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RESEARCH ARTICLE

Pre- and post-COVID-19 pandemic evaluation of soil-transmitted helminth infections among the Kensiu Negrito indigenous community

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ABSTRACT

This study evaluated soil-transmitted helminth (STH) infections among the Kensiu Negrito indigenous community in Kampung Lubuk Legong, Kedah, Malaysia, before and after the COVID-19 pandemic. A total of 70 and 87 participants were examined in 2020 and 2022, respectively. STH infections were detected using the Kato-Katz and formalin-ether concentration methods. The overall prevalence declined from 85.7% in 2020 to 65.5% in 2022, a statistically significant reduction ($p = 0.0054$). *Trichuris trichiura* remained the most common STH infection (year 2020: 84.3%; year 2022: 63.2%), followed by *Ascaris lumbricoides* (2020: 32.9%; 2022: 24.1%) and hookworm (2020: 21.4%; 2022: 25.3%). A statistically significant decrease was observed for *T. trichiura* overall ($p = 0.0039$) and in moderate infections ($p < 0.0001$), while the changes in *A. lumbricoides* and hookworm were not significant. The study employed a descriptive design and statistical comparisons were limited due to the small sample size. Despite this, the findings suggest an overall improvement in STH prevalence post-pandemic. Continued monitoring and culturally sensitive interventions remain essential to address persistent infection and promote long-term health improvements in Orang Asli communities.

Keywords: soil-transmitted helminth; COVID-19; Negrito; indigenous; Peninsular Malaysia.

INTRODUCTION

Soil-transmitted helminth (STH) infections are among the most common neglected tropical diseases globally. The WHO (2023) estimates that 1.5 billion people, or 24% of the world's population, are infected with at least one of the three main types of STH species: roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*) and hookworms (*Ancylostoma duodenale* and *Necator americanus*). The highest burden of STH infections is often observed among rural communities in tropical and subtropical regions with inadequate sanitation, limited access to clean water, and restricted healthcare services (Dunn *et al*., 2016; Parija *et al*., 2017).

Despite various initiatives to combat STH infections, the Malaysian government continues to grapple with this issue, especially within impoverished and socioeconomically marginalised communities, such as the indigenous Orang Asli of Peninsular Malaysia (Ahmed *et al*., 2011; Mohd-Shaharuddin *et al*., 2018; Nisha *et al*., 2020). Malaysia is notable for its multiethnic composition, with a total population of 34.1 million (DOSM, 2024). It was estimated that collectively, the indigenous peoples of Malaysia (currently categorised as Other Bumiputera) represented 12.3% of the country's total population in 2024 (DOSM, 2024). The term "Orang Asli" translates to "original people" or "first people" and refers to the indigenous minority population in Peninsular Malaysia. They are not a homogenous group but are classified into three main ethnicities, namely Senoi, Proto-Malay and Negrito, based on physical traits, language, culture, and economic functions (Masron *et al*., 2013). According to the Department of Orang Asli Development, JAKOA, (2023), the Negrito group is the smallest, accounting for only 3% of the total Orang Asli population and includes six sub-ethnic groups, such as the Kensiu.

The Kensiu Negrito community in northern Peninsular Malaysia was resettled from a nomadic lifestyle into Kampung Lubuk Legong, Baling, Kedah, through the government's Resettlement Plan Scheme (RPS) beginning in the 1950s. While the village now has access to basic infrastructure and is located near a public healthcare clinic, parts of the community still face challenges such as inconsistent water supply to uphill houses and persistent health disparities despite proximity to services.

Since the 1930s, epidemiological studies in Orang Asli communities have reported alarming high STH prevalence, ranging from 57.0% to 98.4% (Lim *et al*., 2009; Mahmud *et al*., 2022). In response, Malaysia launched a National Worm Control Programme in 1974, administering a single dose of pyrantel pamoate to three million primary schoolchildren from rural areas, including Orang Asli settlements (Lim *et al*., 2009; Salleh, 2005). However, the programme was discontinued in 1983 due to various challenges, including the poor efficacy of pyrantel pamoate against *T. trichiura* and hookworm infections, inadequate monitoring and evaluation, and unsupportive socioeconomic and environmental conditions in the targeted areas (Salleh, 2005). Despite subsequent governmental efforts to improve living standards via Resettlement Plans Schemes

(RPS) and other development initiatives, STH remains endemic in Otang Asli communities (Nasr *et al*., 2013; Ngui *et al*., 2015; Muslim *et al*., 2019).

