RESEARCH ARTICLE Open Access

Gema Lingkungan Kesehatan
Vol. 24, No. 1 (2026), pp 124-132
e-ISSN 2407-8948 p-ISSN 16933761
doi: https://doi.org/10.36568/gelinkes.v24i1.366 Journal Homepage: https://gelinkes.poltekkesdepkes-sby.ac.id/

Environmental and Pet-Associated Risk Factor for Hookworm Infection in Coastal East Kalimantan

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Hookworm infection remains an important community health concern, particularly in the coastal areas of East Kalimantan, Indonesia, where environmental conditions facilitate transmission. Key risk factors in this region include the presence of domestic animals (cats and dogs), infection in these pets, and specific types of soil surrounding households. This study aimed to determine the prevalence of hookworm infection and its association with various environmental and behavioral risk factors. A cross-sectional survey was conducted in 2019 among 213 individuals from rural areas of Kutai Kartanegara Regency. Stool specimens were examined using Kato-Katz and Koga Agar Plate (KAP) culture technique. The prevalence of hookworm infection was 33.8% (72/213). Higher infection rates were significantly associated with older age (≥13 years), agricultural occupation, poor sanitation facilities, use of unsanitary water sources, and open defecation practices. Environmental factors, including wet soil, high soil organic carbon content, low elevation, high humidity, frequent rainfall, and proximity to rivers or plantation areas, were also significantly associated with hookworm infection ($p < 0.05$; ORs ranged approximately from 1.7 to 2.9). The presence of hookworm-infected domestic dogs was significantly associated with human infection ($p < 0.001$). These findings highlight that hookworm transmission in coastal East Kalimantan is influenced by an alliance of environmental, behavioral, and animal-related factors. Comprehensive control strategies focusing on sanitation improvement, environmental management, and control of zoonotic reservoirs are essential to reduce infection rates in endemic rural setting.

Keywords: Cat and Dog Infected, Risk Factors, Zoonotic Hookworm, Rural Coastal Area

INTRODUCTION

Hookworm infection remains a significant public health burden, particularly located in tropical and subtropical regions that were low- and middle-income countries. In the globally estimated more than 438 million people were infected by hookworm, with approximately 70% of these infections concentrated in Asia (Bethony et al., 2006; Punsawad et al., 2017). Despite global initiatives targeting soil-transmitted helminthiases, hookworm continues to pose persistent health challenges due to complex socio-environmental determinants and inadequate control efforts, especially in rural and coastal communities (Sedionoto et al., 2019, 2023; Wardell et al., 2017).

Hookworm infection is primarily transmitted through skin contact with soil contaminated by third-stage larvae originating from human faeces. These larvae penetrate intact human skin, migrate through the bloodstream, and eventually extent the small intestine, then mature and cause chronic intestinal blood loss and malnutrition(Forrer et al., 2018a; Garcia, 2014). The infection thrives in warm, humid environments and is strongly associated with poor sanitation, lack of access to clean water, and suboptimal hygiene practices (Hall et al., 1994; Sedionoto & Anamnart, 2023).

Environmental conditions, exceptionally prolonged rainy seasons, have been shown to influence the transmission dynamics of hookworms and other soil-transmitted helminths especially S. stercoralis infection. For instance, studies in Southern Thailand disclosed that the prevalence of *Strongyloidiasis* tends to decrease in areas with long rainy seasons. In contrast, hookworm prevalence remains high, likely due to the resilience of hookworm larvae in wet, vegetated soil environments (Sedionoto et al., 2019, 2023). Comparative findings from Cambodia and Laos further demonstrate a higher burden of hookworm in the regions with in adequate sanitation infrastructure and high rainfall (Forrer et al., 2018b; Vonghachack et al., 2015).

