

Vulnerability of farming communities to malaria in the Bole district, Ghana

Komlagan Mawuli Apélété Yao^{a,*}, Francis Obeng^b, Joshua Ntajal^c, Agbeko K. Tounou^d, Brama Kone^e

^a West African Science Service Center for Climate Change and Adapted Land Use, University of Lomé, Togo

^b Department of Agriculture Extension, Rural Development and Gender Studies at University for Development Studies, Tamale, Ghana

^c One Health Graduate School, Center for Development Research (ZEF), University of Bonn, Germany

^d School of Agriculture, University of Lomé in, Togo

^e University Peleforo Gon Coulibaly, Korhogo, Côte d'Ivoire, and Centre Suisse de Recherches Scientifiques en Côte d'Ivoire

ARTICLE INFO

Article history:

Received 16 March 2018

Received in revised form 10 June 2018

Accepted 30 July 2018

Available online xxxx

Keywords:

Malaria
Economic vulnerability
Malaria cost
Prevention

ABSTRACT

Malaria contributes substantially to the poor health situation in the northern region of Ghana, especially in the Bole district. This paper is an outcome of a study, which assessed the factors that influenced the vulnerability of farming households to malaria, as well as the economic burden of the malaria prevalence in the Bole District, Ghana. The multiple linear regression model was used to analyze the determinants of household's vulnerability to malaria, and to examine the relationship between the non-parametric dependent variable and dichotomous independent variables. The outcome of the study revealed an increase in malaria cases during the rainy season. Total direct cost of malaria care, number of people comprising the farming household, support for malaria prevention, information on mosquito breeding and development, and absenteeism from farm emerged as the main factors, which influenced the households' vulnerability to malaria. Direct and indirect costs of malaria treatment have negatively affected the households' budget. In addition, malaria treatment cost represented a substantial portion of poor farming household income. The direct cost was estimated to GH¢ 4059, and the indirect cost was estimated to GH¢ 4654. It was recommended to the government of Ghana to expand the National Malaria Control Program to the household level and make National Health Insurance Scheme more efficient.

© 2018 The Authors. Published by Elsevier Ltd on behalf of World Federation of Parasitologists.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

The burden of diseases (vector-borne diseases) is increasing in developing regions of the world, in addition to the impact of climate change (IPCC, 2007). While infectious diseases are no longer the leading causes of mortality in the developed world, they remain the main cause of mortality in middle and lower income countries, accounting for more than half of all deaths in Africa (Murray et al., 2001). The deadliest climate sensitive vector-borne disease is probably malaria (WHO, 2004). According to the latest estimates, 198 million cases of malaria occurred globally in 2013 and the disease led to 584,000 deaths, representing a decrease in malaria case incidence and mortality rates of 30% and 47% since 2000, respectively. However, the burden is high in the Sub-Saharan Africa, where an estimated (90%) of all malaria deaths occur, and in children aged under 5 years account for 78% of all deaths.

* Corresponding author.

E-mail address: yaokomlagan@gmail.com. (K.M.A. Yao).

In the West African sub-region, the decrease in malaria incidence was about 54% in the past decade. In sub-Saharan Africa, on average, a child dies of malaria nearly every minute of the day. Ghana recorded about 11.3 million cases of Outpatients Department (OPD) malaria in 2013 (Ghana Statistical Service, 2014). On the average 30,300 of such cases were observed each day in the country's health facilities. Malaria burden is not felt only in the health sector but in every aspect of Ghanaians' social and economic perspective. Three-hundred and fifty million people contract malaria every year in Ghana and approximately 20,000 children die from malaria every year, which translates into 25% of the deaths of children under the age of five (UNICEF, 2007). Also, about 80% of all sick cases reported at the Mankumah Health Center in the Bole district are observed to be malaria-related cases.

A malaria episode has direct financial consequences for the household involved, because of expenditure on medical consultation, diagnosis, treatment, travel, and a special diet for the malaria patient; and malaria exerts a heavy burden on the poorest and the most vulnerable communities. It primarily affects low and lower-middle income countries (Konradsen et al., 1997). Then within endemic countries, the poorest and most marginalized communities are the most severely affected (WHO, 2004) because they have the highest risks associated with malaria and the least access to effective services for prevention, diagnosis, and treatment.

The annual economic costs of malaria in Africa in terms of foregone production have been estimated to be about US \$12 billion (World Malaria Report, 2009). This figure factored in costs of health care, absenteeism, days lost in education, decreased productivity due to brain damage from cerebral malaria, and loss of investment and tourism. Evidence also suggests that the cost burdens differ significantly between wet and dry seasons (Chuma et al., 2010). The importance of infectious disease as a determinant (as well as an account) of poverty has become a prominent argument for international and national investment in the control of infectious diseases as expressed in United Nations (UN) Millennium Development Goal (Sachs, 2002). Regarding the progress made towards the Millennium Development Goals (MDGs), the World Health Organization (WHO) has developed a joint global public health approach to accelerate the progress and to meet the ambitious global target set for 2030 for malaria: at least 90% reduction in malaria incidence by 2030 (compared with 2015) (World Malaria Report, 2017). To estimate the economic costs of malaria in Kenya a cross-sectional household survey was conducted during the of peak malaria transmission season in the poorest areas in four districts in Kenya, with different malaria transmission patterns (Sewe et al., 2017).