In 2020, COVID-19 pandemic caused by SARS-CoV-2 significantly altered daily life and heightened public awareness of hygiene and infection prevention (Strunz *et al*., 2014). Public health measures such as frequent handwashing, use of sanitizers, and improved sanitation, were widely promoted. A study by Seid *et al*. (2022) demonstrated that adherence to hand hygiene during COVID-19 pandemic was significantly associated with a 52% reduction in intestinal parasitic infections (IPIs), underscoring the importance of such practices. However, service disruptions, including school-based deworming and routine health surveillance, may also have impacted STH infection dynamics.

While these findings suggest the potential long-term benefits of sustained hygiene promotion, the actual impact of COVID-19-related interventions on STH infections, particularly among Orang Asli communities, remains unclear. Hence, this study was conducted to assess the prevalence and types of STH infections among the Kensiu Negrito community in Malaysia before and after the COVID-19 pandemic, as well as to evaluate the pandemic's role in shaping these trends.

MATERIALS AND METHODS

Ethics approval

The study protocol approval was approved by the National Medical Research Registry (Reference No.: NMRR-17-3055-37252) and the University of Malaya Medical Centre (Reference No.: 2017925-5593). Additionally, permission to conduct this study was granted by the Department of Orang Asli Development (JAKOA) [Reference No.: JAKOA.PP.30.052 JLD 16 (14)].

Study design and location

This study was an opportunistic, descriptive cross-sectional study conducted in Kampung Lubuk Legong, Baling, Kedah (5°47′ 53″N 100°54′ 22″E), which is home to the Kensiu, a sub-tribe of the Negrito and the only Orang Asli group residing in the northern Peninsular Malaysia (Figure 1). The population in this village is approximately 310 people, with about 245 individuals belonging to the Kensiu sub-tribe (JAKOA, 2023). They are among the smallest and most marginalised indigenous communities in Malaysia, making them an important yet underrepresented population in public health research.

Data collection was conducted in two phases: February to March 2020 (before the COVID-19 lockdown in Malaysia) and September 2022 (post-pandemic). While the study was not originally designed to compare pre- and post-COVID-19 trends, the two datasets allowed for an explanatory comparison of STH prevalence across time. The study did not follow the same individuals at both time points, and COVID-19 status was not assessed. This study does not represent a longitudinal cohort and is not powered for inferential analysis.

Prior to data collection, the research team obtained verbal consent from the village chieftain (Tok Batin) to conduct the study and provided the villagers with a brief explanation of its objectives and procedures. Written consent was obtained from all participants, while for children under 18, parental consent was secured along with assent from those aged 7 to 18. In total, 70 participants were enrolled in 2020, and 87 participants in 2022.

Demographics and socio-economic characteristics

Face-to-face interviews were conducted in Malay using a pre-tested questionnaire. Information collected included household characteristics (ethnicity and household income), maternal characteristics (age, marital status, education level, occupation, and

