Assessment of Malaria Related Anemia and Underweight in Under-Five Age Children in Estie Woreda, South Gondar Zone of Amhara Region, South East Ethiopia

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Abstract

Background

Malaria remains a challenging health problem in malaria endemic regions. Malaria associated anemia represent a major public health problem in sub-Saharan Africa. Both, anemia (reduced in hemoglobin level) and underweight in terms of (weight-for-age) was a critical problem of malaria directly or indirectly. The objective of this study was to assess malaria related anemia and malaria related underweight among under-five years age children in Arushe wanqat kebele. Children's were selected through systematic random sampling technique to select the first children from new vital event registration master list of Arushe wanqat kebele, and then totally 364 children were included. Parasitological, hematological and anthropometric measurements were conducted. Questionnaire survey was also used in order to assess malaria related anemia and weight on children whose age were below five years. Data was analyzed using SPSS software version 20 and was presented in frequency, table, pie chart, bar graph and percentage form. Analysis of Variance (ANOVA), correlation(r), and Chi-square (X^2) tests were used to verify the possible association between *Plasmodium*s pecies, anemia, and underweight at different age (in months).

Results

Prevalence of *Plasmodium falciparum* accounted for 101(27.8%), *Plasmodium vivax* accounted for 84(23.1%), and mixed infection (both *P. falciparum* and *P. vivax*) also accounted for 14(3.8%). The correlation (r) between *Plasmodium* species and hemoglobin concentration ($r = 0.628$; $p = 0.000$); *Plasmodium* species and weight measure ($r = 0.77$; $p = 0.000$). The prevalence of malaria related anemia and underweight were 70.4% and 51.3%, respectively. *Plasmodium falciparum* is the most prevalent species and a notorious cause of anemia among children who were less than five years old. Both anemia (reduction of Hb. in g/dl) and underweight have a positive linear relationship. Malaria-related anemia was also more prevalent than malaria-related underweight among children. The result of the study indicates that there was a strong association between malaria and anemia (association is significant between *Plasmodium* species and hemoglobin concentration; $p < 0.05$); there is also an association between malaria and weight loss or underweight (association is significant between *Plasmodium* species and weight-for-age z-score; $p < 0.05$) at different age groups

Conclusions

The prevalence malaria-related anemia among children in Arushe wanqat kebele was 38.67%.On the other hand, the prevalence of malaria-related weight loss or underweight among children in Arushe wanqat kebele was 28.02%. So, the findings of this study also revealed that malaria remains a public health problem that contributes for anemia and underweight on under five children.

Introduction

Around half a million people die of malaria annually and an estimated 90 per cent of these deaths are in sub- Saharan Africa. More than two-thirds of malarial deaths occur in children under five (WHO, 2015). Where malaria is endemic (present all the year round) children are at greatest risk between six months (when immunity inherited from the mother fades) and about five years (when their own immunity increases). Globally, 293.1 million (47.4%) under five year's children are anemic and 67.6% of these children live in Africa (Benoist et al., 2008). It occurs at all stages of the life cycle but is more prevalent in pre-school aged children (under five years).

In almost all countries in Sub-Saharan Africa, anemia is a moderate or severe public health problem causing significant morbidity and mortality (Hensbroek et al., 2011); also an important cause of morbidity and mortality in African children where resources to determine the underlying etiology remain poor (Brabin, et al., 2001).

Malaria associated anemia represent a major public health problem in sub-Saharan Africa (Bjorkman, 2002). Malaria infection in human by *Plasmodium* species is associated with a reduction in hemoglobin levels, frequently leading to anemia. *Plasmodium falciparum* causes the most severe and profound anemia, with a significant risk of death (Menendez et al., 2000). The pathogenesis of malarial anemia is multifactorial, involving the immune- and non-immune mediate haemolysis of parasitized and non-parasitized erythrocytes (Ghosh, 2007). *Plasmodium falciparum* is resistance to wide range of anti-malarial drugs, age, socio-demographic factors, HIV, couples with parasitic and bacterial infections may influence the prevalence and outcomes of malaria anemia (Ongeche et al., 2006).

Childhood anemia is a condition where a child has an insufficient hemoglobin (Hb) level to provide adequate oxygen to the body tissues. For children between 6 and 59 months, under-fives), the threshold Hb level for being non-anemic is 11.0 grams per deciliter (g/dL) (WHO, 2011). Being low birth weight is associated with fetal and neonatal morbidity and mortality, impairment of growth and development and chronic disease later in life (Chiarotti et al., 2001). Low birth weight: neonate born with a birth weight of ≤ 2499g (Lawn et al., 2010).

Children who survive malaria may suffer long-term consequences of the infection. Repeated episodes of fever and illness reduce appetite and restrict play, social interaction, and educational opportunities, thereby contributing to poor development. An estimated 2% of children who recover from malaria infections affecting the brain (cerebral malaria) suffer from learning impairments and disabilities due to brain damage, including epilepsy and spasticity (Murphy and Breman, 2001).

