

## Factors Associated with Soil-Transmitted Helminths Infections in Children Aged 24–59 Months in Bandung District, Indonesia

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### Abstract

Soil-transmitted helminth (STH) infections remain a major public health concern in developing countries, particularly among lower- to middle-income populations with poor sanitation, limited access to healthcare, and inadequate clean water. Preschool-aged children are especially vulnerable due to their developing immune systems and increased nutritional needs. This study aimed to identify factors associated with STH infections among children aged 24–59 months in Bandung District, Indonesia. A case-control design was employed using secondary data from helminthiasis surveillance conducted between October 2019 and January 2023, involving a total of 261 children. The Kato-Katz technique was used to examine stool samples for the detection of STH species. Among them, 30 (11.5%) were infected with soil-transmitted helminths (STH), comprising ascariasis (11.1%), trichuriasis (0.4%), and hookworm infection (0.4%). Bivariate chi-square analysis revealed significant associations with fathers' education level ( $p=0.0003$ ), BPJS-Healthcare participation ( $p=0.015$ ), water source ( $p=0.015$ ), distance from the water source to the latrine ( $p=0.003$ ), and nail hygiene ( $p=0.018$ ). Multivariate logistic regression confirmed that distance between water source and pit latrine ( $OR=0.265$ ; 95% CI: 0.076–0.92), nail hygiene ( $OR=0.318$ ; 95% CI: 0.13–0.76), and participation in BPJS-healthcare program ( $OR=0.364$ ; 95% CI: 0.15–0.91) were key determinants of STH infection. These findings highlight the importance of addressing environmental and behavioral factors through public health interventions, including improving access to clean water, promoting personal hygiene, and enhancing parental, particularly paternal education, as essential strategies for reducing the risk of STH in children.

**Keywords:** Children, helminths, helminthiasis, risk factors

### Introduction

Intestinal parasitic infections are a prevalent global health issue, specifically in developing nations. The primary contributors to these infections are helminths, known as soil-transmitted helminths (STH), which are spread through contact with contaminated soil.<sup>1</sup> In addition, STH is one of the 20 neglected tropical diseases, primarily prevalent in tropical regions and often ignored in global health agendas.<sup>2</sup> The main STH species that infect humans

include roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*), and hookworm species (*Necator americanus* and *Ancylostoma duodenale*).<sup>3</sup>

According to the World Health Organization (WHO), approximately 1.5 billion people, or 24% of the world's population, are infected with STH, and over 260 million preschool-age children are at risk of infections by these parasites.<sup>4</sup> The high prevalence of STH infections has been reported to be associated with low education levels, poor socioeconomic status, inadequate sanitation, limited medical services, and restricted access to clean water. Warm, humid climates also promote helminths growth, further contributing to the spread of infections through contaminated soil. These infections are also among the leading causes of morbidity and mortality,

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disproportionately impacting populations in lower to middle-income settings.<sup>2,5</sup>

WHO identifies preschool-aged children (2–5 years of age) as a high-risk group for soil-transmitted helminth (STH) infections and schistosomiasis, emphasizing their vulnerability to adverse effects due to their heightened need for micronutrients.<sup>4</sup> In addition to their susceptibility to STH, children in this age group are particularly vulnerable to stunting and malnutrition, which further exacerbates their risk.<sup>6,7</sup> The prevalence of STH infections in stunted children, ranges from 12.5% to 56.5%, primarily due to immune disturbances, inflammation, and gut microbiota imbalances, thereby increasing their susceptibility.<sup>8</sup> STH infections can cause decreased appetite, nutrient absorption issues, iron deficiency, and gastrointestinal problems, leading to malnutrition, stunting, cognitive impairment, and long-term health risks.<sup>9</sup> Although many studies have explored biological and behavioral factors contributing to STH infections, research focusing on sociodemographic factors remains limited. Therefore, this study aims to provide a comprehensive overview of the factors associated with soil-transmitted helminth (STH) infections among children aged 24–59 months in Bandung Regency, as addressing these factors is crucial for reducing STH infections and consequently lowering childhood morbidity and mortality.<sup>10</sup> By identifying the factors associated with STH infection, this study aims to guide targeted public health strategies to reduce STH infections and improve health outcomes in children.