In sub-Saharan African countries, such as Ghana, Tanzania, and Kenya, the economic costs of malaria in children were estimated through health system and household cost integration with costs associated with co-morbidities, complications and productivity losses due to death (Githeko et al., 2014). Several methods were developed to estimate the expected treatment cost per episode per child, across different age groups, by the level of severity and with or without controlling for treatment-seeking behavior. Malaria control and ultimately its elimination is inextricably linked with health system strengthening, infrastructure development and poverty reduction.

In northern Ghana, while the cost of malaria care was just 1% of the income of the rich household, it was 34% of the income of the poor households; and malaria prevalence is high in rain season, which coincides with a farming period (Akazili, 2000). Few studies of vulnerability in low and middle-income populations of African countries to endemic diseases have been conducted, though they account for the largest proportion of the citizens (IPCC, 2014). The national economy depends on agriculture, which employs a very large proportion of the population at risk of malaria; nevertheless, few research reports on the economic impact of malaria are not comprehensively analyzed, particularly the economic burden on households. There is the need to contribute to filling this research gap.

According to (Akazili, 2000), malaria distribution depends on the availability of mosquito breeding habitat, which is related to ponding after rainfall, while the productivity of the breeding habitat is a function of the ambient temperature. Malaria does not just cause illness and deaths around the world; it decreases productivity and increases the risk of poverty for the communities and countries affected. For example, the infection rate is highest during the rainy season, often resulting in decreased agricultural production (Zinszer et al., 2015).

The main objective of the study was to assess the economic vulnerability of farming communities to malaria in Bole district, northern Ghana. Specifically, the study estimated the direct and indirect cost of securing health care against malaria by households and determined the proportion of farmers' household income spent on health care. The multiple linear regression model was found to be more appropriate for analyzing the determinants of household's vulnerability to malaria, and to examine the relationship between the non-parametric dependent variable and dichotomous independent variables. To reach our objectives, a framework was designed to show the most important independent and intervening variables that influence the vulnerability to malaria in the study area.

2. Study area

Ghana is located in Sub-Saharan Africa, and it covers an average area of 238,533 km², with a population of 27,582,821 (Ghana Statistical Service, 2015). In general, Ghana has a tropical climatic condition. The study was conducted in the Bole district located in the northern region of Ghana. The Bole district covers an area of about 4800 km², which is 6.8% of the total landmark of the northern region (Fig. 1). The district experiences a unimodal rainfall pattern, which ranges between 800 mm and 1200 mm per annum and somewhat erratic in nature. The rainfall season begins in May and ends in October. Rainfall is seasonal and is characterized by a single maximum. (See Table 1.)

It has a population of about 61,593; composed of 50.3% of males and 49.6% of females with a growth rate is about 2.9% per annum. The population is sparsely distributed with a density of about 13 per km². Bole is the only urban area in the district. Agriculture is the major economic activity in the district with over 75% of the workforce. The district health services are divided into

