Environmental Risk Factors of Hookworm and *Strongyloides stercoralis* Infections Among School Children in Rural Areas Kutai Kertanegara Regency, Indonesia

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ABSTRACT

Background: Hookworm and S. stercoralis are still challenge in public health problem especially in developing countries where have environmental risk factors that are potential for transmitting of hookworm and S. stercoralis in Kutai Kertanegara Regency, East Kalimantan Province, Indonesia have high-risk factors of the prevalence of hookworm and S. stercoralis especially environmental risk factors.

Methods: In this study was showed the infection rates, correlation analysis between risk factors, and prevalence of hookworm and S. stercoralis were used for statistical analysis. A cross-sectional study was performed among 107 school children participants from rural school children of Kutai Kertanegara Regency, Indonesia. This study used two diagnostic methods: Kato Katz and Koga agar plate culture/KAP culture for diagnosing hookworm and Strongyloides infections. Pearson chi-square analysis was used to the study correlation between environmental risk factors with hookworm and S stercoralis infections.

Results: Hookworm and S stercoralis were found in this study; 37 (31.8) and 11 (10.3%) respectively. hookworm infection has been correlated significantly with school location (OR: 1.78 (95%CI: 0.87-3.71, p-value=0.006). While S. stercoralis infection has correlated significantly such as school location (OR: 1.28 (95%CI: 0.73-2.23, (p=0.027), Environmental risk others have not significantly correlated with hookworm infection among school children. While S stercoralis infection has correlated with environmental risk factors such as the texture of soil (OR: 5.50 (95%CI: 0.84-36.01, p-value: 0.010), wet soil surrounding houses (OR: 5.50 (0.84-36.02, p-value: 0.010). School location in surrounding rice field (OR: 5.50 (95%CI: 0.84-36.02, p-value: 0.012). Elevation in hill area (OR: 5.50 (95%CI: 0.84-36.02, p-value: 0.010).

Conclusions: This study has explained the determinant of environmental risk factors and the prevalence of hookworm infection and *S. stercoralis* in school children. The risk factors should be used for preventing the program of the reduced prevalence of hookworm and S stercoralis infections in school children, especially in rural areas.

Keywords: Environmental risk factors; Hookworm; *S. stercoralis*; School children; Indonesia

INTRODUCTION

The prevalence of hookworm infection and strongyloidiasis is of serious public health concern globally. Hookworm infection and strongyloidiasis are prevalent in poor rural communities in tropical and subtropical areas in many developing countries [1]. They are transmitted through protected contact with soil are endemic in tropical and temperate regions. The prevalence of hookworm infection and strongyloidiasis was estimated in 2010 that 438.9 million people were infected with hookworm and 100 million with strongyloides. Almost 70% of these infections occur in Asia [2-4]. Hookworm infection and strongyloidiasis are transmitted through protected contact with soil are endemic in tropical and temperate regions. Humans acquire the hookworm infection and strongyloidiasis through direct skin contact with infective third-stage larvae where the soil was contaminated by human feces penetrate the intact human skin and eventually reach the small intestine [5]. Generally, hookworm infection and strongyloidiasis are found among poor people with poor environmental sanitation

and where the climate is warm and humid [6,7]. Factors affecting the difference in the distribution of hookworm infection and strongyloidiasis may include good hygiene practices among the population, availability of sewerage system, and the length of the rainy season. Environmental factors have contributed to the transmission of diseases as well as the growth and development of the worms [8,9]. Environmental factors especially the long rainy season may affect the decrease in the prevalence of *Strongyloides stercoralis* infection but not for hookworm infection. The prevalence of strongyloidiasis in south Thailand is lower than in other parts of the country. In contrast, the prevalence of hookworm infection is still high in the south. It is possible because of the failure in the control of hookworm infection due to 10 months-long rainy season in southern Thailand contrasted with 4 months-long rainy season in other parts [10]. The study in Cambodia reported a lower prevalence of strongyloidiasis in the area with heavy rainfall than in low rainfall area. Moreover, a high amount of soil organic carbon content affects the lower prevalence of strongyloidiasis [11]. Epidemiology study of hookworm infection and strongyloidiasis in southern Laos showed 56.1% and 41% respectively where there were heavy rainfall and poor sanitation. In this study, Baerman and Kato-Katz techniques were used for detecting them [12]. In rural Kutai Kertanegara Regency, Indonesia has environmental risk factors of the prevalence of hookworm infection and strongyloidiasis that important to exploration association both of them. We perform a cross-sectional study among school children in rural Muara Kaman district and Marangkayu district to an analysis of characteristics of school children and environmental factor then was correlated with the prevalence of hookworm infection and strongyloidiasis.

METHODS

Study design

The study was carried out in the rural area of Muara Kaman district and Marangkayu district, Kutai Kertanegara Regency, East Kalimantan Province Indonesia. Kutai Kertanegara Regency is located at 0.44019^0S and 116.98139^0E. The average temperature was 28℃ (26℃-32℃). Muara Kaman district has located surrounding the Mahakam River and is closed with a forest area and palm plantation. While Marangkayu has located in the coastal area and surrounding rubber and palm plantation also rice field. We collected data from two elementary schools from the Muara Kaman district and one elementary school from the Marangkayu district. Data would be collected from 100 school children in each district. This research is school children based, was conducted from July 2018 to September 2019. The total of number participants is 107 participants who were joined and send stool samples [13].

