Window of Health Jurnal Kesehatan
journal homepage : www.jurnal.fkmumi.ac.id

ARTICLE RESEARCH
URL article: http://jurnal.fkmumi.ac.id/index.php/woh/article/view/woh9109

Spatial Map Of Hygiene Risk And Infection Of Soil-Transmitted Helminths In Stunting Toddlers In Kaliwates

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ABSTRACT

Soil-transmitted helminths remain major neglected tropical infections affecting approximately 24% of the global population, particularly in areas with poor sanitation and hygiene. Chronic infection may contribute to malnutrition and stunting in children. This study aimed to analyze the spatial distribution of soil-transmitted helminth infections and hygiene risk among stunted toddlers in Kaliwates District. A cross-sectional study was conducted from August 2023 to May 2024 involving 103 stunted toddlers. Stool samples were examined using sedimentation and flotation methods, and hygiene data were collected through caregiver interviews. Fisher's exact test and Moran's Index were applied. The infection prevalence was 8.7%, predominantly hookworm. No significant association was found between hygiene factors and infection ($p>0.05$). Spatial analysis indicated a random distribution pattern. These findings suggest that deworming programs and hygiene promotion should be maintained, and spatial mapping may support targeted interventions.

Keywords: Spatial; Soil-transmitted helminths; hygiene

PUBLISHED BY :
Faculty of Public Health
Universitas Muslim Indonesia
Address :
Jl. Urip Sumohardjo Km. 5 (Campus II UMI)
Makassar, Sulawesi Selatan.
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Article history :
Received 9 December 2024
Received in revised form 2 February 2026
Accepted 16 February 2026
Available online 18 February 2026

INTRODUCTION

Soil-transmitted helminth (STH) infections remain prevalent worldwide, particularly in tropical regions, with the highest prevalence seen in children and young children. Research conducted in Uganda showed that the prevalence of STH infection in children aged 5 years was significantly higher than in children aged 1 year (p=0.009). Soil-transmitted helminth infections are caused by nematodes transmitted through soil as a medium. Soil-transmitted helminth species include two hookworm species (*Necator americanus* and *Ancylostoma duodenale*), *Ascaris lumbricoides*, and *Trichuris trichiura*[1]. Globally, it is estimated that 1.5 billion people are infected, accounting for approximately 24% of the world population[2,3]. In Indonesia, the prevalence of STH infection ranges from 20% to 86%, with an average of 30% [3]. A survey conducted in East Java Province from 2008-2010 reported an STH infection prevalence of 7.95%[4]. Previous studies in various areas of Jember on STH prevalence among children found a prevalence of 5.79% in Jelbuk District[5]. According to Noviasari (2023) and Alfiani (2023), in Jelbuk District, the prevalence of STH infection among children in Sukojember Village was 2.9%, while in Sukowiryo Village, it was 5.4%[6,7]. The high prevalence of STH in children can affect their health and growth[8].

Several factors increase susceptibility to soil-transmitted helminth infection, including malnutrition. Malnutrition weakens the immune system and reduces essential nutrient availability, making young children more vulnerable to infections[9]. Conversely, soil-transmitted helminth infection can worsen nutritional status by reducing food intake, impairing nutrient absorption, and causing nutrient loss[10]. This bidirectional relationship contributes to chronic malnutrition, which is strongly associated with stunting[11]. Stunting reflects long-term nutritional deficiency and is defined as a height-for-age z-score (HAZ) below −2 standard deviations[12]. It typically develops from the prenatal period through the first 24 months of life and represents a form of chronic growth failure[13,14]. According to the 2022 Indonesian Nutrition Status Survey (SSGI), 21.6% of children under five in Indonesia were stunted. The prevalence was 19.2% in East Java Province, with Jember Regency reporting the highest rate (34.9%), including Kaliwates District[15]. In August 2023, 814 stunted toddlers were recorded in Kaliwates District[16].

