

# Soil-transmitted helminth infections and taeniasis on Samosir Island, Indonesia

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## Soil-transmitted helminth infections and taeniasis on Samosir Island, Indonesia

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### ABSTRACT

Soil-transmitted helminth (STH) infections are important causes of morbidity in poorer areas of developing countries, with high endemicity in Southeast Asia. Humans are most often exposed to the infective forms of STHs in areas with sub-standard sanitation. The number of STH infections globally was estimated at 1.5 billion in 2018. In Indonesia, the prevalence of STH infections ranges from 2.5% to 62.0%. STH and taeniasis infections were evaluated on Samosir Island, North Sumatra, Indonesia. Field surveys were conducted in January 2003, February 2005, and February 2006 in Simanindo Subdistrict, with a subsequent survey conducted in the sub-districts of Simanindo and Ronggurnihuta in September 2015. A total of 371 individuals were screened between 2003 and 2006 and 368 were screened in 2015 (314 from Simanindo and 54 from Ronggurnihuta). Fecal samples were collected and examined microscopically by the Kato-Katz technique. The prevalence of STH infections in Simanindo for the years 2003, 2005, 2006, and 2015 was 41.4%, 52.2%, 55.7%, and 46.8%, respectively. The 2015 prevalence of STH infections in Ronggurnihuta was 66.7%. *Taenia asiatica* taeniasis prevalence was 3.4% and 2.2% for the years 2003 and 2005, respectively, with no cases detected in 2006 or 2015. The prevalence of STH infections in Simanindo and Ronggurnihuta was similar to other STH prevalence values reported for Indonesia. Country-level values have not changed substantially from those reported in the 1980s and 1990s, where prevalence ranged from 40% to 70%. Improvement of personal hygiene and environmental sanitation for control of STH infections on Samosir Island will require collaboration among multiple sectors.

### 1. Introduction

Soil-transmitted helminth (STH) infections, which are mainly caused by the human roundworm (*Ascaris lumbricoides*), human whipworm (*Trichuris trichiura*), human hookworms (*Necator americanus* and *Ancylostoma duodenale*), zoonotic hookworm (*Ancylostoma ceylanicum*), and the human threadworm (*Strongyloides stercoralis*), are important causes of morbidity in poorer areas of developing countries, with high endemicity in Southeast Asia (Sato et al., 2010; Sato et al., 2011; Sato et al., 2018a; Senephansiri et al., 2017). Humans are most often exposed to the infective forms of STHs in areas with sub-standard sanitation (Sato et al., 2018b). The number of STH infections globally was estimated at 1.5 billion in 2018 (WHO, 2018). In light and moderate

infections, general symptoms include weakness and susceptibility to co-infections. Increased susceptibility to co-infections has been directly linked to an inability to work and a loss of productivity (Brooker et al., 2004; Stephenson et al., 2000; WHO, 2002). Severe morbidity, consisting of diarrhea, malnutrition, anemia and growth/cognitive stunting, can occur with chronic infections, with preschool- and school-aged children often most severely impacted (Dickison et al., 2000; Gyorkos and Gilbert, 2014; Hotez, 2013).

In Southeast Asia, more than 80 million preschool-aged children were provided with preventive chemotherapy for STH infections in 2016, equivalent to a regional coverage of 75.4% (WHO, 2017). Due to the costs and complex logistics associated with the diagnosis and treatment of infected individuals, preventive chemotherapy by mass

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drug administration (MDA) is currently the preferred course of action (Hotez, 2013; Sato et al., 2018b).

Based on official Ministry of Health data, regional prevalence of STH infections in Indonesia ranges from 2.5% to 62.0% (MHRI, 2017). The highest prevalences were found in low-income communities with poor sanitation (MHRI, 2012). In Indonesia, the first STH control programs began in 1975 (MHRI, 2017). Current control programs include health promotion, surveillance, patient management, and MDA, with the goal of decreasing the prevalence of STHs to less than 10% in all districts and cities by the end of 2019. Determination of prevalence is based on community surveys, with communities categorized as low prevalence (<20%), moderate prevalence (20%–50%), and high prevalence (> 50%) (MHRI, 2017).

In addition to the transmission of STHs, Samosir Island is an endemic area for *Taenia asiatica* (Fan et al., 1988; Kosin et al., 1972; Suroso et al., 2006; Wandra et al., 2006; Zein et al., 2019). Prevalence of taeniasis was reported to range between 1.9 and 20.7% in studies conducted between 1972 and 1990 (Cross et al., 1976; Depary, 2003; Koeshardjono et al., 1987; Kosin et al., 1972).

