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Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting

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Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting

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ABSTRACT:
Background: It is unclear whether common agricultural practices, like livestock farming and maize production, affect the burden of malaria and the subsequent anemia status of reproductive age women in a low income setting.
Methods: A community-based cross-sectional study was conducted among women of reproductive age group, comparing high versus low maize production intensity areas, in rural central Ethiopia. Based on percentage of land cultivated, study areas were categorized as high (≥ 50%) and low (<10%) maize production clusters. Data were collected from 450 randomly selected households (250 from each cluster). Multivariate linear regression was fitted to identify determinants of mean hemoglobin concentration levels.
Result: The mean (± SD) hemoglobin concentration remained statistically the same, across high 13.59 (± 1.39 g/dl) and low 13.39 (± 1.65 g/dl) maize-intensity clusters, (P > 0.05). Women's livestock ownership (β, 0.13; 95% CI: 0.01, 1.12), chicken production (β, 0.21; 95% CI: 0.34, 1.01), and women's parity and abortion status (β, 0.67 and 0.23; 95% CI: 0.17,

0.61 and 0.31, 1.06) were positively associated with hemoglobin concentration levels, P < 0.05. Conversely, gravidity (β, -0.82; 95% CI: -0.65, -0.21) was negatively associated with hemoglobin concentration level, P < 0.05.
Conclusion : Irrespective of maize production intensity, women's reproductive characteristics and livestock farming (particularly, chicken production) were independent predictors of hemoglobin levels.

TRSTMH

Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting.

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Article Type:	Full Length Article
Full Title:	Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting.
Abstract:	Background It is unclear whether common agricultural practices, like livestock farming and maize production, affect the burden of malaria and the subsequent anemia status of women in a low income setting. Methods A community-based cross-sectional study was conducted among women of reproductive age group, comparing high versus low maize production intensity areas, in rural central Ethiopia. Data were collected from 450 randomly selected households. Multivariate linear regression was fitted to identify determinants of mean hemoglobin concentration. Result The mean (± SD) hemoglobin concentration remained statistically the same, across high 13.59 (± 1.39 g/dl) and low 13.39 (± 1.65 g/dl) maize-intensity clusters, ($P > 0.05$). Women's livestock ownership (β, 0.13; 95% CI: 0.01, 1.12), chicken production (β, 0.21; 95% CI: 0.34, 1.01), and women's parity (β, 0.67; 95% CI: 0.17, 0.61) significantly increased hemoglobin concertation levels. Gravidity (β, -0.82; 95% CI: -0.65, -0.21) and women's frequency of abortion (β, -0.23; 95% CI: 0.31, 1.06) significantly lowered hemoglobin concertation. Conclusion Irrespective of maize production intensity, women's reproductive characteristics and livestock farming (particularly, chicken production) were predictors of hemoglobin levels. Promoting women's reproductive health care and livestock based agricultural practices could benefit to enhance the health status of agrarian women in low-income settings.
Manuscript Number:	TRSTMH-D-21-00307

Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting.

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ABSTRACT

Background: It is unclear whether common agricultural practices, like livestock farming and maize production, affect the burden of malaria and the subsequent anemia status of women in a low income setting.

Methods: A community-based cross-sectional study was conducted among women of reproductive age group, comparing high versus low maize production intensity areas, in rural central Ethiopia. Data were collected from 450 randomly selected households. Multivariate linear regression was fitted to identify determinants of mean hemoglobin concentration.

Result: The mean (± SD) hemoglobin concentration remained statistically the same, across high 13.59 (± 1.39 g/dl) and low 13.39 (± 1.65 g/dl) maize-intensity clusters, (P > 0.05). Women's livestock ownership (β, 0.13; 95% CI: 0.01, 1.12), chicken production (β, 0.21; 95% CI: 0.34, 1.01), and women's parity (β, 0.67; 95% CI: 0.17, 0.61) significantly increased hemoglobin concertation levels. Gravidity (β, -0.82; 95% CI: -0.65, -0.21) and women's frequency of abortion (β, -0.23; 95% CI: 0.31, 1.06) significantly lowered hemoglobin concertation.

Conclusion: Irrespective of maize production intensity, women's reproductive characteristics and livestock farming (particularly, chicken production) were predictors of hemoglobin levels. Promoting women's reproductive health care and livestock based agricultural practices could benefit to enhance the health status of agrarian women in low-income settings.

Keywords: Anemia, Hemoglobin, Livestock Keeping, Maize, Women

Introduction

Malaria, an acute febrile illness caused by parasitic protozoa belonging to the Plasmodium species, accounts for more than one million deaths a year worldwide [1,2]. Young children and pregnant women are disproportionately affected by malaria, putting them at higher risk of complications and death, when they become infected [3]. The parasitic protozoa infects the red blood cells causing it to rupture; hence, lowering the amount of red blood cells, which often leads to anemia [4,5]. Malaria during pregnancy could also result in fetal death, prematurity, low birth weight, and severe maternal anemia, among others [6,7].

Today, malarial anemia is a major health problem in endemic areas, yet it is poorly understood and treatment is not straightforward [5,8,9]. The relationship between malaria and iron is complex [9].The mechanisms leading to anemia during the course of malaria are extremely diverse; involving environmental, immunological, dietary and other factors that act differently [9,10]. For example, plasmodium proliferation requires iron, both during the clinically silent liver stage of growth and in the disease associated phase of erythrocyte infection[5]. As variations in the iron levels of susceptible hosts may modulate the frequency and clinical severity of malaria infections, the malaria-attributable fraction of anemia may differ in different settings [10].

Agriculture is one of the environmental factors associated with malaria, with irrigation being one of the main links between agriculture and malaria [11][12]. Certain agro-ecological changes may potentially also be associated with heightened malaria transmission risks [13]. For example, a study from Ethiopia has reported a linear association between intensified maize cultivation and malaria transmission [14]. This was later supported with evidence that the odor of maize pollen attracts female mosquitos for oviposition and provides larval nourishment [15,16]. Maize pollen is found abundantly during the wet season on the surface of water bodies near maize plantings, helping the larvae of the mosquito to develop to the pupal stage more rapidly, more frequently, and produce larger adults [14,17]. While mosquitoes are attracted by the odor of maize pollen, they seem to be repelled by the odor of chickens [18].