History Of Global Malaria Control Efforts In Ethiopia

In 1950s, the WHO attempted a global eradication of malaria in a program similar to the United States Malaria Eradication Program. Although successful in Europe and Australia, it was less so in Asia and South America, and it never got off the ground in Africa. Then in 1960s, eradication program stopped due to insecticide resistance by mosquitoes and drug resistance by malaria parasites and also due to poor infrastructure, particularly in Africa including Ethiopia, and financial constraints. In 1970s and 1980s, little attention was given to malaria and a shift of focus was from eradication to control. Encouraged by the significant progress following Scale Up for Impact (SUFI) and sustained control, the Federal Ministry of Health (FMOH) has committed to the elimination of malaria from the whole country with the goal of nationwide elimination by 2030 (FMOH, 2016).

In order to be successful in the national elimination endeavor, the capacity of the country's health system in terms of availability of trained human resources, adequate finance, and logistics needs to be ensured. The existing surveillance system has to be reoriented in order to detect every infection, treat cases promptly, and submit reports in a timely manner. Monitoring of drugs and insecticides' resistance needs to be done regularly. Furthermore, targeted communities have to be mobilized to own the elimination initiative so they can actively engage in the planning and implementation of appropriate interventions, including proper use of anti-malaria interventions (FMOH, 2017).

The information collected was an essential component in the effectiveness of malaria control and elimination interventions that currently being scaled up. Hence it is used to realign the effectiveness of malaria control measures so as to reduce malaria burden effectively and achieve elimination.

Methods

Description of the Study Area

Estie Woreda is in the Administrative Zone of South Gondar, Amhara Regional State, Ethiopia (Fig. 1). It is situated approximately 676 km northwest of Addis Ababa and approximately 100 km north of Bahr Dar. There are 42 rural kebeles, and three urban kebeles. Estie is bordered by Farta Woreda to the North, Gojjam to the Southwest, Simada Woreda to the East, and Andabet and Dera Woreda to the West. This Woreda is situated at latitude 11°34'N and longitude 36°41'E. This Woreda has a total surface area of 132,373.9 km^2 (Estie Woreda Land Administration office, 2018)

Study Design and Period

All necessary data for the study was collected from September 01/2019 to February 30/2020, a kebele household questionnaire survey, cross-sectional parasitological analysis, hematological and weight measurements were conducted to assess malaria related anemia and underweight on under-five years old children as well as its prevalence.

Study populations and selection criteria

Study population

The source of population was all children aged below five years old and their mothers in Arushe wanqat kebele for the year (2019/20). All selected children who are below five years old and their mothers living in Arushe wanqat kebele were study population.

Inclusion Criteria

All enrolled children whose parents were volunteers, those with an exact date of birth, those with a vaccination card, and those who did not receive malaria treatment. All children aged less than five years old and their mothers who were permanent residents of selected kebeles and households were included.

Exclusion Criteria

Non-volunteer guardians of children who do not have a well-known date of birth, month and year, parents who do not have or lose the vaccination card of their babies in one way or another, and who have undergone any diagnosis and treatment for malaria have been removed. Children whose mothers were severely sick and unable to respond were also excluded.

Sample Size determination

Samples were taken from the registration of Arushe Wanqat kebele master list (2015–2018) on children's who were under five years old with total population number (N = 4000) for sample size determination (n). Among malarious rural kebeles in Estie woreda, Arushe wanqat was randomly selected. Sample size was determined by using a single population proportion formula: $n = {Z^2 * p(1-p)}/{E^2}$. By hypothesizing that 31.3% prevalence of malaria among under-five children in the study area. Where n = sample size required, 10% $=$ possible non response rate or contigency, N = target group total population, and E = 0.05 at 95% confidence interval error margin (Lemeshow et al., 1990). Therefore, the total sample size needed for this study was 364.

Sampling techniques

Sampling interval was calculated by dividing total study population in the selected kebeles by the number of sample units (N/n), which was $4000/364 \approx 11$. The first child was selected within the sampling interval of (1–11) by drawing a random number. Then, the sample was taken from every 11th children of the master list in Arushe wanqat kebele until the required sample size was obtained.

Data collection methods

In addition to blood samples and some other anthropometric data, questionnaire surveys were also performed to assess anemia and weight loss related to childhood malaria. Before the collection of blood samples from the subjects, the consent of the parents/guardians of the children was obtained. With the help of a laboratory technician, blood samples collection was based on the method (Cheesbrough, 2006).

Questionnaire survey

In order to obtain information on demographic character, accommodation type, health-seeking activity, and habit of contacting health organization, and feeding practice and other related issue; a formal questionnaire was administered to the parent or guardian of the children. Using questionnaire data was also collected from parents or caregivers on the signs of anemia and weight loss, malaria prevention measures and feeding practices.

Parasitological examination

The 5μL of blood was taken from each child to diagnose malaria by using *Plasmodium falciparum*/*Plasmodium vivax* (*Pf/Pv*) malaria rapid diagnostic test (RDT) kit. Malaria parasite diagnosis was carried out following (Megnekou et al., 2018).

