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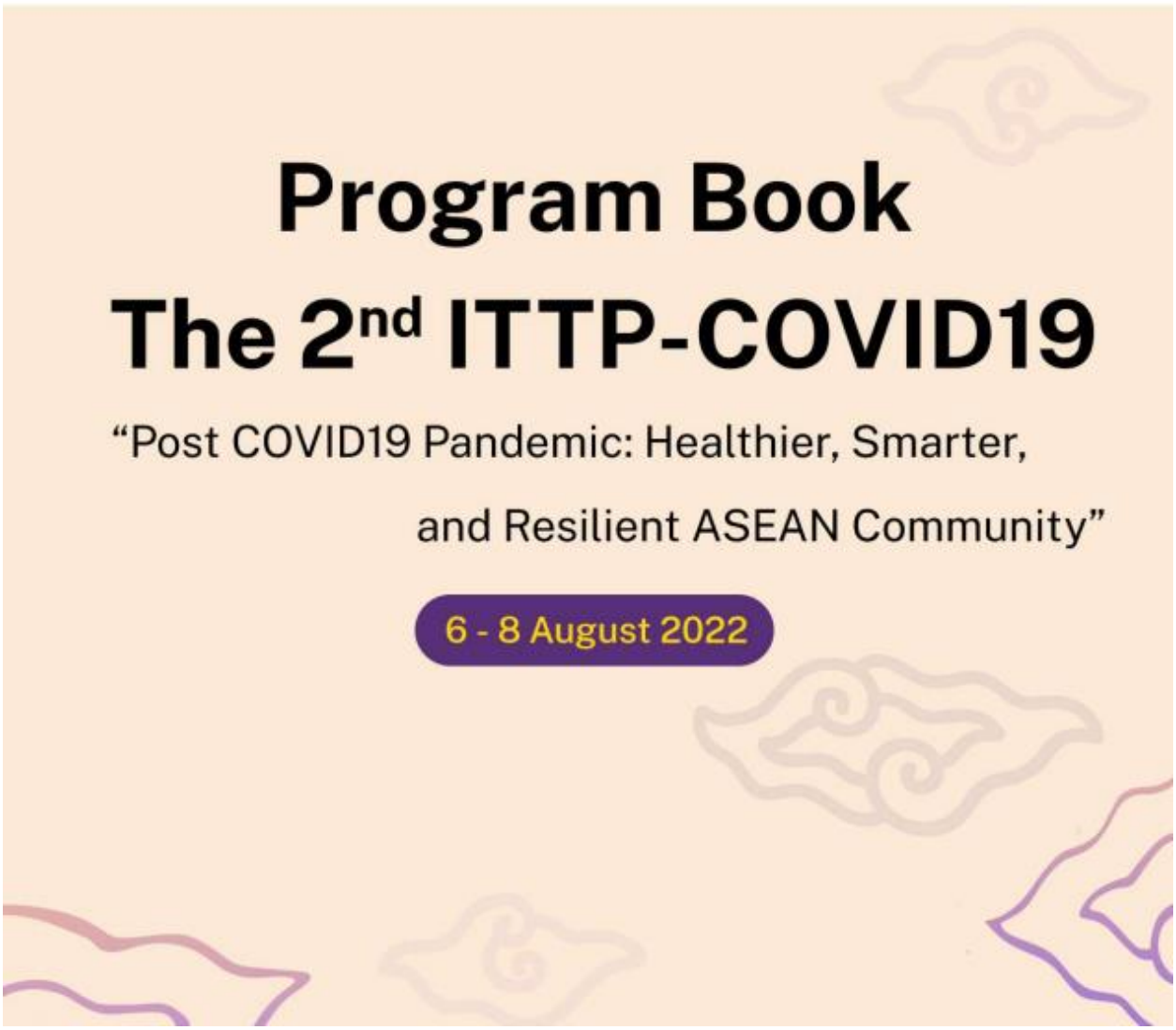

Paper Presentation

05

Paper Presentation (Day 2)

ROOM 2C07			
Track: Health Science			
Topic: Multiple Topics			
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7 August 2022 **Session 3** 3-4 PM Jakarta Time	010	Blego Sedionoto	Currency and Risk Factors of Mono-Hookworm, Strongyloides Stercoralis, and Co-Infection in Rural Communities East Kalimantan Province, Indonesia
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Currency and risk factors of mono-hookworm, S*trongyloides stercoralis,* and co-infection in rural communities East Kalimantan Province, Indonesia

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A b s t r a c t

Background: Hookworm, *S. stercoralis, and* co-infection are still challenged in public health problem especially in developing countries where have risk factors that are potential for transmitting of hookworm, *S. stercoralis* and co-infection. In East Kalimantan Province, Indonesia has high-risk factors of the prevalence of hookworm, *S. stercoralis,* and co-infection, including access sanitation facilities, personal hygiene and environmental risk factors.

Methods: In this study was showed the infection rates, correlation analysis between risk factors and prevalence of hookworm, *S. stercoralis,* and co-infection were used statistical analysis. A cross-sectional study was performed among 213 participants from the rural community of Muarakaman District and Marangkayu Districts, East Kalimantan Province, Indonesia. In this study would show the infection rates, correlation analysis between environmental risk factors, and prevalence of hookworm infection with statistical analysis. In this study used two diagnostic methods: Kato Katz and Koga agar plate culture/KAP culture for diagnosing of hookworm and *Strongyloides* infections. Pearson chi-square analysis was used for study correlation between environmental risk factors with hookworm infection and *S stercoralis* infection and co-infection.

Results: In this study showed of 213 tested samples from the community have 154 (27.7%) cases found positive with hookworm mono-infection and 17 (8.0%) cases found positive with *strongyloides* infection and co-infection 14 (6.6%). the result Pearson chi-square analysis that age (p value= 0.008), occupation, (p value= 0.008), water resources for daily activity (p=0.000, drinking water (p value= 0.000) and toilet (p value= 0.028). personal hygiene have significant correlation with hookworm mono-infection consist frequency of using shoes on out-door (p= 0.006), usual ate row/un-cook vegetable (p= 0.001), washing foot before house-entering (p=0.030), usual use toilet at home (p= 0.035) and usually use sandals in the toilet (0.035). Environmental factors have correlated significant with hookworm mono-infection (p<0.05) such as district (p= 0.000), organic carbon content in soil (p= 0.000), temperature (p= 0.000), humidity (p= 0.000), number day of rainfall (p= 0.000), rainfall volume (p= 0.000), vegetation (p= 0.001), village areas (p= 0.001), dry or wet soil surrounding house (p= 0.010) and live together with human infected with hookworm (p= 0.016). Sanitation facilities and personal hygiene have not significant with *S. stercoralis*. district, the organic carbon content in the soil, humidity, temperature, elevation, number day of rainfall, rainfall volume, elevation, and live together with human infected with *S. stercoralis.* facilitate sanitation of participants and hookworm and *S. stercoralis* co-infection have not associated (p-value > 0.05). usual ate raw vegetable has significantly correlated with hookworm and *S. stercoralis* co-infection (p= 0.020). environmental risk factors with hookworm and *S. stercoralis* co-infection showed organic carbon content in soil and live together with humans infected with hookworm and *S. stercoralis* co-infection have significantly correlated with hookworm and *S. stercoralis* co-infection with p-value = 0.025 and p-value= 000 respectively.

Conclusions: The prevalence of hookworm, *S. stercoralis,* and co-infection in two districts in rural areas in east Kalimantan, Indonesia where deference of risk factor of the infections. Hookworm, *S stercoralis,* and Co-infection have deference of risk factors especially in carbon content, volume n number day of rainfall, elevation, and village areas, that conditions against survival of parasitic larvae in an environment where potential increase for penetration the larvae to human via soil contact and pet contact. Personal hygiene and sanitation facilities supported the conditions. Essential risk factors of the infections should use for controlling and preventing a program of reduction prevalence hookworm and *S stercoralis* infection.

Keywords: Prevalence, Essential Risk Factors, Hookworm, *S. Stercoralis*, Co-Infection, Indonesia

Background

The prevalence of hookworm and *S. stercoralis* infections is of serious public health concern globally. Hookworm infection and *S. stercoralis* infection are prevalent in a poor rural communities in tropical and subtropical areas in many developing country [13]. They are transmitted through in protected contact with soil that is 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 [25, 24, 6]..

Hookworm and *S. stercoralis* infections are transmitted through in protected contact with soil are endemic in tropical and temperate regions. Human acquires 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 small intestine [26].

Generally, hookworm and *S. stercoralis* infections are found among poor people with poor environmental sanitation and where the climate is warm and humid [27, 12]. Factors affecting 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 for transmission of diseases as well as growth and development of the worms [2, 1].

Environmental factors especially the long rainy season may affect the decrease in prevalence of *S. stercoralis* infection but not for hookworm infection. The prevalence of *S. stercoralis* infection in south Thailand is lower than other parts of the country, in contrast, prevalence of hookworm infection is still high in the south. It is possible because 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 [28]. The study in Cambodia reported the high prevalence of hookworm infection and *S. stercoralis* infection, wherein Cambodia has not heavy rain season [16]. While in East Kalimantan, Indonesia has two seasons consist rain season and dry season without hot season, in the rainy season has heavy rain, the season may affect the prevalence of *S. stercoralis* and hookworm infection.

Similarly to epidemiology study in southern Laos that high prevalence of hookworm and *S. stercoralis* together, the prevalences were 56.1% and 41% respectively [11]. Quoted by Forrer et al 2018 about soil organic carbon is an environmental variable that has a contribution for mono hookworm infection, mono *S. stercoralis* infection and co-infection [1]. East Kalimantan province in Indonesia has many characteristics of soil such as carbon content in soil and clay content in soil, However the risk factors of hookworm, S. stercoralis, and co-infection have potential deferent with others countries in South East Asia.

In rural East Kalimantan province Indonesia has environmental risk factors of the prevalence of hookworm infection and *S. stercoralis* where has low sanitation and personal hygiene. We perform a cross-sectional study in a rural community in Muarakaman and Marangkayu district to the analysis of geography, texture of soil, humidity, hookworm and Strongyloides in pet, vegetation, elevation, volume of rainfall, amount days of rainfall yearly, temperature and quality of soil as clay content, organic carbon of soil and pH of soil then was correlated with the prevalence of hookworm and *S. stercoralis* infections.

Methods

Study Setting and Population

We selected two districts in Kutai Kertanegara regency, East Kalimantan to conduct this study: Muara Kaman district and Marangkayu district where these areas 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 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 Lameshow technique. It was calculated using a prevalence rate (p) of 55.4% as detail previous study [23], with 95% confidence interval (z=1.96) and a 10% margin error (d= 0.1). The calculated sample size was 95 participants per district. We assumed that the final sample size would end up being reduced by around 15% due to subjects being unable to pass stool on the study date. Thus we aimed for a sample size of 110 per district. A simple random sampling method was used to select the population from each district. Inclusion criteria were participants who were ≥ 2 years old and lived in both areas. We randomly selected 110 participants per area and then gave them instruction and distributed plastic containers for stool collection. In total 220 participants were enrolled. We collected data from 28 villages such as 12 villages from Muarakaman district and 16 villages from the Marangkayu district. Data collected from 10-15 household with 1-3 participants in each village. This research is a community-based, was conducted during July 2018 to September 2019. Total of number participants is 213 participants who were joined and sent stool samples.[31].