Although many countries have made progress towards elimination of malaria, a reemerging trend of malaria cases and attributable deaths are observed in some countries in Sub-Saharan Africa (SSA) [19]. In 2016, from the estimated 216 million global malaria cases, 90% occurred in the SSA region. Ethiopia is the second most populous country in Africa with over 100 million population [20]. Morbidity and mortality associated with malaria have significantly decreased in the past two decades in the country, yet both malaria and anemia remains a major public health problem with an estimated 68% of the population at risk malaria and at least one-third of women being anemic [21,22].

Withstanding the fact that malaria as a major cause for anemia and its intensity affected by environmental conditions, it is worth to investigate the strength of influence of environmental factors, particularly agricultural practices such as livestock keeping and maize production patterns relate to women's anemia status. Therefore, the present study aimed to determine the association between maize production intensity and cattle ownership with the risk of anemia among reproductive age women in rural central Ethiopia.

Methods

Study area, design and participants

The study used a community-based comparative cross-sectional study design and implemented a cluster analysis to categorize households according to intensity of maize production. The survey was carried out in twenty-four villages from two purposefully selected districts with comparable malaria burden and incidence rate, average annual temperature, agro climatic condition, but differing in maize production intensity. The villages were selected from two districts in Arsi Zone, Oromia region, Ethiopia.

Arsi Zone has four agro-climatic areas mainly due to variation in altitude. The dominant agro-climatic zones are moderately cool (40%) and cool (34%), with the remaining being moderately warm (20%) and cold (6%). According to the latest national population projection from the central statistical authority, the Zone has a population of 3,202,689; which is dominated by rural (86.6%) population [23].

The major food crops produced in the Zone are cereals, pulses and oil seeds. Cereal production covers the largest part of the total area of the Zone, with teff, barley and wheat being the pre-dominant cereals produced. Though not major, cereals like maize, sorghum, and oats are also produced in pocket areas. Among pulses, horse beans and field peas are grown widely. Though cultivated on small fragmented farm lands seasonally; vegetables, fruits, root crops and stimulants are also grown [24].

Sample size and sampling

Sample size was calculated using EPi-INFo version 7 with the following parameters and assumptions: a 95% significance level (2-sided), 80% power, and 24% anemia prevalence among women [25] and an anticipated 10% lower prevalence among women in low maize intensity clusters. This yielded 225 participants per district. The sample was augmented to 450 to allow a 10% non-response rate.

A village was defined as a high maize intensity (cluster) if > 50% of the cultivated land was maize, and was considered low-intensity if <10% of the cultivated land was covered by maize. The classification was based on agricultural data in the zone and information gathered from the districts' agricultural officers and investigator's field survey observations.

A multi-stage sampling design was followed in drawing the sample. In the first step, two comparably similar districts (relatively similar in their malaria burden, but dissimilar in their agro-ecology or maize production intensity) were identified in consultation with the zonal health and agricultural bureaus. The districts included in the study had 35 - 43 Kebeles *(smallest administrative unit with a population of about 5,000 or 1000 households)*. In each Kebele, on average, there were 16 - 23 villages (got) with 40 - 50 households each. In the second step, using a cluster sampling method, 24 villages (12 districts) were selected. In the third step, from each village, 18 - 20 households were selected using systematic random sampling. Women (15-49 years) who were apparently healthy and permanent residents in the selected villages were included. For each household, one woman was interviewed.

Data collection and management

Motivated and experienced health workers who were also proficient in speaking the local language (Afan Oromo) collected the data in the field. A three days of intensive training on data collection, respondent handling and data quality assurance methods were given by the lead investigator (TAZ) and other field staffs. A pre-tested interviewer administered questionnaire, which was originally prepared in English and then translated to the local language *Oromifa* was used to collect socio-demographic, knowledge and malaria related information.

Measurements

Socio-demographic, malaria and maize production related variables

Socio-demographic variables included age, formal education, ethnic background and land ownership. Data related to malaria awareness included modes of transmission, clinical features, mosquito breeding sites and preventive measures. Information on maize production trends and patterns in the local community in the past five years were collected using a separate data extraction tool.

Anthropometric measurements

Anthropometric measurements were taken by the same data collectors twice (duplicate) according to standardized procedures recommended by World Health Organization (WHO) [26]. The women were weighed to the nearest 100 g on electronic scales with a weighing capacity of 140 kg. Height was measured to the nearest millimeter with a portable device equipped with calibrated and standardized height gauges (SECA 206 body meter). The mid-upper arm circumference (MUAC) of the left arm was measured to the nearest millimeter with a non-stretch measuring tape.

Hemoglobin measurements

A blood sample was collected through a finger prick and hemoglobin concentration was measured using a portable HemoCue photometer (AB Leo Diagnostics, Helsinborg, Sweden). The hemoglobin readings were adjusted for altitude [27], and women with values below 12 g/dl were considered anemic.

Malaria history (experience)

Lifetime, recent (last three years) and current (this year) malaria experiences were documented using a structured questionnaire and verified using health records at nearby health facilities (health centers and health posts).

