ECONOMIC AND SOCIAL LINKAGES BETWEEN MALARIA ILLNESS AND CROP PRODUCTION IN YOBE STATE, NIGERIA

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Abstract

The purpose of this article is to stimulate discussion about the links between malaria pandemic and crop production, and to broaden our understanding of the effect of malaria in terms of its economic burden on households and national economic development of endemic economies. It begins with a theoretical framework, emphasising economic development imperative of malaria, and the implication for agricultural development. Using propensity score matching, the likelihood of malaria infection was evaluated in relation to key socioeconomic variables among infected and uninfected households in agricultural communities of Yobe State. Similarly, the linear regression provides empirical evidence to suggest that the instrumented malaria indices significantly reduce crop production among malaria infected households. The economic loss approach further stresses the economic imperative of the opportunity cost of labor among malaria infected households. The empirical results suggest targeting farmers with malaria-specific control and prevention programs in the state.

Key words: Crop production, Malaria illness, household income, Propensity score matching, economic development.

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INTRODUCTION

Malaria affects many more people in the developing world, with over 3 billion people, or half of the world's population in 106 countries and territories. The World Health Organisation (WHO) estimated 216 million malaria cases in 2010, for instance, of which African region accounted for 81%, also the number of estimated malaria deaths in 2010 were 655,000, representing 91% in the African Region, including an estimated 100 million malaria cases with over 300,000 deaths per year in Nigeria. This compares with 215,000 deaths per year in Nigeria from HIV/AIDS (US Embassy in Nigeria, 2011).

Due to the direct and indirect costs, malaria has widespread impacts on socio-economic growth and development, especially in Africa; where in 2006 over 90 percent of deaths from malaria were in Africa, where 45 out of 53 countries were endemic for the disease (WHO, 2008). These estimates render malaria the preeminent tropical parasitic disease and one of the top three killers among communicable diseases (Sachs and Malaney, 2002).

Malaria costs African Continent more than US$12 billion annually, and may also be largely responsible for slow economic growth in African countries, which may account for as much as 1.3 percent per year (WHO, 2010). Malaria can cause morbidity, disability, or death; and all three effects have direct and indirect costs that can affect labour availability and productivity, and ultimately, economic development. The direct costs of malaria treatment and control, and the impacts of these costs on the ability of farm households to adopt new agricultural technologies and improved wellbeing, are the bane of agricultural underdevelopment and poverty in many countries south of Sahara, including Nigeria. The social costs of government spending on malaria control and treatment exerts a tremendous pressure on the financial portfolios of poor countries. In the most heavily affected regions, malaria accounts for 40% of public health spending (Purdy *et al*., 2013). Equally important are the indirect costs of seeking health care and taking care of children and others who are infected by malaria and the relationship of the indirect costs to the farm labour supply and productivity.

The World Health Report (2002) noted there were 300 to 500 million cases of malaria each year, and that between 1 and 3 million deaths, mostly of children, were attributed to the disease, so much so that every 40 seconds a child dies of malaria, resulting in a daily loss of more than 2,000 young lives worldwide. According to the World Health Organization (WHO), malaria kills over a million people each year, mostly in Africa, where more than 90 percent of deaths in 2006, came from malaria.

According to US Embassy in Nigeria (2011), malaria is a major public health problem in Nigeria where it accounts for more cases and deaths than any other country in the world. Malaria is a risk for 97% of Nigeria's population; the remaining 3% of the population live in the malaria free highlands.

Empirical evidence of the effect of direct and indirect costs of malaria on the households, including farm-level analysis of labour availability and productivity are also relevant (Purdy *et al*., 2013; Asenso-Okyere *et al*., 2009a; Asenso-Okyere *et al*., 2009b). There is an understanding, in heuristic terms, that malaria poses a serious threat to economic development in Nigeria. This study, using a case study, attempted to provide empirical evidence of the susceptibility of households to malaria infection in the state in relation to key socioeconomic characteristics. The study also tried to establish the cause-effect relationship between malaria illness and households' economic wellbeing, including farm-level output reduction as a possible reason for the state to be ranked as the least developed, and having the least total GDP of about $2,011 in 2010 (C-GIDD, 2008). But the problem of economic development in the state had degenerated with the increased spate of insurgence, especially the activities of *Boko Haram* which started in the state in 2011, and further compounds the problem of food security in the state.