Parasitological data and case definition

We collected two stool samples of the participant, for collecting stool samples, the first day was requested to head of household and member of household for requesting stool sample, the second day in the morning would start to collect stool samples, were brought to biomedical laboratory, Faculty of Public Health Mulawarman University for diagnosis samples. Another day was done observation environmental condition of houses surrounding the village.

Agar plate culture and Kato Katz technique were used in this study, 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 [32].

For Kato-Katz thick smear, 50 mg of stool was placed on 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

Risk Factors Data

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. The 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 will be collected by questioner and, observation, and length of the rainy season, humidity and temperature per year will collected from the Central Bureau of Statistics (https://www.bps.go.id) and the Central Bureau of meteorology, climatology, and Geophysical of Indonesia (https://www.bmkg.go.id).

Data Analysis

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 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 213 individuals participated in this study. The age ranged between 2 and 70 years from 28 villages, with detail 12 villages from Muarakaman District and 16 villages from Marangkayu District, East Kalimantan Province Indonesia. Among 28 villages collected each village 10-15 households with 2 to 3 participants in each household, in enrolled we would collect 220 participants. In total 220 persons were enrolled. However, 213 analyzed for hookworm and S. stercoralis. Distribution of participants who were collected 95 (44.6%) from Muarakaman district

and 118 persons from the Marangkayu district. Males 130 (61.0) were dominant in the sample study while females 83 (39.0%). The age distribution of sample was 114(53.5%) from 2 to 12 age-old and 99 (46.5%) from 13 age-old and above (46.5%). The main occupation of the sample consist of farmer 70 (32.9%), at home 65 (25.8%), at school 81(38.0%) and others 7(3.3%). Sanitation facilities of participants such as covering the floor indoor, covering yard surrounding house, water waste treatment, water sources for daily activity and drinking sources, and toilets. All of the sanitation facilities were took the data by observation of each household. Personal hygiene of participants was explored by questionnaire such as; usual wear shoes in out-door activity, usual wash foot and hand after soil contact, wash fruit or vegetable before eat, usually eat the un-cook vegetable, usual wash hand after pet contact, usual use toilet at home. This study also explored environmental data that correlate with potential risk of hookworm and *S. stercoralis* infections. The environmental data such as; district, village area, vegetation surrounding houses, elevation from the 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, and having cat or dog.

Table 1 Characteristics of the 213 Participants in a community-based study

Variable	Category	n (%)
Gender	**Male**	**130 (61.0)**
	Female	**83 (39.0)**
Age (years)	**2-12**	**114 (53.5)**
	13 and above	**99 (46.5)**
Main Occupation	**Farmer**	**70 (32.9)**
	At home	**65 (25.8)**
	At school	**81 (38.0)**
	Others	**7 (3.3)**

Occupation	Non-Agriculturist	75 (64.8)
	Agriculturist	138 (35.2)
Kinds of Floor covering indoor of the house	Sanitary floor (cement, wood, etc)	212 (99.5)
	Soil floor	1 (0.5)
Yard covering	Not soil	35 (16.4)
	Soil	178 (83.6)
Water waste treatment	Healthy water waste treatment	108(50.7)
	Without water waste treatment	105 (49.3)
Water sources for daily activity	Sanitary water resources	92 (43.2)
	Un-sanitary water resources	121 (56.8)
Drinking water	Sanitary of drinking water	117(54.9)
	Un-sanitary of drinking water	96 (45.1)
Toilet	Sanitary toilet in the home	181 (85.0)
	Open defecation (plantation, garden, or river	32 (15.0)
Frequency using shoes on out-door	Routine	74 (34.7)
	Un-routine	139 (65.3)
Usual wash foot after soil contact	washing foot after soil contact	26 (12.2)
	Not washing foot after soil contact	187 (87.8)
Washing fruit/vegetable before eaten	Routine	33(15.5)
	Un-routine	180 (84.5)
Usual ate row/un-cook fish/meat/vegetable	No	172 (80.8)
	Yes	41 (19.2)
Pet contact	No	161 (75.6)
	Yes	52 (24.4)

Washing hand after pet contact	Washing hand	4 (1.9)
	At home	209 (98.1)
Washing hand after soil contact	Washing hand	25 (11.7)
	Not washing	188(88.3)
Washing foot before house enter	No	13 (6.1)
	Yes	200 (93.9)
Usual use toilet at home	Yes	116 (54.5)
	No	97 (45.5)
Usual use sandals in toilet	Routine	116 (54.5)
	Un-routine	97 (45.5)
District	Muara Kaman	95 (44.6)
	Marangkayu	118 (55.4)
Organic carbon content in soil (%)	1.37-2.47	91 (42.7)
	>2.47-4.04	122(57.3)
pH the soil	4.26-5.85	102 (47.9)
	>5.85-6.92	111 (52.1)
Clay content in soil (%)	4-18.5	96 (45.1)
	>18.5-42.50	117 (54.9)
Temperature (^{0}C)	28-28.6	118 (55.4)
	>28.6 -29.5	95 (44.6)
Humidity (%)	65	118 (55.4)
	66	95 (44.6)
Number day of rainfall (day)	164	95 (44.6)
	174	118 (55.4)

Rainfall volume (mm^3)	3549	95 (44.6)
	4000	118 (55.4)
Elevation from above of sea (m)	15-41.6	97 (45.5)
	>41.6-50	116 (54.5)
Texture of soil	Sandy soil with organic material	139 (65.3)
	Non-sandy soil with organic material	74(37.3)
Vegetation	Surrounding palm plantation and/or rubber plantation	167 (78.4)
	Surrounding rice field	46 (21.6)
Village areas	Buffer river/sea	166(77.9)
	Hill area	47(22.1)
Dry or wet soil surrounding the house	Dry soil	169(79.3)
	Wet soil	44 (20.7)
Having cat	Not having cat	80 (37.6)
	Having cat	133 (62.4)
Having a dog	Not having dog	4(1.9)
	Having dog	209 (98.1)
Hookworm in cat	Negative	80 (37.6)
	Positive	133 (62.4)
Hookworm in dog	Negative	4 (1.9)
	Positive	209 (98.1)
S. stercoralis in cat	Negative	134 (62.9)
	Positive	79 (37.1)
S. stercoralis in dog	Negative	52 (24.4)

	Positive	**161 (75.6)**
Live together with human infected with *S. stercoralis*	**No**	**194 (91.1)**
	Yes	**19 (8.9)**
Live together with human infected with hookworm	**No**	**152 (71.4)**
	Yes	**61 (28.6)**
Live together with human infected with hookworm and *S. stercoralis* co-infection	**No**	**196 (92.0)**
	Yes	**17 (8.0)**

Fig. 1 Geographic characteristics of Muarakaman (MN) district and Marangkayu (MU) district; a and c show the geographic characteristics of the MN district, b and d show the geographic characteristics of the MU district

Parasitological Findings

Prevalence hookworm infection, *Strongyloides stercoralis* and co-infection were diagnosed by Kato Katz technique and APC method showed of 213 tested samples from the community have 154 (27.7%) cases found positive with mono-hookworm infection and 17 (8.0%) cases found positive with *Strongyloides* infection and co-infection 14 (6.6%). Detail data of prevalence of hookworm, *Strongyloides stercoralis,* and co-infection were explained below:

Table 4 Prevalence of Hookworm, Strongyloides stercoralis and Co-infection among Communities in East Kalimantan Province

Infections	Muara Kaman District		Marangkayu District		Total	
	Positive	Negative	Positive	Negative	Positive	Negative
Mono-Hookworm	50 (52.6%)	45 (47.4%)	9 (7.6%)	109 (92.4%)	59 (27.7%)	154 (72.3%)
S. stercoralis	3 (3.2%)	92 (96.8%)	14 (11.9%)	104 (88.1%)	17 (8.0%)	196 (92%)
Co-infection	3 (3.2%)	92 (96.8%)	11 (9.3%)	107 (90.7%)	14 (6.6%)	199 (93.4%)

The prevalence of mono-hookworm infection in Muara Kaman district is higher than in Marangkayu district was 50 (52.6%) and 9 (7.6%) respectively, while the prevalence *Strongyloides stercoralis*, Marangkayu district 14 (11.9%) is higher than Muara Kaman district 3 (3.2%). The prevalence of co-infection was showed in Marangkayu district 11 (9.3%) where is higher than Muara Kaman district 3 (3.2%).

Mono-Hookworm infection in East Kalimantan province

The prevalence of hookworm infection in East Kalimantan province with positive and negative cases, 59 (27.7%), and 154 (72.3%) respectively, while the prevalence of mono-hookworm infection Muarakaman district 50 (52.6%) is higher than Marangkayu district 9 (7.6%).