Data analysis and quality assurance

Data were cleaned, and was entered to SPSS Version 20 and then transferred to STATA 14 statistical software for analyses. Descriptive *(Fisher's exact test)* and bivariate analysis *(independent sample t-test)* were run to test for associations between categories. Mean hemoglobin concentrations between two groups were compared using independent sample t-test. Multivariate linear logistic regression analysis was applied to identify independent predictors of mean hemoglobin concentration. To ensure data quality, one supervisor (usually the head of the health center) and two senior researchers were assigned to oversee data collection. In addition, the investigator stayed in the field throughout the data collection to check the completeness and quality of the data collected. Field supervisors checked filled questionnaires for consistency and completeness on a daily basis. Besides, about 10% of households were re-interviewed by supervisors in the presence of the lead investigator

Ethical approval

The study protocol was approved by the institutional review boards of the College of Natural and Computational Sciences of Addis Ababa University and the Oromia Regional Health Bureau. The study procedures were in accordance with the Helsinki Declaration of 1975 as revised in 1983. Verbal informed consent was obtained from the eligible participants in the presence of local administrators after a detailed explanation of the purpose and methods of the study.

Results

A total of 443 women of reproductive age, 214 from high and 229 from low maize intensity clusters participated in the study, yielding a response rate of 98.4%. **Table 1** presents selected socio-demographic and anthropometric characteristics of the women from both high and low maize intensity clusters. In total, 71.7% of the participating women were below 30 years of age, and 24.9% were between 30 - 44 years. About 40 % of the women had no formal education and 49.1% had primary level (grades 1 to 6) education. Most of the respondents had less than one hectare of land (76.7%) and had access to clean and safe water sources (87.8%).

More than 90% of the women had height measurements above 150 cm [28]. Based on MUAC assessments, 35.2% of the women were moderately undernourished (MUAC 21-23cm) and 13.3% were severely undernourished (MUAC <21cm) [29].

Table 2 describes livestock ownership and experience of women sleeping with domestic animals in the same house. In total, 83.3% of the women (76.5% from the high- and 89.5% from the low-maize intensity clusters) reported to own livestock. Most frequently owned livestock were oxen (62.3%), cows (52.8%), and donkeys (46.3%). Animals kept in the same house as humans were mostly chicken (20.3%) and cows (13.4%).

Table 3 presents the women's knowledge on malaria, and on transmission and prevention of malaria. Awareness of malaria seems universal as few (2.7%) of the women said that they were unaware of or have not heard about malaria. Chills (84.4%), fever (54.5%) and headache (46.6%) were the most-known symptoms of malaria. However, headache as a symptom of malaria was reported by more women from high maize intensity (56.8%) than from the low maize intensity clusters (36.8%). Convulsion as a sign of malaria was the least known (7.4%) symptom in both clusters.

Mosquitoes were identified as a key mode of transmission of malaria by 58.8% of respondents; person to person transmission (29.9%), eating maize cane / sugar cane (9.7%) and contaminated food (5.3%) were also mentioned. When asked about mosquito breeding sites, stagnant water (72.5%) and household utensils (19.4%) were most frequently mentioned. The rainy seasons, mainly from September to November, were identified as the peak season for mosquito breeding. About 70% of respondents identified the period from September to November as a pick season for malaria transmission, whereas 17.9 % reported June to August as a high season for malaria transmission (**Table 3**).

Table 4 presents the mean hemoglobin concentration of women by maize production intensity and livestock ownership. There were no statistically significant differences between the high and low maize intensity clusters for mean hemoglobin concentration (13.59 ± 1.39 g/dl versus 13.39 ± 1.65 g/dl; P = 0.19) and prevalence of anemia (5.4% versus 9.4%; P = 0.56) (**Figure 1).**

The mean (± SD) hemoglobin concentration for women who owned livestock was significantly higher 14.03 (± 1.16) g/dl) compared to those who did not 13.37 (± 1.68) g/dl. For the individual livestock, only chicken ownership showed a statistically significant difference; women who owned at least one chicken had a significantly higher mean hemoglobin concentration (13.76 ± 1.21g/dl) compared to those who had none (13.09 ± 2.01g/dl). Ownership of other domestic animals did not show significant differences in mean hemoglobin concentrations between the two groups.

Hookworm decreases the hemoglobin concentration of pregnant women by 0.24 g/dl [95% CI: 0.18-0.29]. Multiple pregnancy decreases the hemoglobin concentration of pregnant women by 0.16 g/dl [95% CI: 0.07-0.24]. Induction increases the hemoglobin concentration of pregnant women by 0.09 g/dl [95% CI: 0.02-0.14]. Iron supplementation during pregnancy increases the hemoglobin concentration of pregnant women by 1.02 g/dl [95% CI: 0.97-1.07]. Episiotomy decreases the hemoglobin concentration of pregnant women by 0.05 g/dl [95% CI: 0.01-0.09]. The hemoglobin concentration of pregnant women decreases by 0.15 g/dl per one-unit increase in gravidity [95% CI: 0.09-0.21]. Per one-year increase in the age of pregnant women, the hemoglobin concentration decreases by 0.03 g/dl [95% CI: 0.03-0.04]. The hemoglobin concentration of pregnant women decreased by 0.1 g/dl per each trimester [95% CI: 0.09-0.11]. The hemoglobin concentration of pregnant women increased by 0.14 g/dl per one-gram increment in the birth weight of the newborn [95% CI: 0.02-0.11

Similarly, the multivariate logistic regression analysis (Table 5) showed that a one-unit increase in livestock and chicken ownership increased hemoglobin concentration by 0.13 g/dl and 0.21g/dl (β, 0.13 & 0.21; 95% CI: 0.01, 1.12 & 0.34, 1.01), respectively. A single unit increment of women's parity level also increased mean hemoglobin concertation level by 0.67g/dl (β, 0.67; 95% CI: 0.17, 0.61). Conversely, a unit increase in gravidity and number of previous abortion decreased hemoglobin concertation levels by 0.82g/dl (β, -0.82; 95% CI: -0.65, -0.21) and 0.23 g/dl (β, -0.23; 95% CI: 0.31, 1.06), respectively.