Hematological examination (measuring Hb)

Blood samples were collected from the children by trained health technicians using a finger or heel prick that was carried out with a single retractable, spring loaded, sterile lancet. Blood was then collected in a micro cuvette. A battery operated portable HemoCue analyzer was used for hemoglobin analysis on site and results obtained within 1 min. WHO cut off points to assess hemoglobin levels was used to assess anemia. The cut off points for anemia were: normal Hb levels ≥ 11.0 g/dL, mild anemia Hb = 10.0–10.9 d/dL, moderate anemia Hb = 7.0–9.9 g/dL and severe anemia Hb < 7.0 g/dl (WHO, 2011).

Measuring weight

Weight measured using UNICF provided a digital Seca 874 weight scales (Seca GmbH & Co.Kg.) with good precision and recorded to the nearest 0.1 kg. During weight measurement, participants removed their shoes and jackets and wore light clothing (Hassen and Ali, 2015) and the scale was repeatedly checked for accuracy against a known weight. Weight for age, scores was generated using WHO standards and (DeOnis et al., 2004; WHO, 2006), then underweight was defined as having a Z score below −2 SD (WHO, 2006).

Data analysis

The compiled data was coded and entered into the machine and evaluated using the version 20 software Statistical Package for Social Science (SPSS). The descriptive data was analyzed and presented using the frequency count, percentage, ANOVA, and Chi-square ($\chi 2$) test to verify the potential association between *plasmodium* species and anemia, underweight and sociodemographic characteristics of children under the age of five. A value was considered to be important if the p-value was less than 0.05.

Ethical Considerations

Ethical clearance was obtained from the Ambo University, College of Natural and Computational Sciences ethical committee with Rf. No. CNCS/RCCST/48/2020. Moreover, after describing the purpose and procedures of the research, consent was obtained from the parents of the children selected for study.

Results

Socio-demographic characteristics

In socio-demographic characteristics of children, 171(47%) were males and 193(53%) were females among the total sample in the study (Table 1). As digital weight scale reading showed that most of the children have weight ranges from 4.5–7.5 kg which accounts for 13.7%, 7.6 kg-10.6 kg accounts for 36.85% and a weight greater than 16.8 kg accounts for a small proportion than other weight reading (2.2%) with average weight 11 kg.

However, their age was measured in terms of month, the majority of children selected for the study lies in the 6–11 month range (23.4%). Nevertheless, the three age category such as 24–29, 36–47, and 48–59 month range bears equal proportion and which accounts for 10.4%, these age groups consists minimum amount of sample proportion than another age group. The rest children were found between 18 and 23 and 30–35 month range, and account for 17.9% and 15.7%, respectively.

Table 1
Socio-demographic characteristics of the 364 children.

Variables or Socio-demographic characteristics	Description	Frequency (%)
Sex	Male	171(47%)
	Female	193(53%)
Weight in kg	4.5–7.5	50(13.7%)
	7.6–10.6	134(36.8%)
	10.7–13.7	104(28.6%)
	13.8–16.8	68(18.7%)
	Above 16.8	8(2.2%)
Age in month	6–11	85(23.4%)
	12–17	42(11.5%)
	18–23	65(17.9%)
	24–29	39(10.7%)
	30–35	57(15.7%)
	36–47	38(10.4%)
	48–59	38(10.4%)

Age was measured in terms of the month with mean age 25 months; standard deviation was 14.1 with 198.2 of the variance (Table 2). The average weight of children in kg was 11 with 3.1 standard deviations and 9.6 variances. Level of hemoglobin concentration was measured in g/dl; 10.6, 1.2, and 1.88, respectively for mean, standard deviation, and variance.

Table 2
Descriptive statistics of age (in month), weight (in kg), and hemoglobin concentration (in g/dl).

Variable	N	Average(mean)	Std.Deviation	Variance
Age (in month)	364	25	14.1	198.2
Weight (in kg)		11	3.1	9.6
Hemoglobin conc.(in g/dl)		10.6	1.2	1.88

Prevalence of plasmodium **species by age and sex**

Table 3 shows the prevalence of *Plasmodium falciparum*, *Plasmodium vivax*, and mix-infection (both *Plasmodium falciparum* and *Plasmodium vivax*) according to age and sex. Among 364 examined or diagnosed children for *Plasmodium* parasites, 101(27.7%) of them infected by *P. falciparum*, 84(23.1%) of them infected by *P.vivax* and 14(3.8%) of them infected by both *P. falciparum* and *P. vivax* (mix infection) but 165(45.3%) were negative for *plasmodium* parasite species.

Regarding with sex, females were more infected than males by *Plasmodium* parasites; 93(25.5%) male children were malaria positive out of 171 examined males (46 or 49.5% *P. falciparum*; 41 or 44.1% *P. vivax*; and 6 or 6.5% mixed *plasmodium* species. On the other hand, 106(29.1%) female children were malaria positive out of 193 examined females (55 or 51.9% *P. falciparum*; 43 or 40.6% *P. vivax*; and 8 or 7.5% mixed *plasmodium* species. Based on age group of children, majority of children were infected who lied on 6–11 age months years old, which account for 85(23.6%) children and all of them were positive for malaria (77 or 90.6% *P. falciparum* and 8 or 9.4% mixed infection. But age from 30–35, 36–47 and 48–59 months only bear three children were infected i.e. one child at each age categories or group and each children were positive for *P. vivax.*

Table.3. Prevalence of *P. falciparum*, *P. vivax*, and mixed infection (both *Pf* and *Pv*) based on age and sex of children