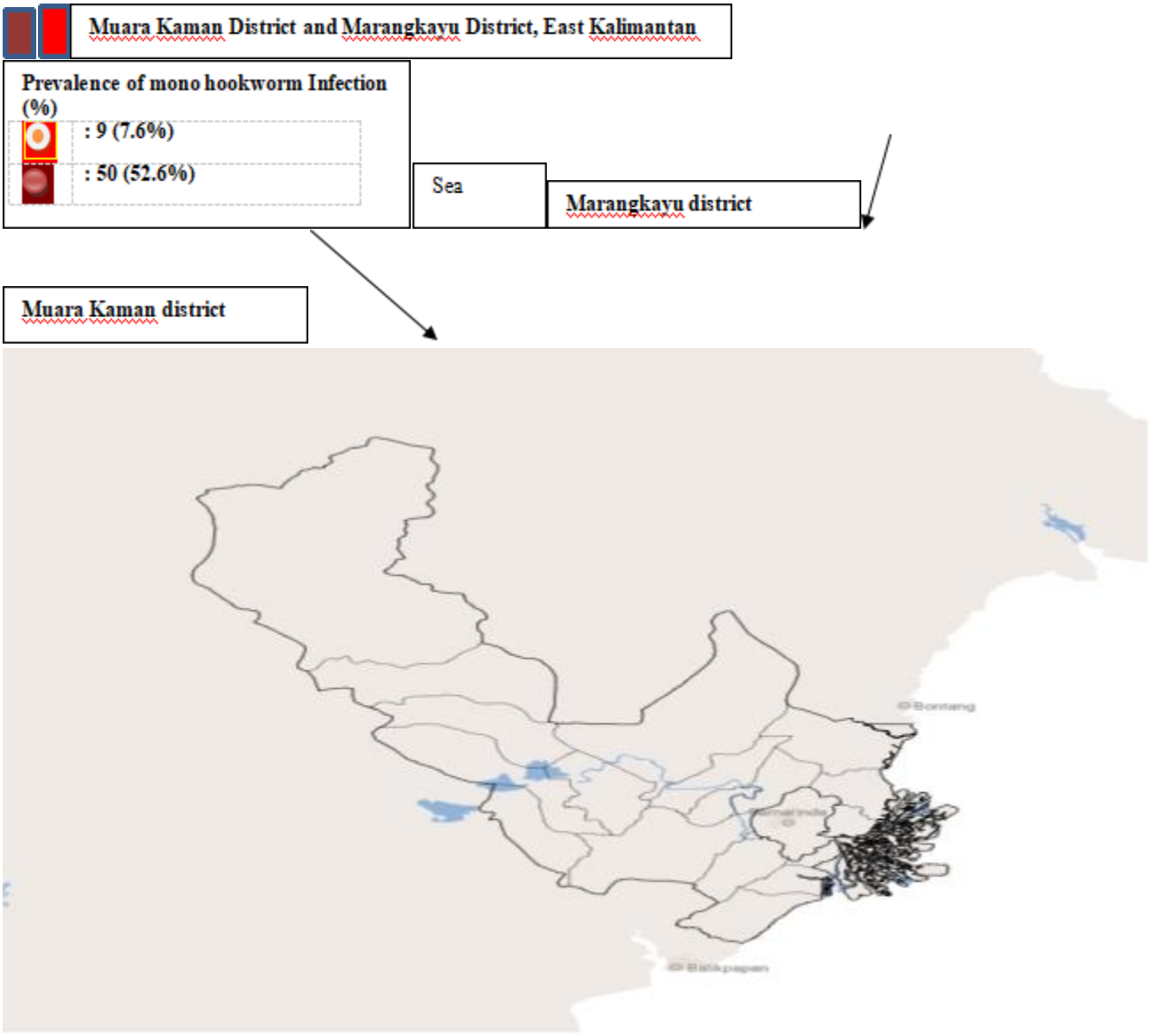

Fig 1. Prevalence of Hookworm Infection in Muara Kaman District and Marangkayu District, East Kalimantan Province

Risk factors of Mono-hookworm infection in East Kalimantan Province

Characteristic, facilitate sanitation of participants and hookworm infection

Table 5. Characteristic, facilitate Sanitation of participants and mono-hookworm infection

Variable	Category	Hookworm infection		
		Negative n(%)	Positive n(%)	*P-value*
Gender	**male**	**89 (68.5)**	**41 (31.5)**	**0.117**
	female	**65 (78.3)**	**18 (21.7)**	
Age (years)	**2-12**	**91 (79.8)**	**23 (20.2)**	**0.008**
	13 and above	**63 (63.6)**	**36 (36.4)**	
Main Occupation	**Farmer**	**46 (65.7)**	**24 (34.3)**	**0.186**
	At home	**45 (81.8)**	**10 (18.2)**	
	At school	**59 (72.8)**	**22 (27.2)**	
	Others	**4 (57.1)**	**3 (42.9)**	
Occupation	**Non-farmer**	**108 (78.3)**	**30 (21.7)**	**0.008**
	Farmer	**46 (61.3)**	**29 (38.7)**	
Kinds of Floor covering indoor of the house	**Sanitary floor (cement, wood, etc)**	**153 (72.2)**	**59 (27.8)**	**0.535**
	Soil floor	**1 (100)**	**0 (0.0) (100)**	
Yard covering	**Not soil**	**24 (68.6)**	**11 (31.4)**	**0.590**
	Soil	**130 (73.0**	**48 (27.0)**	
Water waste treatment	**Sanitary water waste treatment**	**82 (55.6)**	**26 (44.4)**	**0.230**
	Without water waste treatment	**72 (57.1)**	**33(42.9)**	
Water resources for daily activity	**Sanitary water resources**	**78 (84.8)**	**14 (15.2)**	**0.000**
	Un-sanitary water resources	**76 (62.8)**	**45 (37.2)**	
Drinking water	**Sanitary of drinking Water**	**108 (92.3)**	**9 (28.2)**	**0.000**
	Un-sanitary drinking water	**46 (47.9)**	**50 (62.5)**	
Toilet	**Sanitary toilet in home**	**136 (75.1)**	**45 (24.9)**	**0.028**
	Open defecation (plantation, garden or river	**18 (56.3)**	**15 (43.7)**	

Table 6 showed the result of Pearson chi-square analysis that age (p value= 0.008), occupation, (p-value= 0.008), water resources for daily activity (p=0.000, drinking water (p-value= 0.000) and toilet (p value= 0.028) have a significant correlation with mono hookworm infection (p-value < 0.05), while gender, floor indoor, yard covering in outside surrounding house, water waste treatment, water sources, drinking water, and toilet have not significant correlation with mono hookworm infection.

Table 6. Personal hygiene and Mono-hookworm infection

Variable	Category	Mono-hookworm Infection		
		Negative n (%)	Positive n (%)	*P-value*
Frequency using shoes on out-door	**Routine**	**45 (60.8)**	**29 (39.2)**	**0.006**
	Un-routine	**109 (78.4)**	**30 (21.6)**	
Usual wash foot after soil contact	**washing foot after soil contact**	**23 (88.5)**	**3 (11.5)**	**0.049**
	Not washing foot after soil contact	**131 (70.1)**	**56 (29,9)**	
Washing fruit/vegetable before eaten	**Routine**	**26 (78.8)**	**7 (21.2)**	**0.365**
	Un-routine	**128 (71.1)**	**52 (28.9)**	
Usual ate row/un-cook vegetable	**no**	**116 (67.4)**	**56 (32.6)**	**0.001**
	yes	**38 (92.7)**	**3 (7.3)**	
Pet contact	**no**	**111 (68.9)**	**50 (31.1)**	**0.054**
	yes	**43 (82.7)**	**9 (17.3)**	
Washing hand after pet contact	**Washing hand**	**4 (100)**	**0 (0.0)**	**0.211**
	Not washing	**150 (71.8)**	**59 (28.2)**	
Washing hand after soil contact	**Washing hand**	**22 (88.0)**	**3 (12.0)**	**0.062**
	Not washing	**132 (70.2)**	**56 (29.8)**	
Washing foot before house enter	**No**	**6 (46.2)**	**7 (53.8)**	**0.030**
	Yes	**148 (74.0)**	**52 (26.0)**	
Usual use toilet at home	**Yes**	**77 (66.4)**	**39 (33.6)**	**0.035**
	No	**77 (79.4)**	**20 (20.6)**	
Usual use sandals in toilet	**Routine**	**77 (66.4)**	**39 (33.6)**	**0.035**
	Un-routine	**77 (79.4)**	**20 (20.6)**	

Several variables of personal hygiene have a significant correlation with mono-hookworm infection consist frequency using shoes on out-door (p= 0.006), usually ate row/un-cook vegetable (p= 0.001), washing foot before house-entering (p=0.030), usual use toilet at home (p- 0.035) and usual use sandals in the toilet (0.035). While usual wash foot after soil contact, washing fruit/vegetable before eaten, pet contact, washing hand after soil contact, and washing foot before house enter have not significant correlation with hookworm infection.

Environmental Risk Factors of Mono hookworm infection in East Kalimantan

Environmental risk factors of Hookworm infection in East Kalimantan Province, Indonesia

Table 7. Environmental Factors and Hookworm infection

Variable	Category	Hookworm infection		*P-value*
		Negative n (%)	Positive n (%)	

District	**Muarakaman**	**45 (47.4)**	**50 (52.6)**	**0.000**
	Marangkayu	**109 (52.6)**	**9 (7.6)**	
Organic carbon content in soil (%)	**1.37-2.47**	**79 (86.8)**	**12 (13.2)**	**0.000**
	>2.47-4.04	**75 (61.5)**	**47 (38.5)**	
pH soil	**4.26-5.85**	**76 (74.5)**	**26 (25.5)**	**0.490**
	>5.85-6.92	**78 (71.3)**	**33 (29.7)**	
Clay content in soil (%)	**4-18.5**	**66 (68.7)**	**30 (31.3)**	**0.294**
	>18.5-42.50	**88 (75.2)**	**29 (24.8)**	
Temperature (^{0}C)	**28-28.6**	**109 (92.4)**	**9 (7.6)**	**0.000**
	>28.6 -29.5	**45 (47.4)**	**50 (52.6)**	
Humidity (%)	**65**	**109 (92.4)**	**9 (7.6)**	**0.000**
	66	**45 (47.4)**	**50 (52.6)**	
Number day of rainfall (day)	**164**	**45 (47.4)**	**50 (52.6)**	**0.000**
	174	**109 (92.4)**	**9 (7.6)**	
Rainfall volume (mm^3)	**3549**	**45 (47.4)**	**50 (52.6)**	**0.000**
	4000	**109 (92.4)**	**9 (7.6)**	
Elevation from above of sea (m)	**15-41.6**	**47 (48.5)**	**50 (51.5)**	**0.000**
	>41.6-50	**107 (92.2)**	**9 (7.8)**	
Texture of soil	**Sandy soil with organic material**	**103 (74.1)**	**36 (25.9)**	**0.421**
	Non-sandy soil with organic material	**51 (68.9)**	**23 (31.1)**	
Vegetation	**Surrounding palm plantation and/or rubber plantation**	**112 (67.1)**	**55(32.9)**	**0.001**
	Surrounding rice field	**42 (91.3)**	**4 (8.7)**	
Village areas	**Buffer river/sea**	**111 (66.9)**	**55 (33.1)**	**0.001**
	Hill area	**43 (91.5)**	**4 (8.5)**	
Dry or wet soil surrounding the house	**Dry soil**	**129 (76.3)**	**40 (23.7)**	**0.010**
	Wet soil	**25 (56.8)**	**19 (43.2)**	
Having cat	**Not having cat**	**53 (66.3)**	**27 (33.7)**	**0.126**
	Having cat	**101 (57.1)**	**32 (24.1)**	
Having a dog	**Not having dog**	**4 (100)**	**0 (0.0)**	**0.211**
	Having dog	**150 (71.8)**	**59(28.2)**	
Hookworm in cat	**Negative**	**53 (66.3)**	**27 (33.7)**	**0.126**
	Positive	**101 (57.1)**	**32 (24.1)**	
Hookworm in dog	**Negative**	**4 (100)**	**0 (0.0)**	**0.211**
	Positive	**150 (71.8)**	**59(28.2)**	
Live together with human infected with hookworm	**No**	**117 (77.0)**	**35 (23.0)**	**0.016**
	Yes	**37 (60.7)**	**24 (39.3)**	

The results statistical analysis between environmental risk factors with hookworm infection showed several of environmental factors have correlated significant with hookworm infection ($p<0.05$) such as district (p= 0.000), organic carbon content in soil (p= 0.000), temperature (p= 0.000), humidity (p= 0.000), number day of rainfall (p= 0.000), rainfall volume (p= 0.000), vegetation (p= 0.001), village areas (p= 0.001), dry or wet soil surrounding house (p= 0.010) and live together with human infected with hookworm (p= 0.016) . While the pH of the soil, clay content in the soil, the texture of the soil, and hookworm infection in cat, hookworm infection in the dog have not significantly correlated with prevalence of hookworm infection in East Kalimantan province.

