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Soil-transmitted helminthiasis among indigenous communities in Malaysia: Is this the endless malady with no solution?

Mohd-Shaharuddin, N.[1], Lim, Y.A.L.[1], Hassan, N-A.[1], Nathan, S.[2] and Ngui, R.[1*]
[1]Department of Parasitology, Faculty of Medicine, University of Malaya, Kuala Lumpur, Malaysia
[2]School of Bioscience and Biotechnology, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, Selangor, Malaysia
[*]Corresponding author e-mail: romano@um.edu.my
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Abstract. Soil-transmitted helminths (STHs) are the most common intestinal parasitic infections of medical importance in human. The infections are widely distributed throughout the tropical and subtropical countries including Malaysia particularly among disadvantaged and underprivileged communities. This study was conducted to determine the prevalence and pattern of STH infections among *Temuan* indigenous subgroup. A cross sectional study was conducted among five villages in Peninsular Malaysia. Faecal samples and socioeconomic data were collected from each consented participant. Faecal samples were processed using formalin-ether sedimentation and examined under microscope. Data analysis was carried out using SPSS software programme for Windows version 24. A total of 411 participants voluntarily participated in this study. The overall prevalence of STH infections was 72.7% (95% CI = 68.2 – 77%). The most common STH species recorded was *Trichuris trichiura* (58.4%, 95% CI = 53.5 – 63.2%) followed by *Ascaris lumbricoides* (45.5%, 95% CI = 40.6 – 50.5%) and hookworm (23.1%, 95% CI = 19.1 – 27.5%). Multivariate analysis demonstrated that using untreated water was a significant predictor of STH infections in these communities. Our findings demonstrated that STH infections are still prevalent and co-exist with the low SES among this subgroup. Poverty and poor sanitation are the leading factors contributing to this malady. Hence, the reassessments of the existing control measures are needed.

INTRODUCTION

Soil-transmitted helminths (STHs) are a group of parasitic nematode worms causing human infection worldwide. The infections are common in socioeconomically deprived communities where poor environmental sanitation, overcrowding and lack of access to safe water are prevalent (Mehraj *et al.*, 2008). The main species that infect humans are roundworm (*Ascaris lumbricoides*), hookworms (*Ancylostoma duodenale* and *Necator americanus*) and whipworm (*Trichuris trichiura*). Globally, an estimated 438.9 million were infected with hookworm, 819 million with *A. lumbricoides* and 464.6 million with *T. trichiura* (Pullan *et al.*, 2014). The STHs are also one of the world's most important causes of physical and intellectual growth retardation among school-aged children however, they remain largely neglected by the medical and international community (Bethony *et al.*, 2006).

Chronicity, recurrence and multiple infections with several species are common (Steinmann *et al.*, 2008). According to Pullan *et al.* (2014), Southeast Asia (SEA) has the highest reported prevalence of STH infections. Overall, approximately one-third of the world's cases of STHs infection occur in the 11 SEA countries (Jex *et al.*, 2011). In Malaysia, STHs have been recognized as a major public health problem since 1970s (Bisseru & Aziz, 1970). To overcome this problem, national helminth control programmes through mass drug administration (MDA) were initiated in Malaysia in 1974 (Lim *et al.*, 2009). The employment of the strategies to eradicate STHs in Malaysia has been successful until it was discontinued in 1983 (MOH, 1985). Nevertheless, foci of high endemicity of STH infection are still persistent particularly in rural communities where socioeconomic and environmental sanitation are often poor (Lim *et al.*, 2009; Ngui *et al.*, 2011; Sinniah *et al.*, 2012; Anuar *et al.*, 2014; Ngui *et al.*, 2015).

In Peninsular Malaysia, there are 18 subgroups of indigenous communities, collectively known as *Orang Asli* within three main tribes namely Negrito, Senoi and Proto-Malay (Aboriginal-Malays). These communities represent a mere 0.6% of the national population (Mikkelsen, 2015). The *Orang Asli* is not homogenous people as they are geographically, genetically, socioeconomically and culturally diverged. *Temuan* is the biggest subgroup of Proto-Malays tribe who mainly resides in Selangor state. This subgroup is categorised as "settled people" where they live in urban and suburban settlements engaged with various occupations (Nicholas, 2000).

