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Prevalence and Associated Risk Factors of Hookworm and Anemia among Pregnant Women Attending Antenatal Care at Dabat Primary Hospital and Debark General Hospital, Northern Ethiopia

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Abstract

Hookworm infection is a major public health concern and is the major cause of anemia in pregnant women. The aim of this study was to assess the prevalence and risk factors of hookworm and anemia among pregnant women attending antenatal care at Dabat Primary Hospital and Debark General Hospital, northern Ethiopia. A cross-sectional hospital-based study involving 384 pregnant women was conducted from March to June 2023. Stool samples were collected and analyzed for the presence of hookworm infection using wet-mount and formol-ether sedimentation techniques. A blood sample was also collected and analyzed for the hemoglobin (Hb) level of pregnant women. The overall prevalence of hookworm infections was 21.4%, and the prevalence of anemia in this study was 17.7%. The mean Hb value was 14.2 ± 0.07 g/dl, with a range of 7.3–19.6 (Hb) levels. Of the anemic pregnant women, 82.3%, 67.6%, and 7.4% had mild, moderate, and severe anemia, respectively. The result of multivariate logistic regression analysis revealed that residence, monthly income, gestation period, being unable to wear shoes, and soil eating habits were significant predictors of hookworm infection. In addition to this, monthly income, gestation period, and being unable to wear shoes were significant predictors of anemia in pregnant women in the study area. A relatively high prevalence of hookworm infections and anemia was observed among pregnant women. Therefore, the study showed that it needs high work to increase the nutritional requirements of pregnant women since they increase during pregnancy and to help them wear shoes during pregnancy. An integrated hookworm prevention and control program should be designed as an important intervention program for women in general and pregnant women who participated in the study area.

Keywords: Anemia; Hemoglobin; Hookworm; Pregnant women; Risk factor

List of Abbreviations: ANC: Antenatal care; AOR: Adjusted odds ratio; CI: Confidence interval; COR: Crude odds ratio; IPI: Intestinal parasitic infection; SPSS: Statistical package for social science; STH: Soil transmitted helmenth

Introduction

Hookworm infection is a major public health concern, especially in pregnant women, and affects 44 million pregnant women globally [1]. In Sub-Saharan Africa, 37.7 million women of reproductive age are infected with it, and of those, approximately 6.9 million are pregnant women [2]. Hookworm is a common infection in tropical countries, owing to a favorable climate [3], and in poor countries due to socioeconomic factors such as the low quality of domestic water fetched from sources shared with animals, a lack of or poor use of pit latrines, and poor personal hygiene in general [4]. Hookworm infection has a wide range of effects on pregnant women and their fetuses, ranging from asymptomatic to severe infection, which causes malnutrition, anemia, intrauterine growth retardation, and spontaneous abortion [5].

Pregnancy is probably the most hazardous physiological state for a woman because it alters maternal immunity and increases the susceptibility of pregnant women to parasitic infections and disease [6]. Pregnant women are particularly vulnerable to infection, but the effect on pregnancy is not clear and may depend both on how heavy the worm infection is and on the type of worm species involved [7]. As one part of the community, pregnant women are affected by parasitic infection, which consequently leads to a spectrum of adverse maternal and fetal/placental effects [8]. Infection by hookworm is among the major causes of anemia in poor communities, but its impact on causing maternal anemia is poorly understood, and this is the leading cause of maternal health problems [2]. Hookworm is the most prevalent IPI among pregnant women, which induces deficiencies of iron, total energy, protein, and possible folate and zinc, which are vital for fetal development during the gestation period [9, 10].

Anemia is one of the most common global consequences of hookworm in pregnant women. It can be defined as a decline in the oxygen-transporting ability of the blood, which is due to a reduced number of red blood cells and a low concentration of hemoglobin [11]. Anemic conditions are measured in g/dl, which stands for grams per deciliter, and a woman is said to be anemic if her hemoglobin level is less than 11 g/dl. When hemoglobin level was 11 g/dl, the level of anemia was 3; severe when hemoglobin level was 7; moderate when hemoglobin level was between 7.0 and 9.9 g/dl; and mild when hemoglobin level was between 10.0 and 11 g/dl [12].At the global and national levels, anemia affects approximately 38.20% and 22.0% of pregnant women, respectively [12]. This results in 510000 maternal deaths per year as a result of childbirth or early postpartum complications. Anemia is responsible for nearly 20% of maternal deaths, with the majority occurring in developing countries [13]. Anemia is the most common morbidity among pregnant women in Ethiopia, with an overall prevalence ranging between 23%–66.5% and 17.5% according to different studies, with mild anemia accounting for 80% of total anemia [14, 15]. Although pregnancy is one of the most interesting wishes in a woman's life, with increased expectations, there are several conditions that could make the pregnancy painful and treat the full disease: anemia and hookworm infection. Therefore, it is quite natural that pregnant women with any of these conditions would be imposed with a considerable amount of stress on their bodies, as it should be a major concern for them [16]. The management and control of anemia in pregnancy are recorded by the local prevalence statistics, which are not adequate in Ethiopia. The consequences of anemia during pregnancy are a problem that urgently needs to be addressed.