Age (in month)	Males				Females				Total		
	No. Examined	Pf	Pv	Mix(Pf&Pv)	No. Examined	Pf	Pv	Mix(Pf&Pv)	Pf	Pv	Mix (Pf&Pv)
6–11	41	37	0	4	44	40	0	4	77	0	8
12–17	17	1	14	2	25	5	18	1	6	32	3
18–23	30	7	21	0	35	7	24	2	14	45	2
24–29	18	1	4	0	21	3	0	1	4	4	1
30–35	30	0	0	0	27	0	1	0	0	1	0
36–47	18	0	1	0	20	0	0	0	0	1	0
48–59	17	0	1	0	21	0	0	0	0	1	0
Total	171	46	41	6	193	55	43	8	101	84	14

Among twenty-two individuals who were severely anemic (Hb < 7g/dl), both male and female diagnosed children were positive for malaria i.e. all of them were infected by malaria parasite (10 *P. falciparum*; 6 *P.vivax*; and 6 mixed infection (Table 4). All moderately anemic children with (Hb: 7-9.9 g/dl) were also positive for *Plasmodium* species like severely anemic children and which accounts for 42. Among these children, *P. falciparum* accounts for 29, *P. vivax* accounts for 9, and mixed infection accounts for 4. Perhaps, except for one male and one female among seventy-six mild anemic children with hemoglobin cut off 10g/dl to 10.9g/dl, all of them were malaria positive (*P. falciparum* accounts for 35 and *P. vivax* accounts for 39. Within 224 non-anemic individuals or who have hemoglobin levels above 11g/dl, 28 out 105 examined male and 33 out of 119 examined females, a total of 61 children were positive for malaria, and *P. falciparum* accounts for 27, *P. vivax* accounts for 30, and mixed infection accounts for 4.

Table 4
Prevalence of *P. falciparum*, *P. vivax* and mix (*Pf & Pv*) by Hb (g/dl) and sex.

Hemoglobin concentration (in g/dl)	Males				Females				Total		
	No. Examined	Pf	Pv	Mix(Pf& Pv)	No.Examined	Pf	Pv	Mix(Pf& Pv)	Pf	Pv	Mix(Pf& Pv)
< 7g/dl	9	5	2	2	13	5	4	4	10	6	6
7-9.9g/dl	19	13	4	2	23	16	5	2	29	9	4
10-10.9g/dl	38	16	21	0	38	19	18	0	35	39	0
Above 10.9g/dl	105	12	14	2	119	15	16	2	27	30	4
Total	171	46	41	6	193	55	43	8	101	84	14

Association of plasmodium **species with level of hemoglobin concentration and weight measure**

The next two consecutive tables show the association of *plasmodium* species with hemoglobin concentration and weight at particular age category of children, respectively. Except, the second and the seventh age groups ($p > 0.05$) and it is not significant; but *plasmodium* species and hemoglobin concentration were associated and significant ($p < 0.05$). For instance, the association of hemoglobin and malaria parasite at the first age group (6–11 month) (P = 0.014),at the second age group (12–17) (P = 0.32), at the third age group (18–23) (P = 0.000); the fourth age group (24–29) (P = 0.01), the fifth and sixth age group (30–35 & 36–47), respectively (P = 0.000), and seventh age group (48–59) (P = 0.78) (Table 5).

Table 5
Association between hemoglobin concentration and *plasmodium* species on the basis of children age

Age(in month)	Hemoglobin concentration				*Plasmodium* Species.			P-value
	Above 11g/dl	10-10.9g/dl	7-9.9g/dl	< 7g/dl	*Pf*	*Pv*	*Pf&Pv*	
6–11	28	26	18	13	77	0	8	0.014
12–17	17	8	10	7	6	32	3	0.32
18–23	15	35	13	2	14	45	2	0.00
24–29	33	5	1	0	4	4	1	0.01
30–35	56	1	0	0	0	1	0	0.00
36–47	37	1	0	0	0	1	0	0.00
48–59	38	0	0	0	0	1	0	0.78

On the other hand, the association of *Plasmodium* Species and weight-for-age (z-score) the second, sixth and seventh age groups were not significant ($p > 0.05$) relative to children age or on the basis of children age. *Plasmodium* species and weight-for-age (z-score) were associated and significant ($p < 0.05$) on the rest age category. The association of weight-for-age (z-score) and malaria parasite prevalence at the first age group (6–11 month) ($p = 0.02$;<0.05),at the second age group (12–17) ($p = 0.23$;>0.05);at the third age group (18–23) ($p = 0.000$;<0.05); the fourth age group (24–29) ($p = 0.01$;<0.05);the fifth (30–35) ($p = 0.04$;<0.05 ;at the sixth age group (36–47) ($p = 0.98$;>0.05),and seventh age group (48–59) ($p = 0.92$;>0.05) (Table 6).

Table.6. Association between *Plasmodium* species and weight-for-age (Z-score) on the basis of children's age category.

