Evaluating the sensitivity and specificity of symptom-based screening for soil-transmitted helminth infections in children in coastal areas of Indonesia

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Abstract

Soil-Transmitted Helminth (STH) infection is a neglected tropical disease prevalent in many low-income, developing countries with poor environmental sanitation. Children of preschool and school age are particularly vulnerable to STH infection. This study aimed to evaluate the sensitivity and specificity of clinical complaints in detecting STH infection among elementary school-aged children living in coastal areas of Indonesia. A descriptive, observational design was employed, involving 64 children. Data were collected through a structured questionnaire that assessed respondent characteristics and symptoms, followed by a stool examination using the Kato-Katz method to confirm the status of STH infection. The findings revealed a prevalence rate of 21.9% for STH infection. Among the reported complaints, diarrhea demonstrated the highest sensitivity (78.6%). In terms of specificity, complaints of itching around the anus and frequent diarrhea yielded the highest specificity values, at 82% and 74%, respectively. These results highlight key symptomatic indicators that could support early detection and targeted interventions for STH infections in coastal regions.

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Introduction

Soil-transmitted helminth (STH) infection is one of the neglected tropical diseases (NTDs) that poses major public health challenges,[1] particularly in developing, low-income countries.[2] Three primary species are responsible for STH infections in humans: roundworms (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), and hookworms (*Necator americanus* and *Ancylostoma duodenale*).[3,4]

The World Health Organization (WHO) estimates that approximately 2 billion people, or around 24% of the global population, are infected with STH, with *A. lumbricoides* alone affecting about 1.2 billion individuals.[5] Preschool- and school-aged children are particularly vulnerable, with more than 260 million preschoolers and over 657 million school-aged children globally infected.[6] A survey conducted by the Ministry of Health of the Republic of Indonesia reported that the prevalence of helminth infections across several provinces ranged from 40% to 60%. Among school-aged children, the prevalence was even higher, between 30% and 90%.[7] Children aged 6-12 years, typically in elementary school, are particularly susceptible due to factors such as poor personal hygiene.[8] Additional contributing factors include inadequate sanitation facilities and limited knowledge regarding STH prevention strategies.[9]

STH infections have long-term adverse impacts, particularly on children's health, including nutritional deficiencies and impaired cognitive development.[10] Chronic infections[11] can result in stunted growth,[12,13] low Intelligence Quotient (IQ) scores,[14] malnutrition,[15] and anemia,[16] as demonstrated in studies conducted in Ethiopia[17] and other regions.[18,19] Moreover, STH infection has been identified as a significant predictor of stunting among elementary school children. Unlike acute infectious diseases, STH infections typically have a slow pathogenesis and prognosis. Symptoms may vary, and many infected individuals, particularly children, may remain unaware of their condition. Common symptoms associated with STH infection include poor appetite, fre-

quent diarrhea, recurrent abdominal pain, protein loss, itching around the anus,[20] and in severe cases, rectal prolapse. Subclinical infections may present as stunting, weight loss, and reduced cognitive abilities.[21] Given the often non-specific clinical manifestations of STH infection, this study aimed to determine the prevalence of STH infections among elementary school-aged children in coastal areas of Indonesia and to assess the sensitivity and specificity of clinical complaints as potential indicators of STH infection. Identifying the most dominant symptoms associated with STH infection is crucial for early detection and treatment, thereby facilitating better infection control strategies. The initial screening process involves gathering primary complaints from subjects, which is expected to enhance the early identification of infected individuals and improve treatment outcomes. Thus, this study specifically seeks to identify the most common clinical complaints among children with confirmed STH infection through sensitivity and specificity analysis.

Materials and Methods

This study is a descriptive observational study with a cross-sectional design to determine the prevalence and dominant complaints in children infected with STH and to find out the level of specificity and sensitivity of the screening results for each complaint. The population of this study consisted of all children at elementary schools in North Buton Regency, totaling 64 individuals. The total sampling was used in this study. The selection of location and number of samples in this study was made considering the limited research on STH infections in coastal communities, especially in primary school-aged children.

