.7)	62 (17.3)	0.017*
Female	210 (89.7)	24 (10.3)	
Water source			
Open	323 (82.8)	323 (82.8)	0.011*
Closed	183 (90.6)	19 (9.4)	
Cooked drinking water			
No	49 (73.1)	18 (26.9)	0.002*
Yes	457 (87.0)	68 (13.0)	
Eating raw vegetables			
No	270 (87.4)	39 (12.6)	0.169
Yes	236 (83.4)	47 (16.6)	
Washing hands before eating			
No	104 (74.8)	35 (25.2)	<0.001*
Yes	402 (88.7)	51 (11.3	
Washing hands after defecation			
No	104 (74.8)	35 (25.2)	<0.001*
Yes	402 (88.7)	51 (11.3	
Toilet with septic tank			
No	121 (76.1)	38 (23.9)	<0.001*
Yes	385 (88.9)	48 (11.1)	
Having anti-helminthic within six months			
No	498 (85.6)	84 (14.4)	0.620
Yes	8 (80.0)	2 (20.0)	
Total	506 (85.5)	86 (14.5)	592 (100)

*p<0.20, significant to include in multivariate analysis.

Table 3. Multivariate analysis of risk factors associated with STH infection in the study population (n = 592)

Risk factors	Coefficient	p-value	AOR	95% CI	
				Lower	Upper
Sex					
Male	0.499	0.072	1.647	0.956	2.838
Female			1		
Water source					
Open	0.537	0.070	1.711	0.957	3.062
Closed			1		
Cooked drinking water					
No	0.720	<0.001*	2.055	1.106	3.819
Yes			1		
Toilet with septic tank					
No	0.867	<0.001*	2.380	1.461	3.877
Yes			1		

STH remains a public health threat among the indigenous population. Compared to other studies, the STH prevalence in the recent study was significantly lower (14.5%). Meanwhile, a meta-analysis study involving indigenous populations in Southeast Asia and the Western Pacific demonstrated a higher prevalence, with an overall infection rate of 61.4%. *T.trichiura* still plays a pivotal STH species in the study (43.6%), followed by *A.lumbricoides* (32.3%) and hookworm (19.9%). This study also highlights the increasing trends in trichuriasis prevalence among the Indigenous population, which urges further risk factor analysis (Gilmour *et al.*, 2021). Among Amazonian Indigenous people, 72.9% of households demonstrated one or more members who were positive for STH infection. This trend increased due to other variables, such as subsidies and overcrowding (Romero-Sandoval *et al.*, 2017). *T. trichiura* infection was also demonstrated to have a prevalence of more than 50% in a study that enrolled 500 Orang Asli from Malaysia. Meanwhile, *A. lumbricoides* was only positive in 23.8% of the involved participants, which further analysis demonstrated to be age-dependent, associated with another hygienic factor (consuming raw vegetables), and linked to low-income, all of which are factors that contribute to the infecting species (Anuar *et al.*, 2014).

Despite the known benefits of mass deworming, participation in such programs was notably low in this study, with only 1.9% of participants receiving anti-helminthic treatment within the past six months. This low uptake may reflect a lack of awareness, accessibility issues, or the general perception among adults that deworming is primarily targeted at children. The World Health Organization (WHO) recommends deworming interventions primarily for young children (12-23 months), preschool children (24-59 months), school-aged children, adolescent girls (10-19 years old), and reproductive-age women (15-49 years old), including pregnant women in endemic regions (Savioli *et al.*, 2018). Prioritizing these high-risk groups can lead to significant public health benefits, including improved nutritional status, reduced anemia, and better cognitive development in children (Montresor *et al.*, 2020). However, the high proportion of adults in this study suggests that the role of deworming programs in adult populations requires further consideration, particularly in occupational settings with high environmental exposure.

Eradicating STH infection requires a comprehensive and multifaceted approach. First, identifying parasite species and their transmission routes – whether through soil, contaminated drinking water, poor hand hygiene, or food – can help design targeted interventions. Second, understanding the characteristics of the most affected population groups is crucial for effective program implementation. While mass deworming is an essential component of STH control, it should be complemented by sustainable improvements in hygiene and sanitation to prevent reinfection. Interventions such as ensuring access to clean drinking water, promoting proper handwashing practices, and improving sanitation infrastructure must be integrated into long-term public health strategies (Qian *et al.*, 2022).

The success of these interventions should be periodically evaluated using health outcome indicators such as reductions in symptomatic infections, intestinal blood loss, anemia, malnutrition, and growth impairment in children. Ultimately, the goal is to achieve broader health improvements, including enhanced well-being, reduced stunting, better cognitive development, and increased school attendance (Welch *et al.*, 2017). STH eradication will remain elusive without sustained efforts in sanitation improvement and community-wide engagement. Therefore, strengthening public health policies and fostering collaboration between government agencies, healthcare providers, and local communities is imperative to achieving sustainable control and the eventual elimination of STH infections (Cunningham *et al.*, 2024).

CONCLUSION

The study findings indicate a notable prevalence of STH infection in the Simalungun District, though it remains lower compared to other indigenous populations globally. While several factors were associated with STH prevalence, multivariate analysis identified untreated drinking water consumption and household toilets without septic tanks as significant risk factors. To reduce infection rates and maintain hygienic practices, targeted interventions by the local government and community are essential, particularly in improving access to clean water and proper sanitation facilities.

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Conflict of interest statement

All authors confirmed that there is no conflict of interest.

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