Essential risk factors of mono-hookworm infection in East Kalimantan province.

Essential risk factors of hookworm infection showed below:

Table 8. Essential Risk Factors of mono-hookworm infection in East Kalimantan province

Essential risk factors	Category	Hookworm infection		OR(95%Cl)
		Negative n(%)	Positive n(%)	
District	Muarakaman	45 (38.9)	50 (61.1)	4.64 (2.52-8.54)
	Marangkayu	109 (52.6)	9 (7.6)	0.35 (0.26-0.45)
Organic carbon content in soil (%)	1.37-2.47	79 (86.8)	12 (13.2)	0.61 (0.50-0.75)
	>2.47-4.04	75 (61.5)	47 (38.5)	2.52 (1.49-4.29)
Temperature (^{0}C)	28-28.6	109 (92.4)	9 (7.6)	0.35 (0.26-0.45)
	>28.6 -29.5	45 (47.4)	50 (52.6)	4.64 (2.52-8.54)
Humidity (%)	65	109 (92.4)	9 (7.6)	0.35 (0.26-0.45)
	66	45 (47.4)	50 (52.6)	4.64 (2.52-8.54)
Number day of rainfall (day)	164	45 (47.4)	50 (52.6)	4.64 (2.52-8.54)
	174	109 (92.4)	9 (7.6)	0.35 (0.26-0.45)
Rainfall volume (mm^3)	3549	45 (47.4)	50 (52.6)	4.64 (2.52-8.54)
	4000	109 (92.4)	9 (7.6)	0.35 (0.26-0.45)
Vegetation	Surrounding palm plantation and/or rubber plantation	112 (67.1)	55(32.9)	4.02 (1.51-10.73)
	Surrounding rice field	42 (91.3)	4 (8.7)	0.78 (0.69-0.88)
Village areas	Buffer river/sea	111 (66.9)	55 (33.1)	4.12 (1.55-10.97)
	Hill area	43 (91.5)	4 (8.5)	0.77 (0.69-0.87)
Dry or wet soil surrounding the house	Dry soil	129 (76.3)	40 (23.7)	0.50 (0.30-0.84)
	Wet soil	25 (56.8)	19 (43.2)	1.24 (1.02-1.49)

Live together with human infected by hookworm	**No**	**117 (77.0)**	**35 (23.0)**	**0.59 (0.39-0.90)**
	Yes	**37 (60.7)**	**24 (39.3)**	**1.28 (1.02-1.61)**
Age (years)	**2-12**	**91 (79.8)**	**23 (20.2)**	**0.67 (0.51-0.89)**
	13 and above	**63 (63.6)**	**36 (36.4)**	**1.52 (1.07-2.14)**
Occupation	**Non farmer**	**108 (78.3)**	**30 (21.7)**	**0.61 (0.43-0.87)**
	Farmer	**46 (61.3)**	**29 (38.7)**	**1.38 (1.05-1.81)**
Water resources for daily activity	**Sanitary water resources**	**78 (84.8)**	**14 (15.2)**	**0.65 (0.52-080)**
	Un-sanitary water resources	**76 (62.8)**	**45 (37.2)**	**2.13 (1.32-3.46)**
Drinking water	**Sanitary drinking of water**	**108 (92.3)**	**9 (28.2)**	**0.35 (0.27-0.46)**
	Un-sanitary of drinking water	**46 (47.9)**	**50 (62.5)**	**4.60 (2.50-8.46)**
Toilet	**Sanitary toilet in home**	**136 (75.1)**	**45 (24.9)**	**0.49 (0.26-0.93)**
	Open defecation (plantation, garden or river	**18 (56.3)**	**15 (43.7)**	**1.16 (0.99-1.35)**
Frequency using shoes on out-door	**Routine**	**45 (60.8)**	**29 (39.2)**	**1.39 (1.06-1.83)**
	Un-routine	**109 (78.4)**	**30 (21.6)**	**0.59 (0.42-0.85)**
Usual wash foot after soil contact	**washing foot after soil contact**	**23 (88.5)**	**3 (11.5)**	**0.90 (0.82-0.98)**
	Not washing foot after soil contact	**131 (70.1)**	**56 (29,9)**	**2.94 (0.92-9.42)**
Usual ate raw/un-cook vegetable	**no**	**116 (67.4)**	**56 (32.6)**	**4.85 (1.56-15.12)**
	yes	**38 (92.7)**	**3 (7.3)**	**0.79 (0.71 -0.88)**
Washing foot before house enter	**No**	**6 (46.2)**	**7 (53.8)**	**1.09 (0.99-1.20)**
	Yes	**148 (74.0)**	**52 (26.0)**	**0.33 (0.11-0.94)**
Usual use toilet at home	**Yes**	**77 (66.4)**	**39 (33.6)**	**1.47 (1.00-2.18)**
	No	**77 (79.4)**	**20 (20.6)**	**0.76 (0.69-0.96)**
Usual use sandals in toilet	**Routine**	**77 (66.4)**	**39 (33.6)**	**1.47 (1.00-2.18)**
	Un-routine	**77 (79.4)**	**20 (20.6)**	**0.76 (0.69-0.96)**

Muara Kaman district was more 4.46 likely to be infected mono hookworm than Marangkayu district (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000). Organic carbon content in soil >2.47-4.04% was more 2.52 likely to be infected mono hookworm than organic carbon content in soil 1.37-2.47 (OR: 2.52 (95%CI: 1.49-4.29, p-value= 0.000). The temperature in category >28.6-29.5^{0}C was more 4.46 likely to be infected mono hookworm than 28-28.6 (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000), humidity 66% was more 4.46 likely to be infected mono hookworm than humidity 65% (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000)), number day of rainfall (164 days) was more 4.46 likely to be infected mono hookworm than 165 days long rainfall (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000), and rainfall volume (3549 mm^3) was more 4.64 likely to be infected mono hookworm than rainfall volume in category 4000 mm^3 (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000). Vegetation in category surrounding palm and or rubber

plantation was more 4.02 likely to be infected mono hookworm than surrounding rice field (OR: 4.02 (95%CI: 1.51-10.73, p-value= 0.001). Villages area where is in buffer river or sea area were more 4.12 to be infected mono hookworm than hill areas (OR: 4.12 (95%CI: 1.55-10.97, p-value= 0.001). Wet soil surrounding houses were more 1.24 likely to be infected mono hookworm than dry soil (OR: 1.24 (95%CI: 1.02-1.49, p-value= 0.010). Live together with humans infected by hookworm was 1.28 more likely to be infected mono hookworm than has not to live together (OR: 1.28 (95%CI: 1.02-1.61, p-value= 0,016).

Ages old in category 13 years old and above were more 1.52 likely than 2-12 years old (OR: 1.52 (95%CI: 1.07-2.14, p-value= 0.008). Farmers were more 1.38 likely to be infected mono hookworm than others occupation (OR: 1.38 (95%CI: 1.05-1.81, p-value= 0.008). Un-sanitary water resources were more 2.13 likely to be infected mono hookworm than sanitary water resources (OR: 2.13 (95%CI: 1.32-3.46, p-value= 0.000). Participants in un-sanitary drinking water were more 4.60 likely to be infected mono hookworm than a participant in category sanitary drinking water (OR: 4.60 (95%CI: 2.50-8.46, p-value=0.000). Participants in the category open defecation were more 1.16 to be infected mono hookworm than in the category sanitary toilet at home (OR: 1.16 (95%CI: 0.99-1.35, p-value= 0.028). Routine use shoes when in outdoor activity became protecting factor for hookworm infection (OR: 1.39 (95%CI: 1.06-1.83, p-value= 0.006). Participants in the category not washing foot after soil contact were more 2.94 likely than routine washing foot after soil contact (OR: 2.94 (95%CI: 0.92-9.42, p-value = 0.049). No usual ate raw/un-cook vegetable in rural communities East Kalimantan were protecting factor for hookworm infection (OR: 4.85 (95%CI: 1.56-15.12, p-value= 0.001). Participants whom no routine wash foot before house enter were protecting factor for hookworm infection (OR: 1.09 (95%CI: 0.99-1.20, p-value= 0.030)

Participants who use the toilet at home and use sandals in the toilet became protecting factors for hookworm infection (OR: 1.47 (95%CI: 1.00-2.18, p-value= 0.035).

S. stercoralis infection in East Kalimantan

The prevalence of *S. stercoralis* infection in East Kalimantan with positive and negative cases, 17 (8.0%), and 196 (92%) respectively, while the prevalence of *S. stercoralis* infection Marangkayu district 14 (11.9%) is higher than Muarakaman district 3 (3.2%).

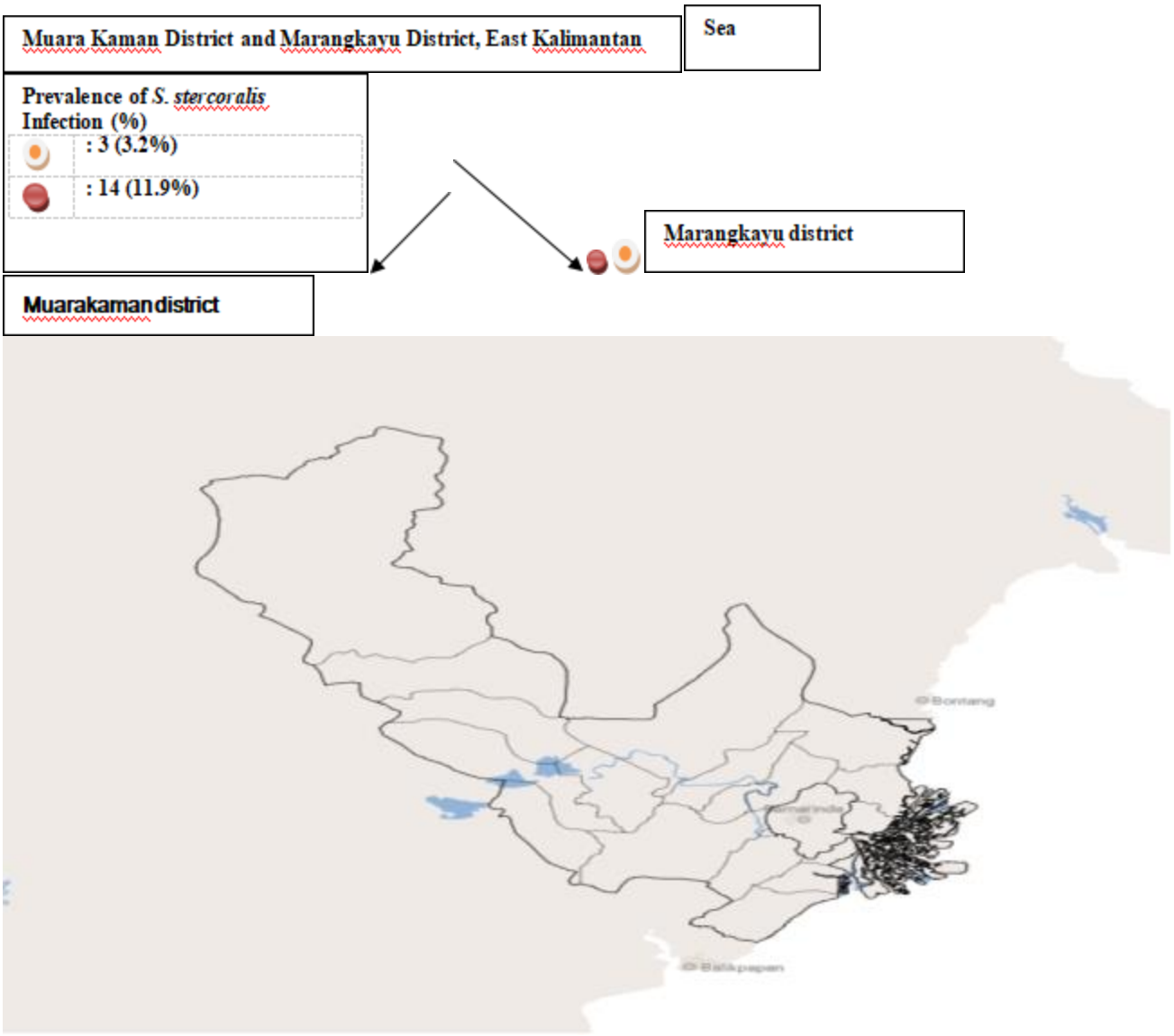

Fig 2. Prevalence *S. stercoralis* infection in Muarakaman district and Marangkayu district, East Kalimantan province

