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Co-infection of *Plasmodium* and soil-transmitted helminth among pregnant women in Abaya district, South Ethiopia: A community-based study

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ABSTRACT

Objectives: Co-infection of malaria with helminths poses significant risks, including fetomaternal hemorrhage, fetal growth retardation, spontaneous abortion, and preterm delivery. However, there is a lack of community studies to demonstrate the prevalence of co-infection of helminths with *Plasmodium* and soil-transmitted helminths (STH) and associated factors among pregnant women in Ethiopia.
Methods: A community-based cross-sectional study was conducted among 287 randomly selected pregnant women in the Abaya district from September to December 2022. Data were collected using a standardized questionnaire. Blood and stool samples were collected from each pregnant woman and data analysis was performed using SPSS. Logistic regression analysis was used to identify associated factors.
Results: The co-infection prevalence of *Plasmodium* and STH was 19.5% (95% confidence interval [CI]: 14.92-24.08%), where STHs were 40.6% (95% CI: 34.9-46.3%) and *Plasmodium* was 32.4% (95% CI: 27-37.8%). Hookworm and *Plasmodium falciparum* were the most commonly identified parasite species. Factors significantly associated with co-infection with *Plasmodium* and STH included the habit of eating soil (adjusted odds ratio [AOR] = 2.70, 95% CI: 1.36-5.34), not using insecticide-treated bed nets (AOR = 3.47, 95% CI: 1.76-6.85), living near stagnant water (AOR = 2.23, 95% CI: 1.07-4.64), and rural residence (AOR = 2.23, 95% CI: 1.07-5.97).
Conclusions: Interventions should prioritize enhancing sanitation, educating pregnant women on the use of insecticide-treated bed nets, avoiding eating soil, and eliminating stagnant water near homes. More research should be conducted on the area using more advanced methods.

Introduction

Parasitic diseases represent a significant barrier to socioeconomic progress, improved health, and survival, especially in developing countries [1]. Malaria is a major concern, with an estimated 125 million pregnancies at risk of malaria infection each year [2]. Malaria during pregnancy has been associated with severe maternal anemia, neonatal deaths, and stillbirths in sub-Saharan Africa [3]. Malaria in pregnancy is associated with adverse pregnancy outcomes, including impaired fetal growth and an increased risk of adverse birth outcomes [4].

The concentration of parasites in the placental intervillous space is a contributing factor to adverse pregnancy outcomes due to malaria in pregnancy. Disruptions in amino acid transplacental transport, glucose transport, and insulin-like growth hormone axis are linked to placental inflammation [5–7]. Changes in placental angiogenesis [8], which affect the villous structure and surface area available for nutrient exchange, along with suboptimal uteroplacental blood flow, can further hinder the transport of nutrients across the placenta. These functional and histologic alterations are likely contributors to impaired fetal growth. The increased susceptibility of pregnant women to malaria also poses a challenge, as it makes them significant carriers of the parasite within the community, potentially complicating efforts to control malaria [8–10].

Soil-transmitted helminth (STH) infections are a significant health concern for pregnant women worldwide, particularly in sub-Saharan Africa. These infections cause severe health risks for both the mother and her fetus. One of the primary concerns is the development of anemia, which is exacerbated by STH infections. Anemia in pregnant women is linked to higher risks of intrauterine growth restriction, low birth weight, and an increase in perinatal mortality rates [11]. Helminths also influence immune system responses and trigger physiologic changes that can impact fertility and pregnancy. These parasites induce specific immune states that may impair conception and negatively affect pregnancy [12]. The prevalence of STH infections among pregnant women in sub-Saharan Africa ranges from 11-31% [13].

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During pregnancy, reduced iron absorption is often attributed elevated and uncontrolled inflammatory markers, such as C-reactive protein and serum hepcidin, which result from co-infections with helminths and malaria [14,15]. Conditions like anemia, fetomaternal hemorrhage, stillbirth, and low birth weight have been noted in pregnant women with co-infections of *Plasmodium* species and helminths [16,17]. In many regions of sub-Saharan Africa, STH and *Plasmodium* species are commonly found together. The distribution of co-infections with *Plasmodium* and helminth species is primarily determined by the exposure of the host to parasites and the associated susceptibility processes [18]. The presence of helminths can increase host susceptibility to co-infections since parasites alter host immune response to both helminths and co-infection [19].