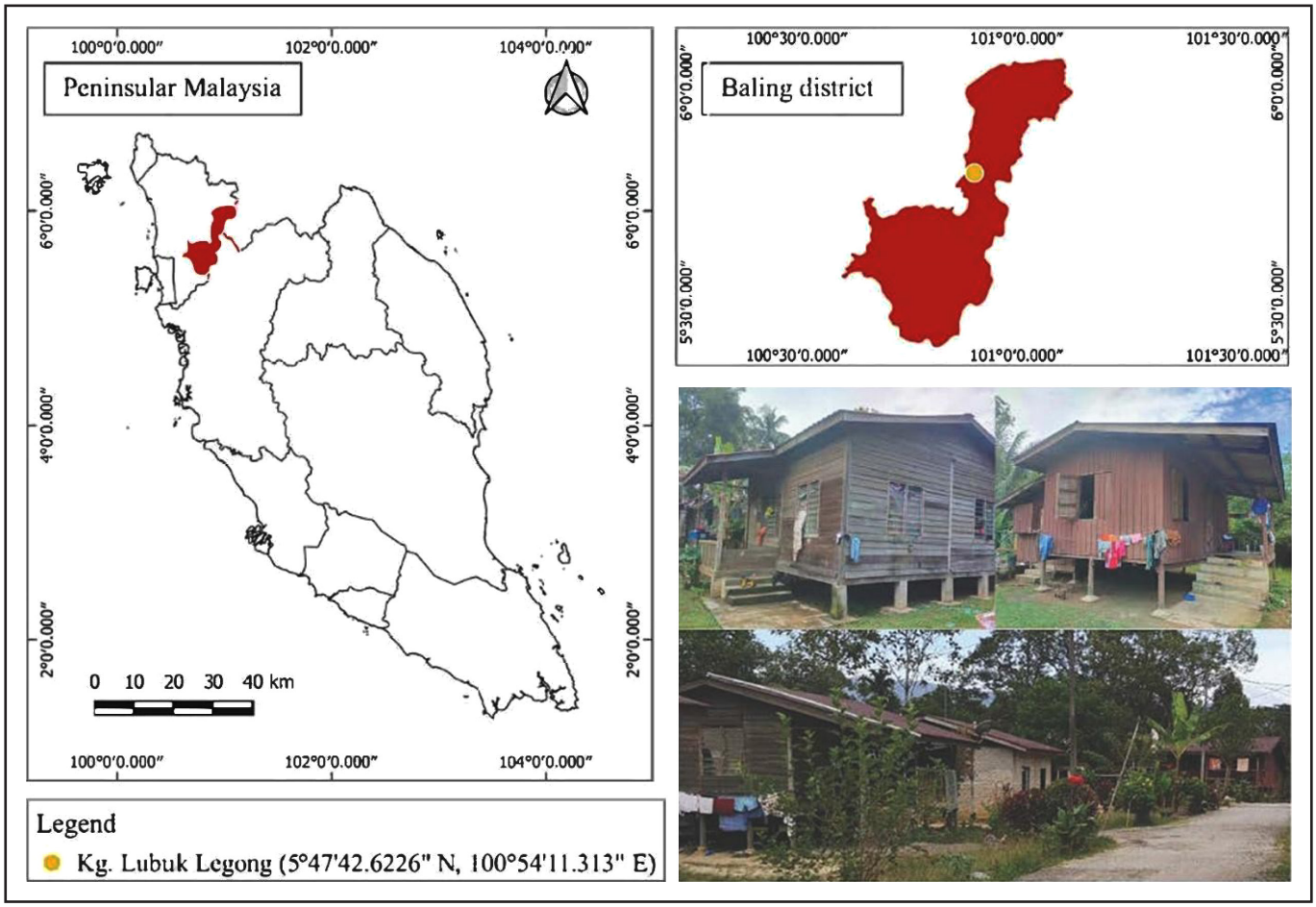

Figure 1. Location of the study site in Kampung Lubuk Legong, Baling, Kedah, Malaysia.

income), and child profiles (gender, age), environmental sanitation and living conditions (water supply and toilet availability), dietary habits (consumption of unboiled water and raw foods such as meat, seafood, and vegetables), hygiene practices (hand washing, defaecation, and footwear use), and prior anthelmintic treatment history.

Collection of faecal samples and STH examination

Following the interviews, each participant received a labelled faecal container with stool collection instructions. Faecal samples were examined using the modified Kato-Katz technique and formalin-ether sedimentation method, as described by Chin *et al*. (2016) and Adisakwattana *et al*. (2020), respectively. A sample was considered positive if any STH species was detected using either method.

The intensity of STH infection was classified as light, moderate, or heavy according to World Health Organization (WHO) guidelines based on the number of eggs per gram (EPG) of feaces: for *T. trichiura* – light (< 1,000 EPG), moderate (1,000 – 9,999 EPG), heavy (≥ 10,000 EPG); for *A. lumbricoides* – light (< 5,000 EPG), moderate (5,000 – 49,999 EPG), heavy (≥ 50,000 EPG); and for hookworm – light (< 2,000 EPG), moderate (2,000 – 3,999 EPG), heavy (≥ 4,000 EPG).

Statistical analysis

Data analysis was performed using IBM SPSS Statistics 27 (IBM Corporation, New York, USA). Categorical variables were summarised using frequencies and percentages, and age was described as a range. Due to the small sample size and exploratory nature of the study, no sample size calculation was performed. While the study primarily focused on descriptive reporting, comparisons of STH prevalence between 2020 and 2022 were conducted using Fisher's Exact Test for 2x2 categorical variables, given its suitability for small or unbalanced cell counts. A significance level of $p < 0.05$ was considered statistically significant.