Study population, sample size, and sampling technique

We selected three elementary schools from two districts in Kutai Kertanegara Regency, East Kalimantan to conduct this study: two elementary schools in Muara Kaman district and one elementary school in Marangkayu district where these schools have differences such as quality of soil, day number, and yearly volume of rainfall, temperature, humidity, elevation, village area, and vegetation, These areas were selected based on the potential risk of hookworm infection and strongyloidiasis, consist rural area, poor sanitation, and hygiene, agriculture activity, and surrounding forest and have not yet data study of hookworm and *S. stercoralis* infection from both areas. The sample size was determined using the single population formula by Stanly Lemeshow technique sampling. It was calculated

using a prevalence rate (p) of 37% as detail previous study [14] with 95% confidence interval (z=1.96) and a 10% margin error (d= 0.1). The calculated sample size was 90 participants in this study. We assumed that the final sample size would end up being reduced by around 10% due to subjects being unable to pass stool on the study date. Thus we aimed for a sample size of 100 school children participants. A simple random sampling method was used to select the population from the district of the school area. Inclusion criteria were participants who were ≥ 7 years old and studied in both school areas. We randomly selected 100 participants and then gave them instructions and distributed plastic containers for stool collection. A total of 107 school children participants were enrolled.

Ethics approval and consent to participate

Official permission and ethical clearance for the collection of human fecal samples were obtained from the headmaster of elementary school and the parent of school children. The study protocol was approved by the Ethical Clearance committee on human rights related to research involving human subjects, Walailak University HE: NO: WUEc-18-034-01.

Data collection and laboratory processing

We collected two stools sample for each school child. For collecting stool samples, the first day was requested to the headmaster of elementary school for requesting stool sample with collected data of questionnaires, second and third day in the morning would start to collect stool samples, were brought to the biomedical laboratory, Faculty of Public Health Mulawarman University for diagnosis samples. Another day was done to observe environmental condition houses surrounding school areas include school sanitation facilities village. We used two methods to diagnosis stool samples, agar plate culture, and the Kato Katz technique. Agar plate culture was done as described by Koga et al., 1991. Briefly, a few grams of stool was placed at the center of nutrient agar and kept at room temperature for five days. Tracks from larva crawling and larvae or adult worms were observed. If positive, 10 ml of 10% formalin was added to the agar surface for 5-10 minutes and transferred to a centrifuged tube. Centrifugation at 2,500 rpm for 5 minutes and supernatant was discarded. The sediment will be examined for hookworm and *S. stercoralis* larvae or adult worm. For Kato-Katz thick smear, 50 mg of stool was placed on a slide and covered with a cellophane paper soaked in glycerin solution for 24 hours. The stool was spread out using a rubber stick. After 30 minutes were examined and counted for eggs [15-17].

Data analysis

Demographic data and personal hygiene of participants were collected by questionnaire, and sanitation facilities each household of participants were collected by observation, while environmental data was collected consist such as vegetation, elevation of soil, kind of pets, kind of soil around houses, length of the rainy season, humidity and temperature per year. Quality of soil as organic carbon content, clay content, and pH were diagnosed by soil laboratory Mulawarman University. Vegetation and kind of soil around houses were collected by observation form, kind of pet would be collected by questioner and observation, and length of the rainy season, humidity and temperature per year will be collected from Central Bureau of Statistics (https://www.bps.go.id) and Central Bureau of meteorology, climatology, and Geophysical of Indonesia (https://www.bmkg.go.id). The prevalence of hookworm infection and *S. stercoralis* infection was stratified according to demographic

data, sanitation facilities and personal hygiene, environmental data, and reported by the descriptive statistic. Statistical analysis was performed by Chi-square using SPSS verse 22. The correlation analysis chi-square to evaluate the association of *S. stercoralis* infection with demographic data, sanitation facilities, personal hygiene, and environmental risk factors and the level of significance was considered as P<0.05 and the analysis of risk estimate by odds ratio Chi-Square with confidence interval 95%.

RESULTS

Demographic characteristics

A total of 107 school children participated in this study. The age ranged between 7 and 13 years from 3 elementary schools, consist of two schools from the Muarakaman district and one school from Marangkayu district, Kutai Kertanegara Regency, Indonesia. Among three elementary schools, we had collected stool samples from grade school 3-6 grade of elementary school. The school is Bunga Jadi elementary school, Puan Cepak Elementary school in the Muarakaman district, and Semangkok elementary school in Marangkayu district. This study collected 107 school children participants. Males 59 (55.1%) were dominant in the sample study than females 48 (44.9%). The age distribution of the sample was 10 and under 60 (56.1%) and 10 age-old above 47(43.9%). This study also explored environmental data that correlate with the potential risk of hookworm and *S. stercoralis* infections the environmental data such as; district, village area, vegetation surrounding houses, elevation from above sea surface, the carbon content in the soil, clay content in the soil, texture of the soil, dry or wet soil surrounding the house of household, humidity, temperature, long rainy season (number day of rainfall yearly), volume of rainfall yearly, having cat or dog, infected by hookworm and *S. stercoralis* in cat and dog, explained detail the data in table 1.