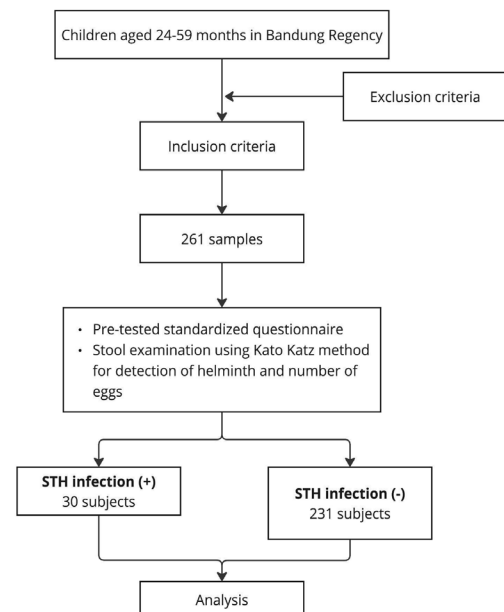
## Methods

This study was a retrospective case-control design using secondary data from helminthiasis surveillance conducted between October 2019 and January 2023. Medical records were collected following ethical exemption approval from the Health Research Ethics Committee of Universitas Padjadjaran (No. 98/UN6.KEP/EC/2024). The minimum sample size required for a 95% confidence interval (CI) was 27 participants, which was calculated by the following formula:

$$n1 = n2 = \left( \frac{Z\alpha\sqrt{2PQ} + Z\beta\sqrt{P_1Q_1 + P_2Q_2}}{P_1 - P_2} \right)^2$$

$$n1 = n2 = \left( \frac{1.96\sqrt{2 \times 0.2 \times 0.8} + 0.84\sqrt{0.35 \times 0.65 + 0.05 \times 0.95}}{0.35 - 0.05} \right)^2$$

$$n1 = n2 \approx 27$$



**Figure 1** Flowchart of the Participant Selection Process for the Study

This descriptive-analytical study applied a case-control approach to investigate risk factors associated with helminthiasis among children aged 24 to 59 months in Bandung Regency. A multistage random sampling method was used to obtain a representative sample. Following the selection of 13 districts, 39 villages, and 29 primary health care centers, a simple random sampling technique was used to select children with helminthiasis. The inclusion criteria included children aged 24 to 59 months who resided in Bandung Regency during the study period, while exclusion criteria consisted of incomplete data, recent anthelmintic drug consumption, and congenital disorders or specific syndromes.

Stool analyses were carried out by a certified laboratory at Dr. Hasan Sadikin Central General Hospital. The Kato-Katz technique was used to detect species of STH, such as *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworms. Data collected included infection type, age, nutritional status, and related factors. Statistical analysis was conducted using Microsoft Excel and SPSS version 27. Bivariate analysis using chi-square tests was applied to determine the association between risk factors and helminthiasis. Multivariate logistic regression was used to evaluate the simultaneous influence of multiple

independent variables. The odds ratio (OR) for the binary outcome variable was evaluated through the univariate analysis. Variables with a p-value < 0.25 were subsequently examined using multivariate analysis to account for potential confounders. Consequently, the final model was reported using the OR with a 95% CI. Statistical test results were considered to exhibit a significant causal relationship when p-value < 0.05.

## Results

Data were collected from October 2019 to January 2023, with 261 children being included in the study. This consisted of 30 children with STH infections (11.5%) and 231 children without STH infections (88.5%). The majority of children with STH infections suffered from ascariasis (11.1%), followed by trichuriasis (0.4%) and hookworm infections (0.38%). In addition, single infections (11.1%) was the most common, followed by a small percentage experiencing dual infections of ascariasis with hookworm (0.4%).

