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Efficiency analysis of malaria incidence among farming households in Kogi State, Nigeria

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ABSTRACT

In view of the varying incidence and prevalence rates of malaria in different parts of Nigeria, there is high tendency of reduction in efficiency and crop productivity among small scale farmers. Therefore, the study examined the technical efficiency of malaria farming households in Kabba/Bunu Local Government Area of Kogi State, Nigeria. Information was elicited from a longitudinal cohort survey of 72 households monitored for eight months during the 2012 farming season. A weekly malaria test was done on the household members by trained health workers with the utilization of Rapid Diagnostic Test Kit. The study categorized households into low and high malaria incidence. Information gathered were analyzed using Descriptive statistics, Stochastic Frontier Model and t- test. Farming households had a mean farm size of 1.83 hectare and majorly cultivated cassava, yam, pepper, maize and sorghum. Family labour negatively affected output of malaria incidence households. Number of day loss to malaria, medical expenses and age of household heads had negative effect on efficiency while frequent use of insecticide-treated mosquito nets and level of education of household heads had positive effect on efficiency of farming households ($F_{13.59}$ and 42.38 ; $P \leq 0.01$) respectively. The study revealed a mean technical efficiency of 0.54 for malaria incidence households in the study area. For better efficiency malaria control strategies needs be tended to in the study area.

Keywords: Efficiency, Farming, households, Insecticide-treated mosquito nets, longitudinal, Rapid Diagnostic Test Kit

INTRODUCTION

The impact of malaria on the agricultural sector is widely felt in Africa since about 70 percent of Africa's population is engaged in agriculture, producing food for consumption and the market (FAO, 2010). Ill-health from malaria causes a decline in crop output, reduction in use of inputs, decrease in area planted and changes in cropping patterns and loss of agricultural knowledge (Mohammed, 2014 and Asante, 2009). An individual worker who experiences onset of absolute illness such as malaria may become less productive or unproductive while he/she is working at his/her current occupation (De Leire and Manning, 2004). The incidence of malaria disease has lots of significant effects on agricultural productivity as it leads to loss of productive time both of the affected person and the caretaker. According to Alves, Andrade and Macedo (2003), healthy individuals are expected to possess higher level of human capital, thus more productive than those with poor health. Generally, poor health due to malaria epidemic results in loss of work days or decrease in worker's capacity, decrease innovation ability and ability to explore diverse farming practices (Ajani and Ugwu, 2008). According to Ibrahim *et al.* (2017), poor health would lead to hardship on farming households including monetary expenditure, loss of labour days and sometimes death. Another study showed that fisher men who were affected by malaria had lower productivity due to the number of days lost to malaria infection (Ayinde *et al.*, 2015). According to Mohammed *et al.* (2019); Kiko, (2013) malaria infected households are more productive than households who are not inflicted with malaria.

Asiamah *et al.* (2014) asserted that farmers who are affected by malaria normally end up ploughing, sowing, weeding, harvesting late among other farm activities resulting to inefficiency and hence low productivity.

Efficiency has remained an imperative subject of empirical investigation especially in developing economies where majority of farmers are asset poor (Nkamleu *et al.*, 2010; Binam *et al.*, 2008 and Amos, 2007).

Social scientists, particularly economists, have studied the impacts of malaria at several scales, examining families and households, looking across communities, and comparing entire nations and continents. The studies like the effect of malaria on agricultural production in Uganda, Farmers' health and agricultural productivity in rural Ethiopia, Effect of Malaria on intensive vegetable production in Cote D'Ivoire, Effect of Malaria on agriculture land use pattern in Kenya, Macroeconomic impact of malaria in Nigeria, Malaria in Children; Implications for the productivity of female caregivers in Nigeria and the Effect of Malaria on Rural Households' Farm Income in Oyo State, Nigeria to specify a few all came to the conclusion that malaria imposes substantial social and economic costs and impedes economic development through several channels, including but certainly not limited to quality of life, fertility, population growth, savings and investments, worker productivity, premature mortality, and medical costs (Sachs and Malaney 2002).