Despite existing literature, there remains a lack of localized, environmental-specific analyses of hookworm prevalence in diverse rural ecosystems, especially in Indonesia. East Kalimantan characterized by high rainfall, extensive vegetation cover, and ongoing land-use changes such as deforestation, presents unique ecological conditions that may affect hookworm transmission differently from other regions(Sedionoto et al., 2023). Moreover, domestic animal ownership, particularly of dogs and cats, may contribute to additional zoonotic transmission risks (Inpankaew et al., 2015), yet remains understudied in rural Indonesian settings.

While prior studies have assessed the general prevalence of hookworm infections in rural Southeast Asia, few have explored the integrated associations of microclimate (temperature, humidity, rainfall), ecological features (soil type, vegetation), and household-level risk factors (sanitation, hygiene behaviour, and animal ownership) within a single comprehensive framework. Addressing this gap is crucial for tailoring locally relevant intervention strategies and advancing the precision of disease mapping and control in helminth-endemic areas.

Domestic animal ownership, particularly dogs and cats, has been increasingly recognized as an important zoonotic risk factor for human hookworm infection. Previous studies in Southeast Asia reported hookworm prevalence ranging from 26–35% among domestic dogs, with molecular evidence demonstrating that more than 20% of human hookworm infections were caused by Ancylostoma ceylanicum, a zoonotic species transmitted from infected dogs and cats (Inpankaew et al., 2015; Kladkempetch et al., 2020). In addition, inadequate sanitation and poor hygiene practices, such as open defecation and inconsistent use of footwear, have been shown to increase the risk of hookworm infection by two- to three-fold in endemic rural communities (Bethony et al., 2006).

Therefore, the relationship between environmental and household factors and hookworm infection be investigated in this study. We conducted a cross-sectional survey in duo to analyze of the key environmental risk factors, such as geographical factors, pet ownership including dog and cat, individual hygiene of the community, and household sanitation facilities of the rural communities in rural coastal areas in East Kalimantan be correlated with zoonotic hookworm infection These factors were then correlated with the prevalence of hookworm infection, providing new insights into the persistence of hookworm in equatorial rainforest ecosystems and offering evidence-based recommendations for more effective parasite control strategies in similar environmental settings.

METHOD

Study design and population

The research was conducted in rural regions of coastal areas of Bunga Jadi and Puancepak Subdistricts, Muarakaman District, and Sebuntal Subdistrict, Marangkayu District in East Kalimantan. This cross-sectional study was carried out between September–Desember, 2019**.** The geographic coordinates of the areas of study are approximately 0.440190°S latitude and 116.981390°E longitude. The region experienced an average temperature of 28°C, with a temperature range of 26°C to 32°C. Muara Kaman is situated along the Mahakam River and is characterized by surrounding forested areas and palm plantations. Conversely, Marangkayu is a coastal area bordered by rubber and palm plantations, as well as rice fields. Data collection encompassed 28 villages, comprising 13 villages within Muara Kaman and 15 within Marangkayu. Villages were selected purposively based on their coastal characteristics and accessibility. Within each village, households were selected using a convenience sampling approach, and all eligible household members aged ≥2 years who agreed to participate were included. In each village, data were obtained from 10 to 15 households, with 1 to 3 participants per household. A total of 213 individuals participated in the study, providing stool samples, alongside the collection of stool specimens from domestic animals residing in the vicinity of participant households.

The method describes the approach used in the research, including the research design, population and sample, data collection instruments, and analysis techniques. The description should be clear enough so that it can be replicated by other researchers. If using an existing method, provide appropriate references.