Research indicates that co-infection of malaria with *Ascaris lumbricoides* during pregnancy can increase the risk of infection by *Plasmodium falciparum* [20]. Furthermore, malaria–Hookworm co-infection is associated with an increased risk of *Plasmodium* parasitemia [21]. Incidences of malaria co-infection with STH have been reported to range from 3-69% [22]. In Ethiopia, where *Plasmodium* and STH infections are likely co-endemic, published data on the prevalence of co-infection among pregnant women is notably lacking. Consequently, conducting studies in this area is essential to understand the extent of the issue, especially in regions like our proposed study area, which lacks scientific or published data to date.

Methods and materials

Study area and period

The study was conducted in the Abaya district from September to December 2022. Located in the West Guji Zone of the Oromia Region in Southern Ethiopia, the administrative center of the Abaya district is Guangua, which is 456 kilometers from Addis Ababa, the capital of Ethiopia. As per the Central Statistical Agency of Ethiopia's 2007 data, Abaya district had an estimated population of 103,348, with 52,015 males and 51,333 females. The district was served by six health centers, and almost all kebeles (small administrative region in Ethiopia) in the district were malaria.

Study design and population

A community-based cross-sectional study was conducted among pregnant women living in selected kebeles of the Abaya district.

Inclusion and exclusion criteria

This study included selected pregnant women who were permanent residents of the selected kebeles in the Abaya district. Pregnant women who had taken antimalarial drugs and anthelminthic drugs in the previous 2 weeks were excluded.

Sample size

The sample size for the prevalence study was calculated using the single population proportion formula, with an assumed population proportion of 13% based on a similar study in Nigeria [23], a 95% confidence interval (CI) and a 5% error margin. To accommodate a 10% non-response rate, the sample size was adjusted to 191.

$$n = \frac{Z^2\alpha/2\ P(1-p)}{d^2} = \frac{1.96^2(0.13)(1-0.13)}{0.05^2} = 174$$

To accommodate a 10% non-response rate, the sample size was adjusted to 191. To account for the design effect, the sample size was further increased by a factor of 1.5, resulting in a final sample size of 287.

Sampling technique

Six kebeles were randomly selected from 31 kebeles in the Abaya district, and 287 pregnant women were chosen from these kebeles. The number of women selected was proportionally allocated across the kebeles. A systematic random sampling method (k = 45) was then employed to select the 287 pregnant women from the chosen kebeles (Figure 1).

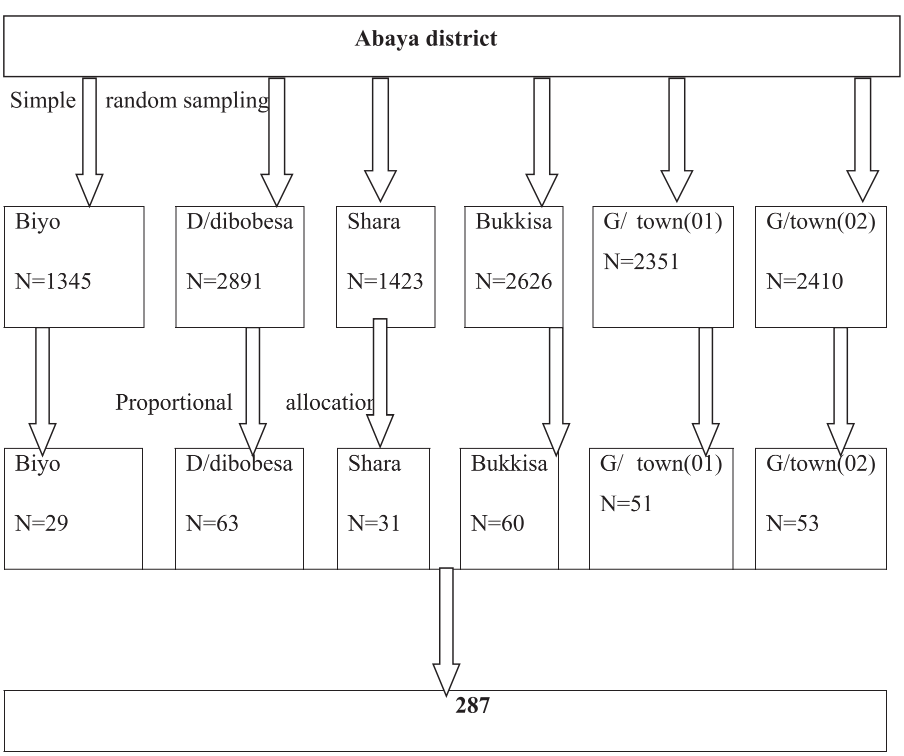

Figure 1. Sampling procedure of pregnant women in the Abaya district.