Several studies have been conducted on the prevalence and associated risk factors of hookworm in pregnant women. Sewnet et al. [17] studied the prevalence of hookworm infection and associated factors among pregnant women attending antenatal care at governmental health centers in Dembecha district. Also, Felister et al. [18] conducted a study on hookworm infection among pregnant women at their first antenatal visit in Lira, Uganda. Both of the studies did not focus on the effect of anemia on pregnant women. Moreover, the infection becomes more severe in pregnant women and their fetuses, and information about the prevalence and associated risk factors of hookworm and anemia in pregnant women has not been documented and published. Therefore, to fill this gap, this study aimed at describing the prevalence and associated risk factors of hookworm and anemia among pregnant women attending antenatal care at Dabat Primary Hospital and Debark General Hospital, northern Ethiopia.

Methods

Study Design, Setting and Population

A hospital-based cross-sectional study was conducted from March to June 2023 to assess the prevalence of hookworm and anemia and the associated risk factors among pregnant women attending antenatal care at Dabat Primary Hospital and Debark General Hospital, northern Ethiopia. Debark, a town in the North Gondar zone, is located 830 kilometers from Addis Ababa. It is located at latitude 13°8 N, longitude 37°54 E, and an elevation of 2850 meters above sea level. The average annual rainfall of the district is between 1900 and 2400 mm, and the average temperature is 12°–20°C (North Gondar Zone Administration Office, 2018). The main economic activity of the rural population is mixed farming. Wheat, barley, peas, beans, and chickpeas are widely cultivated crops and cereals (North Gondar Zone Agricultural and Rural Development Office, 2019). Based on 2007 census data conducted by the central statistical agency of Ethiopia, the total population of this zone is 905,680, of whom 425,846 were males and 479,834 were females. This zone has one general hospital and three primary hospitals that provide health care for the population.

Inclusion and Exclusion criteria

Pregnant women who attended antenatal care during the study period and those who were willing to provide stool and blood samples were included in the study. Pregnant women who were not willing to give stool and blood samples and those who had taken pre-anthelminthics before 2–3 weeks of the study period were excluded from the study.

Sample Size Determination and Sampling Techniques

The sample size for this study was estimated by using the simple proportion formula N = Z2p (1-P)/d2 [19] and considering a 95% confidence interval and 5% margin of error. Since the prevalence of hookworm and anemia in the study area was not known, the sample size of the expected study was calculated using 50% prevalence. Based on the formula, a total of 384 pregnant women were included in the study. A systematic random sampling technique was used to select the study participants.

Method of Data Collection

Questionnaire Survey

A structured questionnaire was prepared and pre-tested with 10 pregnant women who did not participate in the main study and who were attending antenatal care at Debark General Hospital so as to evaluate the quality and strength of the questionnaire. An introduction to the objective of this study was given for study participants to actively fill out the questionnaire. The questionnaire was originally prepared in English and then translated to the Amharic local language and back to English in order to obtain content validity. The pre-tested questionnaires were administered to 384 respondents after being modified and quality-assured to generate data on hookworm and anemia risk factors.

Stool Sample Collection

Instruction was given to all pregnant women on proper handling and avoidance of contamination of the stool specimen by trained laboratory assistance. For the study subjects, disposable plastic cups with applicator sticks were provided, and they were instructed to bring approximately 3 gm of fresh stool specimen each. The collected stool samples were immediately preserved with 10 % of formal solution up to the time of microscopy, which helps in preserving the shape and size of protozoan and helminth parasites and preventing further development. The stool samples were marked or coded with the names of pregnant women for the respective stool samples' identification. The concentrated stools were further processed by the conventional for-

mol ether concentration technique. The stool samples were then processed using various standard operating laboratory parasitological examination procedures. A microscopic examination was carried out to identify the presence of hookworm [20].