Analysis on the pattern of maize production intensity and malaria experience among women of high versus low maize producing clusters showed a convergent trend over time. Sixty two percent of women in high maize intensity clusters had malaria at least once in life, which is significantly higher than the prevalence (52.4%) of women in low maize intensity clusters. No significant difference in malaria experience was observed between the two groups in recent (last three years) and current (same year) (**Figure 2**). The prevalence of anemia for women who had a lifetime, recent and current malaria experience was 60.6%, 45.4% and 24.2%, respectively (**Figure 3).**

Discussion

Employing a community-based comparative cross-sectional study design, we examined the associations between maize production intensity with malaria prevalence and associated anemia prevalence; in a rural resource-limited setting of Ethiopia. The respondents' level of awareness about malaria and its mode of transmission across the two clusters was very high. Although lifetime malaria experience was significantly higher among women from high maize intensity clusters, mean hemoglobin concentration and anemia prevalence did not differ significantly between the two clusters. Ownership of at least a livestock in the household in general, and chicken in particular, was found to be significantly associated with higher mean hemoglobin concentration.

Most women in our study were aware of malaria and knew at least one sign or symptom of the disease. This high level of awareness observed in the area is consistent [30,31] or even higher than many other study sites [32,33] in Ethiopia and elsewhere [34,35]. This could be potentially attributable to successful and efficient implementation of primary health care interventions in Ethiopia, including the rural health extension program [36,37] which aims to improve the community's awareness of common communicable diseases, including malaria, through door-to-door visits. It could also be that, because the study participants live in a malaria endemic area, they have frequently experienced the symptoms, enough to recognize and associate them with malaria.

Interestingly, though some participants mentioned maize as a potential mosquito-breeding site and related maize cane consumption as a potential malaria transmission vehicle, the awareness (perception) about maize production intensity and risk of malaria was consistent across both groups. This perception is consistent with previous evidence suggesting that gravid Anopheles arabiensis (females mosquitoes) are attracted by sugarcane pollen volatiles and oviposit in response to maize pollen odors [15,38].

The recent (last three years) and current (the present year) prevalence of malaria experience across the two clusters having different maize production intensities were statistically non-significant, but lifetime experience of malaria differed between the two groups. This observed higher lifetime malaria experience in the high-intensity maize production cluster is consistent with previous studies that linked maize production intensity with elevated risk of malaria [39]. Lack of difference in the recent and current malaria experience between the two groups, on the other hand, may be linked to intensified and successful national malaria prevention control activities in recent years [30].

On the other hand, our analysis did not show any association between anemia prevalence and mean hemoglobin respectively with maize production intensity, as both were not statistically significant across high versus low maize production intensity clusters (villages). The prevalence of malaria and anemia experience also remained the same during this period, which is consistent with lack of association of anemia and mean hemoglobin. As this is among the few cross-sectional studies relating maize production intensity, malaria and anemia, future studies of different designs including, but not limited to, case-control or prospective cohort, or other longitudinal designs with better control for background differences and other confounders are needed to further investigate the observed associations and trends in our study.

The study also showed that livestock ownership in general, and chicken ownership and domestication in particular, were associated with a significantly higher mean hemoglobin concentration. This could potentially be related to better socio-economic status, and consequent consumption [40]. Several other studies from Ethiopia and elsewhere in the world have indicated that household assets and income level are related to anemia risks [41,42], as anemia is disproportionately concentrated in low socioeconomic groups. A study from Afghanistan for example showed that agricultural assets, including ownership of sheep and chicken, lowers the risk of anemia at least partly due to consumption arising from own-production in the presence of poor market function [43]. A previous study from Ethiopia reported that mosquitoes are repelled by the smell of chickens [18]; the observed positive association between chicken ownership and hemoglobin concentration may therefore also be related to lower malaria risk that subsequently leads to lower anemia risk.

The present study has several limitations that need to be taken into consideration when interpreting the findings. Although we compared two clusters in different districts based on their maize production intensity using a cross-sectional comparative analysis, it is unlikely that some of the statistically significant differences observed between the two categories are attributable only to the factor of classification. Furthermore, data related to malaria experience were collected from secondary sources (health facilities), and interviewing mothers based on memory and presumed diagnosis, such findings may not be as accurate as direct testing and reporting.

Notwithstanding the above-mentioned limitations, our study had also some strength. We collected and combined (crosschecked) data from both health facilities and the community from resource-limited rural settings, where evidence is critically lacking. We also approached the burden of anemia from a new direction, agriculture and malaria, which is hardly available in the literature. Furthermore, the sample size in both groups was adequately powered and the response rate was high.

Generally, we observed that malaria experience was significantly higher among women from high maize intensity clusters compared to the low, but did not differ significantly between the two. On the other hand, ownership of at least one livestock in the household, particularly chicken, was associated with a higher mean hemoglobin concentration, and lower prevalence of anemia. However; unlike previous studies reporting potential association of maize cultivation (maize production intensity) with malaria risks, we did not find such associations in a malaria endemic rural setting.

It is recommended that promoting women's reproductive health care and livestock based agricultural practices could benefit to enhance the health status of agrarian women in low-income settings. Strengthening livestock production by smallholder women in rural low-income settings, particularly poultry could enable them generate income and employment and sustain livelihood opportunities. Further, wide scale nutrition, agricultural and health studies integrated with nutrition and health outcomes are needed to support our finding against a previous hypothesis of lack of association of the contribution maize production for the spread of malaria in similar settings.

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Authors' contributions to manuscript: TAZ designed research. TAZ & AA conducted research, performed statistical analysis, wrote paper. TAZ had primary responsibility for final content. TAZ, WK and AA read, edited and cleaned the draft. All authors have read and approved the final manuscript.

Perceived conflicts of interest: Authors declare no competing interests.

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Figure Legends

Figure 1: Maize production intensity and anemia status among women of high versus low/no maize producing villages in rural Arsi, Central Ethiopia.