Age(in month).	Weight for age(Z score)				*Plasmodium* Species			P-value
	Between +2&+3	Between +2&-2	Between −2&-3	Below -3	*Pf*	*Pv*	*Pf* & *Pv*	
6–11	0	42	30	13	77	0	8	0.02
12–17	1	20	12	9	6	32	3	0.23
18–23	1	37	14	13	14	45	2	0.00
24–29	0	31	4	4	4	4	1	0.00
30–35	1	55	1	0	0	1	0	0.04
36–47	0	37	1	0	0	1	0	0.98
48–59	0	37	1	0	0	1	0	0.92

Prevalence of malaria related anemia and malaria related weight loss (underweight)

Prevalence of malaria related anemia

Malaria-related anemia means simply, anemia caused by infection of malaria parasite instead of iron deficiency. Among the total number of diagnosed or examined children, the number of malaria-infected individuals and who were also positive for anemia (individuals confirmed for both malaria and anemia). Therefore, malaria-related anemia means an anemic individual from malaria-infected children at each age group. Not all malaria-infected children might get anemia and on the other hand, not all anemic children might be malaria positive. For example, among 85 individuals diagnosed for malaria at the first age category, all of them were infected by malaria. Nevertheless, as they were malaria positive, all are not positive for anemia (because there are individuals who were malaria positive but not positive for anemia i.e. shortage of oxygen caring protein or hemoglobin). Out of 85 diagnosed for malaria, all of them were infected with either *P.falciparum* or *P.vivax* or both and then 57 (67.1%) were anemic i.e. this is malaria-related anemia at the first age group (6–11).

The last three age's classes (30–35, 36–47, and 48–59) have only three malaria infected children. Thus, one child at each age group, but only two was anemic. In general, 199 (54.67%) out of 364 children were infected with malaria, and 140(38.46%) out of 199 malaria positive children were anemic (Hb concentration below 11g/dl based on WHO standards of anemia cut off for under-five children) (Table 7).

Table.7.The prevalence of malaria related anemia thresholds for under five children based on (WHO, 2011)

Age(in month)	No of examined	No of malaria positive	Malaria related anemia based on WHO anemia cut-off (WHO,2011)				
			Non-anemic(> 11g/dl)	Mild anemic(10-10.9g/dl)	Moderate anemic(7-9.9g/dl)	Sever anemic(< 7g/dl	Malaria related anemia
6–11	85	85	28	26	18	13	57
12–17	42	41	17	8	10	7	25
18–23	65	61	15	35	13	2	50
24–29	39	9	33	5	1	0	6
30–35	57	1	56	1	0	0	1
36–47	38	1	37	1	0	0	1
48–59	38	1	38	0	0	0	0
Total	364	199	224	76	42	22	140

Prevalence of malaria related weight loss (underweight)

Besides malaria-related anemia, there was also malaria-related weight loss. It can be described relative to children's specific age group and their weight. Among all age classes, high prevalence of malaria related underweight or weight loss was occurred in children who were found in the age range from 6–11 and accounted for 43(50.6%) from 85 total diagnosed and malaria positive children. It is possible to say age classes (30–35, 36–47 and 48–59) have only three malaria-infected children. Thus, one child at each age group and both of them are below standards what is expected based on WHO growth standards (weight –for –age z-score). The overall prevalence of malaria-related underweight or weight loss was 102(28.02%) among malaria-infected children 199(54.67%) (Table 8).

Table.8. The prevalence of malaria related weight loss based on WHO weight for age (z score cut-off) among 364 children (WHO, 2011).

Age (in month)	No of examined	No of malaria positive	Malarial weight loss based on WHO weight for age (z score cut-off)				
			Over weight (+ 2&+3)	Normal(+ 2&-2)	Moderate weight(-2&-3)	Sever underweight(<-3)	Malarial related weight loss
6–11	85	85	0	42	30	13	43
12–17	42	41	1	20	12	9	21
18–23	65	61	1	37	14	13	27
24–29	39	9	0	31	4	4	8
30–35	57	1	1	55	1	0	1
36–47	38	1	0	37	1	0	1
48–59	38	1	0	37	1	0	1
Total	364	199	3	259	63	39	102

Discussion

The risk of malaria infection decreased with increasing age i.e. the prevalence of malaria is inversely related to age. As age increase, the prevalence of malaria decrease and the immunity (capability of defending against deficiency and infectious disease) increases. Such increased susceptibility of younger children to infections has attributed to their poorly developed immune systems (Thorarinsdottir et al., 2005; Kunihya et al., 2016; Ani, 2004).

According to the results of this research the correlation(r) between malaria and anemia was linear positive (as *Plasmodium* species prevalence increase, the prevalence of anemia increase and vice versa) (p = 0.000), an association of *Plasmodium* species and anemia was significant. Children of the households not using a bed net for sleeping were 2.38 times more susceptible to malaria compared to net users. Approximately, 92.11% of the respondents reported using a mosquito net for sleeping, and malaria prevalence was observed to be more than two times higher among households that did not use mosquito nets (23.11%) compared to net user households (8.05%). Hanging a mosquito net is extremely important for preventing malaria (69.76%) while only 1.24% reported that it is not important at all. However, the malaria prevalence was higher for children in those households (9.70%) who mention that the hanging net is extremely important, showing variation between knowledge and practice (Sultana et al., 2017).