Laboratory Examination Procedures

Direct wet mount

After gross examination of the sample characteristics, a direct wet smear was prepared from each of the fresh samples by emulsifying about 2 mg of the stool sample on a clean 26×76 mm glass slide in a drop of normal saline solution. Then the sample was covered with a 22×22mm cover slip and observed using middle power (×10) and high power (×40) objectives for the identification of protozoan trophozoite and cyst stages (WHO, 2003).

Formol-Ether Concentration Method

Formol-ether concentration technique was performed to diagnose all types of worm eggs larvae, and protozoan cysts on each of the stool samples. The technique was performed by adding 7 ml of 10 percent formol in to 2 gram of stool specimen in a small beaker and thoroughly emulsified and brought into suspension. An additional 3- 4 ml of 10 % formol saline was added; this was mixed thoroughly and passed through gauze. Three to four (3 - 4) ml of diethyl ether was added and mixed by inverting and intermittent shaking for 1 minute, and centrifuged at 3,000 rpm for 5 minutes. After centrifugation, the supernatant (layers of ether, debris, and formol saline) was discarded and the sediment (containing the parasites at the bottom of the test tube) was re- suspended in formol saline. The sediment was examined microscopically under 10 × and 40×magnifications for the presence of any parasitic organisms [20]. A morphological feature used in the identification of the parasites microscopically was aided by pictures [21].

Modified Ziehl Neelsen Acid-Fast Stain

Smears were made from 5 mg of the fresh stool samples on 26×76 mm glass slides and stained with Modified Ziehl Neelsen acid-fast stain for the identification of the oocysts of *Cryptosporidium* spp using the ×40 and ×100 objectives [22].

Blood Sample Collection and Hemoglobin Determination Procedures

The study participants were kindly asked to give capillary blood samples. The laboratory technicians performed finger pricks carefully using one appropriate sterilized lancet for one individual to avoid the risk of other infections. Blood samples were taken without the respective gestation period difference at the same time of stool sample collection. The Complete Blood Count machine (model no. BCC300, DURI Company China) was used to determine the Hb level. The first drop of blood was removed and discarded and the next drop was used to fill a test tube which was placed in CBC to determine the hemoglobin level of the study subject. The Hb value was then displayed in g /dl after approximately 50 seconds. The hemoglobin value was used to assess the status of anemia. The prevalence of anemia was tested by measuring hemoglobin concentrations taken from participants. The outcome dependent variable, anemia, is defined as the proportion of pregnant women whose blood hemoglobin concentration was less than 11 g/dl. The anemic status was classified as the category of mild, moderate, and severe anemia when the mother's hemoglobin level was 10–10.9, 7–9.9 g/dl and less than 7 g/dl, respectively.

Data Analysis

After collecting all of the data from parasitological laboratory results and risk factor questionnaires, the data was edited, coded, entered, and processed using SPSS version 24. First, descriptive statistics were computed and the result was reported using frequencies and percentages. A chi-square was used to determine the association of variables. Logistic regression was used to deter-

mine the strength of the association between independent variables and the dependent variables. A univariate analysis was performed and variables with p<0.25 [23] were entered into multivariable logistic regression to identify the determinants of hookworm and anemia among pregnant women. Finally, variables with a p-value <0.05 at a 95% confidence interval were taken as statistically significant.

Result

Socio-Demographic Characteristics Of Pregnant Women

A total of 384 pregnant women were included in the study, which had a 100% response rate. The Participants' ages ranged from 15 to 44 years. The mean age (SD) of the study participants was 28.6 ±0.73 years. Of the total study subjects, 206 (53.6%) were urban dwellers, and 178 (46.4%) were rural residents. From the total population, 342 (89.06%) were married, 28 (7.3%) were single, and the remaining 14 (3.6%) were divorced. Regarding education level, 72 (17.7%) were illiterate, 158 (41.1%) could read and write, 98 (25.5%) attended high school, and 56 (14.6%) attended college or above. Occupationally, 233 (60.6%) were housewives, 46 (11.9%) were government employees, 98 (25.5%) were private workers, and 7 (1.8%) were daily laborers. Economically, 123 (32%) earned more than three thousand Ethiopian Birr, 192 (50%) earned between 1000 and 3000 Ethiopian Birr, and 69 (17.9%) earned less than 1000 Birr (Table 1).