Information on the effects of malaria on agricultural productivity and efficiency exists but is largely inadequate. No known study has been conducted in the area relating malaria incidence with crop productivity and efficiency in a direct manner. This study ascertains malaria incidence/ prevalence in the study area and has tested for malaria in relation to crop productivity and therefore this study identified the determinant of technical efficiencies of malaria infected households and the impact of malaria on efficiency in the study area.

MATERIALS AND METHODS

The study area

The study was conducted in Kabba/Bunu, a Local Government area in Kogi State. The area falls within the Guinea Savannah Zone. The Local Government Area is located in the Western part of the state which falls between latitude 7°N and 31°N of the equator and longitude 50 41'E and 60 15'E, with a population of 145, 446 (NPC, 2006).

The study area is known to have a tropical savannah climate with distinct wet and dry seasons. The wet season range from the Month of April to October while the dry season is between November and March. The annual temperature varies between 27°C and 37°C with relative humidity between 30% and 40% in January and rises between 70% and 80% in July to August. Malaria transmission based on climatic parameters occurs between (May and October). About six and half months of rainy season are estimated to be responsible for malaria transmission in the study area. The soil in the study area is predominantly sandy loam in texture.

The indigenes are farmers engaging in crop production, livestock production and fish rearing. Kabba-Bunnu is blessed with suitable climatic conditions and basically produces food crops such as yam, cassava, cocoyam, maize, millet, rice guinea corn, cowpea and others. [Http:ilen.wikipedia.org/wiki/Kabba/Bunu](http://ilen.wikipedia.org/wiki/Kabba/Bunu)).

In a cohort of farming households in Kabba/Bunu Local Government Area of Kogi State Nigeria, malaria incidence, health expenditure and household farming activities were carefully monitored on a weekly basis over an 8-month period (May-Dec) in the 2012 farming season. The cohort was made up of 72 households involving a random selection of 6 households from 12 villages in the study

area. Malaria diagnosis was confirmed among febrile household members based on the detection of Plasmodium falciparum Histidine Rich Protein II (PfHRP2). The tests were performed by trained health workers when sick member of a household reported to the health facility or during the weekly house visit rounds.

Method of Data Analysis and Model Specification

Descriptive and inferential statistics were used to analyze the data. Descriptive statistics such as frequency, mean, standard deviation and percentages were used to analyze the cropping pattern, malaria incidence and the input and output characteristics of the farming households

A stochastic frontier model was used to estimate the technical efficiency and determinant of technical efficiencies of malaria households while t – Test was used to compare the efficiency levels of low and high incidence malaria households.

Estimation of stochastic frontier model

The application of parametric frontiers in the estimation of technical efficiency in agriculture is shown in various empirical studies. In recent years, the stochastic frontier approach has turned out to be the most popular method because of its ability to take into account measurement error in the output and stochastic elements of production, thereby distinguishing the effect of noise from the effect of inefficiency. The stochastic frontier production function model has the advantage in that it allows simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical efficiency (Battese and Coelli, 1995).

Technical efficiency of an individual farmer is defined in terms of the ratio of the observed output to the corresponding frontier output, given the available technology.

Technical efficiency (TE) = $Y_i/Y_i^* = f(x_i, \exists) \exp(v_i - u_i) / f(x_i, \exists) \exp(v_i) = \exp(-u_i) \dots \dots \dots (1)$

Where Y_i is the observed output and Y_i^* the frontier output

Technically efficient farms are those that operate on the production frontier and the level by which a farm lies below its production frontier is regarded as the measure of technical inefficiency.

For this study, the production technology of crop farmers with incidence of malaria is assumed to be specified by the Cobb-Douglas production function

Defined by;

$$\log Y = \exists_0 + \exists_1 \log X_1 + \exists_2 \log X_2 + \exists_3 \log X_3 + \exists_4 \log X_4 + \exists_5 \log X_5 + \exists_6 \log X_6 + VI - UI \dots \dots \dots (2)$$

Where;

Log represents the natural logarithm

Y represents the output of farmers in kg .