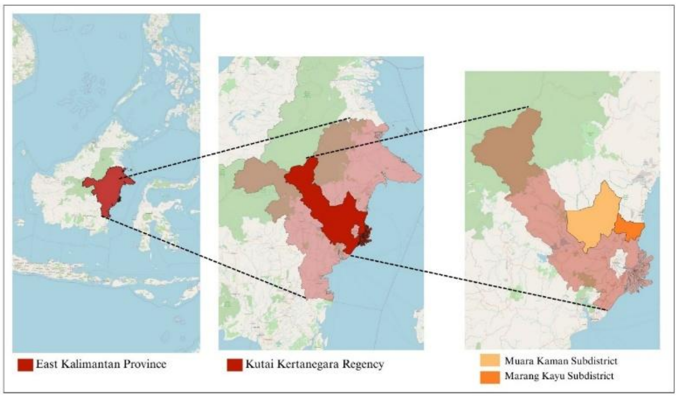

Figure 1. Geographic location of the study sites in East Kalimantan Province, Indonesia. The left panel shows the location of East Kalimantan Province within Borneo Island. The middle panel highlights Kutai Kartanegara Regency within the province. The right panel zooms in on the two study subdistricts: Muara Kaman (yellow) and Marangkayu (orange), where the cross-sectional survey on hookworm and S. stercoralis infections was conducted.

Data collection and laboratory processing

Stool samples were collected over three days from each participant. On the first day, researchers visited households to inform and request cooperation from heads of households and other family members. On the second and third mornings, stool samples were collected and promptly transported to the environmental health Laboratory at the Department of Environmental, Faculty of

Public Health, Mulawarman University, for diagnostic processing. Environmental assessments of household surroundings were also conducted during the study period. Two diagnostic techniques were employed: the agar plate culture (APC) and the Kato-Katz method. The APC method followed the protocol by Koga et al. (1991), wherein a small amount of stool was placed at the center of a nutrient agar plate and incubated at room temperature for five days. The presence of larvae was indicated by visible crawling tracks or direct observation of larvae and adult worms. Positive samples were treated with 10 ml of 10% formalin for 5–10 minutes, transferred into centrifuge tubes, and centrifuged at 2,500 rpm for five minutes. The resulting sediment was then examined microscopically for hookworm larvae or adults. For the Kato-Katz technique, approximately 41.7 mg of stool was placed on a microscope slide, then left for 24 hours covered with a cellophane strip pre-soaked in glycerin. The sample was then evenly spread using a rubber applicator. After 30 minutes, the slide was examined under a microscope for helminth eggs (Anamnart et al., 2010; Katz et al., 1972; KOGA-KITA, 2004).

Operational Definitions

Environmental and household variables were defined using standardized operational criteria. Geographical area was classified into Muara Kaman and Marangkayu subdistricts. Soil characteristics, including organic carbon content, pH, clay proportion, and texture, were determined through laboratory analysis and categorized according to observed value ranges. Climatic variables such as temperature, evaporation rate, number of rainy days, rainfall volume, and elevation above sea level were obtained from official meteorological and geographical records and grouped into two categories based on local distributions. Vegetation surrounding households was classified as plantation (palm or rubber) or rice field, while village characteristics were categorized as river or coastal buffer areas and hilly areas. Soil conditions around houses were classified as dry or wet based on direct field observation.

Household and behavioral variables were assessed through structured interviews and on-site observation. Pet ownership was defined as the regular presence of cats or dogs within the household compound. Hookworm infection in domestic animals was confirmed through stool examination and classified as positive or negative. Sanitation-related variables, including water sources, drinking water, floor type, and toilet facilities, were categorized as sanitary or unsanitary based on protection from contamination, material impermeability, and separation from pollution sources. Personal hygiene behaviors, such as footwear use, handwashing, and foot washing after soil or animal contact, were classified based on routine practice reported by participants.

Data analysis

The structured questionnaires used to collect the personal hygiene and others demographic data of participants. Sanitation conditions at each household were assessed through direct field observations. Environmental variables, including vegetation type, elevation, pet ownership, and soil characteristics surrounding households, were compiled using both field observations and data from credible sources. Parameters of soil such as content of organic carbon in clay proportion, and pH were analyzed at the Soil Laboratory, Mulawarman University. Vegetation and soil type classifications were recorded using observational checklists, while pet ownership data were obtained through interviews and on-site verification. Meteorological data, including annual temperature, humidity, and duration of the rainy season, were retrieved from official databases of the Badan Pusat Statistik Indonesia and the Badan Metereologi Klimatologi dan Geofisika Indonesia. The prevalence of zoonotic hookworm infection was stratified based on environmental risk factor, quality the sanitation, and personal hygiene that summarized using descriptive statistics. To examine associations between infection and potential risk factors, Chi-square tests were performed using SPSS version 22, with a significance threshold set at $P < 0.05$. Additionally, were calculated to determine of the association between and infection prevalence.