All tapeworms, from this region, have been confirmed as *T. asiatica* by multiplex PCR using the mitochondrial cytochrome c oxidase subunit 1 (*cox 1*) gene (Yamasaki et al., 2004; Wandra et al., 2006). However, almost all *T. asiatica* tapeworms in Asia, except for those distributed in parts of Taiwan and the Philippines, are not pure *T. asiatica*, but are instead descendants of *T. asiatica* and *Taenia saginata* hybrids (Ito et al., 2016, 2019; Sato et al., 2018a; Yamane et al., 2013). A main risk factor for taeniasis is eating uncooked pig liver, which is often using in the traditional dish *sang-sang* (Fig. 3).

This study provides findings from a survey of STH and taeniasis infections in the Simanindo and Ronggurnihuta subdistricts of Samosir Island, North Sumatra, Indonesia 12 years after conducting initial surveys in 2003–2006. A risk factor survey for taeniasis infection was also conducted in 2015, with the goal of identifying ongoing unsafe behaviors in this population.

## 2. Materials and methods

Samosir is an island (district) located in North Sumatra Province, Indonesia. The island consists of 9 subdistricts (Fig. 1) with a 2015 population of 123,789 (BPS-SSR, 2016). The subdistricts of Simanindo

and Ronggurnihuta are almost entirely rural. Simanindo contains 21 villages (2015 population of 20,190) and Ronggurnihuta contains 8 villages (2015 population of 8,632) (BPS-SSR, 2016).

Field surveys were conducted in the Simanindo villages of Simarmata and Ambarita in January 2003 and February 2005 and in the villages of Parbalohan and Ambarita in February 2006. In September 2015, field surveys were conducted in the Simanindo villages of Garoga and Ambarita as well as in the village of Lintong Nihuta, which is located in the subdistrict of Ronggurnihuta. Villages were selected based on recommendations from local health centers. Members of the selected villages ( $\geq 2$  years of age) were invited to provide a fecal sample as well as obtain a free check-up at the local health center. Individuals were only sampled once during the surveys. Fecal samples were collected from all participants and examined microscopically using the Kato-Katz technique (Swastika et al., 2017). STH infections were treated with albendazole (400 mg single dose) for one day, unless *T. trichiura* infection was identified, in which case treatment was provided for 3 consecutive days.

During the 2015 survey, a questionnaire was administered to survey participants 15 years of age and older. Information on possible risk factors for taeniasis, including consumption of uncooked liver and improper cooking methods, was obtained. All data were collected by trained health workers and members of the researcher team. A total of 739 villagers participated in the study from 2003 to 2015. Participant's ages ranged from 2 to 80 years. Overall, 266 (36.0%) of the subjects were male and 473 (64.0%) were female (Table 1).

Infection prevalence was determined for all study years. Comparison of infection prevalence by age and sex was conducted using the Pearson's chi square or Fisher's exact test, if one or more of the values in a  $2 \times 2$  contingency table was less than 5. Data analysis was conducted in 2019 using SPSS v.19 (IBM). A  $p$ -value < 0.05 was considered statistically significant.

Data collection was approved by the North Sumatra Provincial Health Office and the Samosir District Health Office (approval number: 440.441.1/1391/IX/2015, dated 27 September 2015).

## 3. Results

The prevalence of STH infections in Simanindo was 41.4%, 52.2%, 55.7%, and 46.8% in 2003, 2005, 2006, and 2015, respectively