According to the descriptive analysis, it was observed that 150 children (57.5%) were boys, and 111 (42.5%) were girls. Overall, the average age of the participants was 2.83 years old. The nutritional status characteristics of children were grouped into nutritional status based on height-for-age and weight-for-age. In addition, it was found that 18.8% and 24.1% of children suffered from underweight and severely underweight conditions, respectively. This study also showed that 21.5% and 34.5% of children suffered from stunting and severe stunting conditions, respectively. Additional detailed information regarding the characteristics of these children was presented in Table 1.

Variables associated with STH infections were analyzed using bivariate chi-square and multivariate logistic regression. In addition, factors were considered significant when their p-value was < 0.05. Based on bivariate chi-square analysis, having a father with a secondary school education (OR= 0.159; 95% CI: 0.21-1.29; p=0.0003), father with a high school education (OR=0.226; 95% CI: 0.87-0.59; p=0.0003), father with a college education (OR=0.735; 95% CI: 0.14-3.98; p=0.0003), participation in BPJS-healthcare program (OR=0.218; 95% CI: 0.06-0.74; p=0.015), water pump as the source of water (OR=0.527; 95% CI: 0.15-1.82; p=0.014), distance between the water source and the pit

latrine (OR=0.268; 95% CI: 0.11-0.63; p=0.002), and nail hygiene (OR=0.322; 95% CI: 0.13-0.77; p=0.018) were identified as 7 significant factors associated with STH infections incidence. The association between factors of STH infections and the incidence of STH infections was highlighted in Table 2.

Table 3 shows the results of the multiple logistic regression analysis, which was conducted in three sequential steps. This

**Table 1 Characteristics of Children Enrolled in the Study (n=261)**

Variable	n (%)
Sex	
Male	150 (57.5%)
Female	111 (42.5%)
Age	
2 years	121 (46.4%)
3 years	62 (23.7%)
4 years	78 (29.9%)
Father's education	
Primary	50 (19.2%)
Secondary	103 (39.5%)
High school	99 (37.9%)
College	9 (3.4%)
Mother's education	
Primary	54 (20.7%)
Secondary	114 (43.7%)
High school	83 (31.8%)
College	10 (3.8%)
Monthly income (IDR)	
500.000-2 million	119 (45.6%)
2-3.5 million	117 (44.8%)
3.5-5 million	12 (4.6%)
>5 million	13 (5.0%)
STH infections	
Ascariasis	29 (11.1%)
Trichuriasis	1 (0.4%)
Hookworm	1 (0.4%)
Infections types	
Single infections	29 (11.1%)
Dual infections	1 (0.4%)
Nutritional status (weight-for-age)	
Normal	149 (57.1%)
Underweight	49 (18.8%)
Severely underweight	63 (24.1%)
Nutritional status (height-for-age)	
Normal	115 (44%)
Stunted	56 (21.5%)
Severely stunted	90 (34.5%)