In addition to stunting, poor hygiene in young children is an important contributing factor to soil-transmitted helminth infection. A study in Deli Serdang reported a strong association between poor hygiene and infection among elementary school students[17]. Young children are particularly vulnerable because they are not yet able to maintain personal hygiene independently[18]. Since hygiene behaviors and environmental exposure vary across locations, the risk of soil-transmitted helminth transmission may also differ geographically. Therefore, spatial distribution analysis is needed to identify geographic patterns of infection and hygiene risk, allowing better understanding of local transmission dynamics. Spatial mapping can reveal areas with higher vulnerability and support more targeted public health interventions.

Spatial analysis is widely used in epidemiology to examine geographic patterns of disease and

identify areas with higher transmission risk[19]. Because infectious disease occurrence is often influenced by environmental and location-related factors, spatial approaches can help reveal local variation in disease distribution[20]. In this study, spatial analysis was applied to explore the geographic distribution of soil-transmitted helminth infections in Kaliwates District and to support locally targeted prevention strategies.

Kaliwates District is one of the sub-districts in Jember Regency with a high prevalence of stunting. As of August 2023, the number of stunted children in Kaliwates was relatively high compared to other sub-districts[16]. However, information on the geographic distribution of soil-transmitted helminth infections among stunted toddlers in this area remains limited, and spatial-based evidence linking hygiene risk and infection has not been well documented at the sub-district level. Therefore, this study aims to explore the spatial distribution of soil-transmitted helminth infections and hygiene risk among stunted toddlers in Kaliwates District to provide locally relevant evidence for targeted control strategies..

METHOD

This study is a descriptive and analytical observational study with a cross-sectional design. The research was conducted from August 2023 to May 2024 in Kaliwates District, Jember Regency. The study population consisted of stunted young children registered at community health posts (posyandu) in Kaliwates District in August 2023, totaling 814 children. The sample size was 103 children, selected using cluster sampling and calculated with the Lemeshow formula. Primary data included hygiene risk factors, home coordinates of the children (using the Avenza app), and laboratory results identifying STH eggs via sedimentation and flotation methods. A structured questionnaire on hygiene was created based on previous research about handwashing habits before eating, nail cleanliness, use of footwear, playing in the dirt, and defecation sites[17,18]. The data on the coordinate points of the research subjects' homes were used to identify the distribution of subjects infected with STH using Moran's index in the ArcGIS application. Microscopic identification of STH eggs was carried out by two researchers based on WHO guidelines (Bench aids for the diagnosis of intestinal parasites) and consulted with parasitologists at the Parasitology Laboratory, Faculty of Medicine, University of Jember. Secondary data, consisting of biodata of stunted children, was obtained from local health centers. Data analysis utilized univariate, bivariate, and spatial analysis (Moran's index). The study received ethical approval by the Ethics Committee of the Faculty of Medicine, Jember University with Ethical Approval Number 2837/UN25.1.10.2/KE/204.

RESULTS

1. Sociodemographic Characteristics of Respondents

The study included 103 respondents. Results indicated that there were 51 male children and 52 female children. The sample of stunted children was aged between 12-59 months, with 54.4% of the children being under 36 months or three years old. Most mothers were in the age group of 20-35 years, totaling 68 individuals. The education level of parents in Kaliwates District was relatively high; the majority

of mothers were high school graduates (42 individuals), and fathers also mostly had high school education (43 individuals). Based on a questionnaire filled out by 103 parents/guardians, the majority had an income below the Jember minimum wage (57.3%).

Table 1. Sociodemographic Characteristics of Respondents

Characteristics	Total (n)	Presentage (%)
Gender		
Male	51	49.5
Female	52	50.5
Toddler Age		
12-35 months	56	54.4
36-59 months	47	45.6
Mother's Age		
20-35 years	68	66
35 years	35	34
Mother's Education		
Did not complete ES	2	1.9
Elementary school	9	8.7
Junior high school	21	20.4
Senior high school	42	40.8
Higher education	29	28.2
Father's Education		
Did not complete ES	2	1.9
Elementary school	15	14.6
Junior high school	17	16.5
Senior high school	43	41.7
Higher education	26	25.2
Economic Level		
≥ UMK (Rp 2.355.662,91)	44	42.7
< UMK (Rp 2.355.662,91)	59	57.3
Total	103	100