RESULTS

Demographic and socio-economic profile

A total of 70 and 87 Kensiu Negrito individuals participated in the studies conducted from February 29 to March 4, 2020 (pre-COVID-19 pandemic), and September 11 to 17, 2022 (post-pandemic), respectively. Participants ranged in age from 4 to 75 years, with the majority being adults. The gender ratio (male: female) was 1:1.3 in 2020 and 1:1.1 in 2022. Table 1 presents the demographic, socio-

Table 1. Demographic, socio-economic, environmental, and behavioural characteristics of the Kensiu Negrito community in Kampung Lubuk Legong, Baling, Kedah

Variables		Year 2020 (N = 70)	Year 2022 (N = 87)
		n (%)	n (%)
Demographic profile			
Gender	Male	30 (48.9)	41 (47.1)
	Female	40 (57.1)	46 (52.9)
Age group	> 18 years	26 (37.1)	47 (54.0)
	≤ 18 years	44 (62.9)	40 (46.0)
Socio-economic & educational profile			
Employment status	Working	14 (20.0)	23 (26.4)
	Housewife	5 (7.2)	11 (12.6)
	Unemployed	8 (11.4)	18 (20.7)
	Student	43 (61.4)	35 (40.3)
Educational level	No formal education	9 (12.9)	14 (16.1)
	Formal education	61 (87.1)	73 (83.9)
Monthly household income	< RM800	40 (76.9)	67 (77.0)
	≥ RM800	12 (23.1)	20 (23.0)
Environmental, sanitation and hygiene behaviour			
Source of water supply	Treated (pipe water)	41 (58.6)	70 (80.5)
	Untreated (river, well, rainwater)	29 (41.4)	17 (19.5)
Presence of toilet	Yes	47 (67.1)	70 (80.5)
	No	23 (32.9)	17 (19.5)
Defecation site	Toilet	51 (72.9)	70 (80.5)
	Others (river, bush)	19 (27.1)	17 (19.5)
Bathing site	Toilet / bathroom	37 (52.9)	63 (72.4)
	Others (river)	33 (47.1)	24 (27.6)
Boiling water before drinking	Yes	55 (78.6)	74 (85.1)
	No	15 (21.4)	13 (14.9)
Wearing shoes outside	Yes	50 (71.4)	84 (96.6)
	No	20 (28.6)	3 (3.4)
Washing hands before eating	Yes	64 (91.4)	83 (95.4)
	No	6 (8.6)	4 (4.6)
Washing hands after defaecation	Yes	52 (74.3)	78 (89.7)
	No	18 (25.7)	9 (10.3)
Washing hands after outdoor activities	Yes	48 (68.6)	72 (82.8)
	No	22 (31.4)	15 (17.2)
Eating undercooked meat	Yes	61 (87.1)	16 (18.4)
	No	9 (12.9)	71 (81.6)
Eating raw vegetable	Yes	42 (60.0)	57 (65.5)
	No	28 (40.0)	30 (34.5)
Consumptions of anthelmintic drugs in the past 3 months	Yes	7 (30.4)	8 (9.2)
	No	16 (69.6)	79 (90.8)

economic, environmental, and behavioural characteristics of the Kensiu Negrito community in Kampung Lubuk Legong, Baling, Kedah, comparing data collected before and after the COVID-19 pandemic.

Unemployment rates were higher post-COVID-19, increasing from 11.4% in 2020 to 20.7% in 2022. Many participants discontinued their education and faced challenges finding employment, as numerous businesses were forced to close due to pandemic-related economic impacts. More than 80% of the community had attended formal schooling; however, over half of the participants reported monthly incomes below RM800 (USD 181, with an exchange rate of 1 USD = MYR4.42). Although the Department of Statistics Malaysia, DOSM (2022) refines the national absolute poverty line as RM2,589 per month, all surveyed households reported earnings below this threshold. RM800 was used as a more stringent cut-off to further differentiate extremely low-income households within the community and better capture the degree of socio-economic marginalisation. Notably, a greater number of Kensiu Negritos reported lower incomes post-pandemic, indicating a significant decline in living standards within the indigenous population due to the pandemic's effects.

Hand hygiene practices within the community are generally commendable, as local authorities and non-governmental organisations actively raised awareness about hand hygiene during the pandemic. However, many individuals still prefer consuming raw vegetables and have not taken anthelminthic drugs in the past three months. Additionally, open defaecation is practised within the community. Despite having access to a treated water supply, about one-third of the population preferred to bathe and wash in the nearby river before the pandemic. However, only a few have continued this practice post-pandemic, likely as a protective measure against contaminated water sources.