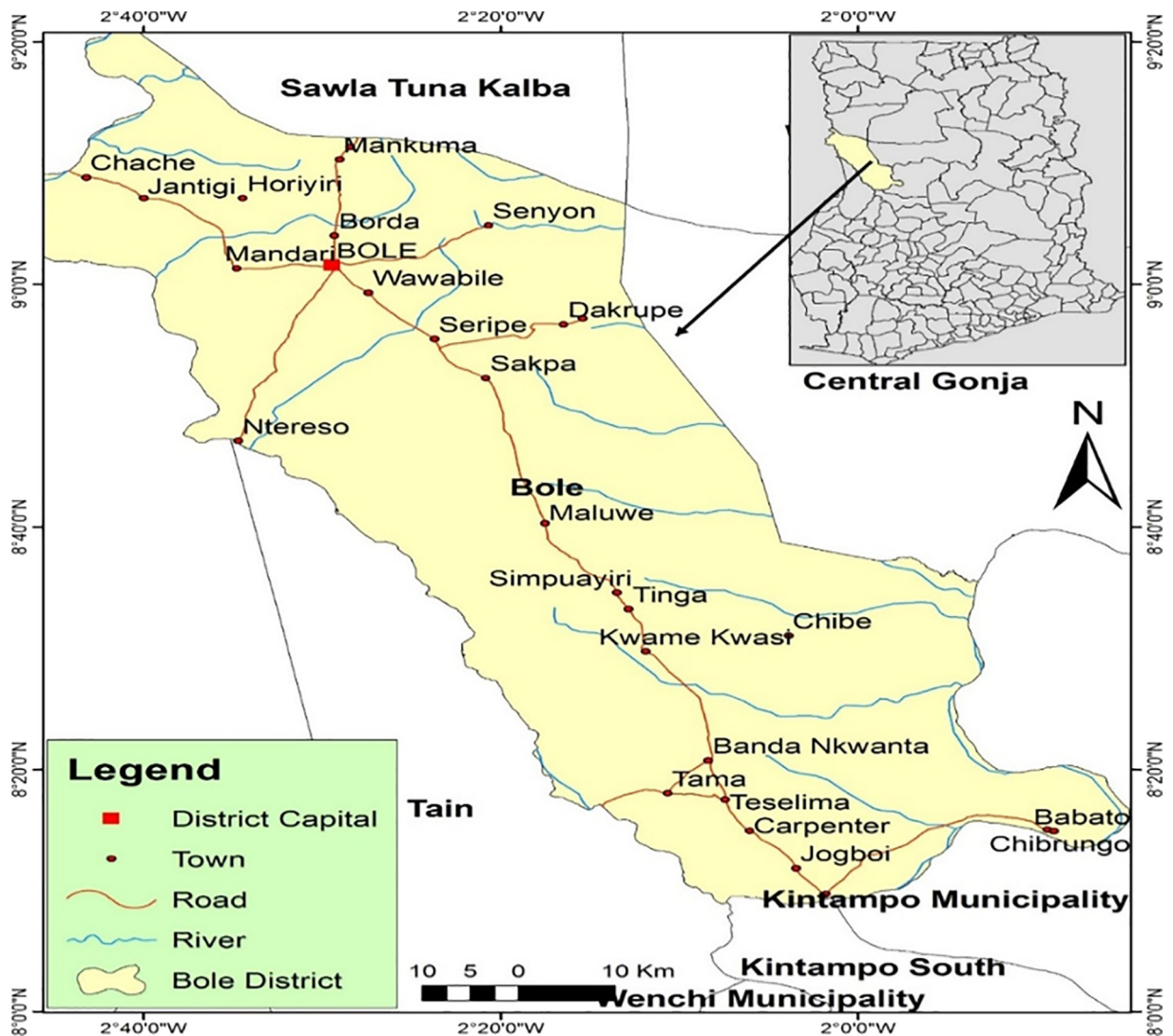


Fig. 1. Map of the target area.

four sub-districts, namely Bole, Tinga, Jama, and Bamboi. Each sub-district has an operational area served by a health facility. Malaria is the major cause of outpatient attendances in the district hospital at Bole, which accounted for of all reported cases from 2008 to 2014 (Ghana Statistical Service, 2014). Due to the erratic and unpredictable rainfall pattern in the district, a number of

Table 1

List of independent variables.

Variables	Description	Measurement	A priori expectation
Literacy level	Number of years of formal education of respondent	Number of years	–
Total direct expenditure	Direct cost of malaria treatment	GHC	+
Family size	Number of persons in the household	Number of persons	–
Support for malaria prevention or treatment	Whether household received support or if household members are assured	Dummy: 1 = yes; 0 = no	±
Prevention of malaria	Use of ITNs, insecticides, or drugs	Dummy: 1 = yes; 0 = no	–
Information about mosquito breeding and development	Knowledge and understanding of the conditions that are suitable for malaria transmission	Dummy: 1 = yes; 0 = no	–
Absenteeism at farm	Number of days of disabilities.	Number of days	+
Flooding	When land not normally covered by water becomes covered by water.	Number of days	+
Decrease of rainfall season	Reduction of days of rainfall	Number of days	–
Increase of temperature	Increasing of annual average maximum temperature	Degrees celsius	+
Flooding		Dummy: 1 = yes; 0 = no	+

small dams and ponds were constructed to conserve water for people and livestock as well as for vegetable production. These water collections serve as potential breeding grounds for mosquitoes.

Climatic conditions produce a favourable climate for all types of mosquitoes, resulting in the widespread of malaria. The three species of human plasmodia found in Ghana include *P. falciparum*, *P. malariae*, and *P. oval*. The most dominant being *P. falciparum* (the main vectors of the parasite are *Anopheles gambiae* and *Anopheles fenestus*). The *P. falciparum* is responsible for the most severe and dangerous form of malaria, with serious complications such as cerebral malaria and death (Asenso-Okyere and Dzator, 1997).

3. Materials and methods

3.1. Data sources and data collection methods

The study used both primary and secondary data sources. Socioeconomic data were obtained through field survey and interviews. The primary data on the economic cost of malaria (direct and indirect) was obtained through questionnaires, interviews, Focus Group Discussion (FGD), and field observations. The target population was five area councils of the Bole district. The data on the population and malaria prevalence were obtained from secondary sources such as the Ghana Statistical Service Ministry of health, the Ghana Health Service and the World Health Organization.