2. Soil-Transmitted Helminth Infections in Stunted Children in Kaliwates District

Table 2. Incidence Rates of Soil-Transmitted Helminth Infections per Village

Village	STH infection		Total(%)
	+ (%)	- (%)	
Kaliwates	1(3.4)	20(69)	21(20)
Mangli	5(17.2)	24(82.8)	29(28)
Sempusari	1(3.4)	28(96.6)	29(28)
Tegal Besar	2(6.9)	22(75.9)	24(23)
Total	9(8.7)	94(91,3)	103(100)

Fecal samples were examined using sedimentation and flotation methods, then analyzed under a microscope. The examination of the research subjects for soil-transmitted helminths (STH) revealed 9 positive STH samples. In Kaliwates Village and Sempusari Village, one infected child was found in each,

while Mangli Village had five cases, and Tegal Besar Village reported two cases, as shown in Table 2. The STH types identified included Hookworm and Ascaris lumbricoides. The prevalence of STH infection in Kaliwates District was 8.7%. A detailed breakdown of the findings is presented in Table 3.

Table 3. Types of STH Found.

STH infection	Total	
	n	%
Ascaris lumbricoides	2	22.2
Hookworm	6	66.7
Mixed (Ascaris lumbricoides & Hooworm)	1	11.1
Total	9	100

3. Risk Factors Of Hygiene in Soil-Transmitted Helminth Infections in Stunted Children in Kaliwates District.

Table 4. Analysis and Quality of Hygiene

Hygiene Risk Factors	Infected with STH		Not Infected with STH		Total (n)	%	*p-value*	*Odd Ratio Value*
	n	%	n	%				
Level of hygiene								
Good	7	77.8%	70	74.5%	77	74.8	1,000	1,200
Poor	2	22.2%	26	25.5%	26	25.2		

Based on the results of the questionnaire, the majority of children had good hygiene, totaling 77 (74.8%) children, while only 26 children (25.2%) had poor personal hygiene practices. The results of the bivariate analysis showed no significant relationship with the cases of STH infection. The results of hygiene quality and hygiene analysis can be seen in Table 4.

Table 5. Results of Bivariate Analysis

Hygiene Risk Factors	Infected STH		Not infected STH		*p-value*	*Odds Ratio Value*
	n	%	n	%		
Washing hands						
No	3	33.3	28	29.8	1.000	1.179
Yes	6	66.7	66	70.2		
Cutting nails						
No	0	0.0%	12	12.8	0.594	0.000
Yes	9	100.0%	82	87.2		
Wearing footwear						
No	1	11.1%	22	23.4	0.680	0.409
Yes	8	88.9%	72	76.6		
Playing in the soil						
Yes	5	55.6%	69	73.4	0.221	0.453
No	4	44.4%	25	26.2		
Defecating in the toilet						
No	4	44.4%	34	36.2	0.438	1.412
Yes	5	55.5%	60	63.8		

Risk factors for hygiene in soil-transmitted helminth infections include handwashing before

meals, nail cleanliness, wearing footwear outside the home, playing in the dirt, and the availability of latrines for defecation. The results of the bivariate analysis showed that all hygiene risk factors had a p-value > 0.05, indicating no significant relationship. The results of the bivariate analysis of STH infection and its association with hygiene risk factors in stunted children can be seen in Table 5.