In recent years, several studies have been conducted highlighting the prevalence of STH infections among indigenous communities from various subgroups and geographical locations in Peninsular Malaysia (Ngui *et al.*, 2011; Sinniah *et al.*, 2012; Anuar *et al.*, 2014; Lee *et al.*, 2014; Ngui *et al.*, 2015; Chin *et al.*, 2016). Nevertheless, none of such studies emphasised exclusively on a specific subgroup that sharing similar geographical location. *Temuan* subgroup resides in areas in vicinity to the urbanisation and has access to many appropriate facilities (i.e. health and socio-development) in comparison to other subgroups which reside in rural or remote areas. However, previous data indicated that the prevalence of STH infections was still alarming among this subgroup (Lee *et al.*, 2014; Ngui *et al.*, 2015). Within this context, the present study was conducted to determine the current status, compare the patterns and possible associated risk factors of STH infections among *Temuan* subgroup from different villages in Selangor, Peninsular Malaysia. The information yielded will be beneficial to facilitate and reassess the existing control measures including the improvement of socioeconomic status, health education and deworming programmes.

MATERIAL AND METHODS

Ethical approval

The study protocol (Ref Number: 20144-104) was approved by the Ethics Committee of the University of Malaya Medical Centre, Malaysia. An advanced notice was provided to the headman of village prior to samples collection. Parents and their children were given an oral briefing by the investigator on the objective and methodology. Written consent forms were only given to those who agreed to participate in this study where they need to sign it. For children and very old participants, the consent was completed by their parents or guardians. For illiterate participants, verbal consent was provided followed by thumb print. The identity and personal particular in this study were strictly kept confidential and to the extent permitted by law, the information is accessible only to the researchers in this study. Data from this study omitted any information that identified the respondents. All data and personal information collected were kept in a safe computer system.

Study design and area

A cross-sectional study was conducted from October 2014 to May 2015 among indigenous communities in Selangor, Peninsular Malaysia without discriminatory to age groups and genders. Five accessible villages (i.e., Pangsun (KP), Gurney (KG), Hulu Tamu (KU), Tun Razak (KT), Kemensah (KM) which represented *Temuan* subgroup were selected using convenient sampling technique (Figure 1). The villages were selected from the available official list permitted by the Department of *Orang Asli* Development, Ministry of Rural and Regional Development, Malaysia taking into consideration the following criteria; 1) accessibility by road

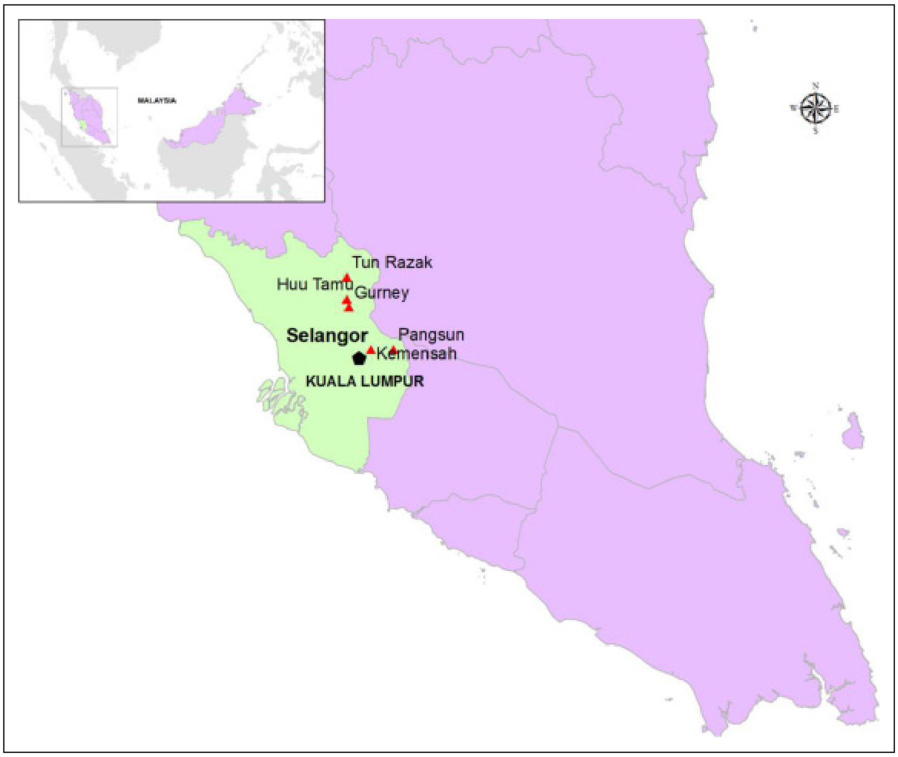

Figure 1. Location of the sampling sites.

and 2) willingness of participation by the head and community members of the villages. Generally, the villages were randomly selected and all participants who involved in this study were voluntarily to take part without being recruited.