X_1 represents the total area of land in hectares on which crops were grown

X_2 represents family labour in man days

X_3 represents hired labour in man days

X_4 stands for quantity of seed in grain equivalence

X_5 represents the quantity of fertilizer used in kilograms

X_6 stands for quantity of herbicides in liters

\exists is the coefficients to be estimated

V_i 's is assumed to be independent and identically distributed normal random errors, having zero mean and unknown variance, $\Phi 2V$;

The U_i 's are the technical inefficiency effects, which are assumed to be independent of V_i s such that U_i 's is the non-negative truncation (at zero) of the normal distribution with mean, u_i , and variance, $\Phi 21$, where U_i is defined by;

$$\mu_i = \ast_0 + \ast_1 Z_{1i} + \ast_2 Z_{2i} + \ast_3 Z_{3i} + \ast_4 Z_{4i} + \ast_5 Z_{5i} + \ast_6 Z_{6i} + \ast_7 Z_{7i} \dots \dots \dots (3)$$

Where:

Z_1 = age (yrs)

Z_2 = adjusted house hold size (numbers)

Z_3 = medical expenses in naira (₦)

Z_4 = farming experience (Yrs)

Z_5 = level of education (Yrs)

Z_6 = Number of times slept under mosquito net (number)

Z_7 = Day loss (number)

\ast = unknown scalar parameters to be estimated

$$\delta^2 = \delta V^2 + \delta U^2 \dots \dots \dots (4)$$

Where gamma (γ) = total output attained on the frontiers which is attributed to technical efficiency. Hence, it is a measure of technical efficiency. The technical efficiency of a farmer is between 0 and 1 (Battese and Coelli, 1995) and is inversely related to the level of the technical inefficiency effect.

Similarly, $(I - Y)$ measure the technical inefficiency of the farms. The estimated Lambda (λ) is expected to be greater than one. Such a result indicates a good fit for the model and the correctness of the specified distribution assumption for V_i and U_i

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} \dots \dots \dots (1)$$

Where:

X_1 = Mean technical efficiency of high malaria incidence households

X_2 = Mean technical efficiency of low malaria incidence households

N_1 = Number of high malaria incidence households

N_2 = Number of low malaria incidence households

S_1^2 = Variance of high malaria incidence households

S_2^2 = Variance of low incidence malaria households

RESULTS

Cropping pattern

Result shows that Eighty percent (80%) of the households cultivated maize as sole crop, 40.28% cultivated millet as sole crop,

and 23.6% cultivated sorghum as sole while only 19.4% planted bambaranut as sole crop. Maize was intercropped with cowpea by 37.5% and with sorghum by 34.7% of the households.

Table1: Distribution of Households According to Type of Crops Cultivated in the Study Area

Crops	Frequency	Percentage
Cowpea	23	31.9
Maize /Cowpea	27	37.5
Maize/ Sorghum	25	34.5
Maize	57	79.7
Millet	29	40.3
Bambaranut	14	19.4
Sorghum	17	23.6

Farming household in the study area had a mean farm size of 1.83 hectare. The entire households studied had between 0.35 – 6 hectares of land while more than half of the households, (55.9%) cultivated between 1.1 to 2 hectares. The average family labour used by the households during the eight

months (May to December) study period was 99.43 man-days with an average hired labour of 13.56 man-days.

The average rate of fertilizer and chemical applied per hectare for all the crops considered in the study area were 18.06kg and 1.23litres respectively.