A present study showed that 29.2% were with malaria infection and 26.2% malaria with mild anemia (47.6%), moderate anemia (42.1%) and severe anemia (29.4%) and the relationship between malaria infection and anemia was statistically significant (Kunihya et al., 2016).

The prevalence rate of malaria-related anemia were 27.0% (Ademowo, 1995); 24.3% (Kuadzi et al., 2011); among children in Ghana 30.0% (Okonko et al., 2012) in Ibadan; 31.6% (Olasunkanmi et al., 2013) in Abeokuta, Nigeria, and 36.4% (Okafor and Oko-ose, 2012). The total malaria prevalence in this study was 54% and the prevalence of any anemia was 38.46%; 70% of anemia was malaria-related with mild (54.28%), moderate (30%), and severe (15.71%) malaria-related anemia. This is consistent with the findings (Kunihya et al., 2016).

Malaria was significantly associated with anemia, and, increasing the hemoglobin level may be associated with a significant reduction of mosquito contact with the children using the malaria prevention strategy (Oladeinde et al., 2012). This is in line with the current study i.e. hemoglobin concentration and malaria contact with children had a linear relationship (like a contact of children with malaria parasite increase, anemia also increase due to reduction of hemoglobin concentration). This reduction of hemoglobin concentration was due to poor utilization habit of the insecticide-treated net by parents and maybe low knowledge, attitude and practice about malaria and anemia relationship, and in addition to low educational qualification.

Even though, malaria causes chronic anemia, impaired growth, and delayed development in young children, but not significantly associated with each other (Wierzba et al., 2001; Sakwe et al., 2019). This is not consistent with the current study.

Children whose parents/guardians attended tertiary education were less prone to anemic with malaria infection; with mild (5.2%), moderate (5.2%), and severe anemia (3.4%). This is due to conscious of child nutrition, prevention of mosquito bites by using any possible means of prevention, and/or they are well informed about malaria because they are enlightened (Kunihya et al., 2016). The same is true in this study because the prevalence of mild, moderate, and severe anemia was higher on those children who had uneducated or illiteracy parents than children whose guardians have primary educational qualification; the prevalence of mild, moderate, and severe anemia was higher on those children who have primary educational status than children whose guardians have secondary and tertiary education qualification. Because, the degree of understanding about transmission, cause, and effect as well as prevention of malaria and anemia decrease from children's guardian who has tertiary education to illiteracy or uneducated parents.

Children whose mothers were aged less than 20 years or 30–39 years were 4.69 and 2.55 times more likely to develop anemia, as compared to those who were aged 40 years and above though results were not significant (Borbor et al., 2014). Mothers who were aged 20 years and above were less likely to have their children to be anemic compared to mothers less than 20 years. Nevertheless, children of mothers aged 40–49 years were 84% and less likely to be anemic compared to those less than 30 years. The reason for the findings in this study regarding age could probably be mothers aged 40 years, above are multiparous, and thus have experience in childcare and feeding practices compared to mothers less than 20 years (Kweku et al., 2012).

Regarding underweight, a study in Nigeria showed that underweight was significantly associated with malaria attacks in children (Jeremiah and Uko, 2007; Hamid Hassen, and Jemal Ali 2015). The relationship between malaria infection and nutritional status was a two-way association. Malnourished children were more likely to be infected by malaria parasites compared to well-nourished children. This is consistent with current result, i.e. those who have low nutritional status, have high prevalence of malaria, anemia and underweight, and vice versa. On the other hand, malaria positive children were more likely to become malnourished than those uninfected. This implies that on one hand, malaria may cause malnutrition, whereas, on the other hand, malnutrition may exacerbate the disease (Sakwe et al., 2019).

Similarly, a study in Sudan indicated that malaria was more often in malnourished than inadequately nourished children (Samani, Willett, and Ware, 1987). According to WHO's Comparative Risk Assessment project, children who were moderate to severely underweight had an increased risk of acquiring clinical malaria than better-nourished children though the difference is not significant (Caulfield et al., 2004).

Both underweight and severe underweight (weight loss) were highly related to malaria and mostly occurred weight loss or underweight was due to malaria infection and it is to be a means of recording high prevalence of weight loss in children. This is because of the low nutritional status of children in which provided by their parents, a poor habit of attending children's growth based on children and mothers health card, and lack of knowledge about the relationship or cause and effect association of malaria, and weight loss.

The prevalence of underweight in both males and females was consistent with the observations of Sumbele et al. (2015) in the Mount Cameroon area, Wamani et al.(2007) in Tanzania that underweight was common among males than females in all age groups (Kamugisha et al., 2006).

Concerning malnutrition, the high prevalence was an indicator of poor feeding habits (low nutritional status of children), absence of attendance habit of health organization, low nutritional and education status, and lack of proper knowledge about nutrition and balanced diets.

Regarding underweight, confirmed malaria case was higher among underweight children than their counterparts (Hassen and Ali, 2015) and the current study finding is in line with a study in Nigeria which showed that underweight were significantly associated with malaria attack in children (Jeremiah and Uko, 2007).