Data collection and laboratory processing

Health extinction workers conducted interviews with participating women in a private room using a pretested questionnaire. Each woman provided a freshly passed stool sample in labeled screw-capped containers. Stool samples were processed using the standard Kato-Katz concentration technique on the same day. Two Kato-Katz slides were prepared for each sample. Hookworms were examined at a nearby health facility within 45 minutes of collection [24]. The average egg count from the two slides was multiplied by 24 to determine the number of eggs per gram of stool for hookworm*, A. lumbricoides,* and *Trichuris trichiura*. Infection intensity was categorized as low (<1,000 eggs/g stool), moderate (1,000-3,999 eggs/g stool), and high (≥4,000 eggs/g stool) [25]. The parasitic load of hookworm*, A. lumbricoides,* and *T. trichiura* was recorded in the prepared laboratory format.

Blood samples were collected from pregnant women who gave their consent. The samples were labeled, refrigerated, and transported to the laboratory for examination to identify *Plasmodium* species. Malaria parasitemia in pregnant women was identified using a rapid diagnostic test (RDT) for antigen detection and Giemsa-stained blood smear microscopy for microscopic examination. The density of asexual parasites per microliter of blood was determined by counting the number of parasites per 200 white blood cells on a thick blood smear, assuming a standard total white blood cell count of 8,000/μl [11].

Quality assurance

The structured questionnaire was initially developed in English and then translated into Amharic and Afan Oromo. It underwent pre-testing and subsequent revisions before the actual data collection. Data collection was conducted by experienced professionals. Before analyzing the data, researchers verified its reliability and consistency. Two skilled laboratory technicians and the principal investigator examined the microscopic slides. A thin smear was declared negative only after 100 microscopic fields had been inspected. In cases of disagreement between the two microscopists, a third senior parasitologist made the final diagnosis and parasite count.

The manufacturer's instructions for the RDTs were strictly adhered to. The readers of the blood smear microscopy were not aware of the RDT results. For quality control, 10% of the Kato-Katz thick smears underwent a secondary examination by a senior laboratory technologist or the principal investigator. In cases of discrepancies in parasite counts, a different senior technician re-examined the slides, and the findings were deliberated until a consensus was achieved.

Data analysis

All data from laboratory tests and interviews were verified and amended for completeness, removing any inappropriate or illogical responses. For quality assurance, the data were encoded, inputted into EpiData version 3.1, and subsequently transferred to SPSS version 25 for analysis. Data were examined using both descriptive and inferential statistics. The relationship between categoric variables and outcome variables was assessed using the chi-square test. Bivariate binary logistic regression analysis was performed for each independent variable, with those having a *P*-value below 0.25 being considered for the multivariate binary logistic regression model. The final model reported adjusted odds ratios (AOR) with 95% CIs. A *P*-value of less than 0.05 was deemed significant in the analysis. The data were ultimately depicted in Tables and Figures.

Results

Sociodemographic characteristics of study participants

A total of 287 pregnant women from six selected kebeles in the Abaya district were enrolled in the study. The mean age of the participants was 27.6 years, with a SD of ±10.07 years. The largest proportion of the participants (34.8%) were in the age group of 26-30 years. Almost all the study participants, 284 (99%) were married. In terms of educational status, the highest proportion of study participants had primary education (40.4%), followed by secondary education (32.8%). Approximately 55.4% of the study participants lived in rural areas. The larger proportion of study participants were in the second trimester of pregnancy (41.8%). The majority (59.9%) of study participants had no antenatal care follow-up (Table 1).

Prevalence of Plasmodium and STH co-infection

The prevalence of malaria co-infection with STH was 56 (19.5%) (95% CI: 14.92-24.08%) in the current study. The prevalence of malaria and STH infection was 93 (32.4%) (95% CI: 34.9-46.3%) and 116 (40.6) (95% CI: 27-37.8%), respectively. The prevalence of *P. falciparum* and *Plasmodium vivax* was 59 (20.6%) and 34 (11.8%), respectively. STH detected in the stools of pregnant women was hookworm (64 [22.3%]), *A. lumbricoides* (45 [15.7%]), and *T. trichiura* (16 [5.6%]). Of the pregnant women who tested positive for STH, 91 (78.4%) had a mild infection, 22 (18.9%) had a moderate infection, and 3 (2.6%) had a severe infection. In addition, 53.3% of pregnant women were infected with at least one type of parasite (Table 2).