Instruments

Laboratory examination to detect the presence of STH infection is carried out by the Kato-Katz method, using the following tools: i) microscope; ii) cellophane (measuring 2.5 cm x 3 cm); iii) wire gauze to filter feces (measuring 3 cm x 4 cm); iv) filter paper (measuring 10 cm x 10 cm); v) thick cardboard paper; vi) waterproof oiled paper (measuring 10 cm x 10 cm); vii) objects glass; and viii) beakers and bottle sets. The materials used include: i) glycerol solution; ii) malachite green solution; and iii) distilled water.[4]

The study was carried out through a series of organized stages. Initially, all children were gathered in their respective classrooms, where the researchers explained the screening activities, specifically the stool examination aimed at identifying STH infections. Students who expressed their willingness to participate were then given an informed consent form, which they or their guardians were required to sign. Following consent, the participants underwent an interview process, during which information regarding their past health history and any complaints potentially related to worm infections was collected. The symptoms explored included poor appetite, frequent diarrhea, recurrent abdominal pain, itching around the anus and nearby areas, as well as any other relevant complaints as outlined in the questionnaire format. After the interview session, the researchers conducted an educational session for the respondents, providing detailed instructions on the correct methods for collecting, storing, and submitting stool samples for examination.

After the educational session, participants were instructed on the proper method for collecting fecal samples. Fecal collection was to be performed in the morning before going to school. Participants were advised to first urinate to avoid contamination, and then collect fresh feces, ensuring it was not mixed with toilet water or urine. The feces were to be collected in a sterile container, first by placing them on plastic paper, and then transferring an appropriate amount into the stool pot using a provided spoon or stick. For solid feces, approximately 2-5 g (about the size of a fingertip) was required, whereas for liquid feces, 10-15 mL were collected. Once collected, the fecal samples were submitted to the researchers. The samples were neither preserved nor refrigerated, but were stored in a designated box to maintain their condition. All fecal samples were delivered to the health center laboratory and examined within 24 hours of collection. The laboratory examination results were meticulously recorded in an examination results logbook prepared beforehand.

Following sample collection and analysis, the data obtained from interviews and laboratory examinations were processed for further evaluation. Data analysis was conducted using both univariate and multivariate methods, utilizing Excel and SPSS version 24 software with a 95% Confidence Interval (CI) (α=0.05). Univariate analysis, performed primarily using Excel, aimed to describe the distribution of respondent characteristics and laboratory outcomes. This step facilitated the calculation of diagnostic test parameters, including sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and diagnostic accuracy. The calculation of sensitivity, specificity, PPV, NPV, and the diagnostic test accuracy value was performed using the following formula:

$$Sensitivity = \frac{TP}{TP + FN}\ x\ 100\%$$

$$Specificity = \frac{TN}{FP + TN}\ x\ 100\%$$

$$PPV = \frac{TP}{TP + FN}\ x\ 100\%$$

$$NPV = \frac{TN}{FN + TN}\ x\ 100\%$$

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}\ x\ 100\%$$

Table 1 shows that the formula can be applied using a 2x2 contingency table that categorizes individuals based on their test results and their true health status as determined by the gold standard. In this arrangement, individuals who test positive and are confirmed sick by the gold standard are classified as True Positives (TP). Those who test positive but are identified as healthy by the gold standard are categorized as False Positives (FP). Conversely, individuals who test negative but are actually sick according to the gold standard are referred to as False Negatives (FN). Lastly, those who test negative and are confirmed healthy by the gold standard are classified as True Negatives (TN).

Ethical clearance

All stages of this study were conducted following ethical recommendations from the Health Research Ethics Commission of Halu Oleo University (Number: 5500/UN29.17.13/ETIK//2024). All respondents participating provided written informed consent.

Results

Demographic data

Demographic data of the subjects in this study include age and gender. Table 2 shows that most of the study subjects, namely 37.5% were aged 8-9 years, and the age group >11 years was the least represented in this study. Table 2 also shows that 53.1% of the study subjects were women and 46.9% were men.

Identification of STH infection

Identification of STH infection is carried out through examination of stool samples with the Kato-Katz method. This examination is carried out by identifying the presence of helminth eggs of the STH group in the feces sample. Based on the examination of 64 stool samples, 14 tested positive for STH worm eggs. All (100%) positive samples were *A. lumbricoides* species.

Table 3 shows that the age group with the highest number of STH infections identified through fecal examination was 10-11 years old, with 6 individuals (42.9%) testing positive. The age groups with the lowest infection rates were 6-7 and 8-9 years, with 4 individuals each (28.6%). No infections were found in participants over 11 years old.

Table 2 shows that, in terms of gender, the majority of those infected were female, with 9 individuals (64.3%), while 5 (35.7%) were male. Additionally, out of the total 64 study participants, 14 individuals (21.9%) tested positive for STH, whereas 50 individuals (78.1%) tested negative.