Table 1: Socio-demographic characteristics of pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023)

Characteristics		Frequency	Percent
	15-19	8	2.08
Age category	20-24	100	26.04
	25-29	114	29.7
	30-34	95	24.7
	35-39	52	13.5
	40-44	7	1.8
Marital status	Married	342	89.06
	Single	28	7.3
	Divorce	14	3.6
Education level	Illiterate	72	18.7
	Read and write	158	41.1
	High school	98	25.5
	College and above	56	14.6
Residence	Urban	206	53.6
	Rural	178	46.4
Occupation	Housewives	233	60.6
	Government employee	46	11.9
	Private worker	98	25.5
	Daily laborer	7	1.8

Monthly income	<1000	69	17.9
	1000-3000	192	50
	Above 3000	123	32

Pregnancy History of Study Subjects

Out of 384 study subjects, 111 (28.9%) pregnant women were in the third trimester (gestational period greater than 28 weeks), while 142 (36.9%) were in the second trimester (gestational period between 13 and 28 weeks), and the remaining 131 (34.1%) participants were in the first trimester (gestational period less than 13 weeks). Nearly half 174 (45.3%) of pregnant women had never been pregnant before; 112 (29.2%) were bigravdae; and the remaining 98 (25.5%) had been pregnant more than twice (Table 2).

Table 2: Medical history of pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023)

Medical history		**Frequency**	**Percent**
Trimester	First	131	34.1
	Second	142	36.9
	Third	111	28.9
Gravid	Primgravidae	174	45.3
	Bigravidae	112	29.2
	Multigravidae	98	25.5

Prevalence of Hookworm Infection Across Socio Demographic Characteristics and Pregnancy History of Study Subjects

The presence of hookworm infection was assessed across the socio-demographic characteristics and pregnancy histories of study subjects. Age, residence, occupation, monthly income, marital status, educational status, trimester, and gravidity were taken as study variables to see the association between risk factors and dependent variables (Table 3). There was a statistically significant association between all socio-demographic characteristics and the pregnancy history of pregnant women and hookworm infection, except for marital status (Table 3).

Regarding the age group, in the age group 35–39, the prevalence of hookworm infection was high; 53.8% (28/52) of pregnant women were infected more than other age groups. Related to education status, illiterate pregnant women were highly infected at 41.7% (30/72) compared to educated pregnant women. Rural pregnant women were also 26.4% (47/178) more infected with hookworm than urban pregnant women. In comparison to pregnant women of different parity levels, primgravidae pregnant women were highly infected at 25.3% (61/112).

Table 3: The prevalence of hookworm infection by socio-demographic characteristics and pregnancy history of pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023).

Risk factors	No examined (%)	Hookworm infection		$\chi 2$	p-value
		Positive n (%)	Negative n (%)		
Age category					
15-19	8(2.08)	2 (25)	6 (45)	31.2	0.001*
20-24	100(26)	16 (16)	84 (84)		

25-29	114(29.7)	18 (15.8)	96(84.2)		
30-34	95(24.7)	16(16.8)	79 (83.2)		
35-39	52 (13.5)	28 (53.8)	24 (46.2)		
40-44	7(1.8)	2 (28.6)	5 (71.4)		
Marital status					
Married	342 (89.06)	67 (19.6)	275(80.4)	5.7	0.32
Single	28 (7.29)	8 (28.6)	20(71.4)		
Divorced	14 (3.64)	7 (50)	7(50)		
Education level					
Illiterate	72(18.7)	30 (41.7)	42 (58.3)	29.5	0.001*
Read and write	158 (41.1)	39 (24.7)	119 (75.3)		
High school	98(25.5)	8 (8.2)	90 (91.8)		
College and above	56(14.5)	5 (8.9)	51 (91.1)		
Residence					
Urban	206(53.6)	35 (16.9)	171 (83.1)	26.3.	0.001
Rural	178 (46.4)	47 (26.4)	131 (73.6)		
Occupation					
Housewives	233(60.67)	55(23.6)	178 (76.4)	11.9	0.003*
Government employee	46(11.97)	5(10.8)	41 (89.1)		
Private worker	98(25.5)	18 (18.4)	80(81.6)		
Daily laborer	7(1.82)	4 (57.1)	3 (42.9)		
Monthly income					
<1000	69(17.96)	38 (55.1)	31 (44.9)	21.6	0.001
1000-3000	192 (50)	30 (15.6)	162 (84.4)		
Above 3000	123(32.03)	14 (11.4)	109(88.6)		
Trimester					
First	131(34.1)	32 (24.4)	99 (75.6)	3.6	0.012
Second	142(36.97)	31 (21.8)	111 (78.2)		
Third	111(28.9)	19 (17.1)	92 (82.9)		
Parity					
Prim gravid	174 (45.3)	44 (25.3)	130 (74.7)	16.7.	0.001
Bi gravidae	112(29.16)	21 (18.7)	91 (81.3)		
Multi gravidae	98 (25.5)	17 (17.3)	81 (82.7)		