Risk factors of *S. stercoralis* infection in East Kalimantan province

Characteristic, Sanitation facilities of participants and *S. stercoralis*

Table 9. Characteristic, Sanitation Facilities of Participants and *S. stercoralis* infection

Variable	Category	*S. stercoralis*

		Negative n (%)	Positive n (%)	*P-value*
Gender	male	122 (93.8)	3 (3.2)	0.218
	female	74 (89.2)	14 (11.9)	
Age (years)	2-12	103 (90.4)	11 (9.6)	0.173
	13 and above	93 (93.9)	6 (6.1)	
Main Occupation	Farmer	67 (95.7)	3 (4.3)	0.160
	At home	47 (85.5)	8 (14.5)	
	At school	75 (92.6)	6 (7.4)	
	Others	7 (100)	0 (0.0)	
Occupation	Non-farmer	124 (89.9)	14 (10.1)	0.114
	Farmer	72 (92)	3 (4.0)	
Kinds of Floor covering indoor of the house	Sanitary floor (cement, wood, etc)	195 (92)	17 (8.0)	0.764
	Soil floor	1 (100)	0 (0.0)	
Yard covering	Not soil	32 (91.4)	3 (8.6)	0.888
	Soil	164 (92.1)	14 (7.9)	
Water waste treatment	Healthy water waste treatment	100 (92.6)	8 (7.4)	0.754
	Without water waste treatment	96 (91.4)	9 (8.6)	
Water resources for daily activity	Sanitary water resources	84 (91.3)	8 (8.7)	0.737
	Un-sanitary water resources	112 (92.6)	9 (7.4)	
Drinking water	Sanitary of drinking water	104 (88.9)	13 (11.1)	0.63
	Un-sanitary of drinking water	92 (95.8)	4 (4.2)	
Toilet	Sanitary toilet in the home	167 (92.3)	14 (7.7)	0.752
	Open defecation (plantation, garden, or river)	29 (90.6)	3 (9.4)	

The table above showed the result of Pearson chi-square analysis of characteristics sanitation facilities have not associated with *S stercoralis* infection.

Table 10. Personal hygiene and *S. stercoralis* infection

Variable	Category	*S. stercoralis*		*P-value*
		Negative n (%)	Positive n (%)	
Frequency using shoes on out-door	Routine	70 (94.6)	4 (5.4)	0.311
	Un-routine	126 (90.6)	13 (9.4)	
Usual wash foot after soil contact	washing foot after soil contact	22 (84.6)	4 (15.4)	0.137
	Not washing foot after soil contact	174 (93.0)	13 (7.0)	
Washing fruit/vegetable before eaten	Routine	31 (93.9)	2 (6.1)	0.658
	Un-routine	165 (91.7)	15 (8.3)	
Usual ate row/un-cook fish/meat/vegetable	No	161 (93.6)	11 (6.4)	0.080
	Yes	35 (85.4)	6 (14.6)	
Pet contact	No	198 (91.9)	13 (8.1)	0.930
	Yes	48 (92.3)	4 (7.3)	
Washing hand after pet contact	Washing hand	4 (100)	0 (0.0)	0.551
	Not washing	192 (91.9)	17 (8.1)	
Washing hand after soil contact	Washing hand	21 (84.0)	4 (16.0)	0.115
	Not washing	175 (93.1)	13 (6.9)	
Washing foot before house enter	No	13 (100)	0 (0.0)	0.273
	Yes	183 (91.5)	17 (8.5)	

Usual use toilet at home	Yes	106 (91.4)	10 (8.6)	0.706
	No	90 (92.8)	7 (7.2)	
Usual use sandals in toilet	Routine	106 (92.4)	10 (8.6)	0.706
	Un-routine	90 (92.8)	7 (7.2)	

The results above showed that personal hygiene had not significant correlated/associated with *S. stercoralis* infection

Environmental Risk Factors of *S. stercoralis* Infection in East Kalimantan

Environmental risk factors and *S. stercoralis* infection in East Kalimantan Province, Indonesia

Table 11. Environmental Factors and *S. stercoralis* Infection

Variable	Category	*S. stercoralis*		*P-value*
		Negative n (%)	Positive n (%)	
District	Muara Kaman	92 (96.8)	3 (3.2)	0.020
	Marangkayu	104 (88.1)	14 (11.9)	
Organic carbon content in soil (%)	1.37-2.47	78 (85.7)	13 (14.3)	0.003
	>2.47-4.04	118 (96.7)	4 (3.3)	
pH soil	4.26-5.85	95 (93.1)	7 (6.9)	0.564
	>5.85-6.92	101 (91.0)	10 (9.0)	
Clay content in soil (%)	4-18.5	89 (92.7)	7 (7.3)	0.737
	>18.5-42.50	107 (91.5)	10 (8.5)	
Temperature (^{0}C)	28-28.6	104 (88.1)	14 (11.9)	0.020
	>28.6 -29.5	92 (96.8)	3 (3.2)	
Humidity (%)	65	104 (88.1)	14 (11.9)	0.020
	66	92 (96.8)	3 (3.2)	

Number day of rainfall (day)	164	92 (96.8)	3 (3.2)	0.020
	174	104 (88.1)	14 (11.9)	
Rainfall volume (mm^3)	3549	92 (96.8)	3 (3.2)	0.020
	4000	104 (88.1)	14 (11.9)	
Elevation from above of sea (m)	15-41.6	94 (96.9)	3 (3.1)	0.016
	>41.6-50	102 (87.9)	14 (12.1)	
Texture of soil	Sandy soil with organic material	125 (89.9)	14 (10.1)	0.123
	Non-sandy soil with organic material	71 (95.9)	3 (4.1)	
Vegetation	Surrounding palm plantation and/or rubber plantation	155 (92.8)	12 (7.2)	0.414
	Surrounding rice field	41 (89.1)	5 (10.9)	
Village areas	Buffer river/sea	154 (92.8)	12 (7.2)	0.446
	Hill area	42 (89.4)	5 (10.6)	
Dry or wet soil surrounding the house	Dry soil	154 (91.1)	15 (8.9)	0.345
	Wet soil	42 (95.5)	2 (4.5)	
Having cat	Not having cat	75 (93.8)	5 (6.3)	0.470
	Having cat	121 (91.0)	12 (9.0)	
Having a dog	Not having dog	4 (100)	0 (0.0)	0.552
	Having dog	192 (91.9)	17 (8.1)	
S. stercoralis in cat	Negative	124 (92.5)	10 (7.5)	0.716
	Positive	72 (91.1)	7 (8.9)	
S. stercoralis in dog	Negative	51(98.1)	1 (1.9)	0.064
	Positive	145 (90.1	9 (9.9)	
Live together with human	No	192 (99.0)	2 (1.0)	0.000

infected with *S. stercoralis*	**Yes**	**4 (21.1)**	**15 (78.9)**

The results of statistical analysis between environmental risk factors with *S. stercoralis* infection showed several of environmental factors have correlated significantly with *S. stercoralis* ($p<0.05$) such as district, the organic carbon content in the soil, humidity, temperature, elevation, number day of rainfall, rainfall volume, elevation, and live together with human infected with *S. stercoralis*. Environmental risk factors which were the highest association/correlation *S. stercoralis* infection were organic carbon content in soil ($p= 0.003$) and live together with humans infected with *S. stercoralis* ($p=0.000$).

Essential risk factors of *S. stercoralis* in East Kalimantan province.

The estimated value of the risk factor of *S. stercoralis* infection explained in table 5 below:

Table 12. Essential risk factors of *S. stercoralis* in East Kalimantan province

Essential risk factors	Category	*S. stercoralis*		OR (95%CI)
		Negative n (%)	Positive n(%)	
District	**Muarakaman**	**92 (96.8)**	**3 (3.2)**	**0.64 (0.50-0.83)**
	Marangkayu	**104 (88.1)**	**14 (11.9)**	**2.66 (0.94-7.51)**
Organic carbon content in soil (%)	**1.37-2.47**	**78 (85.7)**	**13 (14.3)**	**2.56 (1.08-6.07)**
	>2.47-4.04	**118 (96.7)**	**4 (3.3)**	**0.52 (0.31-0.71)**
Temperature (^{0}C)	**28-28.6**	**104 (88.1)**	**14 (11.9)**	**0.64 (0.50-0.83)**
	>28.6 -29.5	**92 (96.8)**	**3 (3.2)**	**2.66 (0.94-7.51)**
Humidity (%)	**65**	**104 (88.1)**	**14 (11.9)**	**2.66 (0.94-7.51)**
	66	**92 (96.8)**	**3 (3.2)**	**0.64 (0.50-0.83)**
Number day of rainfall (day)	**164**	**92 (96.8)e**	**3 (3.2)**	**0.64 (0.50-0.83)**
	174	**104 (88.1)**	**14 (11.9)**	**2.66 (0.94-7.51)**

Rainfall volume (mm^3/year)	**3549**	**92 (96.8)**	**3 (3.2)**	**0.64 (0.50-0.83)**
	4000	**104 (88.1)**	**14 (11.9)**	**2.66 (0.94-7.51)**
Elevation from above of sea (m)	**15-41.6**	**94 (96.9)**	**3 (3.1)**	**0.63 (0.49-0.82)**
	>41.6-50	**102 (87.9)**	**14 (12.1)**	**2.72 (0.96-7.67)**
Live together with human infected with *S. stercoralis*	**No**	**192 (99.0)**	**2 (1.0)**	**0.02 (0.09-0.062)**
	Yes	**4 (21.1)**	**15 (78.9)**	**8.33 (2.27-30.61)**

The result analysis of risk factors and *S. stercoralis* showed the variables that were associated. Participants in Marangkayu district were more than 2.66 to be infected *S. stercoralis* than Muarakaman district (OR: 2.66 95%CI: (0.94-7.51, p-value=0.020). Participants in category organic carbon content in soil 1.37-2.47% were more 2.56 likely to be infected S. stercoralis than organic carbon content >2.47-4.04 (OR: 2.56 (95%CI: 1.08-6.07, p-value= 0.003). Communities in temperature >28.6 -29.5^{0}C were more 2.66 likely than 28-28.6^{0}C (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Participants in humidity 65 were more 2.66 likely than 66 (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Participants in areas with 174 days of rainfall were 2.66 likely than 164 days (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Communities in rainfall volume 4000 mm^3/year were 2.66 likely than 164 days (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Elevation from above of sea >41.6-50 m were more likely than in elevation 15-41.6 (OR: 2.72 (0.96-7.67, p-value= 0.016). Participants who live together with human infected with *S. stercoralis* were more 8.33 likely to be infected S. stercoralis than had not lived together (OR: 8.33 (95%CI: 2.27-30.61, p-value= 0.000).