RESULTS AND DISCUSSION

Environmental Risk Factors on Hookworm Prevalence in East Kalimantan

The prevalence of hookworm infection was determined using the Kato-Katz technique. The APC method was applied to a subset of 213 community samples, revealing that 72 individuals (33.8%) were positive for hookworm infection. Notably, the prevalence of hookworm infection in Muara Kaman district (55.8%) exceeded that observed in Marangkayu district (16.1%), with respective case counts of 53 and 19.

Table 1.
Environmental Risk Factors of the Prevalence of Hookworm in East Kalimantan

Variable	Category	Positive n (%)	P-value
Geographical Area	Muara Kaman	53 (55.8)	0.000
	Marangkayu	19 (16.1)	
Organic carbon in soil (%)	1.37-2.47	21 (23.1)	0.004
	>2.47-4.04	51 (41.8)	
pH soil	4.26-5.85	31 (30.4)	0.313
	>5.85-6.92	41 (36.9)	
Clay in soil (%)	4-18.5	35 (36.5)	0.458

Variable	Category	Positive n (%)	P-value
	>18.5-42.50	37 (31.6)	
Temperature (^{0}C)	28-28.6 >28.6 -29.5	19 (16.1) 53 (55.8)	0.000
Evaporation (%)	65 66	19 (16.1) 53 (55.8)	0.000
Number of rainfall (day)	164 174	53 (55.8) 19 (16.1)	0.000
Volume of rainfall (mm^3)	3549 4000	53 (55.8) 19 (16.1)	0.000
Elevation from above of sea (m)	15-41.6 >41.6-50	53 (55.8) 19 (16.1)	0.000
Texture of soil	Sandy soil Non-sandy soil	46 (33.1) 26 (35.1)	0.764
Vegetation	Plantation (palm or rubber) Rice field	65 (38.9) 7 (15.2)	0.003
Village areas	Buffer river/sea Hill area	65 (39.2) 7 (14.9)	0.002
Quality soil surrounding the house	Dry soil Wet soil	51 (30.2) 21 (47.7)	0.028
Retaining cat	Not having cat Having cat	30 (37.5) 42 (31.6)	0.376
Retaining a dog	Not having dog Having dog	0 (0.0) 72 (34.4)	0.149
Hookworm infection in cat	Negative Positive	0 (0.0) 72 (34.4)	0.474
Hookworm infection in dog	Negative Positive	0 (0.0) 72 (34.4)	0.000

The chi-square analysis identified significant associations between hookworm infection and various environmental risk factors. The prevalence of hookworm was substantially higher in Muara Kaman District (55.8%) compared to Marangkayu (16.1%). Key environmental variables associated with increased hookworm prevalence included high soil organic carbon content (>2.47–4.04%), elevated temperatures (>28.6°C), higher humidity (66%), lower elevation (15–41.6 m), and specific environmental conditions such as wet soils, proximity to palm or rubber plantations, and villages located near rivers or coastal areas ($p < 0.05$). Additionally, the presence of hookworm infection in dogs was significantly correlated with human cases ($p = 0.000$). These results highlight the strong influence of ecological and animal-related determinants in shaping the transmission dynamics of hookworm in the areas.