3.2. Conceptual framework

Empirical studies on vulnerability have shown that a combination of factors may lead to vulnerability of people to malaria in certain areas, for certain period and may create an economic burden in other locations. In light of this, it is difficult to develop a unified economic vulnerability model in the vulnerability assessment process for all specific locations. Apart from the independent variables, which are predictors of farmers' vulnerability to malaria, there are intervening variables (problems) which also contribute significantly to the malaria vulnerability assessment. Hence, this conceptual framework shows the most important independent and intervening variables expected to influence the vulnerability to malaria in the study area. The arrows indicate the expected relationship between the variables in the conceptual framework (Fig. 2).

A conceptual framework (Fig. 2) was designed to show the most important independent and intervening variables that influence the economic burden of malaria in the area. The multiple linear regression model was used to analyze the determinants of household's vulnerability to malaria, and to examine the relationship between the non-parametric dependent variable.

3.3. Data analysis

The multiple linear regression model is used to analyze the determinants of households' vulnerability to malaria. The determinants of household's vulnerability to malaria were analyzed using the multiple linear regression in order to examine the

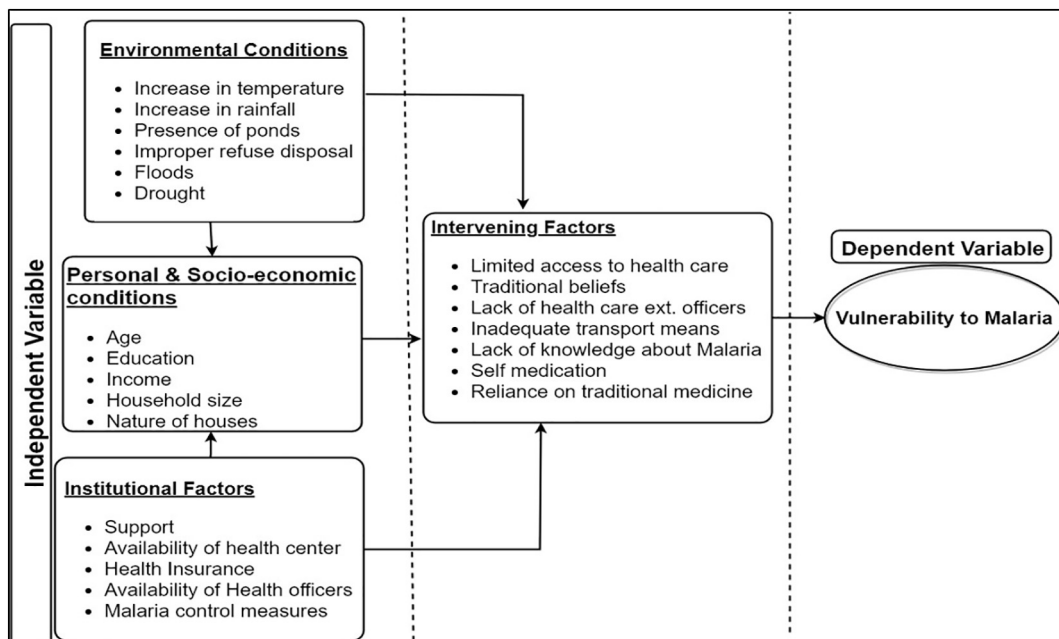


Fig. 2. Conceptual framework.

relationship between the non-parametric dependent variable and dichotomous independent variable. All direct costs were recorded and then estimated to obtain the average and total values of cash expenditure on malaria episode. In estimating the total indirect cost that an economically active malaria patient and caretaker incurred when absent from their normal productive activities due to a malaria attack, the daily average agricultural wage was multiplied by the corresponding number of days. A linear regression model assumes that the relationship between the dependent variable y_i and the p -vector of regressors x_i is linear. This relationship is modeled through a disturbance term or error variable ε_i , an unobserved random variable that adds noise to the linear relationship between the dependent variable and regressors. Thus, the model takes the form;

$$y_i = \beta_1 x_{i1} + \dots + \beta_p x_{ip} + \varepsilon_i = x_i^T \beta + \varepsilon_i, \quad i = 1, \dots, n$$

where T denotes the transpose, so that $x_i^T \beta$ is the inner product between vectors x_i and β .

The multiple linear model employed by this study is empirically specified as follows:

$$Y_i = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e_{ij}$$

(Logonia, 2014)

3.3.1. Variables used malaria vulnerability assessment

Malaria attack frequency of the households is the dependent variable of the model, while exogenous variables are rainfall, temperature, and other socio-economic characteristics.

3.3.1.1. Dependent variable. The malaria attack frequency of the households implies the household's head or at least one of the household's member had experienced malaria in the past six months.

3.3.1.2. Independent variable

3.3.1.2.1. Demographic and socioeconomic variables. Age: It is measured as the number of years the respondent lived since birth, and is one of the important characteristics that affect the responsibility of a person as a head of the family because the more the person aged, the more the person carries the responsibility to take care of the family.

Education: It is measured as the number of years of formal education that the farmer has. Educated household heads may know more about malaria transmission and how to prevent it.