Hookworm and *S. stercoralis* Co-infection in East Kalimantan Province, Indonesia

The prevalence of co-infection of hookworm and *S. stercoralis* in Marangkayu district is higher than in Muarakaman district was 11 (9.3%) and 3 (3.2%) respectively, while the overall prevalence in East Kalimantan was 14 (6.6%)

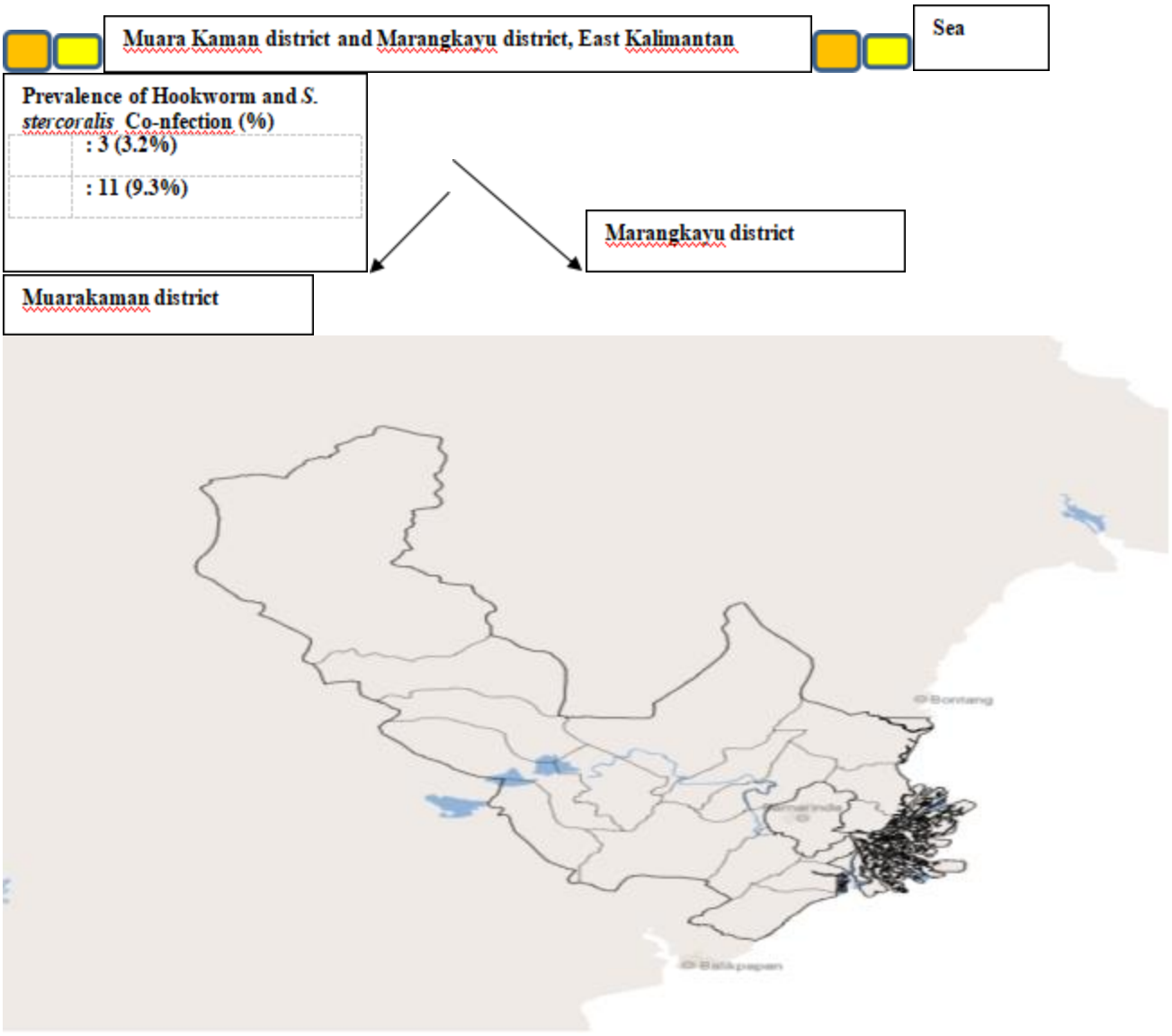

Fig 3. Prevalence hookworm and S. stercoralis coinfection in Muarakaman district and Marangkayu district, East Kalimantan Province

Risk factors of hookworm and *S stercoralis* co-infection in East Kalimantan province

Characteristic, facilitate Sanitation of Participants and Hookworm and *S. stercoralis* Co-infection showed below:

Table 13. Characteristic, facilitate sanitation of participants and hookworm and *S. stercoralis* co-infection

Variable	Category	Co-infection	
		Negative n (%)	Positive n (%)

				P-value
Gender	**male**	**123 (94.6)**	**7 (5.4)**	**0.381**
	female	**76 (91.6.4)**	**7 (8.4)**	
Age (years)	**2-12**	**210 (93.0)**	**8 (7.0)**	**0.779**
	13 and above	**186 (93.9)**	**6 (6.1)**	
Main Occupation	**Farmer**	**67 (95.7)**	**3 (4.3)**	**0.626**
	At home	**50 (90.9)**	**5 (9.1)**	
	At school	**75 (92.6)**	**6 (7.4)**	
	Others	**7 (100)**	**0 (0.0)**	
Occupation	**Non-farmer**	**127 (92.0)**	**11 (8.0)**	**0.264**
	Farmer	**77 (96.0)**	**3 (4.0)**	
Kinds of Floor covering indoor of house	**Sanitary floor (cement, wood, etc)**	**198 (94.4)**	**14 (6.6)**	**0.790**
	Soil floor	**1 (100)**	**0 (0.0)**	
Yard covering	**Not soil**	**33 (94.4)**	**2 (5.6)**	**0.823**
	Soil	**166 (93.3)**	**12 (6.7)**	
Water waste treatment	**Healhty water waste treatment**	**100 (92.6)**	**8 (7.4)**	**0.618**
	Without water waste treatment	**99 (94.3)**	**6 (5.7)**	
Water resources for daily activity	**Sanitary water resources**	**86 (92.4)**	**6 (6.5)**	**0.979**
	Un-sanitary water resources	**113 (93.4)**	**8 (6.6)**	
Drinking water	**Sanitary of drinking water**	**107 (91.5)**	**10 (8.5)**	**0.199**
	Un-sanitary of drinking water	**92 (95.8**	**4(4.2)**	
Toilet	**Sanitary toilet in the home**	**170 (93.4)**	**11 (6.6)**	**0.488**
	Open defecation (plantation, garden, or river	**29 (90.6)**	**3 (9.4)**	

The table above showed the results Pearson chi-square analysis between characteristics, facilitate sanitation of participants, and hookworm and *S. stercoralis* co-infection have not associated (p-value > 0.05).

Personal hygiene and hookworm and *S. stercoralis* co-infection

Table 14. Personal hygiene and Hookworm and S. stercoralis co-infection

Variable	**Category**	**Co-infection**		
		Negative n (%)	**Positive n (%)**	*P-value*
Frequency using shoes on out-door	**Routine**	**71 (95.9)**	**3 (4.1)**	**0.279**
	Un-routine	**128 (92.1)**	**11 (7.9)**	

Usual wash foot after soil contact	**washing foot after soil contact**	**23 (88.5)**	**3 (11.5)**	**0.275**
	Not washing foot after soil contact	**176 (94.1)**	**11 (5.9)**	
Washing fruit/vegetable before eaten	**Routine**	**32 (97.0)**	**1 (3.0)**	**0.372**
	Un-routine	**167 (92.8)**	**13 (7.2)**	
Usual ate row/un-cook fish/meat/vegetable	**no**	**164 (95.3)**	**8 (4.7)**	**0.020**
	yes	**35 (85.4)**	**6(14.6)**	
Pet contact	**no**	**151 (93.8)**	**10 (6.2)**	**0.708**
	yes	**48 (92.3)**	**4 (7.7)**	
Washing hand after pet contact	**Washing hand**	**4 (100)**	**0 (0.0)**	**0.592**
	Not washing	**195 (93.3)**	**14 (6.7)**	
Washing hand after soil contact	**Washing hand**	**22 (88.0)**	**3 (12.0)**	**0.244**
	Not washing	**177 (94.1)**	**11 (5.9)**	
Washing foot before house enter	**No**	**13 (6.6)**	**0 (0.0)**	**0.324**
	Yes	**186 (93.0)**	**14 (7.0)**	
Usual use toilet at home	**Yes**	**109 (93.1)**	**7 (6.0)**	**0.729**
	No	**90 (92.8)**	**7 (7.2)**	
Usual use sandals in toilet	**Routine**	**109 (93.1)**	**7 (6.0)**	**0.729**
	Un-routine	**90 (92.8)**	**7 (7.2)**	

Results analysis Pearson chi-square analysis between personal hygiene and hookworm and *S. stercoralis* co-infection showed that usually ate raw vegetable has significantly correlated with hookworm and *S. stercoralis* co-infection (p= 0.020), and others personal hygiene have not correlated.