Univariate and Multivariate Analysis of Risk Factors in Relation to the Prevalence of Hookworm Infection in Pregnant Women

The univariate and multivariate analyses of risk factors were presented as (COR) and (AOR) at 95% confidence intervals (Table 4). The univariate analysis of hookworm infections across risk factors showed that, with the exception of marital status, all the

risk factors were statistically significant for hookworm infection. However, multivariate analysis showed that residence, monthly income, gestation period, inability to wear shoes, and soil eating habits were significant predictors of hookworm infection (Table 4).

The odds of being infected with hookworm were about 3.89 times higher among rural residents (AOR = 3.89, p = 0.003) compared with urban residents. The odds of contracting hookworm infection were roughly four times higher in women earning 1000 Ethiopian birr per month than in those earning more than 3000 Ethiopian birr per month (AOR = 4.02, p = 0.007). It was also discovered that the odds of being infected with hookworm were more than four times higher in those in their first trimester than in those in their third trimester (AOR = 4.24, p = 0.034). The odds of being infected with hookworm infection were four times higher in women who had not worn shoes than in those who had worn shoes (AOR = 4.1, P = 0.001). Pregnant women who eat soil are two times more highly infected by hookworm than those who do not eat soil (AOR = 2.2; p = 0041) (Table 4).

Table 4: Univariate and multivariate analysis of risk factors in relation to the prevalence of hookworm infection in pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023).

Risk factors	No examined (%)	Positive (%)	COR	P value	AOR	P value
Age category						
15-19	8(2.08)	2 (25)	0. 6 (0.5-0.9)		0.3 (0.1-16.2)	0.26
20-24	100(26)	16 (16)	0.4 (0.1-2. 9)	0.011	0.4 (0.04-1.6)	
25-29	114(29.7)	18 (15.8)	0.2(0.2-4.07)		0.7 (0.02-7.9)	
30-34	95(24.7)	16(16.8)	0.2(0.06-2.4)		0.2 (0.03-5.6)	
35-39	52 (13.5)	28 (53.8)	0.1(0.02-0.9)		0.3 (0.01-1.9)	
40-44	7(1.8)	2 (28.6)	1		1	
Marital status						
Married	342 (89.06)	67 (19.6)	3.6(0.2-25.7)	0.43		
Single	28 (7.29)	8 (28.6)	2.6(0.2-21.6)			
Divorced	14 (3.64)	7 (50)	1			
Education level						
Illiterate	72(18.7)	30 (41.7)	0.1(0.05-0.6)	0.03	1.4 (0.2-14.8)	0.23
Read and write	158 (41.1)	39 (24.7)	0.2(0.14-0.7)		0.9 (0.03-2.3)	
High school	98(25.5)	8 (8.2)	0.3(0.14-1.2)		0.2 (0.4-4.62)	
College and above	56(14.5)	5 (8.9)	1		1	
Residence						
Urban	206(53.6)	35 (16.9)	1	0.001	1	0.003
Rural	178 (46.4)	47 (26.4)	1.54 (2.5-6.9)		3.9 (0.96-7.2)	
Occupation						
Housewives	233(60.67)	55(23.6)	1	0.008*	1	0.56
Government employee	46(11.97)	5(10.8)	2.8 (1.5 -4.2)		0.1 (0.15-7.4)	