KP village (101.88°E, 3.21°N) is a suburban area and situated in Klang valley approximately 40 km from the city of Kuala Lumpur. KG village (101.67°E, 3.42°N) is in vicinity with KU village (101.70°E, 3.46°N) approximately 12 km. KT village (101.65°E, 3.57°N) is considered a suburban area and has the largest population among all villages. KG, KU and KT villages are situated at the northern region of Selangor. KM village (101.77°E, 3.21°N) is also situated in Klang valley and has close proximity (~13 km) from the city of Kuala Lumpur. The average population of each village is between 200 and 300 people.

In general these villages are located at lowland altitude at the outskirt of the jungle. Most of the houses are made of concrete and equipped with electricity and government treated water. However, these facilities were not fully utilised or evenly distributed. Some households still lived in houses made of wood or bamboo. Most of the residents predominantly engaged in farming, rubber tapping and odd jobs such as selling forest products. The sample size was calculated according to the anticipated prevalence of intestinal parasitic infections conducted in this community. Sample size calculation was performed by taking the estimated prevalence of previous study (Ngui *et al.*, 2011) at 73.2% with a 95% level of confidence 5% bound on the error of estimation using the formula by Leedy and Ormrod (1993). The minimum sample size in this study was estimated at 303 participants.

Questionnaire

An oral briefing was instigated by explaining the objectives of the study to the participants and written informed consent was then obtained from them. A pre-tested questionnaire was administered face-to-face by trained field assistants to gather information on demographic data (i.e. age, gender, education attainment), socio-economic (i.e. occupation, household income), behavioural (i.e. personal hygiene practice, food consumption), source of food (i.e. farmed animals and vegetables, wild game), environmental sanitation and living conditions (i.e. water supply, latrine system, garbage disposal system, presence of domestic animals). For children, the questionnaire was completed by interviewing their parents or guardians. The participants were divided into different age groups namely toddlers (1 to 4 years), pre-school children (5 to 6 years), school-aged children (7 to 12 years), teenagers (13 to 17 years) and adults (≥18 years).

Faecal sample collection

After the interviews, a wide screw-capped mouth faecal container (AGS, Malaysia) with an attached scoop was labelled, coded and distributed to each of the participants together with a plastic bag. The participants were instructed to scoop a thumb-sized faecal sample using a provided scoop into the container. Meanwhile, parents and guardians were asked to monitor their children during sample collection to ensure that they placed the samples into the right container. Faecal samples were collected the next day. These samples were then transported to the laboratory within three hours after sample collection. Upon reaching the laboratory, the faecal samples were preserved in 2.5% potassium dichromate and refrigerated at 4°C. Prior to microscopy examination, the faecal samples were processed using formalin-ether concentration technique within 24 hours after collection (Cheesbrough, 1998). Approximately, 1 to 2 g of the faecal sample was mixed with 7mL of formalin and 3mL of ether, centrifuged, stained with Lugol's iodine and finally examined under light microscope.

Statistical Analysis

Statistical analysis was performed using the SPSS software (Statistical Package for the Social Science) programme for Windows version 24 (SPSS Inc., Chicago, IL, USA). For descriptive analysis, percentage was used to describe the characteristics of the studied population including the prevalence of STHs according to villages, age and genders. Pearson's Chi-square (χ^2) on proportion was used to test the associations between each variable. In univariate analysis, the dependent variable was prevalence of STHs, while the independent variables were sociodemographic, behavioural risks, environmental sanitation and living condition characteristics. All variables that were significantly associated with prevalence of STHs in univariate analysis were included in a logistic multivariate analysis model to identify the risk factors of STHs. The level of statistical significance was set as $p<0.05$ and for each statistically significant factor, an odd ratio (OR) and 95% confidence interval (CI) was computed. To ensure that any potentially important predictors were not excluded and also because of a low number of predictor variables, any variables with the borderline significance level of 0.10–0.25 were also included in the multivariate analysis (Bendel & Afifi, 1977).