Risk factors associated with hookworm infection

Table 2

Essential risk factors of the Prevalence of hookworm infection in East Kalimantan province

Variable	Category	n	Positive n (%) hookworm	Hookworm OR (95%CI)
Year-old	2-12 13 and above	114 99	31 (27.2) 41 (41.4)	0.72 (0.59-0.96) 1.36 (1.01-1.84)
Occupation	Non-agriculturist Agriculturist	75 138	40 (29.1) 32 (42.7)	0.69 (0.48-0.98) 1.25 (0.99-1.58)
Floor in door	Sanitary floor Soil floor	212 1	72 (34) 0 (0.0)	2.66 (1.78-3.97) 0.41 (0.30-0.54)
Quality of yard	Not soil Soil	35 178	13 (37.1) 59 (33.1)	1.03 (0.91-1.17) 0.88 (0.46-1.61)
Treatment of Waste water	Treatment Without treatment	108 105	33 (30.6) 39 (37.1)	0.86 (0.66-1.14) 1.16 (0.86-1.56)
Water sources	Sanitary Un-sanitary	92 121	19 (20.7) 53 (43.8)	0.65 (0.53-0.82) 1.96 (1.29-2.98)

Variable	**Category**	**n**	**Positive n (%) hookworm**	**Hookworm OR (95%CI)**
Water for drinking	Sanitary	117	18 (15.4)	0.40 (0.30-0.53)
	Un sanitary	96	54 (56.3)	2.80 (1.86-4.25)
Toilet	Sanitary toilet	181	55 (30.4)	0.45 (0.24-0.85)
	Open defecation	32	17 (53.1)	1.17 (1.02-1.35)
Using shoes on out-door	Routine	74	32 (43.2)	1.26 (1.00-1.59)
	Un-routine	139	40 (28.8)	0.67 (0.47-0.96)
Cleaning foot after soil contact	Washing	26	6 (23.1)	0.94 (0.85-1.03)
	Not washing	187	66 (35.3)	1.70 (0.71-4.05)
Washing fruit/vegetable before eaten	Routine	33	8 (24.2)	0.93 (0.83-1.03)
	Un-routine	180	64 (35.6)	1.60 (0.76-3.36)
Ate raw/un-cook vegetable	No	172	63 (36.6)	1.82 (0.92-3.59)
	Yes	41	9 (22)	0.88 (0.78-1.00)
Pet contact	No	161	60 (37.3)	1.70 (0.95-3.04)
	Yes	52	12 (23.1)	0.86 (0.74-0.99)
After pet contact	Washing hand	4	0 (0.0)	-
	Not washing hand	209	72 (34.4)	1
After soil contact	Washing hand	25	6 (24.0)	0.94 (0.86-1.04)
	Not washing hand	188	66 (35.1)	1.62 (0.67-3.87)
Washing foot before house enter	No	13	7 (53.8)	1.62 (0.68-3.87)
	Yes	200	65 (32.5)	0.44 (0.15-1.25)
Use toilet at home	Yes	116	46 (39.7)	1.39 (0.98-1.97)
	No	97	26 (26.8)	0.78 (0.61-0.99)
Use sandals in toilet	Routine	116	46 (39.7)	1.39 (0.98-1.97)
	Un-routine	97	26 (26.8)	0.78 (0.61-0.99)
Area	Muarakaman	95	53 (55.8)	2.66 (1.78-3.97)
	Marangkayu	118	19 (16.1)	0.41 (0.30-0.54)
Organic carbon in soil (%)	1.37-2.47	91	21 (23.1)	0.77 (0.57-0.89)
	>2.47-4.04	122	51 (41.8)	1.70 (1.15-2.53)
pH soil	4.26-5.85	102	31 (30.4)	0.87 (0.67-1.13)
	>5.85-6.92	111	41 (36.9)	1.17 (0.86-1.60)
Clay in soil (%)	4-18.5	96	35 (36.5)	1.10 (0.85-1.44)
	>18.5-42.50	117	37 (31.6)	0.89 (0.66-1.21)
Temperature (^{0}C)	28-28.6	118	19 (16.1)	0.41 (0.30-0.54)
	>28.6 -29.5	95	53 (55.8)	2.66 (1.79-3.97)
Evaporation (%)	65	118	19 (16.1)	0.41 (0.30-0.54)
	66	95	53 (55.8)	2.66 (1.79-3.97)
Number of rainfall (day)	164	95	53 (55.8)	2.66 (1.79-3.97)
	174	118	19 (16.1)	0.41 (0.30-0.54)
Volume of Rainfall (mm^3)	3549	95	53 (55.8)	2.66 (1.79-3.97)
	4000	118	19 (16.1)	0.41 (0.30-0.54)
Elevation (m)	15-41.6	97	53 (55.8)	2.61 (1.75-3.89)
	>41.6-50	116	19 (16.1)	0.42 (0.32-0.56)
Texture of soil	Sandy soil	139	46 (33.1)	0.94 (0.64-1.38)
	Non-sandy soil	74	26 (35.1)	1.03 (0.84-1.27)
Vegetation	Surrounding plantation (palm or rubber)	167	65 (38.9)	2.85 (1.34-6.24)
	Surrounding rice field	46	7 (15.2)	0.80 (0.71-0.91)
Village areas	Buffer river/sea	166	65 (39.2)	2.92 (1.38-6.24)
	Hill area	47	7 (14.9)	0.74 (0.69-0.90)
Quality soil surrounding the house	Dry soil	169	51 (30.2)	0.56 (0.33-0.94)
	Wet soil	44	21 (47.7)	1.18 (1.00-1.39)
Retaining cat	Not having cat	80	30 (37.5)	1.11 (0.88-1.39)