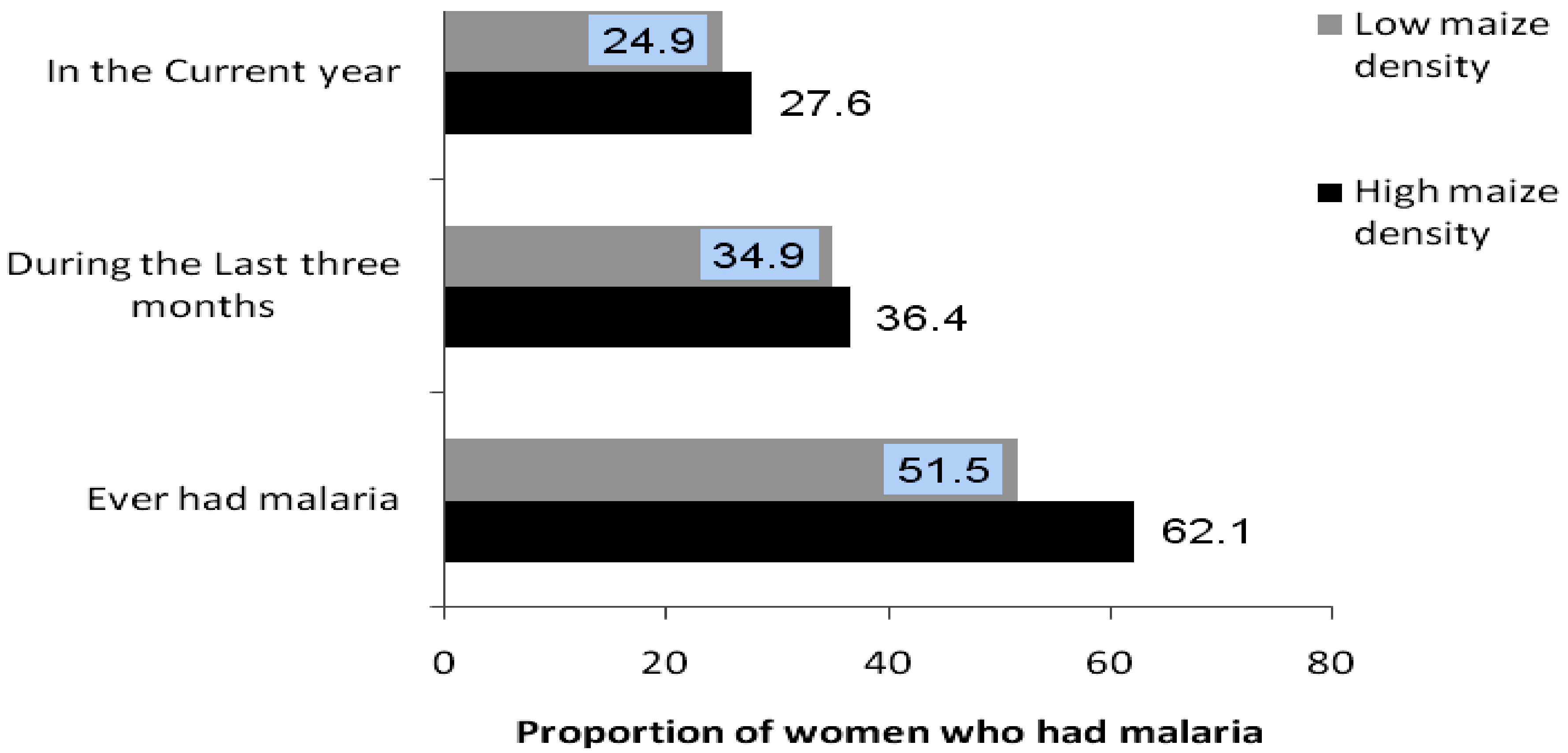
Figure 2: Maize production intensity and malaria experience among women of high versus low/no maize producing villages in rural Arsi, Central Ethiopia.

Figure 3: Anemia status and malaria experience (lifetime, recent and current) among women of reproductive age group in rural Arsi, Central Ethiopia.

List of tables


MAIZE PRODUCTION INTENSITY AND ANEMIA STATUS
Anemic
Non-Anemic
Poroportion of women
100
90
80
70
60
50
40
30
20
10
0
10.2
90.8
5.6
94.4
Low maize production Intensity
High maize production Intensisty

Figure 1



In the Current year
During the Last three months
Ever had malaria
24.9
27.6
34.9
36.4
51.5
62.1
Low maize density
High maize density
0
20
40
60
80
Proportion of women who had malaria