RESULTS

General characteristics

A total of 411 participants from five villages were participated in this study. This comprised of 199 (48.4%) males and 212 (51.6%) females, respectively. The overall ages ranging from 1 to 82 years old with a median of 12 years and a proportion of 15.1%, 10.5%, 26%, 6.8% and 41.6% for the toddlers (1 to 4 years), pre-school children (5 to 6 years), school-aged children (7 to 12 years), teenagers (13 to 17 years) and adults (≥18 years). With the exemption of KG village, more than half of the villagers received formal education attainment, at least until secondary level. Further analysis showed that most of the children (47.2%) had received primary education, 13.9% secondary education and while only 0.5% went for tertiary education. Meanwhile, 38.4% of them had never received any form of formal education.

Although more than half villagers were unemployed (76.4%), it was also noted that majority of the unemployed participants engaged with activities such as collecting jungle products as well as helping their family members in the palm oil and rubber plantations to supplement their family income. The rest of the employed villagers (23.6%) were mainly engaged in odd jobs such as jungle products collector or forager (10.9%) without permanent income. There were 5.4% and 5.1% working in rubber or palm oil plantations and farming, respectively. Whilst only two (0.5%) worked as government employee. The villagers were predominantly poor with a monthly income less than RM500 per household (54.3%).

The main source of water supply is from river located nearby to their villages (60.3%) for bathing/defecating, cooking, drinking and washing. Despite of having latrine facility at home for majority of the population (67.6%), it was not frequently used due to poor maintenance or their habit where river and bush remain the most preferred defecation site. Other general characteristics of each village and their socioeconomic profiles were presented in Table 1.

Prevalence and pattern of STH infections

The overall prevalence of STH infections was 72.7% (95% CI = 68.2–77%) with *T. trichiura* (58.4%; 95% CI = 53.5–63.2%) was the most predominant, followed by *A. lumbricoides* (45.5%; 95% CI = 40.6–50.5%) while hookworm infection had the lowest rate (23.1%; 95% CI = 19.1–27.5%) (Table 2). The overall prevalence of infections were statistically significant between villages ($p<0.05$). KM village had significantly high prevalence of any STH infections (100%; 95% CI = 84–100%) compared to other villages. The lowest

Table 1. Demographic, socioeconomic, environmental, and sanitary behaviour characteristics distribution by villages

Characteristics	KP	KG	KU	KT	KM	Total	χ^2	p
	$N = 67$	$N = 74$	$N = 100$	$N = 137$	$N = 33$	$N = 411$		
	%	%	%	%	%	%		
Gender								
Male	55.2	44.6	57	39.4	54.5	48.4	9.5	0.048
Female	44.8	55.4	43	60.6	45.5	51.6		
Age (years)								
Range	1 – 60	1 – 65	1 – 82	1 – 67	2 – 74	1 – 82	330.3	<0.001
Median	18	10	14	11	14	4		
Age range (years)								
1 – 4 toddlers	11.9	21.6	16	14.6	6.1	15.1	16.7	0.408
5 – 6 pre-school children	7.5	12.2	6	13.9	12.1	10.5		
7 – 12 (school-aged children)	19.4	29.7	26	26.3	30.3	26		
13 – 17 (teenagers)	9	2.7	7	7.3	9.1	6.8		
18 and above (adults)	52.5	33.8	45	38	42.4	41.6		
Age category								
< 12 years old	38.8	63.5	48	54.7	48.5	51.6	9.8	0.044
> 13 years old	61.2	36.5	52	45.3	51.5	48.4		
Education status								
Formal education	59.7	44.6	64	67.9	69.7	61.6	12.6	0.013
No formal education	40.3	55.4	36	32.1	30.3	38.4		
Education category								
No formal education	40.3	55.4	36	32.1	30.3	38.4	25.1	0.014
Primary school	37.3	39.2	52	50.4	57.6	47.2		
Secondary school	22.4	4.1	11	17.5	12.1	13.9		
Tertiary education	0	1.4	1	0	0	0.5		
Occupational status								
Working	37.3	16.2	26	18.2	27.3	23.6	12	0.018
Not working	62.7	83.8	74	81.8	72.7	76.4		