Private worker	98(25.5)	18 (18.4)	1.4(0.25-5.4)		0.1 (0.14-8.9)		
Daily laborer	7(1.82)	4 (57.1)	0.01(1.2-2.3)		0.6 (0.03-2.7)		
Monthly income							
<1000	69(17.96)	38 (55.1)	3.2 (0.12-0.9)	0.001	4.0 (0.1-6.89)	0.007	
1000-3000	192 (50)	30 (15.6)	1.0(0.2-0.18)		2.1 (0.5-8.38)		
Above 3000	123(32.03)	14 (11.4)	1		1		
Trimester							
First	131(34.1)	32 (24.4)	2.6(0.25-3.1)	0.001	4.2 (1.13-6.2)	0.034	
Second	142(36.97)	31 (21.8)	0.89(0.7-2.3)		1.2 (0.3-3.89)		
Third	111(28.9)	19 (17.1)	1		1		
Gravidity							
Prim gravid	174 (45.3)	44 (25.3)	3.3(1.8-5.6)	0.001	1.1(0.13-2.78)	0.22	0.22
0.22							
Bi gravidae	112(29.16)	21 (18.7)	0.45(0.1-1.7)		0.5 (0.23-3.45)		
Multi gravidae	98 (25.5)	17 (17.3)	1		1		
Place of defecation							
Open field	55 (31.2)		4.6 (1.36-8.4)	0.001	3.3 (1.25-7.2)	0.03*	
Toilet	27 (12.9)		1		1		
Source of drinking water							
Pipe	28 (9.6)		1	0.001	1	0.31*	
River	54(59.3)		2.6 (0.2-6.57)		2.1 (0.89-5.6)		
Hand washing before meal							
Yes	77 (20.5)		1	0.016	1	0.001*	
No	5 (55.6)		9.8 (1.8-18.7)		7.3 (1.8-9.8)		
Habit of shoe wearing							
Yes	38 (12.1)		1	0.001	1	0.001	
No	44 (63.7)		4.8 (1.2-7.56)		4.1 (1.03-7.9)		
Soil eating							
Yes	35 (72.9)		3.1 (1.02-3.6	0.001	2.2 (0.89-3.4)	0.041	
No	47(13.9)		1		1		

The Overall Prevalence of Anemia

The overall prevalence of anemia in this study was 17.7% (68/384). The mean Hb value was 14.2 g/dl±0.07 with a range of 7.3–19.6 (Hb) levels. All pregnant women must have hemoglobin levels greater than 11 gm/dl; however, levels less than this indicate iron deficiency or anemia (Table 5).

Table 5: The overall prevalence of anemia and anemic condition among pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023).

Total no examined n	Anemic n (%)	None anemic n (%)	Mild	Moderate	Severe
384	17.7% (68/384)	82.3% (316/384)	67.6% (46/68)	25% (17/68)	7.4% (5/68)

Assessment of Anemia Associated with Socio-Demographic, Pregnancy History, Personal Hygiene And Sanitation Risk Factors Among Pregnant Women

Table 6 shows the univariate and multivariate statistical analysis of anemia across socio-demographic, pregnancy history, personal hygiene, and sanitation risk factors among pregnant women. The result of the univariate analysis showed that age category, education level, residence, monthly income, trimester, gravidity, soil eating habit, and being unable to wear shoes were significantly associated with anemia in pregnant women. However, multivariate analysis showed that only monthly income, trimester, and being unable to wear shoes were the only predictors of anemia in pregnant women (Table 6).

The odds of anemia were six times higher in women earning 1000 Ethiopian birr per month than in those earning more than 3000 Ethiopian birr per month (AOR = 6.32, p = 0.012). The odds of anemia were three times higher in women who were in the first trimester than in those in the third trimester (AOR = 3.01; P = 0.003). Similarly, the odds of being infected with anemia were 4.62 times higher in women who had not worn shoes than in those who had worn shoes (AOR = 4.62, P = 0.001) (Table 6).

Table 6: Univarate and multivariate analysis of anemia by socio-demographic, medical history, personal hygiene and sanitary factors of pregnant women attending antenatal care at Dabat primary hospital and Debark General Hospital (March to June, 2023)

Risk factors	No examined (%)	**Anemic (%)**	COR	P value	AOR	P value
Age category						
15-19	8(2.08)	2 (25)	16 (1.23-18.7)		4.3 (0.23-18.7)	0.25
20-24	100(26)	13(13)	11 (3.6-21.8)	0.001	3.42 (0.19-14.5)	
25-29	114(29.7)	26(22.8)	7.6 (1.04-6.56)		2.4(0.45-8.62)	
30-34	95(24.7)	19 (20)	3.2 (0.45-9.6)		0.89 (0.09-3.4)	
35-39	52 (13.5)	6 (11.5)	14 (1.5-28.9)		0.21 (0.04-4.52)	
40-44	7(1.8)	1(14.3)	1		1	
Marital status						
Married	342 (89.1)	52 (15.2)	1.26 (0.04-6.23)	0.32		
Single	28 (7.29)	13 (46.4)	0.23(0.01-5.7)			
Divorced	14 (3.64)	3(21.4)	1			