Family size: This variable is measured as the number of persons of the household, including the respondent. Large family size may be more subjected to malaria attack.

Income: It is measured as the gross farm income of farmers. A poor household head may be more susceptible to malaria attack because of inadequate feeding.

3.3.1.2.2. Basic climatic variables. These are temperature and precipitation variables, which are computed based on the climate of Northern Ghana.

3.3.1.2.3. Institutional variables. This variable is measured as a dummy. It is believed that households who received some form of assistance, other than malaria prevention methods are expected to likely have a high level of resilience against malaria.

3.4. The economic cost of Malaria

To estimate the economic cost of malaria, the most comprehensive framework developed by [10] was adapted for this study. All direct costs were recorded and then estimated to obtain the average and total values of cash expenditure on malaria episode (Fig. 3).

4. Results and discussions

4.1. Seasonal trend in malaria cases

Malaria cases increased during the rainy season, which starts in April–May and ends in October. The decreased in malaria cases occurred during the dry season. During the rainy season, pools of stagnant water are found and these serve as breeding grounds for the mosquito, which transmit the malaria parasite (Fig. 4). Temperature and relative humidity are also relatively high during the rainy season and these further facilitate the rapid increase in the number of mosquitoes. The result conforms with the finding of a study done by Sewe et al. (2016) in Kenya, and Chikodzi (2013) in Uganda, which indicates a statistically significant relationship between mean parasite density (PD) and the annual pattern of rainfall.

4.2. Determinants of households' vulnerability to malaria

The results of the analysis indicate an r-square value of 83%, at 5% significant level. Farming households' vulnerability to malaria was significantly influenced by the malaria prevention or treatment, information about mosquito breeding and development, household size and total direct cost of treatment. Among these variables, household's size and information about mosquito

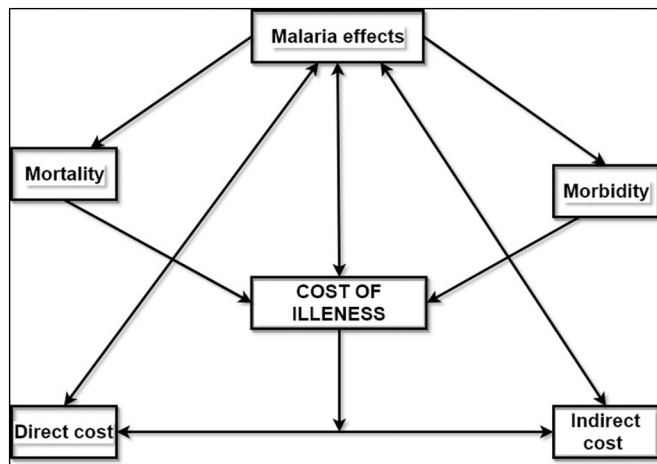


Fig. 3. Framework for estimation of the economic cost of malaria. Source: Adapted from Shepard et al. (Shepard et al., 1990).

breeding and development are negatively related to vulnerability, while the total direct cost of treatment and; support for malaria prevention or treatment are positively related to household vulnerability to malaria (Table 2).

4.3. The economic cost of malaria care

The overall cost was estimated at GH¢ 8713. The indirect cost was estimated at GH¢ 4654 and the direct cost at GH¢ 4059. An average daily income of GH¢ 35.53 and GH¢ 75.48 for the malaria patient and the caregiver respectively was recorded. Furthermore, the average days lost due to malaria episode in six months was estimated at 8.91 days for the malaria patient and 10.54 for the caregiver. This is an enormous loss of productivity for the farming household. The results are in line with a study conducted by IPCC (2014); Sauerborn et al. (1991) in Burkina Faso, which revealed that adult, lost 9 working days due to malaria.

The annual direct cost was estimated by summing the diagnosis-consult cost, the cost of drugs, the cost of transportation (in and out) and the cost of special food. The estimation was based on the following model: $Y = X_1 + X_2 + X_3 + X_4 + X_5$, where:

Y = Direct cost; X_1 = Diagnosis-consultation cost; X_2 = Cost of drugs; X_3 = Cost of transportation; X_4 = Cost of special food; X_5 = other related expenditure. Then:

Diagnosis-consultation cost = GH¢ 0.00; Cost of drugs = GH¢ 4654.00, Cost of transportation = GH¢ 1954.68, Cost of special food = GH¢ 2327.00, other related expenditure (sending people) = GH¢ 372.32. The charges for drugs are unofficial because we considered both the official cost (on prescription) and the unofficial cost (with the peddler). To obtain the cost of transportation, households were asked to provide information about the cost of their common means of transportation.

4.3.1. The direct cost of malaria care

For the 200 farming households selected, the annual total direct cost of seeking malaria care was estimated to GH¢ 9308. The components of direct cost of malaria care were: expenditure on drugs (50%), special food (25%), transport (21%), other related expenditure (4%) and diagnosis-consultation expenditure was free of charge (Fig. 5).