STH = Soil-transmitted Helminths

**Table 2 Factors Associated with STH Infections in Children Aged 24–59 Months**

Risk factors	Total Examined n= 261		Bivariate analysis		
	STH (n= 30)	No-STH (n=231)	OR**	95% CI	p-value*
Age (years)					
2	11 (36.7%)	110 (47.6%)			
3	10 (33.3%)	52 (22.5%)	1.923	0.77-4.81	0.369
4	9 (30%)	69 (29.9%)	1.304	0.51-3.31	
Sex					
Male	17 (56.7%)	133 (57.6%)			
Female	13 (43.3%)	98 (42.4%)	1.038	0.48-2.24	1.000
Nutritional status (weight-for-age)					
Normal	14 (46.7%)	135 (58.4%)			
Underweight	9 (30%)	40 (17.3%)	2.170	0.87-5.38	0.231
Severely underweight	7 (23.3%)	56 (24.3%)	1.205	0.46-3.15	
Nutritional status (height-for-age)					
Normal	9 (30%)	106 (48.9%)			
Stunted	11 (36.7%)	45 (19.5%)	2.879	1.12-7.43	0.075
Severely stunted	10 (33.3%)	80 (34.6%)	1.472	0.57-3.79	
Exclusive breastfeeding practices					
<6 months	8 (26.7%)	50 (21.6%)			
6 months	19 (63.3%)	145 (62.8%)	0.819	0.34-1.99	0.651
>6 months	3 (10%)	36 (15.6%)	0.521	0.13-2.10	
Monthly income (IDR)					
500.000–2 million	19 (63.3%)	100 (43.3%)			
2–3.5 million	10 (33.3%)	107 (46.3%)	0.492	0.22-1.11	0.162
3.5–5 million	1 (3.3%)	11 (4.8%)	0.478	0.58-3.93	
>5 million	0 (0.00%)	13 (5.6%)	0.000		
Father's education					
Primary	14 (46.7%)	36 (15.6%)			
Secondary	6 (20%)	97 (42%)	0.159	0.06-0.45	0.0003
High school	8 (26.7%)	91 (39.4%)	0.226	0.87-0.59	
College	2 (6.6%)	7 (3%)	0.735	0.14-3.98	
Mother's education					
Primary	10 (33.3%)	44 (19%)			
Secondary	12 (40%)	102 (44.2%)	0.518	0.21-1.29	0.319
High school	7 (23.3%)	76 (32.9%)	0.405	0.14-1.14	
College	1 (3.3%)	9 (3.9%)	0.489	0.55-4.31	
Participation in BPJS- Healthcare program					
Yes	3 (10%)	78 (33.8%)			
No	27 (90%)	153 (66.2%)	0.218	0.06-0.74	0.015

**Table 2 Continued**

Risk factors	Total Examined n= 261		Bivariate analysis		
	STH (n= 30)	No-STH (n=231)	OR**	95% CI	p-value*
Water source					
Well	5 (16.7%)	43 (18.6%)			
Pump	6 (20%)	98 (42.4%)	0.527	0.15-1.82	0.015
Electric pump	19 (63.3%)	80 (34.6%)	2.043	0.71-5.85	
Spring water	0 (0%)	10 (4.4%)	0.000		
Distance between the water source and the pit latrine					
<10 m	22 (73.3%)	98 (42.4%)	0.268	0.11-0.63	0.003
>10 m	8 (26.7%)	133 (57.6%)			
Availability of household sanitation facilities					
Yes	29 (96.7%)	215 (93%)	2.158	0.28-16.89	0.721
No	1 (3.3%)	16 (7%)			
Latrine usage					
Yes	24 (80%)	191 (82.7%)	0.838	0.32-2.18	0.914
No	6 (20%)	40 (17.3%)			
Availability of septic tank					
Yes	19 (63.3%)	154 (66.7%)	0.864	0.39-1.91	0.874
No	11 (36.7%)	77 (33.3%)			
Handwashing habit					
Yes	17 (56.7%)	119 (51.5%)	1.231	0.57-2.65	0.736
No	13 (43.3%)	112 (48.5%)			
Wearing shoes/slippers in outdoors					
Yes	26 (86.7%)	203 (87.9%)	0.897	0.29-2.76	1.000
No	4 (13.3%)	28 (12.1%)			
Nail hygiene					
Clean	21 (70%)	203 (87.9%)	0.322	0.13-0.77	0.018
Dirty	9 (30%)	28 (12.1%)			

STH: Soil-Transmitted Helminths; OR: Odds Ratio; CI = Confidence Interval; BPJS: *Badan Penyelenggara Jaminan Sosial*; \*Cochran's and Mantel Haenszel; \*\*Chi-square analysis

stepwise procedure utilized the forward Wald method, a variable selection technique in which predictors are entered into the model based on the significance of the score statistic and removed based on the probability associated with the Wald statistic. According to the results of the multiple logistic regression test, the distance between the water source and the pit latrine (OR= 0.27; 95% CI: 0.11-0.63; p=0.036), nail hygiene (OR=0.32; 95% CI: 0.13-0.76; p=0.010), and participation in BPJS-Healthcare program (OR=0.36; 95% CI: 0.15-0.91; p=0.031) were the significant factors influencing the incidence

of STH infections among children aged 24 to 59 months in Bandung Regency.