Table2: Description of Farm Input used in the Study Area

Inputs	Average	Minimum	Maximum	SD	CV
Land (Ha)	1.83	0.35	6.00	1.19	65.02
Family Labour (Man days)	99.43	25.00	264.00	65.37	65.74
Hired Labour (Man days)	13.56	0.00	49.00	10.03	73.48
Seed (Grain Equivalent)	1067.44	153.00	2257.00	465.51	43.61
Chemical (Litres)	1.23	0.00	8.00	1.99	161.78
Fertilizer (Kg)	18.06	0.00	100.00	30.61	169.53

SD=Standard Deviation, CV=Coefficient of Variation

The maximum number of fever episodes recorded was 24 per the period covered for the study (May to December). During the farming season under consideration, more than half of the farming households (58.33%) had between 1 and 5 episodes of malaria. About 18% of the households were admitted due to malaria fever in the hospital with a maximum of two persons per household in the hospital. A typical farming

household spent an average of ₦8, 515.28 on malaria treatment per annum and ₦1,703.06 per malaria episode. Averagely, households in the study area spent ₦1, 001.39 on transporting to and from hospital taking care of the sick person. A mean sum of ₦2, 955.56 was spent on protective device to eliminate or reduce malaria incidence during the period under consideration. An average of

₦369.44 was spent on prevention per month. The study also revealed that 66.7% of the farming household did not make use

of mosquito net and did not attend to their farm for 38 days

Table 3: Description of Households Malaria Variables

Variables	Mean	Minimum	Maximum	SD
Number with fever	7.00	0.00	24.0	4.86
Number with Malaria	5.01	0.00	17.00	3.49
Number of respondent admitted due to malaria	0.00	0.00	2.00	0.51
Day Loss due to Malaria in Man day	38.30	1.00	94.00	26.99
Number of times slept with net	5.60	0.00	23.00	10.19
Amount spent on treatment(₦)	8,515.28	400	25800	6,242.29
Amount spent on care giving(₦)	1,001.39	100	2750.00	725.98
Amount spent on prevention(₦)	2,955.56	350	9600	1,860.06

A large number of the households (86.11 %) had high malaria incidence. Less than 15%

fell within the low malaria household category (13.89%).

Table 4: Proportion of Malaria in the Farming Household

Malaria Incidence	Frequency	Percentage
High	62	86.11
Low	10	13.89
Total	72	100

Determinant of technical inefficiency of malaria infected households

Table 5 presents results of maximum likelihood estimation of the production frontier and the technical inefficiency of malaria affected households in the study area .The result shows that land and seed are significant at 1% while fertilizer is significant at 10% level .These variables have positive coefficient and are in line with *a priori* expectation. Family labour is significant at 1% level and has a negative coefficient.

The result of the inefficiency model revealed that age of the household head, level of education of household head, medical expenses by households, the

number of days the households are absent from their farms, and the number of times the household members slept under the mosquito net were the significant factors that explained the variation in the inefficiency of crop production among malaria incidence farming households except adjusted household size and years of experience. The coefficients of these variables were found to be positive and significant at 1% level. The coefficient of education and number of times slept under mosquito net is negative and significant at 1% and 5% levels of probability respectively.

Impact of malaria on technical efficiency of farming households.

Table 5: MLE Results of the Production and Technical Inefficiency Model

Variable	Coefficient	Standard error	t-Value
Land (ha)	0.648***	0.156	4.16
Family labour (mamdays)	-0.529 ***	0.153	-3.36
Hired labour (mamdays)	-0.009	0.072	-0.13
Seeds (GEW)	0.310 ***	0.121	2.55
Fertilizer (Kg)	0.573 *	0.031	1.85
Chemical (liters)	-0.084	0.0095	-0.88
Inefficiency model			
Age	0.617 ***	0.230	2.68
Adjusted household size	0.188	0.124	0.15
Medical expenses	0.317 ***	0.116	2.73
Day loss	0.064 ***	0.026	2.46
Educational level	-0.153***	0.047	-3.25
Number slept under mosquito net	-0.945 **	0.0470	-2.01
Years of farming experience	0.0535	0.044	1.20
Diagnostic Characteristics			
$\text{Sigma}^2 (u^2 + v^2)$	0.419	0.105	3.99
$\text{Gamma}u^2 / v^2$	0.906	0.139	.51
Lamda u/ v	3.153		
Log-likelihood function	-36.634		
Sigma –v	0.198	0.061	
Sigma –u	0.617	0.906	
Sample size (n)	72		