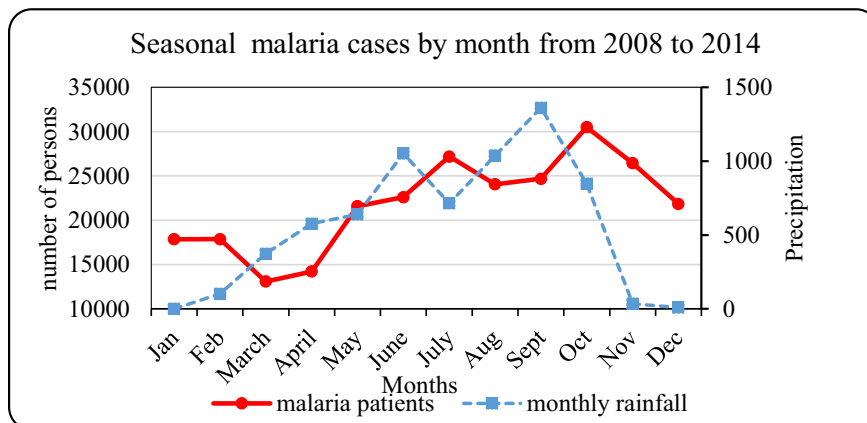


Fig. 4. Seasonal malaria cases for all ages between 2008 and 2014 in Bole District Ghana.

Table 2
Determinants of malaria vulnerability in the community.

Model	Unstandardized coefficients		Standardized coefficients Beta	t	Sig.
	B	Std. error			
(Constant)	2.850	0.891		3.198	0.011
Total treatment expenditure	0.000	0.004	0.019	0.109	0.015**
Educational level of the respondent	-0.111	0.131	-0.142	-0.843	0.421
Number of people in the household of the respondent	-0.039	0.020	-0.351	-1.979	0.079*
Do you have support for malaria prevention or treatment	1.112	0.389	1.246	2.858	0.019**
Do you prevent malaria	-0.446	0.464	-0.272	-0.961	0.361
Do you have some information about mosquito breeding and development	-1.379	0.470	-1.158	-2.935	0.017**
Absenteeism at farm	0.029	0.064	0.083	0.456	0.059*
Does flooding have any effect on malaria transmission	0.019	0.251	0.016	0.075	0.942
If the trend is decreasing in rainfall, how long does the dry season last	-0.129	0.143	-0.172	-0.903	0.390
Effect of increasing temperature	-0.259	0.126	0.405	2.066	0.069*

R Square = 0.835.

Note: ***, **, * means 1%, 5% and 10% significant level respectively.

Contrary to the expectation, expenditure on drugs was the leading components of direct cost of malaria care. This is not supposed to be so in the sense that National Health Insurance Scheme (NHIS) of Ghana is supposed to cover the cost of drugs for malaria treatment. This study is probably showing the inefficiency and the limit of this health insurance.

The free consultation-diagnosis cost is due to health insurance, which covers these services entirely, thus making them free of charge. The proportion of special food (25%) is confirming the study of (Akazili, 2000) done in the Kassena-Nankana district which showed that 30% of the population had the perception that poor quality food worsens the plight of malaria patients than special or good quality food different from the ordinary diet could care malaria. This result confirms the study, which was done by (Akazili, 2000) who found in the Kassena-Nankana district that expenditure on special food (46.2%) and drugs (45.7%) were the major components of direct cost of malaria treatment. The annual average direct cost being GH¢ 40.59 per household, it is not an enormous burden on households, considering the annual average income of malaria patient (GH¢ 12,969) and caregiver (GH¢ 27,550).

4.3.2. Indirect cost

The number of days a malaria patient or the caregiver lost due to malaria episode was considered as the opportunity cost. However, the malaria patients lost 1065 days, while the caregivers lost 757 days. The value of days lost from productivity was estimated by multiplying the prevailing daily average agricultural wage by a total number of days lost. Then, the total value for all days lost in six months for malaria patients was GH¢ 37,839.45 and GH¢ 57,138.36 for caregivers. This implies that annually, the total value for all days lost for malaria patients was GH¢ 75,678.89 and GH¢ 114,276.72 for caregivers.

The total cost of malaria treatment is obtained by summing the direct cost and the indirect cost; $TC = DC + IC$. For a household with malaria patient who has a caregiver, the total cost was GH¢ 189,996.20 and GH¢ 75,719.48 for malaria patient without a caregiver.