4. Spatial Map

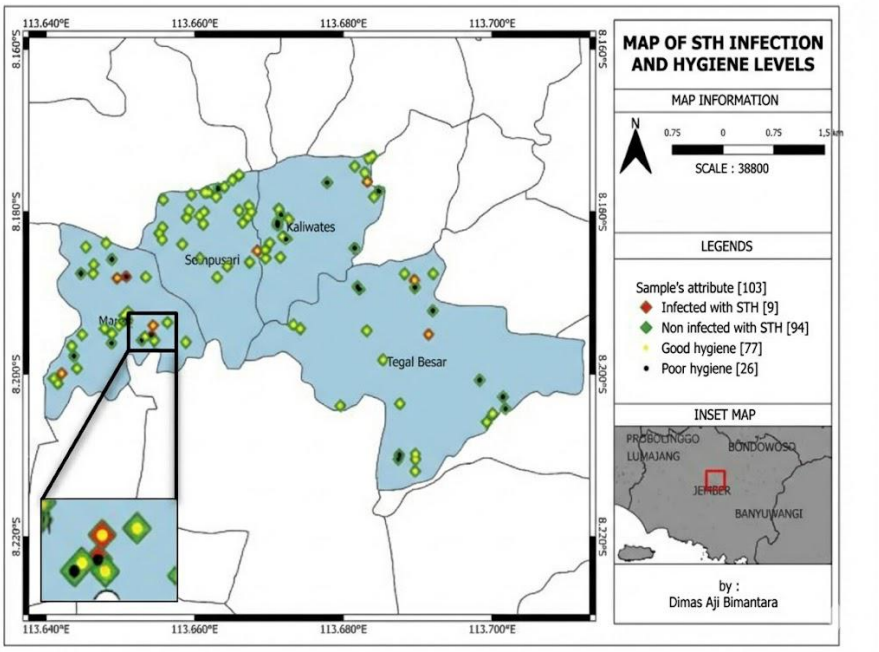

Figure 1. Map of STH Infection and Hygiene Levels.

The map of the distribution of STH infection cases and risk factors was combined using the overlay method. This way, the distribution of stunted children infected with STH and their hygiene conditions can be observed in each village in Kaliwates District. The map shows that stunted children infected with STH are present in all villages, but only two children with poor hygiene were found in Mangli Village. The results of the overlay map of STH infection case distribution and the hygiene distribution map can be seen in Figure 1.

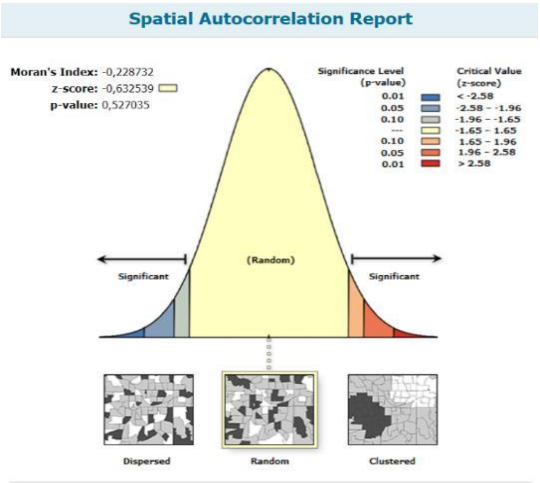

Figure 2. Results of Spatial Autocorrelation Analysis.

Spatial analysis was conducted on stunted children infected with STH using the ArcGIS application to obtain spatial autocorrelation results (Moran's Index). The result obtained is a Moran's Index of -0.228732, indicating negative autocorrelation ($-1 \leq I < 0$). The z-score value is -0.632539, and the p-value is 0.527035, showing a random or stochastic distribution pattern, as shown in Figure 2.

DISCUSSION

In this study, the majority of stunted children had good hygiene, and no relationship was found between hygiene risk factors and STH infection. Similar results were obtained in previous research, which indicated no significant relationship between environmental sanitation and personal hygiene (handwashing habits, nail cleanliness, and footwear use) with soil-transmitted helminth infections in school-aged children in Padang City[21]. This may be influenced by the education level of the parents. The majority of the education levels of the mothers and fathers of stunted children fall into the category of higher education. Higher educational attainment enhances cognitive skills, access to health information, and decision-making capacity, all of which influence preventive health behaviors[22]. In the context of child hygiene, educated parents are more likely to understand the transmission pathways of infectious diseases and the importance of preventive practices such as handwashing, safe food handling, and environmental sanitation[23]. Households with higher educational attainment are more likely to adopt and sustain hygiene-promoting behaviors, thereby reducing infection risk among children[24].