Occupational category								
Not working (housewife/student)	62.7	83.8	74	81.8	72.7	76.4		
Farmer	10.4	8.1	3	0.7	12.1	5.1		
Rubber/palm oil plantation	23.9	0	6	0	0	5.4		
Labor (factory/construction)	1.5	1.4	4	0	0	1.5	102	<0.001
Small business	0	1.4	0	0	0	0.2		
Government employee	0	0	0	1.5	0	0.5		
Others (driver, etc.)	1.5	5.4	13	16.1	15.2	10.9		
Household income (RM/month)								
< RM 500	56.7	73	56	42.3	51.5	54.3	18.7	<0.001
> RM 500	43.3	27	44	57.7	48.5	45.7		
Source of water supply								
Treated (government pipe water)	6	2.7	34	89.8	0	39.7	240.9	<0.001
Untreated (river, mountain, etc.)	94	97.3	66	10.2	100	60.3		
Latrine facilities								
No	32.8	55.4	44	19	0	32.4	51.2	<0.001
Yes	67.2	44.6	56	81	100	67.6		
Type of latrine								
Toilet	55.2	35.1	53	64.2	100	57.7		
Bush	0	2.7	9	13.1	0	7.1	70	<0.001
River	44.8	62.2	38	22.6	0	35.3		
Defecation site								
Open/Indiscriminate	44.8	64.9	47	35.8	0	42.3	43.1	<0.001
Latrine	55.2	35.1	53	64.2	100	57.7		
Garbage disposal								
Indiscriminate	3	0	0	0	0	0.5	10.3	0.035
Collected	97	100	100	100	100	99.5		
Close contact with animals								
No	98.5	85.1	75	86.1	60.6	83.2	29.2	<0.001
Yes	1.5	14.9	25	13.9	39.4	16.8		
Wearing shoes/slippers								
No	11.9	13.5	20	14.6	42.4	17.5	17.7	<0.001
Yes	88.1	86.5	80	85.4	57.6	82.5		
Washing hands after defecation								
No	14.9	12.2	23	16.8	42.4	19.2	16.1	0.003
Yes	85.1	87.8	77	83.2	57.6	80.8		

Table 2. Prevalence of soil-transmitted helminths (STH) infections among *Temuan* subgroup

Village/ Characteristics	*Trichuris trichiura*		*Ascaris lumbricoides*		Hookworms		Any STH	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
KP	67.2	54.6 – 78.2	28.4	18 – 40.7	13.4	6.3 – 24	68.7	56.2 – 79.4
KG	64.9	52.9 – 75.6	47.3	35.6 – 59.3	27	17.4 – 38.6	86.5	76.6 – 93.3
KU	53	42.8 – 63.1	63	52.8 – 72.4	30	21.2 – 40	75	65.3 – 83.1
KT	44.5	36 – 53.2	29.9	22.4 – 38.3	21.2	14.7 – 29	59.1	50.4 – 67.4
KM	100	89.4 – 100	87.9	71.8 – 96.7	21.2	9 – 39	100	89.4 – 100
χ^2	39		57.7		7.2		33.1	
p	<0.001		<0.001		0.126		<0.001	
<12 years old	59.9	53 – 66.6	43.9	37.1 – 50.8	18.9	13.8 – 24.8	73.1	66.6 – 79
>13 years old	56.8	49.6 – 63.8	47.2	40.1 – 54.4	27.6	21.6 – 34.4	72.4	65.6 – 78.5
χ^2	0.41		0.47		4.44		0.03	
p	0.521		0.493		0.035		0.864	

prevalence was reported in KT village (59.1%; 95% CI = 50.4–67.4%). Likewise, KM recorded the highest prevalence for *A. lumbricoides* (87.9%; 95% CI = 71.8–96.7%) and *T. trichiura* (100%; 95% CI = 89.4–100%) (p<0.05) whilst KU village had the highest prevalence of hookworm (30%; 95% CI = 21.2–40%). Hookworm infection was significantly high among adults compared to children (p<0.05).

In general, single infection with *T. trichiura* (21.4%; 95% CI = 17.5–25.7%) was the most common followed by *A. lumbricoides* (8.3%; 95% CI = 5.8–11.4%) and hookworm (2.7%; 95% CI = 1.3–4.3%). With regards to double infection, combination of *T. trichiura* and *A. lumbricoides* were the most predominant (20%; 95% CI = 16.2–24.2%) followed by the combination of *A. lumbricoides* and hookworm (3.4%; 95% CI = 1.9–5.7%) whereas combination of *T. trichiura* and hookworm accounted for 3.2% (95% CI = 1.7–5.4%). Meanwhile, the overall prevalence of triple infections were 13.9% (95% CI = 10.7–17.6%). Patterns of polyparasitism for each of the village were presented in Figure 2.