Variable	Category	n	Positive n (%) hookworm	Hookworm OR (95%CI)
	Having cat	133	42 (31.6)	0.85 (0.60-1.21)
Retaining a dog	Not having dog	4	0 (0.0)	-
	Having dog	209	72 (34.4)	1
Hookworm infection in cat	Negative	80	30 (37.5)	1.11 (0.88-1.39)
	Positive	133	42 (31.6)	0.85 (0.60-1.21)
Hookworm infection in dog	Negative	4	0 (0.0)	-
	Positive	209	72 (34.4)	1

Table 2 summarizes the main factors associated with hookworm infection in East Kalimantan. Higher infection rates were found among individuals aged ≥13 years (41.4%, OR: 1.36), those with agricultural occupations (42.7%, OR: 1.25), and residents of homes using unsanitary water sources (43.8%, OR: 1.96) or consuming unsanitary drinking water (56.3%, OR: 2.80). Open defecation (53.1%, OR: 1.17) and irregular shoe use outdoors (28.8%, OR: 0.67) also contributed to higher risk. Regionally, prevalence was significantly higher in Muara Kaman (55.8%, OR: 2.66) and in areas with high soil organic carbon, warmer temperatures, greater evaporation, volume of rainfall, and elevation from above of sea (ORs ranging 2.61–2.66). Living near plantations or coastal areas increased infection likelihood, while pet ownership and soil characteristics such as pH and texture of soil showed no significant effects.

The predominance of hookworm infection was significantly higher in Muara Kaman District (55.8%, n=53) compared to Marangkayu District (16.1%, n=19 was created in the study. Individuals in Muara Kaman were 2.66 times more likely to be infected with hookworm than those in Marangkayu (OR: 2.66; 95% CI: 1.78–3.97; $p < 0.001$). These patterns may be attributed to differing environmental conditions between the two districts. Environmental risk factors appear to play a major role in the transmission of hookworm. Muara Kaman is characterized by its proximity to palm oil plantations and river systems, which may facilitate hookworm survival and transmission. Similar findings have been reported in other rural settings, such as Manufahi District in Timor-Leste, where hookworm prevalence reached 62.8%(Forrer et al., 2016; Nery et al., 2015).