Environmental risk factors of school children in rural Kutai Kertanegara Regency, Indonesia

Environmental risk factors of school children in rural Kutai Kertanegara Regency explained in detail in table 2 below:

Parasitological Findings

Prevalence of hookworm and *S. stercoralis* infections among school children in Kutai Kertanegara was diagnosed by Kato Katz technique and APC method showed of 107 tested samples from school children that would be showed detail below in table 3:

The prevalence of hookworm infection and *S. stercoralis* infections among school children in the Kutai Kertanegara Regency was 37 (31.8%) and 11 (10.3%) respectively.

District and Prevalence hookworm and *S. stercoralis* infection in school children

Table 1: Characteristics of the 107 school children in rural areas East Kalimantan

Variable	Category	N (%)
Gender	Male	59 (55.1)
	Female	48 (44.9)
Age (years)	< 10 year old	60 (56.1)
	10 and above	47 (43.9)
School location	Bunga Jadi elementary school	49 (45.8)
	Puan Cepak elementary school	24 (22.4)
	Semangkok elementary school	34 (31.8)

Table 2: Environmental risk factors of schoolchildren in rural Kutai Kertanegara Regency, Indonesia

Variable	Category	N (%)
District	Muara Kaman	73 (68.2)
	Marangkayu	34 (31.8)
Organic carbon content in soil (%)	≤ 4.14%	73 (68.2)
	>4.14%	34 (31.8)
pH soil	≤ 6.61	48(22.4)
	>6.61	166 (77.6)
Clay content in the soil (%)	≤ 25.16	34 (31.8)
	>25.16	73 (68.2)
Temperature (℃)	28-28.6	34 (31.8)
	>28.6 -29.5	73 (68.2)
Humidity (%)	65	34 (31.8)
	66	73 (68.2)
Number day of rainfall (days)	164	73 (68.2)
	174	34 (31.8)
Rainfall volume (mm³)	3549	73 (68.2)
	4000	34 (31.8)
Elevation from above of sea (m)	<41.6m	34 (31.8)
	41.6-50m	73 (68.2)
Texture of soil	Sandy soil with organic material	58 (54.2)
	Non-sandy soil with organic material	49 (45.8)
Dry/wet soil surrounding school	Dry	49 (45.8)
	Wet	58 (54.2)
Vegetation	Surrounding palm plantation and/or rubber plantation	48 (44.9)
	Surrounding rice field	59 (55.1)
Village areas	Buffer river/sea	49 (45.8)
	Hill area	58 (54.2)
Having cat	Not having cat	49 (45.8)
	Having cat	58 (54.2)
Having a dog	Not having dog	73 (68.2)
	Having a dog	34 (31.8)
Hookworm in cat	Negative	48 (44.9)
	Positive	59 (55.1)
Hookworm in dog	Negative	73 (68.2)
	Positive	34 (31.8)
S. stercoralis in cat	Negative	49 (45.8)
	Positive	58 (54.2)
S. stercoralis in dog	Negative	73 (68.2)
	Positive	34 (31.8)

Table 3: Prevalence of Hookworm and *S. stercoralis* among School children in Kutai Kertanegara Regency, Indonesia

Infections	Kutai Kertanegara Regency School children		Total
	Positive (%)	Negative (%)	N (%)
Hookworm	37 (31.8)	73 (68.2)	107 (100)
S. stercoralis	11 (10.3)	96 (89.7)	107 (100)

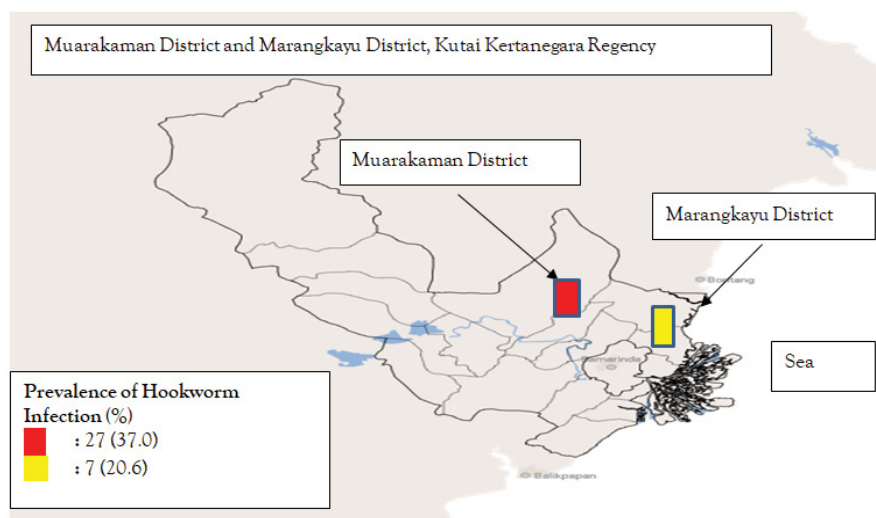Prevalence of hookworm and *S. stercoralis* among school children in Kutai Kertanegara Regency, Indonesia would be explained in table 4 below:

The table above explained that the prevalence of hookworm and

Table 4: District and prevalence of hookworm and *S. stercoralis* infection among school children in Kutai Kertanegara Regency

Infections	Muarakaman district		Marangkayu district		Total	
	Positive (%)	Negative (%)	Positive (%)	Negative (%)	Positive (%)	Negative (%)
Hookworm	27 (37.0)	46 (63.0)	7 (20.6)	27 (79.4)	34 (31.8)	73 (68.2)
S. stercoralis	6 (8.2)	67 (91.8)	5 (14.7)	29 (85.3)	11 (10.3)	96 (89.7)

Figure 1: Prevalence of Hookworm Infection among school children in Muara Kaman District and Marangkayu District, Kutai Kertanegara Regency, Indonesia.