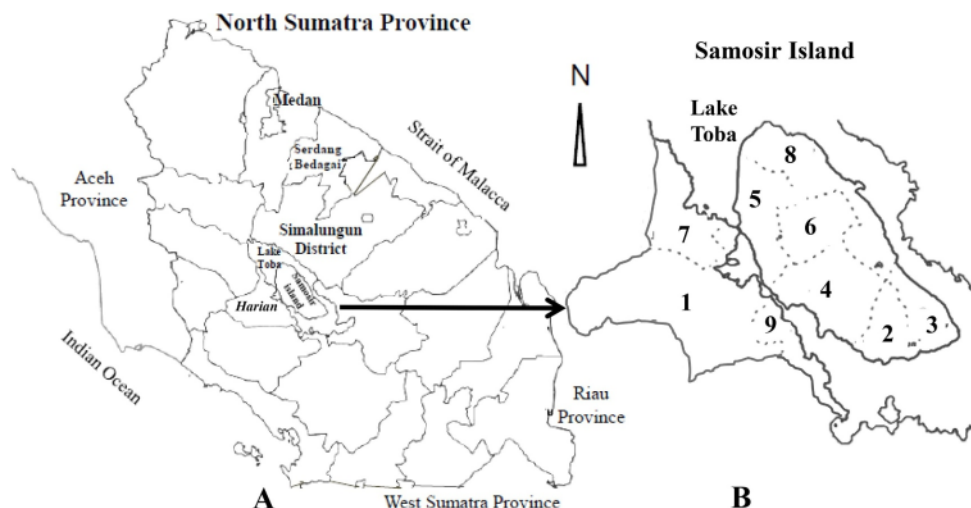


Fig. 1. Maps of North Sumatra Province (A) and Samosir Island (B) showing Simanindo (8) and Ronggurnihuta (6) subdistricts, with the location of field surveys in 2003, 2005, 2006, and 2015. Samosir district consists of Harian (1), Nainggolan (2), Onan Runggu (3), Palipi (4), Pangururan (5), Ronggurnihuta (6), Sianjur Mula-mula (7), Simanindo (8), and Sitio-tio (9).

**Table 1**  
Number and characteristics of subjects from the Simanindo and Ronggurnihuta subdistricts of Samosir Island, North Sumatra in 2003, 2005, 2006, and 2015.

Characteristic	Subdistrict Simanindo				Ronggurnihuta
	2003 (n = 58)	2005 (n = 182)	2006 (n = 131)	2015 (n = 314)	2015 (n = 54)
Age (year)					
Range	18–75	2–73	4–80	2–78	2–80
≤ 15	0	20	55	167	29
> 15	58	162	76	147	25
Sex					
Male	21	77	57	85	26
Female	37	105	74	229	28

(Table 2). The 2015 prevalence of STH infections in Ronggurnihuta was 66.7%. The most common infections were caused by *A. lumbricoides*, except for in 2005 when *T. trichiura* was most prevalent.

The prevalence of *T. asiatica* in Simanindo was 3.4% and 2.2% for the years 2003 and 2005, respectively (data previously published in Wandra et al., 2006). However, there were no taeniasis cases identified in 2006 (0/131) or 2015 (0/368) (Table 2), as well as no history of eating uncooked pig liver based on questionnaire findings.

In 2015, 53.2% (167/314) of the participants from Simanindo were ≤ 15 years of age and 27.1% (85/314) were male. There was a higher prevalence of STH infections in the > 15 years of age group (61.9%) than in the ≤ 15 years of age group (33.5%) ( $p < 0.0001$ ). Males had a higher prevalence of infection (70.6%) compared to females (38.0%) ( $p < 0.0001$ ) (Table 3). STH infections in the > 15 years of age group were most commonly due to *A. lumbricoides* (41.8%), followed by hookworms (27.5%), and *T. trichiura* (23.1%). These same parasites were the most common in the ≤ 15 years of age group. However, hookworms were much less prevalent (1.8%), while *T. trichiura* (48.2%) was more prevalent (Table 3).

In the 2015, 53.7% (29/54) of the participants from Ronggurnihuta were ≤ 15 years of age and 48.1% (26/54) were male (Table 1). There was a higher prevalence of STH infections in the > 15 years of age group (84.0%) than in the ≤ 15 years of age group (51.7%) ( $p = 0.0198$ ). STH infections in the > 15 years age group were predominantly due to *A. lumbricoides* (42.9%), followed by hookworms (38.1%), and *T. trichiura* (4.8%). STH infections in the ≤ 15 years age group were most commonly due to *A. lumbricoides* (33.3%), followed by *T. trichiura* (20.0%), with hookworm infection less common (6.7%) (Table 3).

#### 4. Discussion

Human behavior and the local climate create favorable conditions for parasites to complete their life cycles in Asian countries, including

Indonesia (Sato et al., 2018b). The high temperatures (13.6 °C–32.2 °C), high humidity (average of 85.0%), and largely rural population make Samosir Island an ideal location for the transmission of STHs. The current STH control program, implemented by the Ministry of Health, targets children of preschool and elementary school age (MHRI, 2012). Albendazole and mebendazole can be effective and inexpensive drugs to control STH transmission.

