Prevalence of Hookworm Infection in Schoolchildren with Deference Geography Areas in Indonesia

Blego Sedionoto[1*] and Witthaya Anamnart[2]

[1] Department of Environmental Health, Faculty of Public Health Mulawarman University, Samarinda, 75123, Indonesia
[2] Department of Environmental Health, School of Public Health, Walailak University, Thasala, 80160, Thailand
blego.sedionoto@gmail.com

Abstract. The prevalence of hookworm infection is a serious public health concern globally. Java Island and Kalimantan Island have differential environmental risk factors for hookworm infection, especially rural areas of Indonesia have high-risk environmental factors for the prevalence of hookworm infection. This study showed the infection rates and correlation analysis between environmental risk factors and the prevalence of hookworm infection with statistical analysis. We performed a cross-sectional study among 226 schoolchildren participants from rural areas of East Java Province, Central Java Province, and East Kalimantan Province, Indonesia. This study used two diagnostic methods: Kato Katz and Koga agar plate culture/KAP culture for diagnosing hookworm infections. Pearson chi-square analysis was used to study the correlation between environmental factors and hookworm infection. This study found the prevalence of hookworms in East Java Province 69(97.2%), Central Java Province 20(41.7%), and East Kalimantan Province 48(44.9%). Environmental risk factors, such as: rainy season, quality of soil, and infection hookworm in pets have a significant correlation (p-value < 0.05) with hookworm infection. The prevalence of hookworm infection correlates with environmental factors, and the findings in this research could contribute to decreasing programs of hookworm infection especially in rural community areas.

Keywords: Hookworm infection, Schoolchildren, Deference Geography, Indonesia

1 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 and are endemic in tropical and temperate regions. The prevalence of hookworm infection and strongyloidiasis was

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estimated in 2010 that 438.9 million people were infected with hookworm and 100 million with Strongyloides sp. Almost 70% of these infections occur in Asia [2][3][4].

Hookworm infection and strongyloidiasis are transmitted through protected contact with soil and are endemic in tropical and temperate regions. Humans acquire hookworm infection and strongyloidiasis through direct skin contact with infective third-stage larvae where the soil contaminated by human feces penetrates the intact human skin and eventually reaches 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, the availability of sewerage systems, and the length of the rainy season. Environmental factors have contributed to the transmission of diseases as well as the growth and development of worms [8][9].

Environmental factors, especially the long rainy season may affect the decrease in prevalence of strongyloidiasis 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 possibly because of the failure of the control of hookworm infection due to the 10-month-long rainy season in southern Thailand contrasted with the 4-month-long rainy season in other parts [10].

The study in Cambodia reported a lower prevalence of strongyloidiasis in areas with heavy rainfall than in low rainfall areas. 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 was heavy rainfall and poor sanitation. In this study, Baerman and Kato-Katz techniques were used to detect them [12].

Indonesia has environmental risk factors for the prevalence of hookworm infection and strongyloidiasis, especially in rural areas. Rural East Java Province, Central Java Province, and East Kalimantan Province have differential environmental risk factors for hookworm infection and strongyloidiasis. The study is important to explore the association between both the prevalence of hookworm infection and strongyloidiasis and environmental risk factors.

2 Methods

The study was carried out in rural areas of East Java Province, Central Java Province, and East Kalimantan Province, Indonesia. This research is community-based based, was conducted from July 2018- July 2019. The total of number participants is 226 participants who were joined and sent stool samples.

Collecting stool samples, on the first day to head of the master of school children and the parents of school children requested stool samples, The second day in the morning would started to collect stool samples, which were brought to the parasitology laboratory of B2P2RV Salatiga, Ministry of Health Republic Indonesia for samples from East Java Province and Central Java Province and samples from East Kalimantan were

brought to Parasitology Mulawarman University for diagnosis samples. Another day was spent observing the environmental condition of houses surrounding the village.

Agar plate culture will be done as described by Koga et al., 1991. Briefly, a few grams of stool will be placed at the center of nutrient agar and kept at room temperature for five days. Tracks from larva crawling and larvae or adult worms will be observed. If positive, 10 ml of 10% formalin will be 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 will be discarded. The sediment will be examined for hookworm larvae and S. stercoralis larvae or adult worms.