S. stercoralis among school children in the Muarakaman district was 27 (37.0%) and 6 (8.2%) respectively. The prevalence of hookworm and *S. stercoralis* among school children in Marangkayu was 7 (20.6%) and 5 (14.7%) respectively in figure 1.

Characteristics and hookworm infection and S. stercoralis among school children in East Kalimantan

Characteristics of school children and Hookworm infection distribution of characteristics of school children with detailed in table 5 below:

Prevalence of hookworm infection was higher in males 19 (32.2%) than in females 15 (31.3%), in contrast for prevalence *S. stercoralis* was higher in females 6 (12.5%) than males 5 (8.5%). The age-old group in 10 age-old above was higher for hookworm infection 15 (31.9%) than in the category 7-9 age-old: 19 (31.7%) but for *S. stercoralis* 2-12 age-old; 6 (10.0%) than higher in the category in 10 age-old above 5 (10.5%). was higher than 7-9 age-old; hookworm infection 15 (31.9%) than in category 7-9 age-old: 19 (31.7%) but for *S. stercoralis* 2-12 age-old; 6 (10.0%). The highest prevalence of hookworm and *S. stercoralis* infections in school locations was Puancepak elementary school 14 (58.3%) and 5 (20.8%) respectively.

Environmental Risk Factors of Hookworm infection and *S. stercoralis* in Kutai Kertanegara Regency, Indonesia

Environmental risk factors of Hookworm infection and *S. stercoralis* in Kutai Kertanegara Regency, Indonesia, the result Person chi-square was explained in table 6 below:

The table above showed that hookworm infection was higher in Muara Kaman district 27 (37.0%) than in Marangkayu district 7 (20.6%), was contrasted prevalence *S. stercoralis* was higher in Marangkayu district 5 (14.7%) than Muara Kaman district 6 (8.2%). In category organic carbon content in the soil, hookworm infection was higher in category ≤ 4.14% than in category >4.14%

Table 5: Characteristics and hookworm infection and *S. stercoralis* among school children in Kutai Kertanegara Regency, Indonesia

Variable	Category	Positive n (%)		P-value	
		Hook-worm	*S. stercoralis*	Hook-worm	*S. stercoralis*
Gender	Male	19 (32.2)	5 (8.5)	0.916	0.495
	Female	15 (31.3)	6 (12.5)		
Age (years)	< 10 year old	19 (31.7)	6 (10.0)	0.978	0.914
	10 and above	15 (31.9)	5 (10.5)		
School location	Bunga Jadi elementary school	13 (26.5)	1 (2.0)	0.006	0.027
	Puan Cepak elementary school	14 (58.3)	5 (20.8)		
	Semangkok elementary school	7 (20.6)	5 (14.7)		

with prevalence was 27 (37.0%) and 7 (20.6%) respectively. *S. stercoralis* was higher in category >4.14% than in category ≤ 4.14% with prevalence was 5 (14.7%) and 6 (8.2%) respectively. In pH ≤ 6.61 hookworm infection was higher than in pH>6.61 with the prevalence was 14 (58.3%) and 20 (24.1%) respectively. Hookworm infection was higher in temperature ≤29.02 0C than in category >29.020C with prevalence was 27 (37.0%) and 7 (20.6%) respectively. *S. stercoralis* was higher in temperature >29.020C than ≤29.02 0C with prevalence was 5 (14.7%) and 6 (8.2%) respectively. Hookworm infection was higher in humidity <65.4 while S stercoralis was high in humidity 65.4-66 with prevalence was 27 (37.0%) and 5 (14.7%) respectively. Hookworm infection was high in number day of rainfall 164 days and *S. stercoralis* was high in number rainfall 174 days with prevalence was 27 (37.0%) and 5 (14.7%) respectively. The prevalence of hookworm infection also was high in the capacity of rainfall 3549 and *S. stercoralis* was high incapacity of rainfall 4000 with the prevalence was 27 (37.0%) and 5 (14.7%) respectively. Prevalence hookworm infection and

Table 6: Environmental Risk Factors of the prevalence of hookworm and *S. stercoralis* infections among school children in Kutai Kertanegara Regency, Indonesia