In the present study, no statistically significant association was observed between hygiene-related risk factors and STH infection ($p = 1.000$; OR = 1.200). The odds ratio suggests only a minimal difference in the likelihood of infection between children categorized as having poor versus good hygiene, and this estimate should be interpreted cautiously. Given the non-significant p-value, the observed association may be attributable to random variation rather than a true underlying relationship. While some stunted children demonstrated generally good hygiene practices based on measured indicators, this does not exclude the possibility of intermittent or unmeasured environmental exposures. For example, frequent contact with soil during play activities may increase exposure to infective stages of soil-transmitted helminths, particularly hookworm larvae capable of penetrating intact skin. Furthermore, STH transmission is influenced by multifactorial determinants, including environmental contamination, sanitation infrastructure, climatic conditions, and community-level transmission dynamics. Individual hygiene behavior represents only one component within this broader ecological framework. Therefore, despite the lack of statistically significant association in this study, primary prevention strategies—such as regular handwashing with soap, consistent use of footwear when outdoors, avoidance of potentially contaminated soil, and proper latrine use—remain aligned with established public health recommendations for STH control. The current findings should thus be interpreted as context-specific and not as evidence against the importance of hygiene in STH prevention.

The spatial distribution map illustrates the presence of stunted children and positive soil-

transmitted helminth cases across four villages in Kaliwates District. The distribution of stunted children appeared relatively uniform across villages, which is consistent with local government surveys reporting a high and evenly distributed stunting prevalence in the district. Mangli Village recorded the highest number of positive cases, while other villages reported fewer cases. These differences may reflect unmeasured contextual factors, such as population density, environmental conditions, or access to healthcare. However, these factors were not directly assessed in this study and should therefore be considered as possible assumptions rather than confirmed explanations. Spatial analysis was conducted to examine the geographic distribution of cases. The Moran's Index indicated a negative autocorrelation ($I = -0.228732$), with a z-score of -0.632539 and a p-value of 0.527035, suggesting a random distribution pattern. Similar findings have been reported in Rambipuji District. A random spatial pattern indicates that cases are not geographically clustered[25]. However, this finding should be interpreted cautiously, as the relatively small number of positive cases may influence spatial pattern detection.

The hygiene distribution map provides information on hygiene levels among stunted children across villages in Kaliwates District. Sempusari Village showed the fewest cases of poor hygiene, with only one child identified. Although this finding is descriptive, it may be useful for local health authorities in planning targeted hygiene promotion and monitoring programs. Villages with lower hygiene levels may benefit from prioritized education and preventive interventions to reduce potential infection risk.

An overlay map combining the distribution of soil-transmitted helminth infection cases and hygiene levels was developed to explore their spatial relationship. The map identified two cases of infected stunted children with poor hygiene in Mangli Village, while several infected children were also observed to have good hygiene practices. These findings indicate that infection can occur across different hygiene categories. However, no clear spatial pattern linking hygiene levels and infection was observed. This result should be interpreted cautiously, as the relatively small number of positive cases may limit the ability to detect meaningful associations.

This study demonstrates the value of spatial analysis as an approach to understanding community health problems. Spatial mapping allows clearer visualization of infection distribution and hygiene risk at the local level, which can support evidence-based planning for prevention and control programs. The use of spatial maps may assist health authorities in designing more targeted interventions aimed at reducing transmission risk and improving child health outcomes.

CONCLUSIONS AND RECOMMENDATIONS

The prevalence of soil-transmitted helminth infection among stunted children in Kaliwates District was relatively low (8.7%). The identified species included hookworm and Ascaris lumbricoides, with hookworm being more prevalent. Most stunted children had good hygiene, and no significant association was observed between hygiene and infection. Spatial analysis indicated a random distribution of both infection cases and hygiene risk across Kaliwates District. This study has several limitations. The relatively small number of positive cases and the cross-sectional design may limit the

ability to detect associations and preclude causal inference. Despite these limitations, the findings suggest that deworming programs for stunted toddlers through Posyandu should be maintained. Spatial mapping may assist in planning targeted interventions. Further research with larger samples and longitudinal designs is recommended to better identify risk factors for soil-transmitted helminth transmission.

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