Figure 2

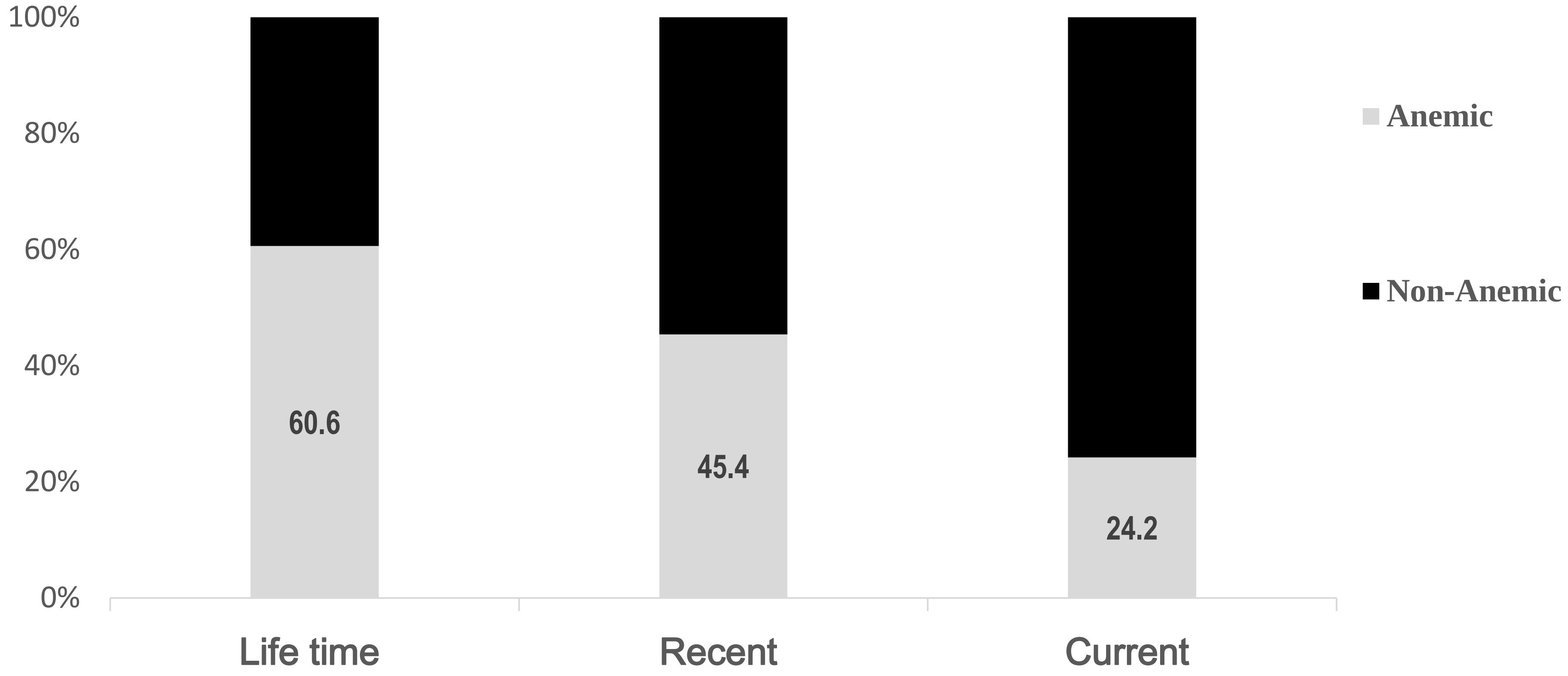

100%
80%
60%
40%
20%
0%
60.6
45.4
24.2
Life time
Recent
Current
Anemic
Non-Anemic

Figure 3

Tables

Table 1: Socio-demographic and anthropometric characteristics of women in high and low/no maize producing villages in rural Arsi, Central Ethiopia.

Maternal characteristic	**High maize density area, n (%)**	**Low/no maize producing area, n (%)**	**Total n (%)**
Total households, n (%)	214 (48.3)	229 (51.7)	443 (100)
Age (years)			
15 -29	166 (72.5)	151 (70.9)	318 (71.7)
30 -44	58 (25.3)	52 (24.4)	110 (24.9)
45-49	5 (2.2)	10 (4.7)	15 (3.4)
Educational Status			
Unable to read & write	90 (42.1)	82 (35.8)	172 (38.8)
Primary education	94 (43.9)	119 (52)	213 (49.1)
Secondary education	28 (13.1)	26 (11.4)	54 (12.2)
Tertiary education	2 (0.9)	2 (0.9)	4 (0.9)
Ethnic background			
Oromo	167 (78.0)	215 (93.9)	382 (86.2)
Amhara	31 (14.5)	5 (2.2)	36 (8.1)
Guraghe	9 (4.2)	2 (0.9)	11 (2.5)
Others	7 (3.3)	7 (3.1)	14 (3.2)
Height (cm)			
<145	6 (2.0)	6 (2.0)	8 (1.8)
145 - 150	18 (7.9)	18 (7.9)	28 (6.3)
>150	202 (94.4)	205 (89.5)	407 (91.9)
MUAC (cm)			
< 21	25 (11.7)	34 (14.8)	59 (13.3)
21 -23	65 (30.4)	91 (39.7)	156 (35.2)
> 23	124 (57.9)	104 (45.4)	228 (51.5)
Land size (Hectares)			
< 1	157 (75.5)	178 (77.7)	335 (76.7)
1 - 2	43 (20.7)	41 (17.9)	84 (19.2)
> 2	8 (3.8)	10 (4.4)	18 (4.1)
Water source*			
Safe	157 (86.0)	205 (89.5)	389 (87.8)
Unsafe	30 (14.0)	24 (10.5)	54 (12.2)

**Safe water sources include bottled water, pipe water and any treated (protected water); unsafe water sources include water from river, unprotected spring or any other unprotected or untreated water sources*

Table 2: Livestock ownership and domestication characteristics of women among high versus low/no maize producing villages in rural Arsi, Central Ethiopia

Livestock **ownership and domestication status**	**High maize density area, n (%)**	**Low/no maize producing area, n (%)**	**Total n (%)**
Ownership of Domestic animals			
Have at least one (any)	163 (76.5)	205 (89.5)	368 (83.3)
Cow	109 (51.9)	123 (53.7)	232 (52.8)
Ox (Oxen)	120 (56.1)	156 (68.1)	276 (62.3)
Sheep	25 (11.7)	34 (14.8)	59 (13.3)
Goat	50 (23.4)	87 (38)	137 (13.3)
Chicken	63 (29.4)	117 (51.1)	180 (40.6)
Donkey	73 (34.1)	132 (42.6)	205 (46.3)
Horse	4 (1.9)	4 (1.7)	8 (1.8)
Dog	20 (9.3)	19 (8.3)	39 (8.8)
Others	6 (2.8)	0 (0)	6 (1.4)
Domestication of animals[1]			
Cow or ox	26 (12.1)	32 (14.0)	58 (13.1)
Sheep (goat)	10 (4.7)	13 (5.7)	23 (5.2)
Chicken	26 (12.1)	64 (27.9)	90 (20.3)
Donkey (Horse)	12 (5.6)	31 (13.5)	43 (9.7)
Calf	15 (7.0)	20 (8.7)	35 (7.9)

[1] Domestication of animals means that the animals sleep with humans in the same house

Table 3. Knowledge about malaria, malaria transmission and prevention of women among high versus low/no maize producing villages in rural Arsi, Central Ethiopia