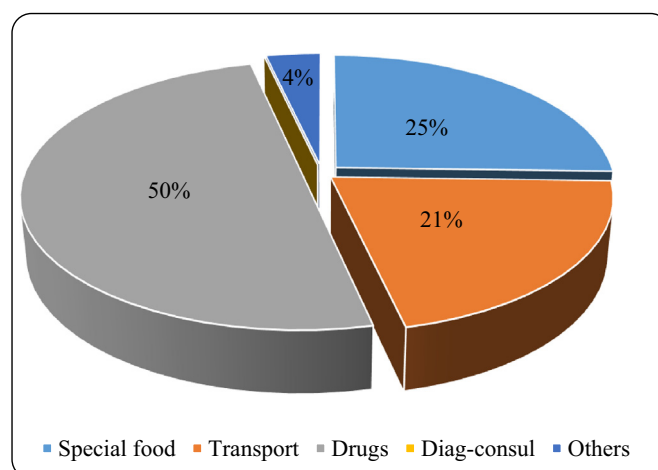


Fig. 5. Components of direct cost household incur on malaria care.

Table 3

Farming household basic and occasional expenditure in Bole District, Ghana.

Item (basic and occasional)	Annual expenditure GHC	% of total expenditure
Food	63,048	32.6%
Clothing and wares	36,240	18.7%
Education	35,800	18.5%
Healthcare	20,494	10.6%
Utilities	20,297	10.5%
Capital goods	3172	2.2%
Funerals, wedding, etc.	5392	1.3%
Rent	3172	0.8%
TOTAL	187,615	100%

4.4. Malaria cost as a percentage of total expenditure

An average of 2.68 malaria cases per household for one year period is recorded and this cost (direct and direct) a household on average GHC 67.8, which represented 3.5% of total average annual expenditure per household. Given the share of health expenditure of 10.6%, the annual cost of malaria was 33% of the annual households' health care expenditure. This may be a substantial burden to farming households if we consider the fact that malaria is one of the diseases causing a health problem in the district (Table 3) (Ghana National Malaria Control Program Report, 2012).

4.5. Malaria cost incurred by households as a percentage of annual income (in quintiles)

The mean annual income of the bottom poor (quintile 1) was estimated at GHC 453.10. Compared to the top rich quintile with mean annual income of GHC 83,138.89. Given that the mean malaria cost was GHC 501.35, the cost of malaria was as much as 110.6% of the total annual income of patients of quintile 1, 12.1% of quintile 2; 5.8% of quintile 3; 2.8% of quintile 4 and only 0.6% of the total annual income of the quintile 5. This clearly shows that the very poor are the ones who are more challenged when it comes to malaria treatment. Their income levels are very low for those in the first quintile and this implies that the greater percentage of their income is spent on taking care of the sick. The fact that they spent up to 110.6% of their income means that they can only take care of their health with support from other sources. This result was in line with the report of Sharma et al. (1991) and Konradsen et al. (1997) that the brunt of malaria cost falls more on the poorest.

5. Conclusion

The papa assessed the factors that influenced the vulnerability of farming households to malaria, as well as the economic burden of the malaria prevalence in the Bole District, Ghana. Malaria incidence in Bole district was not only due to the increase in temperature but also due to some socio-economic conditions. The analysis of the factors influencing vulnerability to malaria among households in Bole District revealed that total treatment expenditure, number of people in the respondents' household, information about mosquito breeding and development, absenteeism from the farm and increased in temperature were the main predictors of vulnerability to malaria.

As part of the underlying factors of the households' vulnerability to malaria, expenditure on the malaria drugs accounted for quite a high percentage of direct cost (50%), which is contrary to our expectation because the Ghana National Health Insurance Scheme was supposed to cover the diagnosis-consultation and the cost of drugs. The study revealed that both direct and indirect cost associated with malaria episode was a critical burden to farming households. The direct cost was estimated to GHC 4059, and the indirect cost was estimated to GHC 4654 respectively. As the proportion of malaria cost to annual income was 110.6% of malaria patients, who were poor, it was only 0.6% of rich patients. Climate changes over years might likely have effects on the vulnerability of households to malaria since malaria is considered as a climate-sensitive disease.

In sum, the vulnerability of households to malaria in the Bole district is dynamic. The underlying factors of the economic vulnerability are likely to change in the course of time, due to interventions. Expansion of the National Malaria Control program to the Bole district will contribute to building the resilience of the farming community. It was also recommended to the households in the community to take advantage of the national malaria sensitization programs, keep the surrounding physical environment clean, adopt the habit of using insecticide bed nets, and regular malaria check-up exercise. Efforts to reduce the vulnerability of the farming community comes with adaptation co-benefits, which are crucial to achieving human security and sustainable development. Malaria is a complex disease, which requires collective efforts to eradicate it.

Author contributions

Komlagan Yao and Francis Obeng designed the study and developed the methodology. Komlagan Yao performed the fieldwork under the supervision of Francis Obeng and Agbeko K. Tounou. Joshua Ntajal contributed towards data analysis and drafting of the manuscript. Brama Kone, Francis Obeng, Agbeko K. Tounou and Joshua Ntajal edited the final thesis report and the manuscript.

Conflict of interest

The authors of this paper declare no conflict of interest.