Environmental risk factors of hookworm and *S. stercoralis* co-infection in East Kalimantan

Environmental risk factors of Hookworm and *S. stercoralis* co-infection in East Kalimantan Province, Indonesia

Table 15. Environmental factors and hookworm and *S. stercoralis* co-infection

Variable	**Category**	**Co-infection**		***P-value***
		Negative n (%)	**Positive n (%)**	
District	**Muara Kaman**	**92 (96.8)**	**3 (3.2)**	**0.071**
	Marangkayu	**107 (90.7)**	**11 (9.3)**	
Organic carbon content in soil (%)	**1.37-2.47**	**81 (89.0)**	**10 (11.0)**	**0.025**
	>2.47-4.04	**188 (96.7)**	**4 (3.3)**	
pH soil	**4.26-5.85**	**97 (95.1)**	**5 (4.9)**	**0.346**

	>5.85-6.92	**102 (91.9)**	**9 (8.1)**	
Clay content in soil (%)	**4-18.5**	**90 (93.7)**	**6 (6.3)**	**0.863**
	>18.5-42.50	**109 (93.2)**	**8 (6.8)**	
Temperature (^{0}C)	**28-28.6**	**107 (89.8)**	**11 (9.3)**	**0.071**
	>28.6 -29.5	**92 (96.8)**	**3 (3.2)**	
Humidity (%)	**65**	**107 (89.8)**	**11 (9.3)**	**0.071**
	66	**92 (96.8)**	**3 (3.2)**	
Number day of rainfall (day)	**164**	**92 (96.8)**	**3 (3.2)**	**0.071**
	174	**107 (89.8)**	**11 (9.3)**	
Rainfall volume (mm^3/year)	**3549**	**92 (96.8)**	**3 (3.2)**	**0.071**
	4000	**107 (89.8)**	**11 (9.3)**	
Elevation from above of sea (m)	**15-41.6**	**94 (96.9)**	**3 (3.1)**	**0.061**
	>41.6-50	**105 (90.5)**	**11 (9.5)**	
Texture of soil	**Sandy soil with organic material**	**90 (93.7)**	**6 (6.3)**	**0.079**
	Non-sandy soil with organic material	**105 (95.2)**	**8 (6.8)**	
Vegetation	**Surrounding palm plantation and/or rubber plantation**	**156 (93.4)**	**11 (6.6)**	**0.987**
	Surrounding rice field	**43 (93.5)**	**3 (6.5)**	
Village areas	**Buffer river/sea**	**155 (93.4)**	**11 (6.6)**	**0.953**
	Hill area	**44 (93.6)**	**3 (6.4)**	
Dry or wet soil surrounding the house	**Dry soil**	**157 (92.9)**	**12 (7.1)**	**0.542**
	Wet soil	**42 (95.5)**	**2 (4.5)**	
Having a cat	**Not having a cat**	**77 (96.2)**	**3 (3.8)**	**0.197**
	Having a cat	**122 (91.7)**	**11 (8.3)**	
Having a dog	**Not having a dog**	**4 (100)**	**0 (0.0)**	**0.592**
	Having a dog	**195 (93.3)**	**14 (6.7)**	
Hookworm in cat	**Negative**	**77 (96.2)**	**3 (3.8)**	**0.197**
	Positive	**122 (91.7)**	**11 (8.3)**	
Hookworm in dog	**Negative**	**4 (100)**	**0 (0.0)**	**0.592**
	Positive	**195 (93.3)**	**14 (6.7)**	
Strongyloides in cat	**Negative**	**126 (94.0)**	**8 (6.0)**	**0.644**
	Positive	**73 (92.4)**	**6 (7.6)**	
Strongyloides in dog	**Negative**	**102 (98.1)**	**1 (1.9)**	**0.120**
	Positive	**294 (91.9)**	**13 (8.1)**	
Usual ate row/un-cook fish/meat/vegetable	**no**	**164 (95.3)**	**8 (4.7)**	**0.020**
	yes	**35 (85.4)**	**6(14.6)**	
Live together with human infected with hookworm and *S. stercoralis* co-infection	**No**	**193 (99.5)**	**1 (0.5)**	**0.000**
	Yes	**6 (31.6)**	**13 (68.4)**	

The results of statistical analysis between environmental risk factors with hookworm and *S. stercoralis* co-infection showed organic carbon content in soil and live together with humans infected with hookworm and *S. stercoralis*

co-infection have significantly correlated with hookworm and *S. stercoralis* co-infection with p-value = 0.025 and p-value= 000 respectively.

Essential risk factors of hookworm and *S. stercoralis* co-infection in East Kalimantan Province.

The estimated value of the risk factor of hookworm, *S. stercoralis,* and co-infection explained in table 16 below:

Table 16. Essential Risk Factors of Hookworm and *S stercoralis* Co-infection in East Kalimantan province

Essential risk factors	Category	Co-infection		OR (95%Cl)
		Negative n (%)	Positive n (%)	
Organic carbon content in soil (%)	1.37-2.47	81 (89.0)	10 (11.0)	2.07 (0.90-4.79)
	>2.47-4.04	188 (96.7)	4 (3.3)	0.57 (0.30-0.83)
Usual eat raw/un-cook fish/meat/vegetable	no	164 (95.3)	8 (4.7)	0.41 (0.21-0.81)
	yes	35 (85.4)	6(14.6)	1.44 (0.91-2.28)
Live together with human infected with hookworm and *S. stercoralis* co-infection	No	193 (99.5)	1 (0.5)	0.03 (0.01-0.07)
	Yes	6 (31.6)	13 (68.4)	13.58 (2.05-89.77)

Communities in areas with organic carbon content in soil 1.37-2.47% were more 2.07 likely to be infected hookworm and *S. stercoralis* co-infection than in areas with organic carbon content in soil >2.47-4.04 (OR: 2.07 (95%CI: 0.90-4.79, p-value= 0.025). Participants who usually eat raw vegetables were more 1.44 likely to be infected hookworm and *S. stercoralis* co-infection than un-usual eat raw vegetables (OR: 1.44 (0.91-2.28, p-value= 0.020). Participants who live together with human infected with hookworm and *S. stercoralis* co-infection were more 13.58 likely to be infected hookworm and *S. stercoralis* co-infection than had not live together with human infected with hookworm and *S. stercoralis* co-infection (OR: 13.58 (2.05-89.77, p-value= 0.000)

Risk factors associated with hookworm, *S. stercoralis* , and Co-infection.

Muarakaman district was more 4.46 likely to be infected mono hookworm than Marangkayu district (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000). Organic carbon content in soil >2.47-4.04% was more 2.52 likely to be infected mono hookworm than organic carbon content in soil 1.37-2.47 (OR: 2.52 (95%CI: 1.49-4.29, p-value= 0.000). The

temperature in category >28.6-29.5^{0}C was more 4.46 likely to be infected mono hookworm than 28-28.6 (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000), humidity 66% was more 4.46 likely to be infected mono hookworm than humidity 65% (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000)), number day of rainfall (164 days) was more 4.46 likely to be infected mono hookworm than 165 days long rainfall (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000), and rainfall volume (3549 mm^3) was more 4.46 likely to be infected mono hookworm than rainfall volume in category 4000 mm^3 (OR: 4.64 (95%CI: 2.52-8.54, p-value= 0.000). Vegetation in category surrounding palm and or rubber plantation was more 4.02 likely to be infected mono hookworm than surrounding rice field (OR: 4.02 (95%CI: 1.51-10.73, p-value= 0.001). Villages area where is in buffer river or sea area were more 4.12 to be infected mono hookworm than hill areas (OR: 4.12 (95%CI: 1.55-10.97, p-value= 0.001). Wet soil surrounding houses were more 1.24 likely to be infected mono hookworm than dry soil (OR: 1.24 (95%CI: 1.02-1.49, p-value= 0.010). Live together with humans infected by hookworm was 1.28 more likely to be infected mono hookworm than has not to live together (OR: 1.28 (95%CI: 1.02-1.61, p-value= 0,016).

Ages old in category 13 years old and above were more 1.52 likely than 2-12 years old (OR: 1.52 (95%CI: 1.07-2.14, p-value= 0.008). Farmers were more 1.38 likely to be infected mono hookworm than others occupation (OR: 1.38 (95%CI: 1.05-1.81, p-value= 0.008). Un-sanitary water resources was more 2.13 likely to be infected mono hookworm than sanitary water resources (OR: 2.13 (95%CI: 1.32-3.46, p-value= 0.000). Participants in un-sanitary drinking water were more 4.60 likely to be infected mono hookworm than participants in the category sanitary drinking water (OR: 4.60 (95%CI: 2.50-8.46, p-value=0.000). Participants in the category open defecation were more 1.16 to be infected mono hookworm than in the category sanitary toilet at home (OR: 1.16 (95%CI: 0.99-1.35, p-value= 0.028). Routine use shoes when in outdoor activity became a protecting factor for hookworm infection (OR: 1.39 (95%CI: 1.06-1.83, p-value= 0.006). Participants in the category not washing foot after soil contact were more 2.94 likely than routine washing foot after soil contact (OR: 2.94 (95%CI: 0.92-9.42, p-value = 0.049). No usual ate raw/un-cook vegetable in rural communities East Kalimantan were protecting factor for hookworm infection (OR: 4.85 (95%CI: 1.56-15.12, p-value= 0.001). Participants whom no routine wash foot before house enter were protecting factor for hookworm infection (OR: 1.09 (95%CI: 0.99-1.20, p-value= 0.030). Participants who use toilet at home and use sandals in toilet became a protecting factors for hookworm infection (OR: 1.47 (95%CI: 1.00-2.18, p-value= 0.035).

The result analysis of risk factors and *S. stercoralis* showed the variables that were associated. Participants in Marangkayu district were more than 2.66 to be infected *S. stercoralis* than Muarakaman district (OR: 2.66 95%CI: (0.94-7.51, p-value=0.020). Participants in category organic carbon content in soil 1.37-2.47% were more 2.56 likely to be infected *S. stercoralis* than organic carbon content >2.47-4.04 (OR: 2.56 (95%CI: 1.08-6.07, p-value= 0.003). Communities in temperature >28.6 -29.5^{0}C were more 2.66 likely than 28-28.6^{0}C (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Participants in humidity 65 were more 2.66 likely than 66 (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Participants in areas with 174 days of rainfall were 2.66 likely than 164 days (OR: 2.66 (95%CI: 0.94-

7.51, p-value= 0.020). Communities in rainfall volume 4000 mm^3/year were 2.66 likely than 164 days (OR: 2.66 (95%CI: 0.94-7.51, p-value= 0.020). Elevation from above of sea >41.6-50 m were more likely than in elevation 15-41.6 (OR: 2.72 (0.96-7.67, p-value= 0.016). Participants who live together with humans infected with *S. stercoralis* were more 8.33 likely to be infected S. stercoralis than had not lived together (OR: 8.33 (95%CI: 2.27-30.61, p-value= 0.000).

Communities in areas with organic carbon content in soil 1.37-2.47% were more 2.07 likely to be infected hookworm and *S. stercoralis* co-infection than in areas with organic carbon content in soil >2.47-4.04 (OR: 2.07 (95%CI: 0.90-4.79, p-value= 0.025). Participants whom usual eat raw vegetable were more 1.44 likely to be infected hookworm and *S. stercoralis* co-infection than un-usual eat raw vegetable (OR: 1.44 (0.91-2.28, p-value= 0.020). Participants who live together with humans infected with hookworm and *S. stercoralis* co-infection were more 13.58 likely to be infected hookworm and *S. stercoralis* co-infection than had not lived together with human infected with hookworm and *S. stercoralis* co-infection (OR: 13.58 (2.05-89.77, p-value= 0.000)

Discussion

The prevalence of mono-hookworm infection in Muarakaman district is higher than in Marangkayu district was 50 (52.6%) and 9 (7.6%) respectively, while the prevalence *Strongyloides stercoralis*, Marangkayu district 14 (11.9%) is higher than Muarakaman district 3 (3.2%). Prevalence of co-infection was showed in Marangkayu district 11 (9.3%) where is higher than Muarakaman district 3 (3.2%). The study was similar to the south Thailand study where hookworm infection higher than *S. stercoralis* [28]. The deference of environmental factor between Muarakaman district and Marangkayu district should be affected by the higher hookworm infection and lower of *S. stercoralis* in Muarakaman district consist vegetation surrounding area of villages and geographical location where Muarakaman district be located surrounding palm plantation and river area. Similar study in the Manufahi district, Timor Leste where is a rural area with prevalence of hookworm infection was 62.8% [29].