Screening results for STH infection complaints in primary school children

Screening for complaints related to STH infection in primary school-aged children is carried out covering complaints such as frequent diarrhea, decreased/reduced appetite, frequent abdominal pain, and itching in the area around the anus/rectum. The complete distribution of respondents, based on screening complaints related to STH infection in children, is presented in Table 4.

As shown in Table 4, the most frequently reported complaint among children infected with STH was diarrhea, experienced by 78.6% of those who tested positive. Further analysis based on the screening data allowed for the calculation of sensitivity, specificity, PPV, and NPV for each commonly reported symptom.

Diarrhea demonstrated the highest sensitivity (79%) and a specificity of 74%, with a PPV of 46% and a high NPV of 93%. This suggests that diarrhea is a fairly sensitive indicator of STH infection, and its absence strongly indicates that the child is not infected. Decreased appetite also showed a relatively good performance, with a sensitivity of 71%, specificity of 66%, PPV of 37%, and NPV of 89%, indicating that its absence is also a useful sign for ruling out infection.

Frequent abdominal pain, however, had a lower sensitivity (36%) and PPV (26%), although its specificity was 72% and NPV was 80%. This suggests that abdominal pain alone may not be a strong predictor of STH infection. On the other hand, frequent

Table 1. 2x2 contingency table (gold standard).

Test results	Sick	Healthy	Total
Positive	TP	FP	TP+FP
Negative	FN	TN	FP+TN
Total	TP+FN	FP+TN	TP+FP+FN+TN

Table 2. Characteristics of research subjects based on age and gender (N=64).

Characteristics of respondents	Frequency	Percentage (%)
Age (years)		
6-7	23	35.9
8-9	24	37,5
10-11	14	21.9
>11	3	4.7
Gender		
Male	30	46.9
Female	34	53.1
Total	64	100

Table 3. STH infection detection by age group and sex (N=64).

Characteristics of respondents	Positive		Negative	
	n	%	n	%
Age (years)				
-7	4	28.6	19	38.6
8-9	4	28,6	20	40
10-11	6	42.9	8	16
>11	0	0	14	21.9
Gender				
Male	5	35.7	25	50
Female	9	64.3	25	50

itching in the anal area presented a sensitivity of 64%, a relatively high specificity of 82%, a PPV of 60%, and an NPV of 98%. This suggests that the absence of this symptom is a strong indicator that the child is not infected, and its presence may serve as a useful sign in identifying potential STH infection cases.

According to the calculation results, among the four main symptoms or complaints reported by respondents, the one with the highest sensitivity and specificity was frequent diarrhea, with a sensitivity of 79% and a specificity of 74%. In contrast, the symptom with the lowest sensitivity and specificity was abdominal pain, with a sensitivity of 36% and a specificity of 72%. Therefore, it can be concluded that diarrhea, decreased appetite, abdominal pain, and frequent anal itching are not definitive indicators of STH infection in children. However, diarrhea, having the highest sensitivity and specificity values in this study, may be considered a more reliable symptom.

The complete sensitivity and specificity values for the screening results are presented in Table 5 and illustrated in the form of a Receiver Operating Characteristic (ROC) graph (Figure 1). Among the complaints evaluated, frequent diarrhea showed the highest diagnostic performance with an Area Under the Curve (AUC) of 0.763 (95% CI: 0.619-0.907, p=0.003), indicating a good level of accuracy in distinguishing between infected and non-infected children. Frequent itching in the anal area also demonstrated strong diagnostic potential, with an AUC of 0.731 (95% CI: 0.570-0.893, p=0.009). Decreased appetite or less eating yielded an AUC of 0.687 (95% CI: 0.529-0.845, p=0.033). On the other hand, frequent abdominal pain had the lowest diagnostic value with an AUC of 0.539 (95% CI: 0.364-0.713, p=0.661).

As shown in Figure 1, the ROC curves of each complaint further confirm these findings, with curves for diarrhea and anal itching showing better separation from the reference line compared to abdominal pain, which closely follows the diagonal, indicating poor discriminative power.

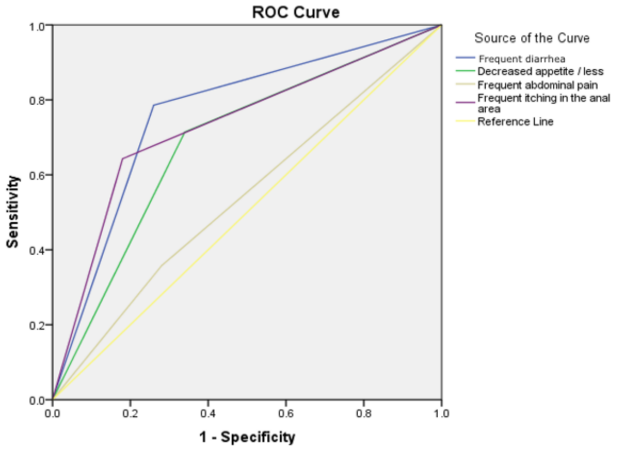

Figure 1. Area under the receiver operating characteristic (ROC) related to complaints in STH infection.