## Discussion

This study identified *Ascaris lumbricoides* as the most prevalent species of STH, followed by *Trichuris trichiura* and hookworms. These findings are consistent with those reported by Wang et al. in China, where the prevalence of ascariasis among preschool-aged children ranged from 4.7% to 29.5%,<sup>11</sup> but contrast with those of Alelign et al. in Northwestern Ethiopia,<sup>12</sup> where



**Table 3 Multivariate Logistic Regression for STH Infections**

Risk Factors	Coefficient	OR*	95% CI	p-value**
Step 1				
Distance between water source and pit latrine	-1.317	0.268	0.11-0.63	0.002
Step II				
Distance between water source and pit latrine	-1.282	0.277	0.12-0.66	0.003
Nail hygiene	-1.071	0.343	0.14-0.84	0.020
Step III				
Distance between water source and pit latrine	-1.329	0.265	0.76-0.92	0.036
Nail hygiene	-1.145	0.318	0.13-0.76	0.010
Participation in BPJS-Healthcare program	-1.010	0.364	0.15-0.91	0.031

OR: Odds Ratio; CI = Confidence Interval; \*Forward-Wald; \*\*Logistic regression analysis

hookworms were the predominant STH species. *Trichuris trichiura* had also been reported as the dominant species in other regions of Ethiopia and Côte d'Ivoire.<sup>13,14</sup> In Southeast Asia, *Ascaris lumbricoides* contributes the highest burden among soil-transmitted helminth infections in children, with prevalence rates ranging from 21.2% to 50% of cases.<sup>15</sup>

The association between potential risk factors and the incidence of STH infections was analyzed in this study. These results showed that the highest percentage of children with STH infections occurred among those whose fathers had the lowest education level, namely primary school. Meanwhile, the highest percentage of children with STH infections occurred among those whose mothers had a secondary school education. Father's education level was significantly associated with the incidence of STH infections in the bivariate analysis. Compared to fathers with only primary education, those with secondary, high school, and college education had lower odds of having children with STH infections, with odds ratios (OR) of 0.159, 0.226, and 0.735, respectively. These findings align with those reported by Pasaribu et al. in North Sumatera, where secondary and high school education levels among fathers were associated with reduced odds of STH infection, with ORs of 0.58 and 0.45, respectively.<sup>16</sup> On the other hand, mother's education was statistically not significant. A study conducted by Ramadhanti et al. on fathers and early childhood children in Sukamukti Village, Bandung Regency, showed that 67% of children were in the secure attachment category, 29% in the ambivalent attachment category, and 4% in the avoidant attachment category. In this pattern, fathers

served as responsive, sensitive, and nurturing figures, playing a crucial role in the lives of their children.<sup>17</sup> Higher parental education, particularly in health-related fields, equipped children with the knowledge to promote healthy living and provide nutritious diets for their families.<sup>18</sup>

In addition to the role of parental education, access to healthcare services also plays a critical part in reducing the burden of infectious diseases, participation in the BPJS-Healthcare program as a form of universal health coverage for Indonesian citizens was also important to provide access to adequate healthcare and quality services, which could assist in disease prevention and management.<sup>19</sup> The results showed that the percentage of children infected with STH who had participated in the BPJS-Healthcare program was lower compared to children without STH infections who participated in the BPJS-Healthcare program. Participation in this program was significantly associated with the incidence of STH infections in bivariate and multivariate analyses. In addition, it was associated with an OR of 0.364 for the incidence of STH infections compared to non-participants of the BPJS-Healthcare program. This association underscores the broader importance of healthcare access in facilitating timely disease prevention and management.