Given the severe malaria impacts, this study examined the effect of malaria on households in Nigeria's state of Yobe. In specific terms, the study attempted to estimate the likelihood of malaria infection, and the causal link between crop output and key malaria indices among the households.

2.0 THEORETICAL FRAMEWORK

2.1 Malaria in Households Economy

The conceptual framework adopted by Asenso-Okyere *et al*. (2009), which was developed by the UN Secretariat to evaluate the impact of HIV/AIDS on agriculture was adapted in Figure 1. It is true that malaria results in morbidity and sometimes death especially in the endemic countries south of Sahara where Nigeria has the largest population. Malaria morbidity, whether of the economically active population or not, affects labor availability and productivity. When active population is infected, labor availability is constrained directly and indirectly through care giving to other members of the household infected by malaria. Therefore, the likely effect of malaria infection on the household may be seen in the loss of productive time, giving rise to decrease in land area put under production, untimely farm operations, and consequently

decreasing household farm income and food security (Asenso-Okyere *et al*., 2009). This view was also supported by De Leire and Manning (2004) that an individual worker who experiences onset of health impairment or absolute illness becomes less productive or unproductive, respectively while he is working at his or her current occupation. Two strands of effect of labor availability on individual's income established in economic theory are the role of health over wage rate and the part it plays in the decisions relating to supply of labor and, decisions on how many hours of labor to supply (Alaba and Alaba, 2009). According to Alves *et al.* (2003), healthy individuals are expected to possess a higher level of human capital, and would be more productive than those with poor health. At the household level, where fundamental decisions are made, malaria strips families of their main sources of financial and non-financial resources.

Malaria involves both direct and indirect costs; costs of treatment and prevention directly affect investment in agriculture, and often lead to dissaving, thereby causing disruption in the economic and social prosperity of the household. Often times, the household may engage some mechanisms such as sale of productive and household assets, including cash borrowing to cope with cost of malaria treatment. Asenso-Okyere *et al*. (2009) noted that the direct cost of treating and preventing malaria could constrain households to adopt several measures, including reduction in area under cultivation, planting of less labor-intensive crops, changes in cropping patterns, adoption of labor-scarce innovations that may constitute less productive farming techniques, and reduction in the use of farm inputs. They further noted that the potential impact of malaria for women engaged in food production can be very significant, especially in some parts of Africa where women account for about 70 percent of agricultural labor force and 60-80 percent of household food crops producers (Todaro, 2000; FAO, 2010). Consequently, malaria infected households may resort to adoption of coping mechanisms such as household labor reallocation and the hiring of labor, these strategies have cost implications. Malaney (2003) noted that the heavy economic burden imposed by malaria on households could have significant micro-economic consequences as it interferes with household's ability to save and invest in education and physical capital. In terms of education, agricultural experience may be acquired over time, especially in developing countries where majority of farmers do not have formal education; as reported by Ochi *et al*. (2007) that over 90 percent of farming population in agricultural communities in Nigeria did not have formal education. For this reason farming knowledge represents an important incorporeal asset, which can be lost, especially through death of agriculturally resourceful farmer who may be responsible for spill-over technology adoption in his area.

2.2 Epidemiology of Malaria

Malaria and poverty may have some link. Malaria has been called the epidemic of the poor (Asenso-Okyere *et al*., 2009). Malaria endemic countries had income levels in 1995 of only 33 percent that of countries without malaria (Gallup and Sachs, 2001). A closer look at the global spread of malaria may suggest that the endemic countries may be found in tropical Africa, especially south of savannah, Latin America and Asia, which also coincide with world lowest GDP per capita. However, we posit that malaria is a climatic phenomenon; being that the environmental conditions of a region tend to support the more efficient malaria mosquito vectors distribution and hence the intensity of the disease, than associating malaria pandemic directly with poverty in these countries. Climate therefore plays an important role in the spread of malaria mosquitoes. Conditions such high humidity and rainfall in West Africa are known favourable factors for breeding of malaria mosquitoes.