Variable	Category	Positive n (%)		P-value	
		Hookworm	*S. stercoralis*	Hookworm	*S. stercoralis*
District	Muara Kaman	27 (37.0)	6 (8.2)	0.09	0.304
	Marangkayu	7 (20.6)	5 (14.7)		
Organic carbon content in the soil (%)	≤ 4.14	27 (37.0)	6 (8.2)	0.09	0.304
	>4.14	7 (20.6)	5 (14.7)		
pH soil	≤ 6.61	14 (58.3)	5 (20.8)	0.002	0.053
	>6.61	20 (24.1)	6 (7.2)		
Clay content in the soil	≤ 25.16	27 (37.0)	6 (8.2)	0.09	0.304
	>25.16	7 (20.6)	5 (14.7)		
Temperature (°C)	28-28.6	27 (37.0)	6 (8.2)	0.09	0.304
	>28.6 -29.5	7 (20.6)	5 (14.7)		
Humidity (%)	65	27 (37.0)	6 (8.2)	0.09	0.304
	66	7 (20.6)	5 (14.7)		
Number day of rainfall (days)	164	27 (37.0)	6 (8.2)	0.09	0.304
	174	7 (20.6)	5 (14.7)		
Rainfall volume (mm³)	3549	27 (37.0)	6 (8.2)	0.09	0.304
	4000	7 (20.6)	5 (14.7)		
Elevation from above of sea (m)	<41.6	7 (20.6)	6 (8.2)	0.09	0.304
	41.6-50	27 (37.0)	5 (14.7)		
Texture of soil	Sandy soil with organic material	21 (36.2)	10 (17.2)	0.284	0.01
	Non-sandy soil with organic material	13 (26.5)	1 (2.0)		
Dry/wet soil surrounding school	Dry	13 (26.5)	1 (2.0)	0.284	0.01
	Wet	21 (36.2)	10 (17.2)		
Vegetation	Surrounding palm plantation and/or rubber plantation	13 (27.1)	1 (2.1)	0.347	0.012
	Surrounding rice field	21 (35.6)	10 (16.9)		
Village areas	Buffer river/sea	13 (36.5)	1 (2.0)	0.284	0.01
	Hill area	21 (36.2)	10 (17.2)		
Having cat	Not having cat	13 (36.5)	1 (2.0)	0.284	0.01
	Having cat	21 (36.2)	10 (17.2)		
Having a dog	Not having a dog	27 (37.0)	6 (8.2)	0.09	0.304
	Having a dog	7 (20.6)	5 (14.7)		
Hookworm/ *S. stercoralis* in cat	Negative	-	1 (2.0)	-	0.01
	Positive	34 (31.8)	10 (17.2)		
Hookworm/ *S. stercoralis* in dog	Negative	27 (37.0)	6 (8.2)	0.09	0.304
	Positive	7 (20.6)	5 (14.7)		

S. stercoralis same as was higher in elevation 41.6-50m with the prevalence was 27 (37.0%) and 5 (14.7%) respectively. Hookworm infection and *S. stercoralis* were higher in vegetation surrounding school and village with category rice fields than palm plantation and/or rubber plantation than in category with prevalence were 21 (35.6%) and 10 (16.9%) respectively. Prevalence of hookworm infection was higher in village area with category buffer river or coastal area than in hill area with prevalence was 13 (36.5%) and 21 (36.2%), in contrast with *S. stercoralis* was higher in hill area than in buffer river or coastal areas with the prevalence was 10 (16.9%) and 1 (2.0%). In the category having a cat, the prevalence of hookworm and *S. stercoralis* was 21 (36.2%) and 10 (17.2%) respectively. In the category of having a dog, the prevalence of hookworm infection and *S. stercoralis* was 7 (20.6%) and 5 (14.7%) respectively. Prevalence of hookworm infection with category cat infected hookworm was 34 (31.8%) while the prevalence of *S. stercoralis* with category cat infected *S. stercoralis*

was 10 (17.2%). Prevalence of hookworm infection with category dog infected hookworm was 7 (20.6%); while the prevalence of *S. stercoralis* infection with category dog infected *S. stercoralis* was 5 (14.7%). Hookworm infection has significantly correlated with the pH of the soil (p= 0.002). Environmental risk others have not significantly correlated with hookworm infection among school children. *S. stercoralis* has significantly correlated with the texture of soil (p=0.010), Dry or wet soil surrounding house (p=0.010), Vegetation (p=0.012), Village areas (p=0.010), having a cat and infected *S. stercoralis* in cat (p=0.010) (Figure 2).

Essential environmental risk factors of the prevalence of hookworm and *S. stercoralis* infections among school children in Kutai Kertanegara Regency

The estimated value of the risk factor of hookworm infection and *S. stercoralis* among school children in Kutai Kertanegara Regency explained in table 7 below:

Hookworm infection and S. stercoralis infection had been correlated significantly with school location Muara Kaman district school 1.78 times more likely to be infected with hookworm than Marangkayu district school location (OR: 1.78 (95%CI: 0.87-3.71, p-value=0.006). Marangkayu district school 1.28 times more likely to be infected with S. stercoralis than Muarakaman district school location (OR: 1.28, 95%CI: 0.73-2.23, p=0.027). The soil with pH > 6.61, 1.78 times more likely to be infected with hookworm (OR: 1.78 (95%CI: 0.87-3.71, p= 0.002). Environmental risk others have not significantly correlated with hookworm infection among school children. While the texture of the soil in category sandy soil with organic material 5.50 times more likely to be infected with S. stercoralis than non-sandy soil (OR: 5.50 (95%CI: 0.84-36.01, p= 0.010). Wet soil surrounding houses 5.50 times more likely to be infected with S. stercoralis than dry soil surrounding houses (OR: 5.50 (0.84-36.02, p=0.010). Surrounding rice field 5.50 times more likely to be infected with S. stercoralis than surrounding palm or rubber plantation (OR: 5.50 (95%CI: 0.84-36.02, p=0.012). Hill area 5.50 times more likely to be infected with S. stercoralis than buffer river or coastal area (OR: 5.50 (95%CI: 0.84-36.02,
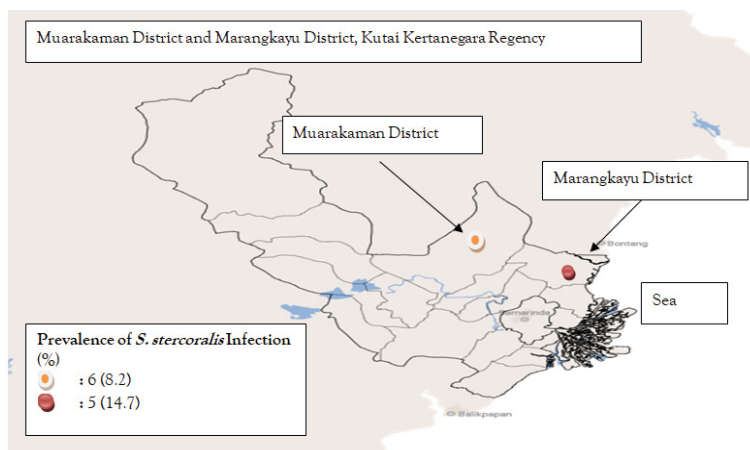

Figure 2: Prevalence S. stercoralis Infection in Muarakaman District and Marangkayu District, East Kalimantan Province

Table 7: Essential Environmental risk factors of hookworm infection and S. stercoralis infection among school children in Kutai Kertanegara Regency, Indonesia

Variable	Category	n	Positive no (%)		hookworm	S. stercoralis
			hookworm	S. stercoralis	OR (95%CI)	OR (95%CI)
Gender	male	59	19 (32.2)	5 (8.5)	1.03 (0.65-1.61)	0.80 (0.45-1.44)
	female	48	15 (31.3)	6 (12.5)	0.98 (0.68-1.41)	1.24 (0.63-2.42)
Age (years)	12-Feb	60	19 (31.7)	6 (10.0)	0.99 (0.63-1.57)	0.96 (0.49-1.91)
	13 and above	47	15 (31.9)	5 (10.5)	1.01 (0.70-1.44	1.03 (0.59-1.82)
District	Muarakaman	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
	Marangkayu	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
Organic carbon content in soil (%)	≤ 4.14	24	14 (58.3)	5 (20.8)	1.47 (1.09-1.97)	1.47 (0.85-2.55)
	>4.14	83	20 (24.1)	6 (7.2)	0.33 (0.17-0.67)	0.43 (0.20-0.93)
pH soil	≤ 6.61	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
	>6.61	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
Clay content in the soil	≤ 25.16	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
	>25.16	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
Temperature (⁰C)	28-28.6	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
	>28.6 -29.5	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
Humidity (%)	65	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
	66	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
Number day of rainfall (days)	164	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
	174	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
Elevation from above of sea (m)	<41.6	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
	41.6-50	73	27 (37.0)	6 (8.2)	1.78 (0.87-3.71)	0.67 (0.33-1.36)
Texture of soil	Sandy soil with organic material	58	21 (36.2)	10 (17.2)	1.29 (0.79 -2.10)	5.50 (0.84-36.01)
	Non-sandy soil with organic material	49	13 (26.5)	1 (2.0)	0.82 (0.58-1.16)	0.55 (042-0.72
Dry/wet soil surrounding school	Dry	49	13 (26.5)	1 (2.0)	0.82 (0.58-1.16)	0.55 (042-0.72
	Wet	58	21 (36.2)	10 (17.2)	1.29 (0.79 -2.10)	5.50 (0.84-36.01)

Vegetation	Surrounding palm plantation and/or rubber plantation	48	13 (27.1)	1 (2.1)	0.84 (0.60-1.19)	0.56 (0.43-0.74)
	Surrounding rice field	59	21 (35.6)	10 (16.9)	1.25 (0.77-2.05)	5.39 (0.82-35.29)
Dry/wet soil surrounding school	Dry	49	13 (26.5)	1 (2.0)	0.82 (0.58-1.16)	0.55 (0.42-0.72)
	Wet	58	21 (36.2)	10 (17.2)	1.29 (0.79 -2.10)	5.50 (0.84-36.02)
Village areas	Buffer river/sea	49	13 (26.5)	1 (2.0)	0.82 (0.58-1.16)	0.55 (0.42-0.72)
	Hill area	58	21 (36.2)	10 (17.2)	1.29 (0.79 -2.10)	5.50 (0.84-36.02)
Having cat	Not having cat	49	13 (26.5)	1 (2.0)	0.82 (0.58-1.16)	0.55 (0.42-0.72)
	Having cat	58	21 (36.2)	10 (17.2)	1.29 (0.79 -2.10)	5.50 (0.84-36.02)
Having a dog	Not having dog	73	27 (37.0)	6 (8.2)	1.80 (0.87-3.71)	0.67 (0.33-1.36)
	Having dog	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)
Hookworm/ S. stercoralis in cat	Negative	48	-	1 (2.0)	-	0.55 (0.42-0.72)
	Positive	59	34	10 (17.2)	-	5.50 (0.84-36.02)
Hookworm/ S. stercoralis in dog	Negative	73	27 (37.0)	6 (8.2)	1.80 (0.87-3.71)	0.67 (0.33-1.36)
	Positive	34	7 (20.6)	5 (14.7)	0.79 (0.62-1.01)	1.28 (0.73-2.23)