Knowledge	**High** (> 50%) **maize intensity area, n (%)**	**Low** (< 10%) **maize intensity area, n (%)**	**Total n (%)**
Heard about malaria			
Yes	211 (98.6)	220 (96.1)	431 (97.3)
Knows signs of malaria			
Fever	122 (57.8)	113 (51.3)	235 (54.5)
Headache	120 (56.8)	81 (36.8)	201 (46.6)
Chills	171 (81)	193 (84.3)	364 (84.4)
Loss of Appetite	49 (23.2)	58 (26.4)	107 (24.8)
Joint pain	38 (18)	47 (21.3)	85 (19.7)
Convulsion	13 (6.0)	19 (8.6)	32 (7.4)
Known mode of transmission			
Mosquito bite	125 (59.2)	127 (57.7)	252 (58.5)
Person to person	75 (35.5)	54 (24.5)	129 (29.9)
Eating contaminated food	12 (5.7)	11 (5)	23 (5.3)
Eating sugar cane	5 (2.4)	7 (3.2)	12 (2.8)
Eating maize cane	12 (5.6)	12 (5.5)	30 (6.9)
Other causes	19 (9)	11 (5)	30 (6.9)
Knowledge of mosquito breeding site			
Stagnant water	162 (75.5)	159 (69.4)	321 (72.5)
Running water	4 (1.9)	4 (1.7)	8 (1.18)
Maize and/or maize pollen	10 (4.7)	5 (2.2)	15 (3.4)
Household utensils	43 (20.1)	43 (18.8)	86 (19.4)
Knowledge of mosquito breeding season			
Rainy season (Jun - August)	40 (18.7)	38 (16.6)	78 (17.9)
Autumn (September - November)	148 (69.2)	162 (70.7)	310 (70)
Others	26 (12.1)	24 (10.5)	50 (11.3)

Table 4: Mean hemoglobin concentration according to maize production intensity and Livestock ownership of women among in rural Arsi, Central Ethiopia

	Hemoglobin level

Variable	**No (%)**	(Mean ± SD)	**P - value***
Maize production intensity			
High	214 (49.4)	13.59 ± 1.39	0.19
Low/No	229 (50.6)	13.39 ± 1.65	
Owns livestock (at least one)			
Yes	368 (84.9)	14.03 ± 1.16	0.02*
No	74 (15.1)	13.37 ± 1.68	
Cow			
Yes	253 (53.6)	13.62 ± 1.73	0.30
No	180 (46.4)	13.27 ± 1.49	
Ox (Oxen)			
Yes	276 (63.7)	13.47 ± 1.65	0.79
No	156 (46.3)	13.51 ± 1.57	
Chicken			
Yes	180 (41.6)	13.76 ± 1.21	0.00*
No	255 (58.4)	13.09 ± 2.01	
Sheep/goat			
Yes	59	13.51 ± 1.94	0.96
No	304	13.48 ± 1.56	
Donkey/Horse			
Yes	205	13.34 ± 1.80	0.07
No	230	13.61 ± 1.43	

**Independent sample t-test*

Table 5: Linear regression analysis of the effect of maize production intensity, livestock ownership and women's reproductive characteristics of on mean hemoglobin concentration, rural Arsi, Central Ethiopia.

Variable	β	Standard error	β (95% CI)		P-value
			Upper	Lower	

Land ownership	0.10	0.11	-0.005	0.435	0.44
Gravida (number)	-0.82	0.11	-0.65	-0.21	0.00†
Parity (number)	0.67	0.11	0.17	0.61	0.001†
Abortion (number)	0.23	0.19	0.31	1.06	0.00†
Maize production intensity	-0.025	0.003	-0.008	0.005	0.62
Cattle ownership	0.13	0.28	0.01	1.12	0.04†
Cow ownership	-0.03	0.004	-0.01	0.01	0.54
Ox (Oxen) ownership	-0.07	0.24	-0.63	0.17	0.27
Sheep ownership	-0.07	0.24	-0.47	0.44	0.89
Goat ownership	-0.03	0.18	-0.45	0.24	0.55
Camel ownership	0.04	0.94	-0.99	2.72	0.36
Donkey/Horse ownership	0.043	0.186	-0.22	0.51	0.45
Chicken ownership	0.21	0.17	0.34	1.01	0.00†
Malaria history	-0.004	0.11	-0.33	0.12	0.36
Dietary diversity	-0.042	0.17	-0.50	0.18	0.375
Iron supplementation (history)	-0.05	0.18	-0.44	0.28	0.08

†*Statistically significant*

hamzah fkmunsri <hamzah@fkm.unsri.ac.id>

Thank you for the review of TRSTMH-D-21-00307R1

1 message

Transactions <em@editorialmanager.com> 21 December 2021 at 21:26
Reply-To: Transactions <journals@rstmh.org>
To: Hamzah Hasyim <hamzah@fkm.unsri.ac.id>

Manuscript Number: TRSTMH-D-21-00307R1
Manuscript Title: Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting.
TRSTMH

Dear Hamzah,

Thank you for reviewing the above manuscript.

You can access the reviewers' comments and the decision letter (when available) by logging into Editorial Manager

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We appreciate your time and effort in reviewing this paper and greatly value your assistance as a reviewer for TRSTMH . We hope you will take the time to review for us again in future. If you are interested in submitting a manuscript to TRSTMH yourself, our instructions to authors can be found on our website: https://academic.oup.com/trstmh/pages/Manuscript_Instructions

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Editorial Office on behalf of Emma Williams, Managing Editor
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TRSTMH-D-21-00307
"Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting."
Original Submission

Hamzah Hasyim (Reviewer 1)

Reviewer Recommendation Term:	Major Revision
Custom Review Question(s):	**Response**
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Do you think this research would benefit from an accompanying blog post or commentary?	N/A

Comments to Editor:

Dear Editor

After major revision, I recommend the manuscript published in the journal of Tropical Medicine and Hygiene (RSTMH).

As a result, if the writers choose to submit the document, they should make the appropriate revisions.

Best,

Reviewer

Comments to Author:

The research was of interest to the reviewer.