For the Kato-katz thick smear, 50 mg of stool will be placed on a slide and covered with a cellophane paper soaked in glycerin solution for 24 hours. The stool will be spread out using a rubber stick. After 30 minutes will be examined and counted for eggs

Environmental data was collected such as vegetation, the elevation of soil, the kind of pets, the kind of soil around houses, the 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 the soil laboratory at Mulawarman University. Vegetation and kind of soil around houses will be collected by observation form, kind of pet will be collected by questioner and observation, and length of 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 and Strongyloides infection was stratified according to environmental data and reported by descriptive statistics. Statistical analysis was performed by Chi-square and regression using SPSS verse 21. The correlation analysis was analyzed by Pearson Chi-square to evaluate the association of hookworm and Strongyloides infections with environmental risk factors and the level of significance was considered as $P<0.05$.

Official permission and ethical clearance for the collection of human fecal samples was obtained from the local provincial government of East Java, Central Java, and East Kalimantan. The study protocol was approved by the Ethical Clearance Committee on human rights related to research involving human subjects, Walailak University HE: number WUEc-18-034-01.

3 Results

A total of 226 schoolchildren participated in this study. We collected data from five schools such as three schools from East Kalimantan, one school from East Java, and one school from Central Java, with detail three provinces are Central Java Provinces, East Java Provinces, and East Kalimantan Province, all of areas research were conducted in rural and agriculture area with the areas have differences characteristic of environmental risk factors.

3.1 Parasitological Findings

Prevalence hookworm and Strongyloides infection/strongyloidiasis were diagnosed by the Kato Katz technique and the APC method showed of 226 tested samples from children 137(60.63%) cases found positive with hookworm infection and 25(11.1%) cases found positive with Strongyloides infection and addition finding of Ascaris lumbricoides as 124(9.84%). Detailed data on the prevalence of hookworm and Strongyloides infections were explained in Table 1.

Table 1. Prevalence of Soil Transmitted Helminths among School children in Indonesia (226 Participants)

Infections	East Java		Central Java		East Kalimantan		Overall Positive	p-value
	Positive n (%)	Negative n (%)	Positive n (%)	Negative n (%)	Positive n (%)	Negative n (%)		
Hookworm	69 (97.2)	2 (2.8)	20 (41.7)	28 (58.3)	48 (44.9)	59 (55.1)	137 (60.63)	0.000
S. stercoralis	0 (0)	71 (100)	0 (0)	48 (100)	25 (23.4)	82 (76.6)	25 (11.1)	0.000
Ascaris sp	3 (4.2)	68 (95.8)	2 (4.2)	46 (95.8)	11 (10.3)	96 (89.7)	124 (9.84)	0.205

The prevalence of hookworm infection 137(60.63%) is highest than other infections and the prevalence of strongyloidiasis only was found in East Kalimantan Province with 25(11.1%) cases and was not found in East Java Province and Central Java Province. The correlation of prevalence hookworm infection and strongyloidiasis is significant (p = 0.000).

3.2 Prevalence of Hookworm Infection in Indonesia

Distribution of prevalence hookworm infection among communities in Indonesia with stratified each province of area study were explained in Table 2.

Table 2. Prevalence of Hookworm infection as stratified by Province

Research area	Hookworm Infection		Total n (%)	*P*-value
	Positive n (%)	Negative n (%)		
East Java	69 (97.2)	2 (2.8)	71 (100)	0.000
Central Java	20 (41.7)	28 (58.3)	48 (100)	
East Kalimantan	48 (44.9)	59 (55.1)	107 (100)	
Total	137 (60.6)	89 (39.4)	226 (100)	

The highest prevalence of hookworm infection was found in East Java is 69(97.2%) from total 71 children, therefore the lowest prevalence of hookworm infection was found in Central Java province is 20(41.7%) among 48 children, Percentage of prevalence hookworm infection in East Kalimantan 48(44.9%) is higher than in Central Java.

Correlation between prevalence of hookworm infection and province of school children area was showed by Pearson X2 that hookworm infections were significantly correlated with province (p = 0,000). East Java province has several deference of environmental risk factors including as quality of soil, kind of vegetation, number day rain yearly, humidity and temperature those are determinant the highest percentage of hookworm infection than other provinces.

3.3 Hookworm Infection, Gender, and Age Group

The prevalence hookworm infection and demographical data especially such as gender and age groups that were detailed in table 3.