p=0.010). Having a cat and infected S. stercoralis in cat 5.50 times more likely to be infected with S. stercoralis than the un-having cat and non-infected (OR: 5.50, 95%CI: 0.84-36.02, p=0.012).

DISCUSSION

Prevalence of hookworm infection was higher in male 19 (32.2%) than in female 15 (31.3%), in contrast for prevalence S. stercoralis was higher in female 6 (12.5%) than male 5 (8.5%). Age-old group in 10 age-old above was higher for hookworm infection 15 (31.9%) than in category 7-9 age-old: 19 (31.7%) but for s. stercoralis 2-12 age-old; 6 (10.0%) than higher in category in 10 age-old above 5 (10.5%). was higher than 7-9 age-old; hookworm infection 15 (31.9%) than in category 7-9 age-old: 19 (31.7%) but for s. stercoralis 2-12 age-old; 6 (10.0%). The highest prevalence of hookworm infection and S. stercoralis in school locations was Puancepak elementary school 14 (58.3%) and 5 (20.8%) respectively.

S. stercoralis infection has correlated significantly such as school location (p=0.027). Muarakaman district school 1.78 times more likely to be infected with hookworm than the Marangkayu district school location (OR: 1.78 (95%CI: 0.87-3.71, p-value=0.006). Marangkayu district school 1.28 times more likely to be infected with S. stercoralis than Muarakaman district school location (OR: 1.28, 95%CI: 0.73-2.23, p=0.027). The deference of environmental factors between Muara Kaman district and Marangkayu district should be affected by the high of hookworm infection and the low of S. stercoralis in Muara Kaman district than in Marangkayu district. Environmental risk factors of hookworm infection more than S. stercoralis that the environmental risk factors to add to the high prevalence of hookworm infection. Muara Kaman district has located surrounding palm plantation and river area. The environmental conditions should affect the increasing or decreasing prevalence of S. stercoralis infection in a rural area [18]. A similar study in Manufahi district, Timor Leste where is a rural area with a prevalence of hookworm infection was 62.8% [19].

The table above showed that hookworm infection was higher in Muara Kaman district 27 (37.0%) than in Marangkayu district 7 (20.6%), was contrasted prevalence S. stercoralis was higher in Marangkayu district 5 (14.7%) than Muarakaman district 6 (8.2%). In category organic carbon content in the soil, hookworm infection was higher in category ≤ 4.14% than in category > 4.14% with prevalence was 27 (37.0%) and 7 (20.6%) respectively. S. stercoralis was higher in category > 4.14% than in category ≤ 4.14% with prevalence was 5 (14.7%) and 6 (8.2%) respectively. In pH ≤ 6.61

hookworm infection was higher than in pH>6.61 with the prevalence was 14 (58.3%) and 20 (24.1%) respectively. Hookworm infection was higher in temperature ≤29.02 0C than in category >29.020C with prevalence was 27 (37.0%) and 7 (20.6%) respectively. S. stercoralis was higher in temperature >29.020C than ≤29.02 0C with prevalence was 5 (14.7%) and 6 (8.2%) respectively. Hookworm infection was higher in humidity <65.4 while S stercoralis was high in humidity 65.4-66 with prevalence was 27 (37.0%) and 5 (14.7%) respectively. Hookworm infection was high in number day of rainfall 164 days and S. stercoralis was high in number rainfall 174 days with prevalence was 27 (37.0%) and 5 (14.7%) respectively. The prevalence of hookworm infection also was high incapacity of rainfall 3549 and S. stercoralis was high incapacity of rainfall 4000 with the prevalence was 27 (37.0%) and 5 (14.7%) respectively. Prevalence of hookworm infection and S. stercoralis same as was higher in elevation 41.6-50m with the prevalence was 27 (37.0%) and 5 (14.7%) respectively. These studies showed that elevation has contributed to the distribution of the prevalence of hookworm and S. stercoralis infections [20]. Environmental factors of hookworm infection in Kutai Kertanegara Regency has similar with south Thailand including long rainy season, temperature, and several geography areas, then the prevalence of hookworm infection in Kutai Kertanegara Regency (33.8%) is higher than in south Thailand but equal for S. stercoralis infection, [10]. The study has different from the epidemiology study of S. stercoralis infection in Southern Laos where showed was 41% where has heavy rainfall and poor sanitation [21].