Prevalence and intensity of STH infections pre- and post-COVID-19

The overall STH infection rate significantly decreased from 85.7% in 2020 to 65.5% in 2022 (p = 0.0054), as shown in Table 2. A statistically significant decline was observed for *T. trichiura* overall (84.3% to 63.2%, p = 0.0039), especially in moderate infections (p < 0.0001). The proportion of light infections increased slightly but not significantly (p = 0.1504), while heavy infections remained low in both years.

For *A. lumbricoides*, changes in overall prevalence (32.9% to 24.1%, p = 0.2838). As well as by infection intensity, were not statistically significant except for a drop in moderate infections (p = 0.0006). Hookworm prevalence showed no significant change overall (21.4% to 25.3%, p = 0.5584), nor did all intensity-specific patterns (p > 0.05).

Mono- and polyparasitism patterns are summarised separately in Table 3. *T. trichiura* remained the dominant monoinfection in both years, while triple infections increased from 5.7% in 2020 to 10.3% in 2022.

Table 2. Prevalence and intensity of soil-transmitted infection (by species) among the Kensiu Negrito community in 2020 and 2022

STH species		Year 2020 (N = 70)			Year 2022 (N = 87)			*p* value
		n (%)	95% CI	Arithmetic mean EPG (SE)	n (%)	95% CI	Arithmetic mean EPG (SE)	
Overall STH infection		60 (85.7)	75.3-92.9	NA	57 (65.5)	54.6-75.4	NA	0.0054*
Trichuris trichiura								
	Overall	59 (84.3)	73.6-91.9	2378.85 (411.39)	55 (63.2)	52.2-73.3	779.35 (173.91)	0.0039*
	Light	31 (44.3)	32.4-56.7	372.63 (48.94)	49 (56.3)	45.3-66.9	405.55 (70.72)	0.1504
	Moderate	26 (37.1)	25.9-49.5	3937.79 (463.24)	5 (5.8)	1.9-12.9	3127.20 (141.05)	<0.0001*
	Heavy	2 (2.9)	0.4-9.9	13209.00 (2728.50)	1 (1.1)	0.03-6.2	7356.00 (NA)	0.5861
Ascaris lumbricoides								
	Overall	23 (32.9)	22.1-45.1	18161.61 (3075.07)	21 (24.1)	15.6-34.5	35477.714 (35477.71)	0.2838
	Light	4 (5.7)	1.6-14.0	140.25 (78.25)	12 (13.8)	7.3-22.9	749.00 (395.61)	0.0593
	Moderate	18 (25.7)	16.0-37.6	20081.33 (2563.40)	5 (5.8)	1.9-12.9	26707.20 (3080.15)	0.0006*
	Heavy	1 (1.4)	0.04-7.7	55692.00 (NA)	4 (4.6)	1.3-11.4	150627.00 (51775.21)	0.1842
Hookworm								
	Overall	15 (21.4)	12.5-32.9	1343.07 (507.55)	22 (25.3)	16.6-35.8	1214.18 (268.03)	0.5584
	Light	11 (15.7)	8.1-26.4	336.23 (133.58)	15 (17.2)	10.0-26.8	504.00 (144.48)	1.000
	Moderate	3 (4.3)	0.9-12.0	3289.50 (605.77)	6 (6.9)	2.6-14.4	2482.00 (278.12)	0.5079
	Heavy	1 (1.4)	0.04-7.7	6579.00 (NA)	1 (1.1)	0.03-6.2	4260.00 (NA)	1.000

CI = Confidence interval; EPG = Eggs per gram; SE = Standard error; NA = Not applicable; * significant difference $p \leq 0.05$.

Table 3. Soil-transmitted helminth mono- and polyparasitism patterns in the Kensiu Negrito community in 2020 and 2022

STH species	Year 2020 (N = 70)		Year 2022 (N = 87)	
	n (%)	95% CI	n (%)	95% CI
T. trichiura	27 (38.6)	27.2–51.0	23 (26.4)	17.6–37.0
A. lumbricoides	0 (0.0)	0	1 (1.1)	0.03–6.2
Hookworm	1 (1.4)	0.04–7.7	1 (1.1)	0.03–6.2
T. trichiura + *A. lumbricoides*	19 (27.1)	17.2–39.1	11 (12.6)	6.5–21.5
T. trichiura + Hookworm	10 (14.3)	7.1–24.7	12 (13.8)	7.3–22.9
A. lumbricoides + Hookworm	0 (0.0)	NA	0 (0.0)	NA
T. trichiura + *A. lumbricoides* + Hookworm	4 (5.7)	1.6–14.0	9 (10.3)	4.8–18.7

CI = Confidence interval; NA = Not applicable.