Associated risk factors of STH infections

Univariate analysis demonstrated that factors such as low household income (<RM 500) (OR = 1.21; 95% CI = 1.07–1.37; p=0.002), using untreated water supply (OR = 3.15; 95% CI = 2.01–4.93; p<0.001), the absence of toilets (OR = 1.25; 95% CI = 1.12–1.40; p<0.001) and indiscri-minate defecation (OR = 1.63; 95% CI = 1.03–2.56; p=0.035) were significantly associated with STH infections (Table 3). Multivariate analysis further confirmed that using untreated water had 2.5 times greater (95% CI = 1.52–4.07; p<0.001) more likely to have any STH infections.

DISCUSSION

The results of the present study indicated that STH infections are still remains a major health problem among indigenous communities in Peninsular Malaysia with an overall prevalence of 72.7%. Recent study among various subgroup including *Mah Meri*, *Temuan*, *Jakun*, *Semelai* and *Orang Kuala* from Peninsular Malaysia indicated that

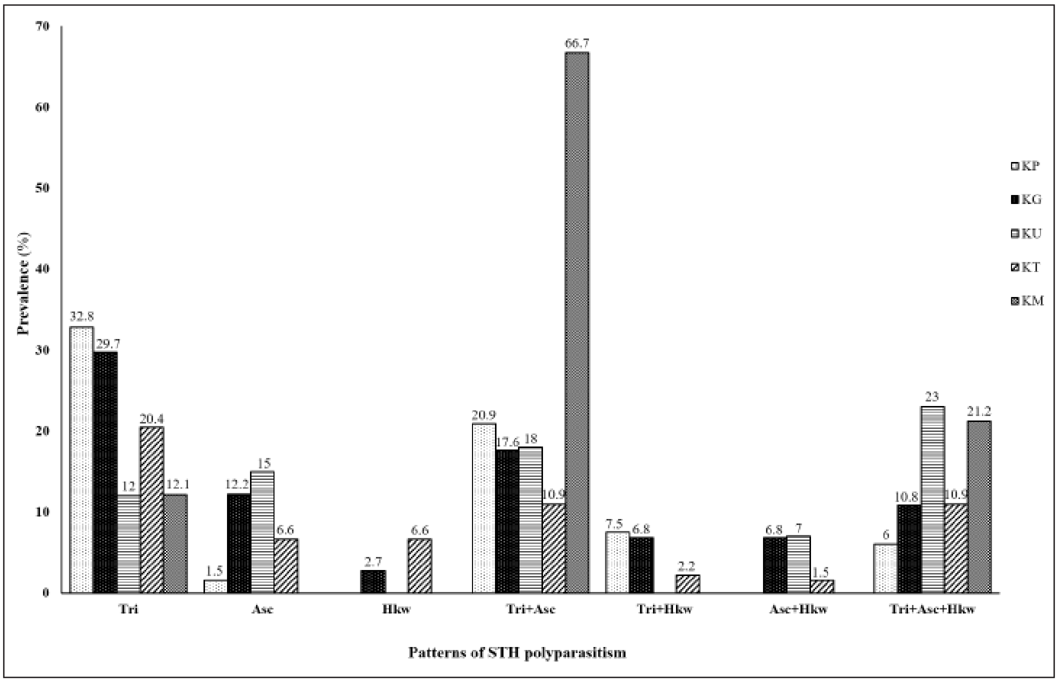

Figure 2. Prevalence of single, double, and triple infections of soil-transmitted helminth (STH) at the village level.

Table 3. Potential associated risk factors of STH infections among *Temuan* subgroup as determined by univariate analysis