The values found in Simanindo are similar to other STH prevalence values reported for Indonesia, which range from 2.5% to 62.0% (MHRI, 2017). These values have not changed substantially from those reported in the 1980s and 1990s, where prevalence ranged from 40% to 70% (Margono, 2003). Past studies have shown the efficacy of MDA on whipworms to be limited. In a 2006 study conducted in elementary and junior high school students in Simanindo, 59.6% of students were positive for *T. trichiura* eggs two weeks after being administered a single dose of albendazole (Wandra et al., unpublished). Two doses of albendazole/mebendazole may need to be considered for improved results (Namwanje et al., 2011).

In the 2015 survey in Simanindo, individuals > 15 years of age and males had the highest prevalence of STH infections (Table 3). The lower prevalence of hookworm infection in the younger age group may be due to improved health education provided in local schools as part of the nationwide STH control initiative. However, the high prevalence of *T. trichiura* infection in the younger age group may be due to inadequate treatment from health facilities or during the MDA program. Due to the techniques used in this study, there was no speciation of hookworms. Therefore, future studies should include molecular identification of hookworm infections.

In Ronggurnihuta, although not statistically significant, the higher prevalence of hookworm infection in the > 15 years of age group and in females may be due to the large amount of time that these groups spend working in the fields. During the 2015 study, many female participants in Ronggurnihuta were barefoot (Fig. 2c), which may pose an opportunity for additional education about hookworm transmission. Health education is essential for the control of STH infections, with a need to educate children starting at a very young age (Kobayashi et al., 2006; Kojima and Takeuchi, 2006; Kojima et al., 2007; Takeuchi et al., 2007; Wulanyani et al., 2019).

Both the study subdistricts of Simanindo and Ronggurnihuta are predominately rural, but Simanindo has a small tourist industry and more interaction with outside communities. The 2015 prevalence in Simanindo was less than that in Ronggurnihuta, which may reflect the more rural atmosphere of Ronggurnihuta. This difference in communities can be illustrated by the use of an easily contaminated local pond for domestic purposes in Ronggurnihuta (Fig. 2a,b). However, due to the small number of samples collected in Ronggurnihuta, further studies are needed to draw any real conclusions.

No cases of taeniasis were identified in 2006 or 2015. There was also no claim of eating uncooked pig liver during the 2015 survey. This

**Table 2**  
Prevalence of STH infection and *T. asiatica* taeniasis in the Simanindo and Ronggurnihuta subdistricts of Samosir Island, North Sumatra in 2003, 2005, 2006, and 2015.

Infecting parasite	Number and prevalence (%)				Ronggurnihuta 2015 (n = 54)
	Simanindo 2003 (n = 58)	2005 (n = 182)	2006 (n = 131)	2015 (n = 314)	
STH infection	24 (41.4)	95 (52.2)	73 (55.7)	147 (46.8)	36 (66.7)
<i>A. lumbricoides</i> (Al)	11 (19.0)	18 (9.9)	16 (12.2)	52 (16.6)	14 (25.9)
<i>T. trichiura</i> (Tt)	3 (5.2)	30 (16.5)	11 (8.4)	48 (15.3)	4 (7.4)
Hookworms (HW)	2 (3.4)	15 (8.2)	11 (8.4)	26 (8.3)	9 (16.7)
Al+Tt	6 (10.3)	11 (6.0)	13 (9.9)	10 (3.2)	4 (7.4)
Al+Hw	2 (3.4)	6 (3.3)	3 (2.3)	9 (2.9)	3 (5.6)
Tt+Hw	–	11 (6.0)	8 (6.1)	2 (0.6)	–
Al+Tt+Hw	–	4 (2.2)	11 (8.4)	–	2 (3.7)
<i>T. asiatica</i>	2/58 (3.4)*	4 (2.2)*	–	–	–

\* Wandra et al., 2006.

**Table 3**Prevalence of STH infection and *T. asiatica* taeniasis by age and sex in the Simanindo and Ronggurnihuta subdistricts of Samosir Island, North Sumatra in 2003, 2005, 2006, and 2015.