Counseling and promotion of breastfeeding and adequate complementary food intake, and child growth monitoring are some of the more effective and affordable interventions for preventing low birth weight and improving child growth (ACC/SCN, 2001). Studies have found an increased risk of malaria among underweight children (Williams et al., 1997). Underweight was identified as a risk factor for malarial anemia in Gambian children (Man et al., 1998). This is also consistent with this study; children's who have got food and breast feeding access also were less susceptible for either underweight or anemia or coexistence of both anemia and underweight

According to health professional suggestions on babies and mother heath card about baby's growth conditions or status, lack of attending the wellbeing of their babies frequently was present. This is due to lack of education (because most of the guardians or parents were uneducated), and professional type (being farmer's); indirectly either lack of knowledge or shortage of time to attend children's wellbeing. The level of education of the caregiver was associated with the risk of being malnourished. Children of illiterate mothers were more likely to become malnourished compared to those that had basic education (Sakwe et al., 2019). Sex of child and level of education of caregiver (e.g. illiteracy and primary educational level), was significant in this study as risk factors for underweight.

Conclusion

The result of the study indicates that there was a strong association between malaria and anemia (association is significant between *Plasmodium* species and hemoglobin concentration; $p < 0.05$); there is also an association between malaria and weight loss or underweight (association is significant between *Plasmodium* species and weight-for-age z-score; $p < 0.05$) at different age groups.

The prevalence malaria-related anemia among children in Arushe wanqat kebele was 38.67%.On the other hand, the prevalence of malaria-related weight loss or underweight among children in Arushe wanqat kebele was 28.02%. So, the findings of this study also revealed that malaria remains a public health problem that contributes for anemia and underweight on under five children.

Habit of attending the growth status of babies based on mothers and babies heath card, high nutritional status, vaccination or immunization, low utilization practice f insecticide treated net, breast feeding and food feeding have significantly associated with malaria anemia and under weight

Declarations

Ethics approval and consent to participate

The study protocol was approved by an ethical review committee with Rf. No. CNCS/RCCST/48/2020 at college of Natural and Computational Science, Ambo University. All the information that was obtained about the subjects was kept confidential. Written cosent was obtained from all participants.

Consent for publication

Not applicable

Availability of data and material

Data generated or analyzed during this study are included in this article.

Conflict of interests

The authors declare that they have no conflict interests.

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Authors' contributions

DB: Conceived designed, data management, analysis, and interpretation of the findings and drafting the manuscript. DB and TK: analysis, interpretation, and reviewing the manuscript. The two authors read and approved the final manuscript.