Commodity farming and maize cultivation can affect malaria load and anaemia in low-income women. Community-based cross-sectional research in central Ethiopia contrasted high and low maize production areas. Four hundred fifty households were studied at random. Multiple linear regression was used to find mean haemoglobin determinants. The mean (SD) haemoglobin concentration did not differ between the high (13.59) and low (1.65). Animal ownership (0.13), chicken production (0.21), and parity (0.67). Both abortion frequency (-0.23) and gravidity (-0.82) lowered haemoglobin concentration. Infertility and farming (particularly poultry farming) predicted haemoglobin levels. Women's reproductive health and livestock farming could improve rural women's health. Kindly write a reply letter to each recommendation.

One of the important publications cited asks whether livestock protects against malaria or helps its spread. A cross-sectional study conducted in Indonesia's endemic rural areas is accessible at https://pubmed.ncbi.nlm.nih.gov/30126462/.

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TRSTMH-D-21-00307
"Livestock ownership and reproductive characteristics, not maize production, are associated with women’s anemia in malaria endemic low-income setting."
Original Submission

(Reviewer 2)

Reviewer Recommendation Term:	Major Revision

Comments to Author:

Zerfu and co-authors investigated "Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting" with a community based cross sectional study design. And I am glad to have the opportunity to review this work. I very much liked the underlying hypothesis and would have been very happy if the authors used difference analysis approach. My specific comments:
Malaria is a very local disease and even the risk varies from a household to a household, for example, due to housing conditions (did the authors have data on housing condition?). Therefore, it may not be a good idea to consider all the residents in either high or low maize production area as having equal exposure. It would have been ideal to consider serological markers reflecting a cumulative exposure to malaria infection to understand the burden of malaria clearly (potentially correlating with the haemoglobin levels). Anyway, the effort to explore (also inform the limitation of) malaria history data was good. Figure 2 is also informative but also indicative of the need for finer approaches to the question at hand as we see there is no major difference in malaria experience between high and low maize intensity areas.
Did the authors differentiate malaria experience by species, vivax or falciparum? Was the distribution the same in the comparison groups? As it is known, malaria anaemia is more of falciparum problem??
Did the authors consider other causes of anaemia in the locality? As they try to relate anaemia with abortion history (though inconsistent regression coefficient was reported in the abstract and the main table - Abstract line number 15 and 16, the points estimate of abortion is not within the CI, also look at the sign of the coefficient (also not consistent with table 5)), the notion seems to have iron deficiency (due to blood loss) in mind. Parity goes the other way round?? Was it due to cultural post-natal better nutrition? What about anaemia caused by helminth infection? Without controlling for these factors, is it possible to assess the association of maize farm intensity with anaemia -and that is mediated by malaria? In addition, if you think that malaria was in the causal path from maize farm intensity to the development of anaemia, should you adjust for it in the analysis as if it is a confounder? Could you think of different analysis strategy?
Dietary diversity is good but no details about how it was calculated.
Did the authors consider the sampling strategy in their analysis? How did they consider any unobserved variations in the villages/districts in their analysis? Or did they consider clustering for estimating the standard errors? Or did they use appropriate command of analysis for survey designs or consider sampling weights in their analysis?
Is not multicollinearity a problem when you have cattle ownership vs each cattle in the same model? Did you not consider number of cattle instead?
How could gravidity and parity (also abortion) associations happen in an opposite direction, that is, gravidity was negatively but parity (also abortion) was positively predicting haemoglobin level?
If high maize intensity is defined as >50%..., we expect higher variations across the villages considered within this category compared to those with low intensity (<10%). So, do you think such a comparison to be plausible? Is it not diluted? Did you have such a data for each village? Did you ask each household about whether they used to be maize farmers or their proximity to any of the vector breeding places? For a maize farm to be accelerating malaria transmission, there should exist a favourable vector breeding site nearby - within a flight range of the mosquito. Are mosquito breeding grounds the same (considered to be) in both groups? I think this point justifies the need to consider such unobserved variations during data analysis. Random effect models may help.

Close

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CC: ********

TRSTMH-D-21-00307 : Livestock ownership and reproductive characteristics, not maize production, are associated with women's anemia in malaria endemic low-income setting.

Dear ******** ********,

Thank you for submitting your manuscript to TRSTMH . We have had your manuscript peer reviewed and the reviewers raise several points that we would like you to address in a revision before we consider your paper further. If you are able to resolve all the issues outlined in the reviewers' comments below to the editor's satisfaction, and revise the paper accordingly, we will be pleased to reconsider it. However, we can give no guarantee of its ultimate acceptance. The reviewers and I all found the topic interesting and thought that the research presented in the manuscript can help to advance our understanding of environmental and social determinants of malaria. However, both reviewers have provided extensive comments and suggestions that will need to be addressed in a revised version. Please note that Reviewer 1 has provided most of their comments in a separate attachment, which you will need to access as described below.

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Did the authors consider the sampling strategy in their analysis? How did they consider any unobserved variations in the villages/districts in their analysis? Or did they consider clustering for estimating the standard errors? Or did they use appropriate command of analysis for survey designs or consider sampling weights in their analysis?
Is not multicollinearity a problem when you have cattle ownership vs each cattle in the same model? Did you not consider number of cattle instead?
How could gravidity and parity (also abortion) associations happen in an opposite direction, that is, gravidity was negatively but parity (also abortion) was positively predicting haemoglobin level?
If high maize intensity is defined as >50%..., we expect higher variations across the villages considered within this category compared to those with low intensity (<10%). So, do you think such a comparison to be plausible? Is it not diluted? Did you have such a data for each village? Did you ask each household about whether they used to be maize farmers or their proximity to any of the vector breeding places? For a maize farm to be accelerating malaria transmission, there should exist a favourable vector breeding site nearby -within a flight range of the mosquito. Are mosquito breeding grounds the same (considered to be) in both groups? I think this point justifies the need to consider such unobserved variations during data analysis. Random effect models may help.