In the classification of soil organic carbon content, hookworm infection was more prevalent in soils with organic carbon levels of >2.47–4.04% (41.8%, n=51) compared to those with levels of 1.37–2.47% (23.1%, n=21). Individuals exposed to soils with higher organic carbon content were 1.70 times more likely to be infected with hookworm than those in the lower category (OR: 1.70; 95% CI: 1.15–2.53; $p = 0.004$). A study in Cambodia found that higher soil organic carbon did not significantly affect hookworm prevalence but may have influenced S. stercoralis infection (Khieu et al., 2014). This is consistent with our findings in East Kalimantan, where higher organic carbon content did not appear to reduce hookworm prevalence but may have contributed to lower S. stercoralis infection. Sebastian et al. (2018) noted that soil organic carbon indirectly influences nematode populations through its effects on food sources, particularly bacteria such as Escherichia coli. According to Höss et al., (2001), organic carbon adsorbed onto bacterial cells can enhance the availability of these microorganisms as food for nematodes, potentially supporting hookworm development (Höss et al., 2001).

Hookworm infection was more prevalent in areas with temperatures ranging from >28.6–29.5 °C (55.8%, n=53) compared to those with 28.0–28.6 °C (16.1%, n=19). Individuals living in areas with higher temperatures were 2.66 times more likely to be infected with hookworm (OR: 2.66; 95% CI: 1.79–3.97; $p = 0.001$). In terms of humidity, hookworm infection was more common in areas with 66% relative humidity (55.8%, n=53) than in those with 65% (16.1%, n=19), with a significantly higher risk observed at 66% humidity (OR: 2.66; 95% CI: 1.79–3.97; $p = 0.001$). Similarly, higher prevalence was observed in areas experiencing 174 rainy days (55.8%, n=53) compared to 164 days (16.1%, n=19), and with annual rainfall volumes of 3549 mm versus 4000 mm, both favoring increased hookworm transmission (OR: 2.66; 95% CI: 1.79–3.97; $p = 0.001$). These findings suggest that geographical factors such as temperature, humidity, and rainfall patterns significantly influence the predominance of hookworm infection. Previous studies have shown that the rainy season enhances the survival and transmission of these parasites (Anamnart et al., 2015; Sedionoto et al., 2019, 2023). In rural areas where open defecation occurs in rubber or palm plantations, runoff from elevated plantation areas can carry parasite eggs or larvae downhill into villages and rice fields, increasing the risk of transmission. This mechanism likely contributes to infection among both adults and children, especially those playing in contaminated environments near their homes.

The predominance of hookworm infection was higher at lower elevations (15–41.6 m), with 53 cases (55.8%), compared to higher elevations (>41.6–50 m), which recorded only 19 cases (16.1%). Individuals living at elevations of 15–41.6 m were 2.61 times more likely to be infected with hookworm than those at higher elevations (OR: 2.61; 95% CI: 1.75–3.89; $p = 0.001$). These findings suggest that elevation contributes significantly to the spatial distribution of hookworm infection, consistent with previous studies by Raso et al., (2006). Environmental conditions in East Kalimantan, such as prolonged rainy seasons, elevated temperatures, and geographic features, support hookworm transmission and resemble those reported in southern Thailand. Notably, the prevalence of hookworm infection in East Kalimantan (33.8%) is higher than that reported in southern Thailand (Anamnart et al., 2015; Raso et al., 2006).

Hookworm infection was found to be significantly higher in areas surrounded by palm and/or rubber plantations (65 cases; 38.9%) compared to rice field environments (7 cases; 15.2%). Individuals living near palm or rubber plantations were 2.85 times more likely to be infected with hookworm than those near rice fields (OR: 2.85; 95% CI: 1.34–6.24; p = 0.003). The elevated temperatures typically found under palm and rubber plantations align with previous findings indicating higher hookworm prevalence in warmer environments. These plantations often create moist, shaded microenvironments favorable for the survival and transmission of hookworm larvae, particularly where soil contamination by human or animal feces occurs. Agricultural areas are recognized as common zones for soil-transmitted helminth (STH) infections, with hookworm commonly present. Notably, contamination in agricultural zones may stem from zoonotic transmission involving domestic animals, such as dogs and pigs (Inpankaew et al., 2015).