Acknowledgment

The Federal Ministry of Education and Research, Germany, through West Africa Science Service Center for Climate Change and Adapted Land Use (WASCAL), funded this work. Great thanks to the Director of WASCAL Togo, Prof. Kouami KOKOU, Sefako A. SEGBE, Folly KUEVI, Dr. Aklesso Egbendewe and Dr. AFAGLA Kodjo, for their support.

References

- Akazili, J., 2000. Economic Costs of Seeking Malaria Care to Households in the Kassena-Nankana District of Northern Ghana. Ph.D. thesis. University of Cape Town (124 pp).
- Asenso-Okyere, W.K., Dzator, J.A., 1997. Household Cost of Seeking Malaria Care. A Retrospective Study of Two Districts in Ghana. *Soc. Sci. Med.* 45, 659–667.
- Chikodzi, D., 2013. Spatial modelling of malaria risk zones using environmental, anthropogenic variables, and geographical information systems techniques. *J. Geosci. Geomat.* 1 (1), 8–14. <https://doi.org/10.12691/jgg-1-1-2>.
- Chuma, J., Vincent, O., Catherine, M., 2010. The economic costs of malaria in four Kenyan district: do household costs differ by disease endemicity? *Malar. J.* 2010 (9), 149.
- Ghana National Malaria Control Program Report, 2012. National Malaria Control Program Report Accra, Ghana.
- Ghana Statistical Service, 2014. The 2014 Population and Housing Census. National Analytical Report. Ghana Statistical Service, Accra.
- Ghana Statistical Service, 2015. Population and Housing Census Estimates. Ghana Statistical Service, Accra Ghana.
- Githeko, A.K., Ogallo, L., Lemnge, M., Okia, M., Ototo, E.N., 2014. Development and validation of climate and ecosystem-based early malaria epidemic prediction models in East Africa. *Malar. J.* 2014 Aug 22 (13), 329. <https://doi.org/10.1186/1475-2875-13-329>.
- IPCC, 2007. Impacts, adaptations, and vulnerability. The contribution of Working Group 2 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1–976.
- IPCC, 2014. Impacts, adaptations, and vulnerability. The contribution of Working Group 2 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1–177.
- Konradsen, F., Van Der Hoek, Wim, Priyane, H.A., Felix, P.A., 1997. Measuring the economic cost of Malaria to households in Sri Lanka. *American J. Med. Hyg.* 56, 656–660.
- Logonia, M.J., 2014. Effect of Adoption of Soil and Water Conservation Technologies on Food Security among Smallholder Farmers in Kumbungu District and Kasena-Nankana East Municipality of Ghana.
- Murray, C., Lopez, A., Mathers, C., Stein, C., 2001. The Global Burden of Disease 2000 Project. Aims, Methods, and Data Sources. World Health Organization, Geneva.
- Sachs, J.D., 2002. A new global effort to control malaria. *Science* 298, 122–124.
- Sauerborn, R., Shepard, D.S., Ettlting, M.B., Brinkmann, U., Nougara, A., 1991. Estimating the direct and indirect cost of Malaria in a Rural District of Burkina-Faso. *Trop. Med. Parasitol.* 42, 219–223.
- Sewe, M.O., Ahlm, C., Rocklov, J., 2016. Remotely sensed environmental conditions and malaria mortality in three malaria-endemic regions in western Kenya. *PLoS One* 11, e0154204. <https://doi.org/10.1371/journal.pone.0154204>.
- Sewe, M.O., Tozan, Y., Ahlm, C., Rocklöv, J., 2017. Using remote sensing environmental data to forecast incidence at a rural district hospital in Western Kenya. *Sci. Rep.* 7, 2589. <https://doi.org/10.1038/s41598-017-0256>.
- Sharma, D.S., Ettlting, M.B., Brinkmann, U., Sauerborn, R., 1991. The economic cost of Malaria in Kheda District, Gujarat. *Indian J. Malariol.* 27, 149–155.
- Shepard, D.S., Brinkmann, U., Ettlting, M.B., Sauerborn, R., 1990. Economic Impact of Malaria in Africa. Vector Biology and Control (VBC) Project, Arlington, Virginia.
- UNICEF, 2007. Malaria and Children: Progress and Intervention Coverage. Vol. 4. UNICEF, New York Retrieved from. http://www.unicef.org/health/files/MalariaOct6forweb_final.pdf.
- World Health Organization, 2004. Sources and Prices of Selected Products for the Prevention, Diagnosis, and Treatment of Malaria. pp. 1–66 (Switzerland Geneva).
- World Malaria Report; World Health Organization: Geneva, Switzerland. 2009. pp. 1–33.
- World Malaria Report 2017. World Health Organization, Geneva (Licence: CC BY-NC-SA 3.0 IGO).
- Zinszer, K., Kigozi, R., Charland, K., Dorsey, G., Brewer, T.F., Brownstein, J.S., Kanya, M.R., Buckeridge, D.L., 2015. Forecasting malaria in a highly endemic country using environmental and clinical predictors. *Malar. J.* 2015 (14), 245. <https://doi.org/10.1186/s12936-015-0758-4>.