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Figures

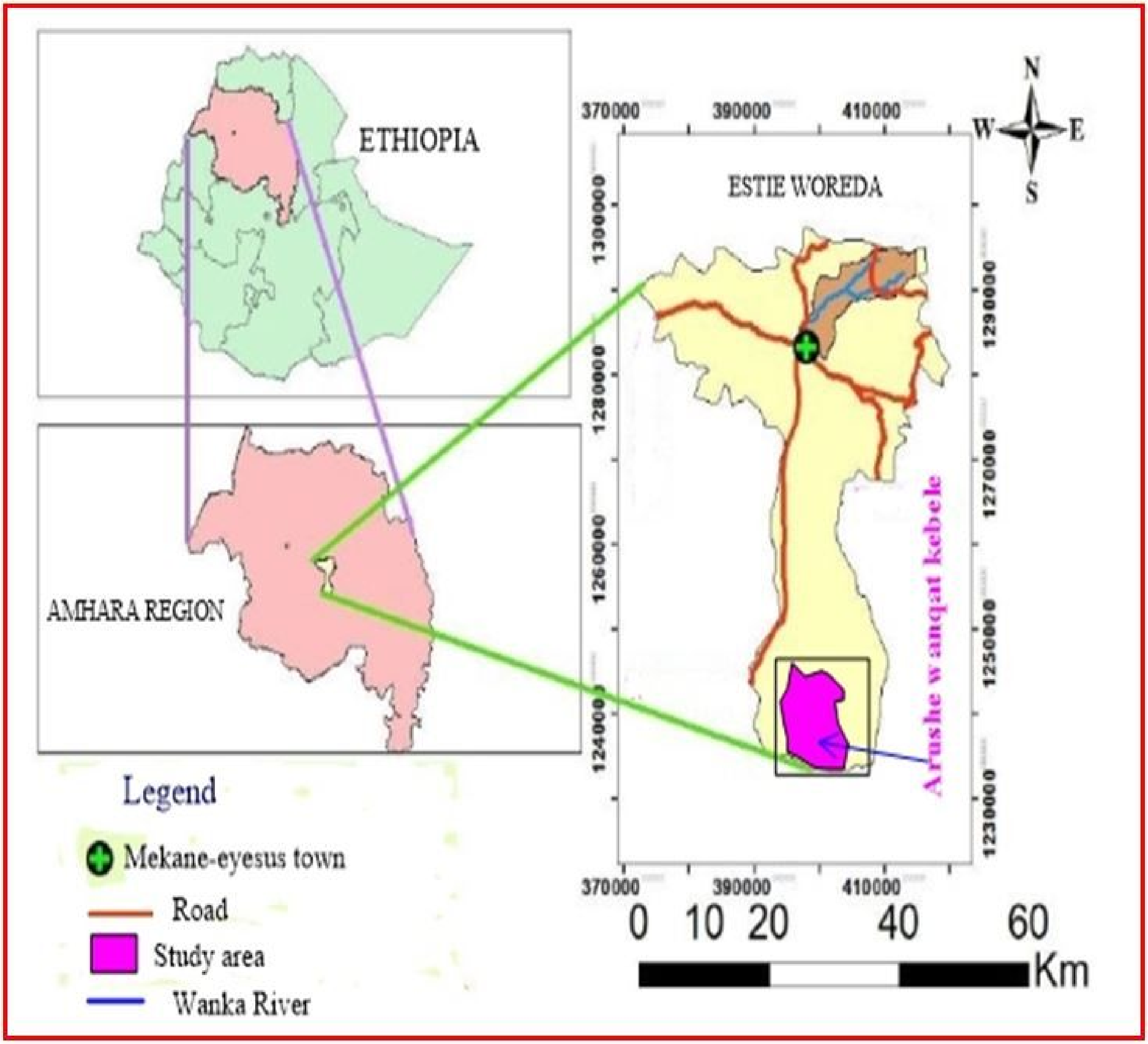

Figure 1

Map of study area (Source: Estie Woreda Land Administration office, 2018)

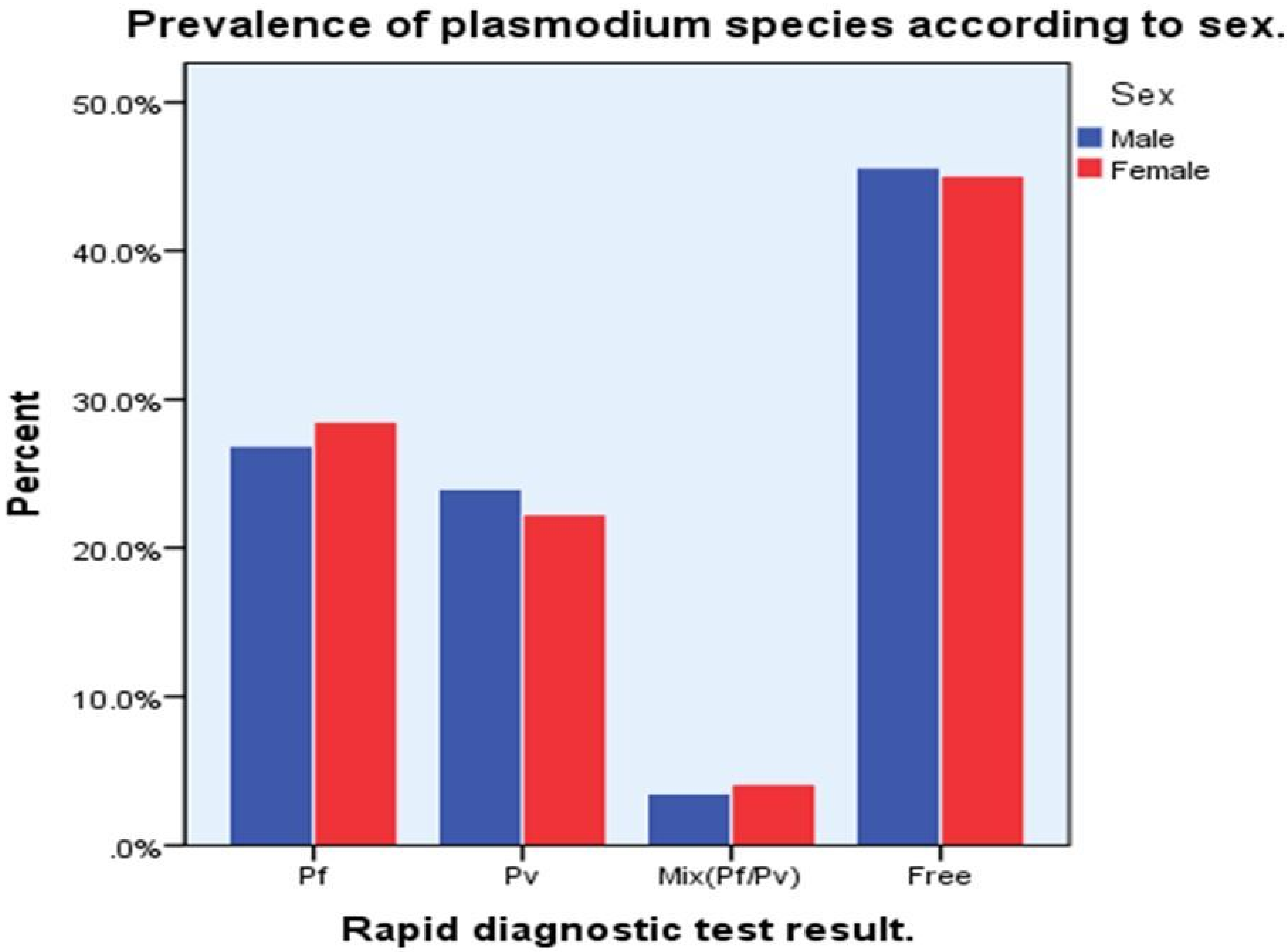

Figure 2

Prevalence of *plasmodium* species among examined children by sex