The predominance of hookworm infection was higher in village areas categorized as river buffer or coastal zones (65 cases; 39.2%) compared to hilly areas (7 cases; 14.9%) (OR: 2.92; 95% CI: 1.38–6.24; p = 0.002). Hookworm infection was also more likely to occur in households surrounded by wet soil than dry soil (OR: 1.18; 95% CI: 1.00–1.39; p = 0.028). A study in Ngorongoro, Tanzania, reported a higher prevalence of soil-transmitted helminths, including hookworms, in low-elevation, moist ecozones compared to dry highlands (Eltantawy et al., 2021). These consistent patterns demonstrate that hydrological and topographic features such as river buffers, soil moisture, and elevation are key determinants of local STH transmission dynamics and should inform targeted control strategies.

In the classification of pet ownership, the predominance of hookworm infection was higher among participants who owned cats or dogs compared to those who did not. Notably, participants whose pets were infected with hookworms exhibited elevated infection rates. The hookworm infection among participants with hookworm-infected dogs was 72 cases (34.4%). Although the odds ratio for hookworm infection among participants with hookworm-infected dogs was slightly lower (OR: 0.97; 95% CI: 0.50–0.99), the association was statistically significant (p = 0.000). These findings suggest a complex dynamic of zoonotic transmission between humans and domestic animals, particularly dogs, and highlight the importance of including animal health in control strategies for hookworm infections. Recent molecular studies have demonstrated that in regions with close contact between humans and animals, zoonotic transmission plays a significant role in sustaining hookworm endemicity. For example, a study in Cambodia found that over 20% of human hookworm infections were caused by *A. ceylanicum*, with genetic sequencing confirming transmission from infected dogs and cats (Kladkempetch et al., 2020). Dogs frequently move between households, agricultural fields, and water sources during the day and often stay around human dwellings at night, increasing the risk of environmental contamination with helminth eggs and larvae. In contrast, cats in the same context tend to remain closer to households and show less interaction with fields or ponds, potentially contributing to a lower zoonotic transmission risk (Inpankaew et al., 2015; Sedionoto et al., 2021).

The persistence of hookworm infection in endemic rural settings, particularly those with close human-animal interactions and poor sanitation, underscores the need for integrated control strategies that extend beyond treating human hosts alone. Interventions should include routine pet deworming, improvements in environmental sanitation, community health education, and the promotion of personal hygiene practices, particularly hand and foot washing after contact with soil. By addressing these factors simultaneously across sectors, targeted and sustainable reductions in hookworm prevalence can be achieved, aligning with global efforts to control soil-transmitted helminth infections in resource-limited tropical regions.

CONCLUSIONS

The hookworm infection in rural coastal East Kalimantan was strongly influenced by environmental conditions, sanitation infrastructure, and personal hygiene practices, all of which facilitated the survival and transmission of infective larvae. Key environmental determinants such as soil quality, rainfall patterns, vegetation type, and village characteristics were found to significantly increase the risk of hookworm infection. This study provides updated epidemiological insights into the burden and determinants of hookworm in rural communities. Targeted interventions focusing on demographic characteristics, sanitation improvement, and behavioral hygiene practices are essential for effective control and prevention strategies, particularly in endemic rural settings.

SUGGESTION

Given the significant correlation between hookworm infection and environmental, behavioral, and zoonotic factors in rural coastal regions, it is advisable to implement integrated public health interventions to tackle this issue. These should include regular deworming of pets, community health education programs that focus on hygiene practices such as wearing shoes and washing hands after touching soil, and improved sanitation infrastructure in homes. More research is needed to investigate how hookworm infections spread during different seasons and how well One Health-based interventions, which combine strategies for human, animal, and environmental health, work in areas where the disease is prevalent.

ACKNOWLEDGMENTS

We sincerely thank the participants and local authorities in Bunga Jadi, Puancepak, and Sebuntal Sub-Districts for their valuable cooperation. This study was funded by a grant from Walailak University (Contract No. 17/2561) and supported by the East Kalimantan Provincial Government, Indonesia.

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