Table 3. Prevalence of Hookworm Infection as stratified by gender and age groups

Research area	Hookworm Infection		Total	*P*-value
	Positive n (%)	Negative n (%)		
Gender				0.431
Male	65 (58.0)	47 (42.0)	112 (100)	
Female	72 (63.2)	42 (36.8)	114 (100)	
Class				0.223
Pre-school	15 (88.2)	2 (11.8)	17 (100)	
Class 1				
Class 2	3 (100)	0 (0)	3 (100)	
Class 3	16 (88.9)	2 (11.8)	18 (100)	
Class 4	13 (56.5)	10 (43.5)	23 (100)	
Class 5	31 (50.0)	31 (50.0)	62 (100)	
Class 6	35 (52.2)	32 (47.8)	67 (100)	
	24 (66.7)	12 (33.3)	36 (100)	

Hookworm infection in female was known higher than male with 72(63.2%) and 65(58.0%) respectively from 114 female participants and 112 male participants. Gender has not significant correlated with hookworm infections (p = 0.431). Hookworm infection was found dominant among school children class level 1(100%) and school children class level 2 (88,9%). The present showed a significant correlation between level of study with hookworm infection is negative (p = 0.223).

3.4 Environmental Factors and Hookworm Infection

Statistical analysis of hookworm and Strongyloides infection between environmental factors such as geography, texture of soil, infection status of pet, humidity, vegetation, elevation, amount day of rain, volume of rain, temperature, pH, clay content of soil, organic carbon of soil, explained detail in Table 4.

Table 4. Correlation Quality of Soil and Hookworm infection

Quality of Soil	Status of Diagnosis Participants		*P*-value
	Positive n (%)	Negative n (%)	
Texture of soil			0.000
Sandy clay	17 (70.8)	7 (29.2)	
Loamy sand	13 (38.2)	21 (61.8)	
Sand	89 (74.8)	30 (25.2)	
Clay	18 (36.7)	31 (63.3)	
Organic Carbon content (5 school children areas)			0.000
Area 1 (1.50%)			
Area 2 (1.83%)			
Area 3 (2.77%)	69 (97.2)	2 (2.8)	
Area 4 (3.13%)	17 (70.8)	7 (29.2)	
Area 5 (7.22%)	20 (41.7)	28 (58.3)	
	18 (36.7)	31 (63.3)	
	13 (38.2)	21 (61.8)	
Clay content (5 areas)			0.000
Area 1 (1.2%)			
Area 2 (1.9%)	20 (41.7)	28 (58.3)	
Area 3 (3.0%)	13 (38.2)	21 (61.8)	
Area 4 (34.7%)	69 (97.2)	2 (2.8)	
Area 5 (38.6%)	18 (36.7)	31 (63.3)	
	17 (70.8)	7 (29.2)	
pH of soil (5 areas)			0.000
Area 1 (4.26)			
Area 2 (6.60)	17 (70.8)	7 (29.2)	
Area 3 (7.22)	20 (41.7)	28 (58.3)	
Area 4 (7.40)	18 (36.7)	31 (63.3)	
Area 5 (7.79)	13 (38.2)	21 (61.8)	
	69 (97.2)	2 (2.8)	

Sandy soil with 89(74.8%) hookworm infection is highest level of the prevalence of hookworm infection than others types of soil; organic carbon content in area 1 (1.50%) with 69(97.2%) hookworm infection is highest level of the prevalence of hookworm infection than others cluster; clay content in Area 3 (3.0%) with 97.2% hookworm infection is highest level of the prevalence of hookworm infection than others cluster and pH of soil in cluster Area 5 (7.79) with hookworm infection 97.2% is highest level of the prevalence of hookworm infection than others cluster. Texture, organic carbon content, clay content and pH of soil have significant correlated with hookworm infection ($p = 0.000$).

Correlation climatology and hookworm infection detail was explained in Table 5. Temperature in area 2 (22.00C) with hookworm infection 97.2% is highest than others area. Humidity in area 4 (90) with hookworm infection 97.2% is highest than others area. Temperature and humidity have significant correlated with hookworm infection ($p = 0.000$).