However, access to healthcare alone is not sufficient to eliminate the risk of STH infections. This limitation highlights the need for a more comprehensive, integrated approach centered on water, sanitation, and hygiene (WASH). WASH strategies aimed to improve water access (quality, quantity, and distance), sanitation facilities (such as latrines and waste management), and

hygiene practices (like handwashing and safe water storage). These strategies significantly reduced the odds of STH infections rates.<sup>20</sup> From observations and interviews, it was found that the majority of the community had water sources. In this study, water sources typically were from dug wells or artesian water used for daily purposes. The data showed that the majority of children with STH infections use water electric pumps as their clean water source, followed by water pumps and water wells. Meanwhile, the majority of children without STH infections use water pumps as their clean water source, followed by water electric pumps, water wells, and spring water. The water source significantly influenced the incidence of STH infections in the bivariate analysis. Water sources such as water pumps, electric pumps, and spring water had OR of 0.527, 2.043, and 0.000, respectively, compared to water wells for the incidence of STH infections, which was not influenced solely by the water source. Another contributing factor was the distance between the water source and the pit latrine. The requirements for proper waste disposal included having a waste drainage system with a distance of at least 10 meters between the water source and the drainage channel.<sup>21</sup> Based on observations and interviews with the community, it was found that in some households, the placement of the water sources and the pit latrines was inappropriate. The percentage of children with STH infections who had a distance between the water source and the pit latrine of less than 10 m was lower than the percentage of children without STH infections who had a distance between the water source and the pit latrine of more than 10 m. Distance between the water source and the pit latrine of more than 10 m was statistically significant and associated with an OR of 0.265 for the incidence of STH infections compared to those with the distance between the water source and the pit latrine of less than 10 m. These findings are consistent with those reported by Sinaga et al. in Bandar Lampung City, which demonstrated a significant association between STH infection and both the water source and the proximity between the water source and the pit latrine. The study found that the risk of STH infection was approximately 3 times higher when the water source was contaminated and located less than 10 meters from the latrine. This could occur because the flow of water from the water source was contaminated by latrine waste. When residents use this contaminated water for washing and cooking, it could introduce microbes, including STH nematodes, into food.<sup>22</sup>

In addition to waterborne transmission, children are also at high risk through direct contact with contaminated environments. Children's activities often involved direct contact with dirty objects and soil contaminated with worm eggs, making it highly likely for the eggs to adhere to their hands and feet, particularly becoming lodged in the gaps between their nails. In addition, children commonly engage in hand-to-mouth behaviors, which increases their risk of ingesting contaminated soil or materials adhered to their fingers and nails, further elevating their vulnerability to STH infections.<sup>23</sup> This study also examined the association between nail hygiene and the incidence of STH infections. Nails were considered clean when the 5 fingers were not blackened due to dirt. Based on the observations, it was found that the number of children with STH infections who had clean fingernails and toenails was fewer compared to those without STH infections. Good nail hygiene was statistically significant and associated with an OR of 0.318 for the incidence of STH infections compared to those with bad nail hygiene. This finding is consistent with the study by Komalasari et al. in Palembang City, which reported that children with poor nail hygiene had a 3.3 times higher risk of parasitic worm infection, further highlighting nail hygiene as a critical factor in the incidence of STH infections.<sup>24</sup>

Other potential determinants, such as nutritional status, showed variable infection rates across different weight and height categories, but these differences were not statistically significant, contradicting the findings of some regional studies that suggested a stronger association.<sup>1,8,9</sup> Similarly, economic factors, breastfeeding practices, and household sanitation measures, such as latrine usage and septic tank ownership, also showed no significant statistical correlation with the incidence of STH, challenging the findings from previous studies.<sup>12,25</sup>

In conclusion, the father's education, BPJS-Healthcare program, access to clean water sources, distance between water sources and pit latrine, and nail hygiene were statistically significant factors influencing the incidence of STH infections among children aged 24 to 59 months. The findings highlight the importance of addressing both environmental and behavioral determinants in reducing the burden of STH infections. Specifically, promoting good nail hygiene and improving access to clean water, alongside behavioral interventions targeting hand-to-mouth activities in children, are crucial

for effective prevention. Public health strategies should prioritize educational campaigns, particularly targeting fathers, to foster better hygiene practices and improve sanitation conditions.

This study has several limitations. The use of self-reported data through questionnaires may have introduced recall bias, as participants could have provided socially desirable responses. In addition, the sample size, while adequate for the study's scope, may limit the statistical power and generalizability of the results, particularly given the large target population. Future studies with larger samples and longitudinal approaches are recommended to validate these findings and explore causal pathways more thoroughly.

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