Factors associated with Plasmodium and STH co-infection

Of the variables evaluated, the habit of eating soil (AOR = 2.7, 95% CI: 1.36-5.34), living near stagnant water (AOR = 2.23, 95% CI: 1.07-4.64), rural residence (AOR = 3.1, 95% CI: 1.597-5.965), and not using insecticide-treated nets (ITN) (AOR = 3.47, 95% CI: 1.76-6.85) were significantly associated with the co-infection of *Plasmodium* and STH (Table 3).

Table 1
Distribution of sociodemographic and obstetric characteristics of pregnant women in the Abaya district, South Ethiopia, September to December 2022.

Variables	Category	Number	Percent (%)
Age	18-20	65	22.6
	21-25	83	28.9
	26-30	100	34.8
	31-35	6	2.1
	36-40	33	11.5
Marital status	Married	284	99
	Divorced	2	0.7
	Single	1	0.3
Educational status	Unable to read and write	51	17.8
	Primary school	116	40.4
	Secondary school	94	32.8
	College and above	26	9.1
Parity	Primigravida	115	40.1
	Multigravida	172	59.9
Gestational age	First trimester	90	31.4
	Second trimester	120	41.8
	Third trimester	77	26.8
Antenatal care follow up	Yes	115	40.1
	No.	172	59.9
Residence	Rural	159	55.4
	Urban	128	44.5

Table 2
Prevalence of STH and Plasmodium infections among pregnant women in Abaya district, South Ethiopia, September to December 2022.

Plasmodium or STH species	Number (%)
Hookworm	55 (19.2)
Ascaris lumbricoides	39 (13.6)
Trichuris trichiura	13 (4.5)
Hookworm and Ascaris lumbricoides	6 (2.09)
Hookworm and Trichuris trichiura	3 (1.04)
Plasmodium falciparum	59 (20.6)
Plasmodium vivax	34 (11.8)
Plasmodium and STH Co-infection	56 (19.5)
No infection	134 (46.7)

STH, soil transmitted helminth.

Discussion

Plasmodium and STH usually coexist in Ethiopia, where malaria is endemic. In the current study, the prevalence of STH and malaria co-infection was 19.5%. This finding is comparable with previous studies conducted in Gabon, reported 16.6% and 15% [26,27]. However, the prevalence of co-infection in our study was higher than the prevalence of co-infection reported in Kenya (6.8%) [11], Jimma (7.7%) [28], and Nigeria (3%) [29]. In addition, the current finding is lower compared with the study conducted in Nigeria (43.1%) [30]. The differences in findings of the studies are attributed to the magnitude of malaria and parasites in the regions, government interventions, socioeconomic status, community awareness levels, and geographical variations.

The prevalence of STHs among pregnant women in the current study is 40.6%. The current finding is comparable to the Jimma study of 41% [28]. However, this finding is lower compared with the Northern Ethiopia study of 51.5% [31] and the Mecha district Ethiopia study of 70.6% [32]. However, it is higher compared with the study in Northwest Ethiopia (21.1%) [33] and Jimma town (19.7%) [34]. The discrepancy between this study and others may be due to differences in sample size, soil type, socioeconomic level, and geographical variations.

Malaria is the most serious public health problem in Ethiopia, where it is widespread throughout the country. In this study, the prevalence of malaria was 32.4%. A similar result was found in a study conducted in Zambia with 31.8% [35]. However, lower results were found in studies conducted in West Ethiopia (10.2%) [36], Middle Belt Ghana (20.4%) [37], Arbaminch (9.1%) [38], and Ghana (8.9%) [39]. On the other hand, the current finding is lower compared with the study in Nigeria (41.6%) [40]. Differences in malaria management techniques [41], malaria endemicity, and time of data collection may explain the variance in results. The current study was conducted during a significant malaria transmission season, which may explain the higher prevalence of malaria parasitemia among pregnant women found in this study. Furthermore, the incidence and transmission of malaria are currently increasing in all malaria-endemic regions, including Ethiopia [42].