Education level						
Illiterate	72(18.7)	22 (30.6)	2.42 (0.56-5.42)	0.001	1.2 (0.15-4.6)	0.46
Read and write	158 (41.1)	38 (24.1)	1.23 (0.12-4.85)		0.56 (0.04-3.5)	
High school	98(25.5)	6 (6.1)	0.99 (0.08-2.45)		0.01 (0.01-1.28)	
College and above	56(14.5)	2 (3.6)	1		1	
Residence						
Urban	206(53.6)	26 (12.5)	1	0.011	1	0.23
Rural	178 (46.4)	42 (23.6)	3.32 (0.56-6.28)		1.4 (0.63-3.85	
Occupation						
Housewives	233(60.7)	52(22.7)	1	1.82		
Government employee	46(11.97)	2(4.3)	1.56 (0.04-2.21)			
Private worker	98(25.5)	11 (11.2)	0.47 (0.03-1.56)			
Daily laborer	7(1.82)	3 (42.9)	0.05 (0.01-1.08)			
Monthly income						
<1000	69(17.96)	13 (18.8)	13.2 (2.87-21.6)	0.001*	6.32 (0.94-24.3)	0.012
1000-3000	192 (50)	32 (16.7)	4.25 (1.25-8.75)		2.5 (0.67-8.6)	
Above 3000	123(32.03)	23 (18.7)	1		1	
Trimester						
First	131(34.1)	25 (19.1)	3.12 (0.23-6.7)	0.002	3.01 (0.04-.6.7)	0.003
Second	142(36.97)	26 (18.3)	1.21(0.21-4.3)		1.05(0.15-3.25)	
Third	111(28.9)	17 (15.3)	1			
Gravidity						
Prim gravid	174 (45.3)	32(18.4)	3.24 (0.86-4.23)	0.002	2.10 (0.35-3.47)	0.62
Bi gravidae	112(29.16)	23 (20.5)	0.65 (0.45-2.7)		0.42 (0.12-3.08)	
Multi gravidae	98 (25.5)	13 (13.3)	1		1	
Habit of shoe wearing						
Yes	315(82)	52 (16.5)	1	0.001		0.001*
No	69(18)	16 (23.2)	6.2(1.52-7.73)		4.62 (1.56-8.26)	
Soil eating						
Yes	48(12.5)	17(35.4)	1.08 (0.25-4.35)	0.05	0.78 (0.02-2.44)	0.23
No	336(87.5)	51 (15.2)				

Discussion

Knowing about the epidemiology of hookworm and anemia is very important in reducing detrimental effects on the lives of mothers and their offspring's. In line with this idea, the present study attempted to assess the prevalence and associated risk factors of hookworm and anemia in pregnant women attending antenatal care at Dabat primary hospital and Debark general hospital. The overall prevalence of hookworm infection among pregnant women in the present study was 21.4% (78/384). This finding is in agreement with the finding of 18.5% in Ghana [24]. The findings of the current study are lower than those of the study conducted among pregnant women in Dembecha district, northwest Ethiopia, at 32% (17), Vietnam at 78.15% (25), Ghana at 45% (26), and Uganda at 45% [27]. Differences in findings among various studies can be explained by variations in geography, socioeconomic conditions, the study population, and the level of awareness about the transmission of hookworm infection. The current finding, on the other hand, revealed a higher prevalence rate than the 7% found in a study conducted in Hossana, Ethiopia [28], 1.3% in Addis Abeba, Ethiopia (29), and 5.5% in Bahir Dare, Ethiopia [8]. It was also higher than the prevalence of hookworm in Kenya (3.9%), Nigeria (30%), and Ghana (13.9%) [31]. The high prevalence of hookworm among pregnant women in the study area might be due to the low socioeconomic and educational status of pregnant women, their failure to wear shoes, their use of contaminated and unhygienic water, and their habit of eating soil and raw vegetables.

This study has shown that gardening barefooted (AOR = 4.1, P = 0.001), not having access to a toilet (AOR = 3.3, P = 0.03), and not washing their hands before meals (AOR = 7.3, p = 0.001) were strongly associated with hookworm infection among pregnant women attending antenatal care in Debark General Hospital. The association between gardening barefoot and infection with hookworm emanates from the fact that rural women do much fieldwork, including harvesting and weeding crops, without protective footwear, thereby exposing them to infective hookworm larvae and thereby increasing their risk of getting infected. Similar findings were also obtained in a study from Ethiopia in which hookworm infection was demonstrated to be significantly associated with walking barefoot as well [32].