Table 4. Distribution of respondents based on screening complaints related to STH infection (N=64).

Complaints	Positive		Negative	
	n	%	n	%
Frequent diarrhea				
Yes	11	78.6	13	26
No	3	21.4	37	74
Decreased appetite				
Yes	10	71.4	17	34
No	4	28.6	33	66
Frequent abdominal pain				
Yes	5	35.7	14	28
No	9	64.3	36	72
Frequent itching in the anal area				
Yes	9	64.29	9	18
No	5	35.71	41	82

Table 5. Area under the curve.

Variables	Area	Std. Error	Asymptotic Sig.	Asymptotic 95% CI	
				Lower Bound	Upper Bound
Frequent diarrhea	.763	.073	.003	.619	.907
Decreased appetite	.687	.080	.033	.529	.845
Frequent abdominal pain	.539	.089	.661	.364	.713
Frequent itching in the anal area	.731	.082	.009	.570	.893

CI, confidence interval.

Discussion

The present study identified a STH infection prevalence of 21.9% among elementary school-aged children in a coastal Indonesian community, corroborating previous reports of the burden of these neglected tropical diseases in resource-limited settings.[22] The observed female predominance in infection rates aligns with existing literature,[23] suggesting gender-specific behavioral factors may mediate transmission dynamics. The cultural practice of *kengkeng* – a traditional barefoot game predominantly played by female children – likely represents a significant environmental exposure pathway, consistent with established epidemiological evidence linking barefoot soil contact with STH transmission.[24,25]

The epidemiological profile of STH infection in this coastal community appears multifactorial in origin. First, the region's hydrogeological characteristics, marked by limited access to improved water sources and sanitation infrastructure, create an environment conducive to the perpetuation of fecal-oral transmission cycles.[26] Second, our findings support the well-documented association between low health literacy and STH prevalence,[27] highlighting critical gaps in community knowledge regarding disease transmission and prevention modalities. Third, the combination of socioeconomic deprivation and geographic isolation common in many coastal communities intensifies these risk factors, which may explain the consistently high disease burden despite ongoing control efforts.

From a diagnostic perspective, our results demonstrate that common clinical manifestations – particularly diarrhea – exhibit predictive value for STH infection. However, their limited specificity underscores the well-recognized challenge of symptom overlap in pediatric populations.[26] The relatively higher specificity of perianal itching reflects prior findings concerning its diagnostic value for enterobiasis,[28] although its reduced sensitivity warrants caution in clinical practice. These observations collectively reinforce current WHO guidelines recommending parasitological confirmation for accurate STH diagnosis in endemic areas.[22]

The public health implications of these findings are threefold. First, the identification of gender-specific risk behaviors suggests the potential utility of targeted interventions, such as gender-segmented deworming programs or footwear distribution initiatives. Second, the demonstrated limitations of symptom-based screening underscore the continued need for investments in accessible diagnostic capacity, particularly in remote coastal regions. Third, our findings support the implementation of integrated control strategies that combine mass drug administration with Water, Sanitation, and Hygiene (WASH) interventions.[29]

Several study limitations warrant consideration. The cross-sectional design precludes causal inference, while the modest sample size may limit statistical power and generalizability. Furthermore, the use of single stool samples for parasitological diagnosis, while operationally pragmatic, may underestimate true prevalence due to known day-to-day variation in egg excretion.[30] Future research should prioritize longitudinal designs with repeated parasitological sampling, expanded geographic coverage to capture regional heterogeneity, and implementation science approaches to evaluate context-appropriate intervention strategies.

Conclusions

The findings of this study paint a concerning yet actionable picture of STH transmission among children in Indonesia's coastal communities. While diarrhea emerged as a sensitive indicator of infection, and perianal itching showed reasonable specificity, these clinical signs alone proved inadequate for definitive diagnosis, underscoring the indispensable role of stool testing in these resource-limited settings. The persistence of STH reflects a perfect storm of environmental contamination, inadequate WASH infrastructure, and insufficient health literacy – challenges that demand integrated solutions combining targeted deworming, footwear distribution programs, and community-led sanitation improvements.

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