Table 5. Correlation Climatology and Hookworm Infection

Climatology	Status of Diagnosis Participants		*P*-value
	Positive n (%)	Negative n (%)	
Temperature			0.000
Area 1 (20.5^{0}C)	20 (41.7)	28 (58.3)	
Area 2 (22.0^{0}C)	69 (97.2)	2 (2.8)	
Area 3 (28 ^{0}C)	13 (38.2)	21 (61.8)	
Area 4 (29.5 ^{0}C)	35 (47.9)	38 (52.1)	
Humidity			0.000
Area 1 (65%)	13 (38.2)	21 (61.8)	
Area 2 (66%)	35 (47.9)	38 (52.1)	
Area 3 (82)	20 (41.7)	28 (58.3)	
Area 4 (90)	69 (97.2)	2 (2.8)	

Detail distribution and correlation of vegetation, location with hookworm infection explained in Table 6. Highest percentage for prevalence of hookworm infection by stratified vegetation is palm plantation, which 55.2% hookworm infection. Prevalence of hookworm infection that showed by geography area is highest in buffer of river (59.9%), where location village of participant is surrounding river. Elevation where was found highest of prevalence hookworm infection in station 3 (50m) with hookworm infection 69.8%. Vegetation, geography area and elevation all of the environmental risk factors have significant correlation with hookworm infection (p = 0.000).

Table 6. Vegetation and Location and Hookworm Infection

Vegetation and Location	Status of Diagnosis Participants		*P*-value
	Positive n (%)	Negative n (%)	
Vegetation			0.000
Coffee	69 (97.2)	2 (2.8)	
Vegetable	20 (41.7)	28 (58.3)	
Palm and rubber	48 (44.9)	59 (55.1)	
Geography of villages area			0.000
Buffer of sea/coastal area	13 (38.2)	21 (61.8)	
Buffer of river	17 (70.8)	7 (29.2)	
Hill	18 (36.7)	31 (63.3)	
Mountain area	89 (74.8)	30 (25.2)	
Elevation from above of sea surface (m)			0.000
Station 1 (32m)	35 (47.9)	38 (52.1)	
Station 2 (50m)	13 (638.2)	21 (61.8)	
Station 4 (700m)	69 (97.2)	2 (2.8)	
Station 5 (841m)	20 (41.7)	28 (58.3)	

Variable of rainy season that consist as number day of rain yearly, number month of rain yearly and volume of rain yearly, and detail distribution and correlation with hookworm infection explained in Table 7. Prevalence of hookworm infection stratified by number of day rain yearly Station 1 (122 days) is highest hookworm infection with prevalence was 97.2%. Area 1 (7 months) where has 7 months of long rainy season is highest prevalence of hookworm infection 97.2%. Station 1 (2937mm) of volume of rain yearly was found hookworm infection 97.2% is highest. The number day, month and volume of rain yearly have correlated with hookworm infection (p = 0.000).

Table 7. Rainy Season and Hookworm Infection

Rainy Season	Status of Diagnosis Participants		*P*-value
	Positive n (%)	Negative n (%)	
Number day of rain yearly			0.000
Station 1 (122 days)	69 (97.2)	2 (2.8)	
Station 2 (139 days)	20 (41.7)	28 (58.3)	
Station 3(152 days)	35 (47.9)	38 (52.1)	
Station 4(174 days)	13 (38.2)	21 (61.8)	
Area 1 (7 months)	69 (97.2)	2 (2.8)	
Area 2 (8 months)	20 (41.7)	28 (58.3)	
Area 3 (10 months)	48 (44.9)	59 (55.1)	
Volume of rain yearly			0.000
Station 1 (2937mm)	69 (97.2)	2 (2.8)	
Station 2 (2990mm)	35 (47.9)	38 (52.1)	
Station 3 (3689mm)	20 (41.7)	28 (58.3)	
Station 4 (4000mm)	13 (38.2)	21 (61.8)	

3.5 Hookworm Infection in Pet and Hookworm Infection in Human

Distribution and correlation of hookworm infection in pet and hookworm infection in human with detail explained in Table 8. Participants were infected by hookworm with infected cat by hookworm 48(44.9%) while they whose non-infected cat by hookworm 89(74.8%), participants whose Participants were infected dog by hookworm 117(65.7%), analysis pearsonX2 hookworm in human has significant correlated with infected cat and dog by hookworm with p value 0.000 and 0,002 respectively.