Variables	Prevalence (%)	OR (95% CI)	*p* value
Gender			
Male	74.4	1.17 (0.76 – 1.81)	0.474
Female	71.2	1	
Age category			
<12 years old	73.1	1.04 (0.67 – 1.60)	0.864
>13 years old	72.4	1	
Occupation status			
Working	72.2	0.96 (0.58 – 1.60)	0.882
Not working	72.9	1	
Household income			
< RM 500	78.9	1.21 (1.07 – 1.37)	*0.002
> RM 500	65.4	1	
Water category			
Untreated (river, mountain, etc.)	81.9	3.15 (2.01 – 4.93)	*<0.001
Treated (government pipe water)	58.9	1	
Presence of latrine			
No	84.2	1.25 (1.12 – 1.40)	*<0.001
Yes	67.3	1	
Defecation category			
Open/Indiscriminate	78.2	1.63 (1.03 – 2.56)	*0.035
Latrine	68.8	1	
Close contact with animals			
Yes	81.2	1.76 (0.92 – 3.35)	0.085
No	71.1	1	
Wearing shoes/slippers			
No	18.7	0.72 (0.4 – 1.32)	0.291
Yes	81.3	1	
Washing hands after defecation			
No	21.4	0.57 (0.31 – 1.05)	0.066
Yes	78.6	1	

OR: odds ratio; CI: confidence interval.
*Significant risk factor (p<0.05).

Temuan subgroup had similar findings to the present study, 72% (Ngui *et al.*, 2015). Another study reported by Lee *et al.* (2014) on this subgroup showed overall prevalence of 53.2%. Thus, the prevalence of STH infections among *Temuan* indigenous community is consistent over the years. Interestingly, KM village which located neighbouring to Kuala Lumpur city centre showed the prevalence rate of a hundred percent. This variation is most likely associated with personal hygiene practice and socioeconomic status (SES). This finding corresponds with previous studies justifying that poor sanitation and low SES increase susceptibility of STH infections (Al-Delaimy *et al.*, 2014; Ross *et al.*, 2017). No significant difference between males and females indicated that these infections were non-discriminatory to genders, a finding that was in accordance to previous studies (Liao *et al.*, 2017; Rajoo *et al.*, 2017).

The prevalence of each helminth species was in agreement with previous studies conducted in Malaysia where *T. trichiura* is the leading species followed by *A. lumbricoides* and hookworm (Ngui *et al.*, 2011; Anuar *et al.*, 2014; Lee *et al.*, 2014; Ngui *et al.*, 2015). In contrast, a most recent study conducted among indigenous communities in East Malaysia reported that *A. lumbricoides* was the most predominant species followed by hookworm and *T. trichiura* (Rajoo *et al.*, 2017). Thus, the transmission of STH infections among the indigenous communities are not predominantly associated with the geographical area, but more related with the poor socioeconomic status, personal hygiene, lack of basic amenities and low educational attainment (Ngui *et al.*, 2011; Al- Delaimy *et al.*, 2014; Anuar *et al.*, 2014; Lee *et al.*, 2014; Ngui *et al.*, 2015).

The prevalence of *T. trichiura* and *A. lumbricoides* infections between children and adults was generally similar between age groups. This result indicates that most probably these age groups were evenly exposed to these parasites and reinfection among adults over the time is common in highly endemic areas (Lim *et al.*, 2009; Bopda *et al.*, 2016). Another highlight of the present study is adults were more likely to be infected with hookworm than children. It is thought that the transmission of hookworm in adults is associated with agricultural pursuits such as working at the plantation and foraging jungle products (Anderson & May, 1991; Brooker *et al.*, 2004). Recent mathematical model-based studies of STH transmission revealed that the burden of infections covered all age groups especially hookworm infections where prevalence and intensity is highest among adults (Truscott *et al.*, 2014; Anderson *et al.*, 2015).

Findings of the present study demonstrated that defecating indiscriminately, absence of latrine facility at home, using untreated water for their daily activities and lower household income were the risk factors of being infected with STHs in these communities. These significant predictors were in agreement with studies conducted previously (Lee *et al.*, 2014; Ngui *et al.*, 2015; Sanchez *et al.*, 2016; Rajoo *et al.*, 2017; Ross *et al.*, 2017). Although some houses were built-in with toilets such as cemented pit latrine or pour-flush toilet, many of them did not fully utilise it especially when they were doing routine work such as foraging jungle products or washing clothes at the nearby river, they tended to defecate at the river or bushes. Recent study reported untreated water supply increases the odds of infections with orally-ingested STH species (Echazú *et al.*, 2015). It is evident that safe drinking water along with adequate sanitation has implications on STH infections (Strunz *et al.*, 2014).