Hookworm infection and S. stercoralis were higher in vegetation surrounding school and village with category rice field than palm plantation and/or rubber plantation than in category with prevalence were 21 (35.6%) and 10 (16.9%) respectively. rice fields may be supported by the potential infection by S. stercoralis during farmer activity. Although in an agricultural area with loamy soil common to find a high of soil-transmitted helminth infection especially hookworm [22]. Prevalence of hookworm infection was higher in village area with category buffer river or coastal area than in hill area with prevalence was 13 (36.5%) and 21 (36.2%), in contrast with S. stercoralis was higher in hill area than in buffer river or coastal areas with the prevalence was 10 (16.9%) and 1 (2.0%). These studies equal with study S stercoralis in Cambodian children that high (20.2%) prevalence of S stercoralis among school children in the village area surrounding the lake [23]. In the category having a cat, the prevalence of hookworm and S. stercoralis was 21 (36.2%)

and 10 (17.2%) respectively. In the category of having a dog, the prevalence of hookworm infection and *S. stercoralis* was 7 (20.6%) and 5 (14.7%) respectively. Prevalence hookworm infection with category cat infected hookworm was 34 (31.8%) while the prevalence of *S. stercoralis* with category cat infected *S. stercoralis* was 10 (17.2%). Prevalence of hookworm infection with category dog infected hookworm was 7 (20.6%); while the prevalence of *S. stercoralis* infection with category dog infected *S. stercoralis* was 5 (14.7%). Hookworm infection has significantly correlated with the pH of the soil (p= 0.002). Environmental risk others have not significantly correlated with hookworm infection among school children. *S. stercoralis* has significantly correlated with the texture of soil (p=0.010), Dry or wet soil surrounding the house (p=0.010), Vegetation (p=0.012), Village areas (p=0.010), having a cat and infected *S. stercoralis* in cat (p=0.010). The soil with pH >6.61, 1.78 times more likely to be infected with hookworm (OR: 1.78, 95%CI: 0.87-3.71, p= 0.002). Environmental risk others have not significantly correlated with hookworm infection among school children. While the texture of the soil in category Sandy soil with organic material 5.50 times more likely to be infected with *S. stercoralis* than non-sandy soil (OR: 5.50, 95%CI: 0.84-36.01, p= 0.010). Wet soil surrounding houses 5.50 times more likely to be infected with *S. stercoralis* than dry soil surrounding houses (OR: 5.50 (0.84-36.02, p=0.010). Surrounding rice fields 5.50 times more likely to be infected with *S. stercoralis* than surrounding palm or rubber plantation (OR: 5.50, 95%CI: 0.84-36.02, p=0.012). Hill area 5.50 times more likely to be infected with *S. stercoralis* than buffer river or coastal area (OR: 5.50 (95%CI: 0.84-36.02, p=0.010). Supporting environmental factors against the survival of hookworm and S. stercoralis. When communities defecated in rubber or palm plantation could be spread in village or rice fields that condition was caused elevation plantation is higher than the village and rice field elevation, runoff water from plantation or forest when rainfall brings the eggs or larvae hookworm and S. stercoralis from hill to village and yard of the school.

Having a cat and infected *S. stercoralis* in the cat 5.50 times more likely to be infected with *S. stercoralis* than an un-having cat and non-infected (OR: 5.50, 95%CI: 0.84-36.02, p=0.012). Having a cat and hookworm and *S. stercoralis* infection in the cat have high significance with hookworm and *S. stercoralis* infections that due to the variables have a contribution for surviving of parasitic larvae of hookworm and *S. stercoralis* then potential increase for penetration the larvae to human via soil contact and pet contact. Quoted by G. Strkolcova (2016) [24] that humans and animals are most often infected via contact soil contaminated by infective filariform larvae that penetrate host skin. This study had shown pH and the texture of the soil correlate with the survival of hookworm and S. *stercoralis* and heavy rainfall affected for reducing and increasing the distribution of hookworm and *S. stercoralis* infections. In general condition soil surrounding school, more than 80% covered with soil was close the location with plantation and forest that have a high position for contamination from plantation and forest. In poor countries with a tropical climate, where have environmental conditions favorable for transmission hookworm and *S. stercoralis* infection the prevalence still high [23].

Explained with Garcia (2007) [25] that a significant increase in the prevalence of hookworm and *S. stercoralis* infection with environmental conditions. Changing environmental conditions, specifically deforestation and subsequent silting of the local river, have caused periodic flooding with deposition on a layer of sandy loam topsoil could increase soil moisture, and support by the low quality of sanitation facilities and hygiene personal to add the increasing of *S. stercoralis* infection. These conditions, all of which are conducive to *S. stercoralis* transmissions, have allowed *S. stercoralis* infection to reemerge as an important human pathogen in this area [18].

CONCLUSION

Environmental risk others have not significantly correlated with hookworm infection among school children. While *S. stercoralis* infection has correlated with environmental risk factors such as the texture of the soil, wet soil surrounding houses, school location in surrounding rice fields. This study has explained the determinant of risk factors and the prevalence of hookworm infection and *S. stercoralis*. Essential of the risk factors of the infections should be used for preventing the program of reduction prevalence hookworm and *S. stercoralis* infection.

ACKNOWLEDGEMENT

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