DISCUSSION

This study compares STH infection rates among the Kensiu Negrito people at Kampung Lubuk Legong before and after the COVID-19 pandemic. The results indicate a statistically significant reduction in overall STH prevalence post-pandemic. This reduction may be linked to the administration of anthelmintic drugs to participants by the research team during the last field visit in 2020 (Tee *et al*., 2022). In addition, movement control orders implemented during the pandemic (March 2020 to March 2022) restricted community interactions, which may have reduced opportunities for person-to-person transmission outside of household units. Although rare, human-to-human transmission of STH via contaminated environments and shared sanitation practices has been documented (Jourdan *et al*., 2018).

Despite these factors, STH prevalence remains high. The increase in hookworm prevalence after the pandemic, though not statistically significant, could be linked to lapses in footwear compliance and reduced public health outreach on footwear during the pandemic, which are known risk factors for hookworm infection through skin contact with contaminated soil.

Findings from this study are consistent with a previous investigation by Anuar *et al*. (2014), which assessed STH infections across three Orang Asli tribes in Peninsular Malaysia, including the Negrito group. Compared to that earlier study, which reported a higher overall prevalence trichuriasis, the present findings suggest some degree of improvement in intensity and distribution, though infection remains persistent.

In addition, the community receives periodic STH awareness education from local healthcare personnel and non-governmental organisations, particularly during outreach and follow-up visits. Although awareness is reportedly high, behavioural compliance remains limited. For instance, field observations showed that many children do not wash their hands before eating or after playing with animals and often walk barefoot. These behaviours may be shaped by their traditional cultural practices that persist despite relocation and access to improved amenities.

The Malaysian government has implemented nationwide deworming programmes, targeting children over two years old at government healthcare facilities and in schools for children aged 6 – 12 (MOH, 2013a; MOH, 2013b; MOH, 2018). These interventions have been effective in most urban, suburban, and rural Malaysian populations (Jamaiah & Rohela, 2005; Wong *et al*., 2021), yet their impact among the indigenous people, including the Kensiu Negrito remains limited. This could be due to non-compliance with anthelmintic drug administration or potential resistance to albendazole in treating trichuriasis (Ahmadi Jouybari *et al*., 2016).

Moving forward, more targeted strategies are pivotal to reduce STH infections among the Kensiu Negrito specifically. Consistent efforts and tenacity are needed to continue deworming, education, and a surveillance cycle to potentially achieve success. Raising awareness within the community through gamification and creative approaches could help change behaviour, as we are now in the digital era.

Since the Kensiu are resettled on the outskirts of a village and provided with improved quality housing, water supply, and latrines, a behavioural change approach may be effective to encourage them to adopt healthier habits. For example, using the "three Rs" – reminder, routine, and reward – may help create positive habits (Harvard Health Publishing, 2016). This strategy should be multi-faceted, innovative, and adaptive to the digital age. With growing smartphone use and social media influence among the indigenous community, targeted campaigns on these platforms can promote better hygiene practices, reducing intestinal parasitic infections. Using gamification to encourage habit change could foster a willingness to adopt healthier practices. However, these initiatives need to be carefully, thoughtfully, and sensitively designed, taking into account their ancestral beliefs, customs, culture, and language. Another potential approach is introducing the Health Education Learning Package (HELP) to the Kensiu community. HELP has been shown to reduce soil-transmitted helminth (STH) infection intensity in Pahang (Al-Delaimy *et al*., 2014). Assessing its effectiveness or the impact of a tailored version in this context could provide valuable insights and potential benefits.

CONCLUSION

The elimination of STH infections within indigenous communities hinges on the implementation of precise, impactful strategies. This requires a steadfast, unified collaboration among local authorities, non-governmental organizations, and researchers, with an unwavering focus on fostering lasting behavioural change. Most critically, indigenous populations must be empowered as key participants in this process. By actively involving them, a profound sense of ownership and accountability is cultivated. This inclusive approach not only ensures the sustainability of interventions but also profoundly enhances the overall health, resilience, and well-being of their communities.

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Conflict of Interest

The authors declare that they have no conflict of interests.

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