Subdistrict (year)	Infesting parasite	Age (year)		Number and prevalence (%)			p-value
		≤ 15	> 15	p-value	Male	Sex Female	
Simanindo (2003)*	<i>T. asiatica</i>	0/0 (0.0)	2/58 (3.4)	—	0/21 (0.0)	2/37 (5.4)	0.5299
Simanindo (2005)*	<i>T. asiatica</i>	0/20 (0.0)	4/162 (2.5)	0.6251	4/77 (5.2)	0/105 (0.0)	<b>0.0306</b>
Simanindo (2006)	<i>T. asiatica</i>	0/55 (0.0)	0/76 (0.0)	—	0/57 (0.0)	0/74 (0.0)	—
Simanindo (2015)	<i>T. asiatica</i>	0/167 (0.0)	0/147 (0.0)	—	0/85 (0.0)	0/229 (0.0)	—
Ronggurnihuta (2015)	<i>T. asiatica</i>	0/29 (0.0)	0/25 (0.0)	—	0/26 (0.0)	0/28 (0.0)	—
Simanindo (2015)	STH infection	56/167 (33.5)	91/147 (61.9)	< 0.0001	60/85 (70.6)	87/229 (38.0)	< 0.0001
	<i>A. lumbricoides</i> (Al)	14/56 (25.0)	38/91 (41.8)	<b>0.0390</b>	11/60 (18.3)	41/87 (47.1)	<b>0.0003</b>
	<i>T. trichiura</i> (Tt)	27/56 (48.2)	21/91 (23.1)	<b>0.0016</b>	35/60 (58.3)	13/87 (14.9)	< 0.0001
	Hookworms (Hw)	1/56 (1.8)	25/91 (27.5)	< 0.0001	5/60 (8.3)	21/87 (24.1)	<b>0.0136</b>
	Al+Tt	9/56 (16.1)	1/91 (1.1)	<b>0.0007</b>	6/60 (10.0)	4/87 (4.6)	0.3175
	Al+Hw	5/56 (8.9)	4/91 (4.4)	0.3020	2/60 (3.3)	7/87 (8.0)	0.3103
	Tt+Hw	0/56 (0.0)	2/91 (2.2)	0.5251	1/60 (1.7)	1/87 (1.1)	0.6514
Ronggurnihuta (2015)	STH infection	15/29 (51.7)	21/25 (84.0)	<b>0.0198</b>	14/26 (53.8)	22/28 (78.6)	0.0540
	<i>A. lumbricoides</i>	5/15 (33.3)	9/21 (42.9)	0.5656	6/14 (42.9)	8/22 (36.4)	0.6985
	<i>T. trichiura</i>	3/15 (20.0)	1/21 (4.8)	0.2870	1/14 (7.1)	3/22 (13.6)	0.6431
	Hookworms	1/15 (6.7)	8/21 (38.1)	0.0514	2/14 (14.3)	7/22 (31.8)	0.4315
	Al+Tt	3/15 (20.0)	1/21 (4.8)	0.2870	3/14 (21.4)	1/22 (4.5)	0.2794
	Al+Hw	1/15 (6.7)	2/21 (9.5)	0.6274	1/14 (7.1)	2/22 (9.1)	0.6686
	Tt+Hw	0/15 (0.0)	0/21 (0.0)	—	0/14 (0.0)	0/22 (0.0)	—
	Al+Tt+Hw	2/15 (13.3)	0/21 (0.0)	0.1667	1/14 (7.1)	1/22 (4.5)	0.6460

\* Wandra et al., 2006.

may be due to a local education program focusing on the need to eat only cooked pork and viscera (Fig. 3). However, since *T. asiatica* has been reported to survive for up to 40 years (Ito et al., 2019; Zein et al., 2019), there may still be tapeworm carriers on Samosir Island, especially in the more rural and remote areas. Vigilance must also be maintained since a new region that is endemic for *T. asiatica* has been identified in palm farming areas in Simalungun District, which is located between Lake Toba and the provincial capital city of Medan (Zein et al., 2019) (Fig. 1A).

## 5. Conclusions and perspectives

Neglected Tropical Diseases (NTDs), including STH infections and

taeniasis, continue to be a problem in Indonesia. Comprehensive planning is needed to develop a sustainable program to control these parasites. A multidisciplinary approach has been shown to be a promising strategy to help marginalized people (Wibawa and Satoto, 2016). Improvement of personal hygiene and environmental sanitation for control of STH infections on Samosir Island will likely require collaboration among multiple sectors.

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**Fig. 2.** Pictures showing the use of natural pond water for washing clothes in Ronggurnihuta Subdistrict (a, b) next to a small health center (Poskesdes) (c), and an electric pumping system for water at the health center (d). The pond water is used for washing hands, feet, dishes, and clothes and can be contaminated with fecal material.



Fig. 3. Pictures showing local people preparing (a) a traditional dish (*sang-sang*) using well cooked pork or dog meat (c, d) in Simanindo Subdistrict. Pig liver cut into small pieces (b) (Suroso et al., 2006; Wandra et al., 2006).

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#### Declaration of Competing Interest

The authors report no conflict of interest. The authors are responsible for the content and writing of this paper.

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