(*) (**) (***) signify significant at 10%, 5% and 1% respectively

Table 6 presents the technical efficiency ranges of malaria farming households. Technical efficiency varies widely among the sample households, with a mean technical efficiency value of 0.54, minimum and maximum values of 0.11 and 0.92 respectively. Technical efficiency skewed heavily towards 0.70-0.89 range, this represents the modal group with 34.72% of the sampled household in this efficiency category. None of the low

malaria incidence households operates below technical efficiency scores of 50%. Majority of the high malaria incidence households (72.13%) operate below technical efficiency scores of 70% while about 42.62% are operating below technical efficiency score of 50%. The mean efficiency for high and low malaria incidence household are 0.48 and 0.84 respectively.

Table 6: Frequency Distribution of Technical Efficiency Ranges of the Farm Households in the Study Area

Technical efficiency ranges	High incidence N = 62	malaria Low incidence N = 10	malaria All Household N = 72
	Frequency		
0.1 – 0.29	15.0 (24.59)	00(0.0)	15.00 (20.83)
0.30 – 0.49	11.00 (18.03)	00(0.0)	11.00(15.27)
0.50 – 0.69	18.00 (29.51)	1.00 (9.10)	19.00 (26.38)
0.70 – 0.89	17.00 (27.86)	8.00 (72.72)	25.00 (34.72)
0.90 – 1.00	0	2.00 (18.18)	2.00 (2.78)
Total	62.00 (100)	11.00 (100)	72. 00 (100)
Mean	0.48	0.84	0.5 [P<0.01]
Maximum value	0.82	0.92	0.92
Minimum Value	0.11	0.68	0.11

MLE Computed results; Figures in parenthesis are percentages

DISCUSSION

The respondents practice inter-cropping with twelve different crops identified in the area. However, the crops cultivated by more than 15% of the farming households were used for analysis; a similar approach was adopted by (Mohammed *et al.*, 2019; Lawal, 2006). The major crops grown by the sampled households are maize, sorghum, cowpea, millet and bambaranut. Households had an average of 8 episodes of malaria occurrence in a year. This is in line with the study of (Attanayake *et al.*, 2000). A typical household in the study area slept under mosquito net twenty three times with an average of six times in the periods under survey. This may explain the high incidence of malaria during the eight month period of the study. Due to malaria incidence, farming households were unable to go to their farms 38 days out of the 99 days of family labour in the study area. The findings of this study are closely similar to those of Ajani and Ashagidigbi (2008) and Alaba and Olumuyiwa (2006). Ajani and Ashagidigbi (2008) in their study on the effect of malaria on rural households' farm income in Oyo State, Nigeria, found that the increase in malaria incidence had a significant effect on the health and farm

income of the farmers through increase in the number of days of incapacitation of an average of 22 days. On the other hand Alaba and Olumuyiwa (2006) recorded an average number of work day loss per malaria episodes by productive adults in farming households was 16 days. This finding also corroborates the findings of Badiane and Ulimwengu (2013) where farming household's loss an average of 30 days of work within a year in Uganda.

Result on the Proportion of malaria in the farming household revealed that household's members had at least one episode of malaria based on the proportion of household members with malaria and categorized into two viz; those households with less than 20% malaria incidence within the eight month of the study and households with above 20% episodes of malaria incidence. Therefore, households with proportion of less than 0.2 are classified as low malaria incidence households (14 %), while households with proportion greater than 0.2 were classified as high malaria incidence households (86%). (Mohammed *et.al.*, 2016)

The farm inputs utilized by the households were land, labour, planting materials, fertilizer and chemicals. The coefficient of

variation of 65.02 reveals a high disparity in the farm size of the households in the study area. High variability was recorded in the levels of all inputs used by the households except for seed. This finding suggests that majority of the farming households' source planting materials from previous harvest

The result of the estimation of the production frontier and the technical inefficiency of malaria affected households in the study area shows that land and seed are significant at 1% while fertilizer is significant at 10% level. These variables have positive coefficient and are in line with *a priori* expectation thus implying that as each of these variables is increased, *ceteris paribus*, output increases.