Although all villages have access to better amenities and health provider, nonetheless they are still behind in many ways. Re-infection occurs rapidly after treatment and STH remains a malady to these communities. Discontinuation of mass deworming programme to schoolchildren in 1983 worsens the scenario (MOH, 1985). In order to receive anthelminthic drug, they have to visit health clinic or buy the drug at local drugstores without appropriate monitoring system (periodic treatment). This may cause inefficiency of the drug and consequently lead to drug resistance (Vercruysse *et al.*, 2011). In reaching the 2020 goals by controlling and eliminating STH infections via London Declaration, the government should sustain, expand and extend drug access programmes to ensure the necessary supply of drugs and other interventions to control STH infections (London Declaration, 2017). Adequate funding to implement the programmes is necessary to achieve these goals. World Health Organization (WHO) has recommended that the component of water, sanitation and hygiene (WASH) are critical in the prevention and care for all the 17 neglected tropical diseases (NTDs) including STH infections (Water and Sanitation Interventions, 2013). Based on the WASH guidelines by increasing access to sufficient amounts of safe water for personal hygienic such as bathing and doing laundry and also access to safe water for drinking or food preparation, reducing open defecation, increasing improved sanitation coverage, wearing shoes outside and hand washing are among of the control measures that can be applied to eliminate STH.

Japan and South Korea are among the countries that have successfully combated the STH infections (Hong *et al.*, 2006; Schaafsma *et al.*, 2015). Although elimination of STH took at least 25 to 30 years for both Japan and Korea, undoubtedly mass deworming programmes, hygiene and sanitation improvements played major roles in the elimination of STH infections (Schaafsma *et al*., 2015). Persistent health education aims to increase awareness and to change the health-related behaviour towards STH infections in the population. Interactive sessions with these communities in disseminating information via posters, video messages, brochures and role-play are likely to foster their perceptions on STH infections. Mass drug administration by itself is unlikely to eradicate the transmission of STHs in the absence of sanitation, safe water supplies, health education and overall economic development (Bieri *et al*., 2013). Hence, preventive measures such as providing safe water, adequate sanitation and administration of anthelminthic drugs at regular intervals to populations at risk are required with the intention of maintaining individual worm burdens at levels below those that cause morbidity and mortality (Albonico *et al*., 2006).

This study has certain limitations that need to be considered while interpreting the results. Firstly, only single fecal sample was collected due to lack of the cooperation from the participants. The optimal laboratory diagnosis for STH infections requires multiple fecal examinations of at least three specimens collected over several days.

Secondly, only formalin ether concentration technique was used in the present study. Concentration method alone has poor sensitivity for diagnosing STH infections. This may have underestimated the true prevalence of STH infections, whereby only moderate and high worm burdens are more sensitive to be detected. Thus, a more accurate estimated prevalence of STH infections would have been obtained if a multiple fecal sample collection and a more sensitive diagnostic method was used. Climate is an important determinant of transmission of STH infections. Adequate moisture and warm temperature are essential for larval development in the soil (Brooker & Michael, 2000). Recent study in Malaysia demon-strated that there was a significant association between *A. lumbricoides* infection and land surface temperature (LST) (Ngui *et al*., 2014). In other words, as the temperature increases, transmission and prevalence of infection decrease. Such observations are most probably due to the effects of heat and low humidity on the embryonation and survival of ova. Moreover, Dunn (1972) conducted a field survey to investigate the intestinal parasitism among different indigenous communities living in different habitats in the Malaysian rain forest reported that communities at higher and cooler elevation suffer less from STH infections. However, the effect of climate such as moisture and temperature on the transmission of STH infections was not included in the present, a subject that warrants further investigation in future.

CONCLUSION

Soil-transmitted helminthiasis remains a major public health problem and seemingly an endless malady among the indigenous communities in Malaysia. STH infections, low SES along with poor environmental and sanitation practices are synonymous. Despite vast socioeconomic and education programmes implemented by the government and other non-profit organizations, these communities are still behind in many ways. Environmental sanitation in the control of STH infections is a slow process and changes in the attitude and practices of the people are even slower. There is also evidence to suggest that environmental sanitation alone cannot control STH infections. A combination of methods, including mass treatment and the improvement of the nutritional status of the community, supported with effective health education, is more likely to succeed. Hence, the reassessment of the existing control measures including the improvement of socioeconomic status, health education to create awareness about health and hygiene and mass periodic deworming programmes are indeed needed. This in turn will lead to a greater opportunity for a better future in terms of health and educational attainment particularly among children. This eventually will improve their health status and put them on par socially and economically with the general communities in Malaysia.

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Competing interest

None declared

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