Table 8. Hookworm infection in Pet and Hookworm Infection in Human

Pets	Status of Diagnosis Participants		*P*-value
	Positive n (%)	Negative n (%)	
Hookworm in cat			0.000-
Infected cat	48 (44.9)	59 (55.1)	
Non infected cat	89 (74.8)	30 (25.2)	
Hookworm in dog			0.002
Infected dog	117 (65.7)	61 (34.3)	
Non infected dog	20 (41.7)	28 (58.3)	

4 Discussion

Results of statistical analysis showed that environmental factors have an association with the prevalence of hookworm infection, the environmental factors, including the geography of an area, hookworm in dogs, humidity, vegetation, and elevation. number of days of rain yearly, number of months of rain yearly, volume of rain, and quality of soil as texture, organic carbon of soil, clay content of soil, and pH of soil have significance (p-value<0.05) with prevalence of hookworm infection in Indonesia [13].

The prevalence of hookworm infection correlated with environmental risk factors including as quality of soil (texture, organic carbon content, clay content pH of soil, climatology (Temperature and humidity), geography of area, vegetation, elevation, rainy season (number of days, month, and volume of rain yearly) infected cat and dog by hookworm infection [14].

Results of statistical analysis showed that environmental risk factors have an association with the prevalence of hookworm infection, the environmental factors, of quality of soil (texture, organic carbon content, clay content pH of soil, climatology (Temperature and humidity, geography of area, vegetation, elevation. The rainy season (number of days, months, and volume of rain yearly) and infected cats and dogs by Strongyloides sp. have significance (p-value <0.05) with the prevalence of strongyloidiasis in Indonesia [15].

Hookworm infection and strongyloidiasis are both neglected tropical diseases [16]. In poor countries with tropical climates, conditions favorable for the transmission of these parasites have a higher prevalence of hookworm infection and strongyloidiasis [17]. Furthermore, low socioeconomic status and low hygiene living conditions of the rural population are strongly associated with hookworm infection and strongyloidiasis. In southeast Asia, a recent work in Cambodia reported a very high infection rate in Takeo Province [11]. In Indonesia, especially in East Kalimantan, there have been few studies on both hookworm infection and strongyloidiasis.

Environmental factors of hookworm and strongyloidiasis in East Kalimantan are similar in South Thailand including the long rainy season, temperature, and several geographical areas, then the prevalence of hookworm infection in East Kalimantan Province (44.1%) is higher than in South Thailand but equal for Strongyloidiasis, that condition was caused other environmental risks factors like quality of soil such as organic carbon of soil, clay content, and pH. [10]. TE Prevalence of hookworm infection in East Kalimantan is similar to studies in southern Laos and Cambodia where hookworm is still high but more than the prevalence of strongyloidiasis. The study in Cambodia reported a lower prevalence of strongyloidiasis in areas with heavy rainfall than in low rainfall areas. Moreover, a high amount of soil organic carbon content affects the lower prevalence of strongyloidiasis (Khieu et al., 2014). Epidemiology study of hookworm infection and strongyloidiasis in Southern Laos showed 56.1% and 41% respectively where there was heavy rainfall and poor sanitation. In this study, Baerman and Kato-Katz techniques were used to detect them [12].

Environmental factors of hookworm infection and strongyloidiasis in East Kalimantan have significance with high prevalence hookworm infection and strongyloidiasis such as geography, vegetation, humidity, volume and amount day of rain organic

carbon of soil and clay content of soil, the environmental factors make survival of infective larvae of hookworm and Strongyloides, had explained with [18] that a significant increase in the prevalence of hookworm infection and Strongyloides with environmental conditions. Changing environmental conditions, specifically deforestation and subsequent silting of local rivers, have caused periodic flooding with deposition on layers of sandy loam topsoil and increased soil moisture. These conditions, all of which are conducive to hookworm transmission, have allowed hookworms to reemerge as an important human pathogen in this area. This example emphasizes the value of longitudinal surveillance data for monitoring disease prevalence. Shifts in the prevalence of infectious disease can be caused by environmental changes, including planned human activity, or can be an indirect consequence of political strife, and these factors should always be considered when changes in infectious disease patterns are detected.

5 Conclusion

The prevalence of hookworm and Strongyloides infections among schoolchildren in Indonesia has correlation with environmental factors. Result of the study analysis can make strong contribution for preventing program by ecological root. Preventing program of reduction prevalence hookworm and Strongyloides infections by treatment of environmental risk factors is effectively program for decreasing of hookworm and Strongyloides infections in Indonesia.

Author's Contribution

All authors conceived of the idea and participated in the design of this study. BS conducted the study. BS and WA were responsible for the interpretation of the results and drafting of manuscript and reading for intellectual content.

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