Family labour is significant at 1% level and has a negative coefficient. The negative signs of family labour imply increase in this variable decreases farming households output all things being equal. The non-conformity of family labour coefficient to *a priori* expectation is probably due to high malaria incidence in the study area.

Further result revealed that age of the household head, level of education of household head, medical expenses by households, the number of days the households are absent from their farms, and the number of times the household members slept under the mosquito net were the significant factors which explain the variation in the inefficiency of crop production in the malaria farming households. The coefficients of the age of the household head, medical expenses by households and the number of days the households are absent from their farms were found to be positive and significant at 1% level. The positive signs of these variables are in accordance with *a priori* expectations. The positive coefficient implies that as one or all of these variables increase, inefficiency in production also

increases. Similarly Aheisibwe, 2008 in his study on the effect of malaria on agricultural crop production in Uganda found out that a day loss due to malaria resulted into a 0.153 percent reduction in agricultural production. This also corroborates the findings of Ajani and Ugwu (2008) who found out that health variable as measured by the number of days lost was statistically significant at 5 percent with its coefficient large and positively related to the efficiency of farmers.

The negative sign of the coefficient of level of education implies that as the level of education increases, inefficiency in production decreases. The negative coefficient of use of mosquito net implies that increase in the number of times slept under mosquito net decreases inefficiency of the farming households. Therefore age, medical expenses, day loss, level of education and numbers of times slept under mosquito net are the significant factors affecting technical inefficiency in the malaria farming households in the study area. Further analysis showed that technical efficiency skewed heavily towards 0.70-0.89 range, this represents the modal group with 34.72% of the sampled household in this efficiency category while 65.28% are in the inefficiency category. The mean technical efficiency value of 0.54 % indicates that if input usage is increased by 46%, the farming households in the study area will be operating on a production frontier. The wide variation in technical efficiency estimates is an indication that most of the farming households are still using their resources inefficiently in the production process and there still exists opportunities for improvement on their current level of technical efficiency.

The mean efficiency of low malaria incidence households is significantly higher than the high incident household at 0.01

level of probability. This confirms that low malaria incidence households are more technically efficient thus the need to eradicate malaria

CONCLUSION

A total of 72 households participated in the study involving 432 household members. Households were categorized into low and high malaria based on the proportion of households with malaria. It can be concluded from the findings of this study that there is high incidence of malaria in Kabba/Bunnu Local Government Area of Kogi State. Most farming households operate on a small scale and majorly cultivated maize, cowpea, millet, bambaranut nut and sorghum. High variability was recorded in the levels of all inputs used by the households except for seed. The coefficient of land, family labour and seed are significant at 1% levels and were found to be the major factors influencing crop production in the study area. Age of the household heads, level of education, medical expenses, day absent by households from farm and times slept under the mosquito nets significantly influence the efficiency of crop production in the malaria farming households and are important policy variables and determinant of efficiency which can be incorporated into the agricultural policy in Nigeria in order to raise the current level of technical efficiency and hence the level of productivity in the Nigerian agricultural sector. Low malaria incidence farming household are more efficient than the high malaria incidence farming household at 0.01 level of probability.

Based on these findings the following recommendations are made:

In view of high malaria incidence, number of day loss to malaria and the number of times slept under the mosquito nets in the study area, an effective malaria control programme in the study area would decrease malaria incidence and thereby

improve agricultural production and efficiency considerably.

Considering the positive relationship between number of day loss and inefficiency in crop production efforts should be aimed at facilitating early detection of malaria with the use of Rapid Diagnostic Test (RDT) early enough for effective treatment. This would not only lower medical expenses but also reduce the number of work day lost.

The study area should be targeted for free medical treatment by government creating a platform where farming households have access to the National Health Insurance Scheme (NHIS) that will ensure prompt treatment of malaria thus reducing the number of days of incapacitation and hence increasing efficiency in crop production.

Awareness should be created on the use of mosquito nets. The study area should be targeted for free net distribution and training on utilization

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