The result Pearson chi-square analysis that age, occupation, water resources for daily activity, drinking water and toilet have a significant correlation with mono hookworm infection. We found that ages-old in category 13 years old and above were more likely to be infected mono-hookworm than 2-12 years old (36.4% vs, 20.2%). Farmers were more likely to be infected mono hookworm than other occupations (38.7% vs. 21.7%). Un-sanitary water resources were more likely to be infected mono hookworm than sanitary water resources (37.2% vs 15.2%). Participants in un-sanitary drinking water were more likely to be infected mono hookworm than participant in the category sanitary drinking water (62.5% vs. 28.2%). Participants in the category open defecation were more to be infected mono hookworm than in the category sanitary toilet at home (43.7% vs. 24.9%). Routine of use shoes, wash foot after soil contact, wash foot before house-entering, use the toilet at home and use sandal in the toilet were associated risk factor of mono hookworm infection. The risk factors were protecting risk factors. The result

Pearson chi-square analysis of characteristics sanitation facilities have not associated with *S stercoralis* infection. Results analysis Pearson chi-square analysis between personal hygiene and hookworm and *S. stercoralis* co-infection showed that usually ate row/un-cook fish/meat/vegetable has significantly correlated with hookworm and *S. stercoralis* co-infection (p= 0.020), and others personal hygiene have not correlated. Participants whom usual eat raw vegetable were more likely to be infected hookworm and *S. stercoralis* co-infection than un-usual eat raw vegetable (14.6% vs, 4.7%).

The results statistical analysis between environmental risk factors with hookworm infection showed several of environmental factors have correlated significant with hookworm infection such as district (p= 0.000), organic carbon content in the soil (p= 0.000), temperature (p= 0.000), humidity (p= 0.000), number day of the rainfall (p= 0.000), rainfall volume (p= 0.000), vegetation (p= 0.001), village areas (p= 0.001), dry or wet soil surrounding house (p= 0.010) and live together with human infected with hookworm (p= 0.016) . While the pH of the soil, clay content in the soil, texture of the soil, and hookworm infection in cat, hookworm infection in the dog have not significant correlated with the prevalence of hookworm infection in East Kalimantan province. Muara Kaman district was more likely to be infected mono hookworm than Marangkayu district (52.6% vs, 7.6%). Organic carbon content in soil >2.47-4.04% was more likely to be infected mono hookworm than organic carbon content in soil 1.37-2.47 (38.5% vs 13.2%). A previous study in Cambodia was explained that a high amount of soil organic carbon content affects to the lower prevalence of *S. stercoralis* infection [16], equal with study in East Kalimantan which organic carbon soil more in became have effected for reducing *S. stercoralis* but did not for hookworm infection, In contrast, organic carbon soil more in became had not been effected for reducing hookworm infection, in this study showed where organic carbon content in soil >2.47-4.04% has higher hookworm infection than organic carbon content 1.37-2.47%. Quoted by Sebastian H, at al (2018) organic carbon content in soil has indirect effect for nematode but the effect via food organism, usually the effect of organic carbon on abundance, cell size, and activity of the bacteria (*Escherichia coli*). Adsorption of organic carbon on bacterial cells, serving as food for the nematodes, may have been an important factor for the availability of organic carbon for hookworm [33]. The temperature in category >28.6-29.5^{0}C was more likely to be infected mono hookworm than 28-28.6 (52.6% vs, 7.6%), humidity 66% was more likely to be infected mono hookworm than humidity 65% (52.6% vs, 7.6%), number day of rainfall (164 days) was more likely to be infected mono hookworm than 165 days long rainfall (52.6% vs, 7.6%), and rainfall volume 3549 mm^3 was more 4.46 likely to be infected mono hookworm than rainfall volume in category 4000 mm^3 (52.6% vs, 7.6%). Vegetation in the category surrounding palm and or rubber plantation was more likely to be infected mono hookworm than the surrounding rice field (32.9% vs 8.7%). Villages area where is in buffer river or sea area were more to be infected mono hookworm than hill areas (33.8% vs, 8.5%). Wet soil surrounding houses were more likely to be infected mono hookworm than dry soil (43.2% vs, 23.7%). The survival of hookworm and *S. stercoralis* was supported by environmental factors. When communities defecated in rubber or palm plantation could be spread in the village or rice field that condition was caused elevation plantation is higher than village and rice field elevation, runoff water from plantation or forest when rainfall maybe bring the

eggs or larvae hookworm and *S.stercoralis* from human or animal feces from hill to village and field rice, and became a high risk for zoonotic diseases [30,15]. Potential infected together via field rice and rubber and palm plantations adult communities also for children when they were playing around houses. Live together with humans infected by hookworm was more likely to be infected mono hookworm than has not to lived together (39.3% vs, 23.0%).

The results of statistical analysis between environmental risk factors with *S. stercoralis* infection showed several of environmental factors have correlated significantly with *S. stercoralis* ($p<0.05$) such as district, the organic carbon content in the soil, humidity, temperature, elevation, number day of rainfall, rainfall volume, elevation, and live together with human infected with *S. stercoralis*. Environmental risk factors which were the highest association/correlation *S. stercoralis* infection were organic carbon content in soil ($p= 0.003$) and live together with human infected with *S. stercoralis* ($p=0.000$). Marangkayu district was more likely to be infected S. stercoralis than Muara Kaman district (11.9 vs. 3.2). Participants in the category of organic carbon content in soil 1.37-2.47% were more 2.56 likely to be infected S. stercoralis than organic carbon content >2.47-4.04 (14.3% vs, 3.3%). Communities in temperature >28.6 -29.5^{0}C were more likely than 28-28.6^{0}C (11.9% vs, 3.2%). Participants in humidity 65 were more 2.66 likely than 66 (11.9% vs, 3.2%). Participants in areas with 174 days of rainfall were likely than 164 days (11.9% vs, 3.2%). Communities in rainfall volume 4000 mm^3/year were likely than 3549 mm^3/year (11.9% vs, 3.2%). Collaboration many environmental risk factors could support the survival of larvae the worms. Environmental factors of hookworm and *S.stercoralis* infection in East Kalimantan has similar to south Thailand including long rainy season, temperature, and several geography areas, then the prevalence of hookworm infection in East Kalimantan Province (44.1%) is higher than in south Thailand but equal for *S.stercoralis* infection, [28]. In contrast quote by the epidemiology study of *S.stercoralis* infection Southern Laos showed was 41% where has heavy rainfall and poor sanitation. [11]. Elevation from above of sea >41.6-50 m was more likely than in elevation 15-41.6 (12.1% vs, 3.1%). Participants who live together with humans infected with *S. stercoralis* were more 8.33 likely to be infected *S. stercoralis* than had not lived together (78.9% vs, 1.0%). This study showed participants who positive *S. strercoralis* infection has live together with other positive *S. strercoralis* infection through one household or neighbor where live close was dominant, same as environmental risk factor, personal hygiene, and sanitation facilities became caused together infection.

The results of statistical analysis between environmental risk factors with hookworm and *S. stercoralis* co-infection showed organic carbon content in soil and live together with humans infected with hookworm and *S. stercoralis* co-infection have significantly correlated with hookworm and *S. stercoralis* co-infection with p-value = 0.025 and p-value= 000 respectively. Communities in areas with organic carbon content in soil 1.37-2.47% were more likely to be infected hookworm and *S. stercoralis* co-infection than in areas with organic carbon content in soil >2.47-4.04 (11.0% vs, 3.3%). Participants whom usual eat raw vegetable were more likely to be infected hookworm and *S. stercoralis* co-infection than un-usual eat raw vegetable (OR: 1.44 (14.6% vs, 4.7%). Participants

who live together with human infected with hookworm and *S. stercoralis* co-infection were more likely to be infected hookworm and *S. stercoralis* co-infection than had not lived together with humans infected (68.4% vs, 0.5%). the environmental factors make survive of infective larvae of *S. strercoralis* hookworm and co-infection, had explained by Garcia, et al (2007) that a significant increase in the prevalence with environmental conditions [1]. Changing environmental conditions, specifically deforestation and subsequent silting of the local river, have caused periodic flooding with deposition on the layer of sandy loam topsoil could increase soil moisture, and supported by the low quality of sanitation facilities and hygiene personal to add the increasing of *S. strercoralis* hookworm and co-infection. These conditions, all of which are conducive to *S. strercoralis* hookworm and co-infection transmissions, have allowed *S. strercoralis* hookworm and co-infection to reemerge as an important human pathogen in this area [1].

District, organic carbon content in soil, humidity, temperature, elevation, number day of rainfall, rainfall volume, and elevation 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. This study had shown that the quality of soil and climatology such as humidity, temperature has a correlation with survival of hookworm and *S. stercoralis,* and heavy rainfall affected for reducing and increasing distribution hookworm and *S. stercoralis*. In general condition soil surrounding houses more than 80% covering with soil was close to the location with plantation and forest that have high position for contamination from plantation and forest. And besides personal hygiene and sanitation facilities still not save for protecting skin from larvae hookworm and *S. stercoralis* also in file rice and palm or rubber plantation. (8). In poor countries with tropical climate, In poor countries with a tropical climate, where have environmental condition favorable for the transmission of hookworm and *S.stercoralis* infection the prevalence still high [5].

Conclusions

This study demonstrated the prevalence of hookworm, *S. stercoralis,* and co-infection in two districts in rural areas in East Kalimantan, Indonesia where deference of risk factor of the infections. Hookworm, S stercoralis, and Co-infection have deference of risk factors especially in carbon content, volume n number day of rainfall, elevation, and village areas, that conditions against the survival of parasitic larvae in an environment where potential increase for penetration the larvae to human via soil contact and pet contact. Personal hygiene and sanitation facilities supported the conditions. Essential risk factors of the infections should use for preventing program of reduction prevalence hookworm and *S stercoralis* infection.

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Availability of data and materials

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Authors' contribution

All authors conceived of the idea and participated in the design of this study. BS, WA, and JT conducted the study. BS, SW, SP, WA, and JT were responsible for interpretation of the results and drafting of manuscript and reading for intellectual content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Official permission and ethical clearance for the collection human fecal samples were obtained from the head of the village and head of the household. The study protocol was approved by the Ethical Clearance Committee on human right related to research involving human subjects, Walailak University HE: No. WUEc-18-034-01.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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