The overall prevalence of anemia among pregnant women in the present study was found to be 17.7%. The prevalence of anemia obtained in this study was almost consistent with other studies: 16.6% from Gondar, northwest Ethiopia [33]; 17.5% in east Wollega, Oromia [15]; 16.3% from Shire Town, Shire, Tigray, and northern Ethiopia [34]; and 16.4% from Wondo Genet district, southern Ethiopia [35]. The result of this study was much lower than the previous studies conducted among pregnant women attending antenatal clinics. 53.9% from Gilgel Gibe Dam area, southwest Ethiopia (36), 36.1% from Tigray, northern Ethiopia [37], 51.9% from Shir Ethiopia Hospital [14], and 30.5% from Dera District, northwest Ethiopia [38].

The mean Hgb value in the study was 14.2 g/dl ±0.07 with a range of 7.3–19.6 (Hb) level. Of the anemic pregnant women, 82.3%, 67.6%, and 7.4% had mild, moderate, and severe anemia, respectively. In comparison to studies conducted in South Gondar [38] and Tigray [37] the current study found a low severity of anemia. This difference might be due to better socio-economic status, good dietary habits, and functional iron with folic acid supplements among pregnant women in the area of the recent study. Although the prevalence and severity of anemia were lower in the recent study, those anemic women are poor in socio-economic conditions. The monthly income of those women less than $1,000 was one factor in anemia (AOR = 6.32). The gestation period being in the first trimester was also a significant factor in the occurrence of anemia (AOR = 3.01). Barefooted pregnant women are highly susceptible to the parasitic infection of hookworm, with a significant association with anemia (AOR = 4.62).

The relative high requirement for iron causes pregnant women to be at a high risk for iron deficiency [39]. The risk of anemia and the mean hemoglobin level are high at the first gestational age of pregnant women. This is due to the high requirement for micronutrients for fetal growth and development [40]. According to the findings of this study, the mean hemoglobin level among pregnant women was different, but it was low in the second and third trimesters. This may be due to other factors relat-

ed to the personal behavior of pregnant women in taking iron supplement tablets and the habit of dietary taking experienced in the last gestational period. The mean hemoglobin level varies across the number of gravidae and can determine the anemic status of a pregnant woman. From the findings of this study, the mean hemoglobin level was different at different birth intervals for pregnant women. This finding is consistent with the recent study reported in Pakistan [41].

Conclusion and Recommendation

The result of this study indicated that the overall prevalence of hookworm infection and anemia among pregnant women attending antenatal care at Debark General Hospital was high. This study also identified determinant factors associated with hookworm and anemia. The study identified that residence, monthly income, gestation period, inability to wear shoes, and soil eating habits were significant predictors of hookworm infection. In addition to this, monthly income, gestation period, and being unable to wear shoes were significant predictors of anemia in pregnant women in the study area. The results showed that the prevalence of hookworm was highly associated with anemia and was found to be a serious health problem in the study area. Therefore, the study showed that it was concluded that hookworm infections and anemia were high in pregnant women in the study area, and therefore it needs high work to increase the nutritional requirements of pregnant women since they increase during pregnancy and to help them wear shoes during pregnancy. These findings indicate the widespread presence of hookworm infection and anemia among study participants in the study area, emphasizing the need for immediate intervention strategies to address this public health concern. An integrated hookworm prevention and control program should be designed as an important intervention program (nutritional programs or hygiene promotion campaigns) for women in general and pregnant women who participated in the study area are required.

Limitation of the Study

The study period and participants are too small that makes generalization based on the observed result very difficult, also the cross-sectional design's inability to establish causality was the study limitations.

Ethical Approval

The study was approved by the Ethical Clearance Committee of the Research Directorate of Debark University, and permission was obtained from Dabat and Debark Hospital. The pregnant women were informed about the study, and then informed consent was obtained from those who were 16 years old and older before the commencement of the study. For under--16-year-old participants, informed consent was obtained from their guardians. A code number was given to each pregnant woman, and their names were not disclosed to anyone other than the one who was involved in the research. Participation in the study was on a voluntary basis, and study subjects were free to withdraw from the study before and after the collection of stool samples without losing any of the benefits they were supposed to obtain from the hospital. Those who were found to be positive for any of the parasites were informed by the clinicians about possible treatment.

Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Author's Contribution

GA conceived and designed the study, extracted and analyzed data, interpreted results, and drafted the manuscript. MM was involved in study selection, quality assessment, interpretation of results, and review of the manuscript.

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