The factors identified in the current study as being associated with *Plasmodium* and STH co-infection in the study area included the habit of eating soil (AOR = 2.7, 95% CI: 1.36-5.34), living near stagnant water (AOR = 2.23, 95% CI: 1.07-4.64), not using ITN (AOR = 3.47, 95% CI: 1.76-6.85), and residence (AOR = 3.1, 95% CI: 1.60-5.97).

The habit of eating soil was associated with co-infection with *Plasmodium* and STHs. The current study showed that pregnant women who eat soil have about a three-fold higher risk of contracting an infection than those who do not. This may be because the soil may contain STH parasites, which are likely to be transmitted through the soil. Living near stagnant water was another factor associated with co-infection with *Plasmodium* and STHs. Compared with pregnant women living far from vector breeding sites, those living close to them had a 2.3 times higher risk of malaria and co-infection with STH. This finding was comparable to another similar study in Jimma [28], in which soil feeding habits and living near stagnant water were significantly associated with malaria and co-infection with STH. Stagnant water is a feeding ground for mosquitoes, increasing the number of vectors that carry and transmit the *Plasmodium* parasite.

Another factor significantly associated with co-infection with *Plasmodium* and STHs was residence. Compared with women living in urban areas, pregnant women living in rural areas had a three-fold increased risk of co-infection with *Plasmodium* and STHs. This may be because urban dwellers are more educated and have access to the media for health information compared with rural dwellers.

Finally, co-infection with *Plasmodium* and STHs is associated with the use of ITN. Compared with women who used ITNs at home, pregnant women who did not use ITNs had a 3.5-fold increase in the risk of co-infection with *Plasmodium* and STHs. However, other similar studies in Nigeria [29,30,43] identified parity, low income, age, and marital status (single) as possible factors associated with malaria and STH co-infection. Therefore, focusing on the potential risk factors identified in this study may reduce malaria and STH co-infection in pregnant women.

The limitation of this study is the use of a cross-sectional design, which does not allow to establish a cause-and-effect relationship between exposure and outcome.

Conclusion

The co-infection of *Plasmodium* and STHs is one of the health problems among pregnant women living in the Abaya district. The habit of eating soil, living near stagnant water, not using ITN, and residence were factors significantly associated with co-infection with soil-transmitted *Plasmodium*. Therefore, interventions that include removing stagnant water, health education to improve sanitation, avoiding eating soil, and using ITN should be provided to pregnant women. Further research

Table 3
Factors associated with malaria and STH co-infection among pregnant women in Abaya district, September to December 2022.

Independent variables		Plasmodium and STH co-infection		Adjusted odds ratio (95% confidence interval)	*P*-value
		Yes: Number (%)	No: Number (%)		
Habit of eating soil	Yes	41 (25.8)	118 (74.2)	2.7 (1.360-5.339)	0.005
	No.	15 (11.7)	113 (88.3)	1	
Residence	Urban	36 (31.3)	79 (68.7)	1	
	Rural	20 (11.64)	152 (88.3)	3.1 (1.597-5.965)	0.001
Living near stagnant water	Yes,	26 (30)	67 (72)	1	
	No.	30 (15.5)	164 (84.5)	2.23 (1.07-4.64)	0.0032
Insecticide treated net	Yes,	27 (39.7)	41 (60.3)	1	
	No.	29 (13.2)	190 (86.8)	3.47 (1.76-6.85)	0.000
Previous history of Plasmodium infection	Yes,	10 (14.1)	61 (85.9)		
	No.	46 (21.3)	170 (78.7)		

STH, soil transmitted helminth.

should be conducted on a similar title by using advanced methods like polymerase chain reaction to identify the exact prevalence of the parasite.

Declarations of competing interest

The authors have no competing interests to declare.

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Ethical approval

The study protocol was approved by the Ethical Review Board of Bule Hora University (BHU/IRB/2411/14). The study was conducted following the Declaration of Helsinki. Written informed consent was obtained from all study participants. Each participant's information and their laboratory test results were also kept confidential. Pregnant women who tested positive for *Plasmodium* species and soil helminthic infections were referred to the antenatal care clinic at a nearby health facility for treatment and medical advice and were followed up to ensure proper treatment.

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Author contributions

All authors have made substantial contributions to the design, data collection supervision, methodology, analysis, and interpretation of the data and have critically reviewed and approved the final manuscript.

Data availability

All necessary data sets on which the conclusions of this article are based are included in the manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijregi.2024.100475.

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