The name "malaria" was derived from the Italian, "mal aria", or bad air, to denote the fact that malaria is associated with dirty environment – marshes and swamps characterised by rot and decay that give foul air. The United States, in the early times, had witnessed tragedies of the disease then known as "fever and ague", believed by historians to have peaked around 1875. Malaria had been a significant factor in virtually all of the military campaigns involving the United States; in World War II and the Vietnam War, for instance, more personnel time was lost due to malaria than to bullet" (USDHHS, 2007). The real cause of malaria, *Plasmodium* parasite was discovered by the French Scientist, Alphonse Laveran in 1880. In about 1900, scientists working in India and Italy discovered that Anopheles mosquitoes are responsible for transmitting malaria. Over 100 species of Plasmodium are known, but four of these commonly infect humans. *Plasmodium falciparum* is responsible for most malaria deaths, especially in Africa. *Plasmodium vivax*, geographically, is the most widespread species, and it is less problematic in terms of infection, but now mostly found in the tropics and Asia. *Plasmodium malariae* has the greatest persistence in the blood than any other species, has been eliminated from the temperate climate, but still persists in Africa. *Plasmodium ovale* generally occurs in West Africa. Africa, especially south of Sahara, appears to be the reservoir for mosquitoes.

2.3 Linkages between Malaria Illness and Economic Development

Figure 2 describes the relationship between malaria infection and economic development with substantial input from Abegunde and Stanciole (2006). Our starting assumption is that diseases in general, and malaria, in particular deprive individuals of their productivity due to morbidity and death. The effect of malaria is also widely felt as worker productivity lowers with

increased sick leave, absenteeism, and premature mortality of the workforce (Asenso-Okyere *et al*., 2009). For many, the transmission period of malaria coincides with the planting season, which further lowers agricultural productivity, resulting in food security problem as supply-demand gap gets widened, causing the need to seek external intervention, in terms of food aid, which may predispose the household and/or nation to high external interference through aids and food politics.

Diseases generally reduce intergenerational skills and wealth transfer, to the extent that the educational capital, especially for children can be impacted negatively by malaria infection at critical stages of child's development during pregnancy, and early childhood which consequences may include anaemia, low birth weight and premature birth, leading to educational disabilities, cognitive impairment and physical retardation. There are far reaching implications of cognitive impairment, for instance in children, namely; producing a generation suffering from educational difficulties in life –individuals not well equipped, in terms of academic qualification, skills, experience, reasoning, etc due to mental and/or physical challenges as a result of malaria infection – cannot aspire for equal opportunities in life with their counterpart that did not suffer such health challenges, thereby giving rise to generation of social and economic inequalities. Inequality breeds social disaffection in society; such is the bane among groups and individuals causing all forms of insecurity in our present world. Socioeconomic inequality inevitably leads to dependency, both at microeconomic and macroeconomic levels. At microeconomic level, a household in dependency may easily become vulnerable and a source of different forms of exploitation. The parallel applies at macroeconomic level; in which the society becomes dependent on external aids to meet the needs of its people. Unfortunately, such a society cannot enjoy true political and economic independence, to the extent that the stronger donor countries would always want to influence and dominate the internal decision machinery of the recipient countries.

Dependency also leads to reduced access to factors of production, whether at household or national levels, leading to low saving and investment, and ultimately low gross domestic product (GDP) and national income (NI). Diseases in general, deprive individuals of their productive potential. According to Asenso-Okyere *et al*. (2009), malaria burden may invariably challenge individual or household income and savings, and compete with investment activities. From country perspective, diseases may reduce life expectancy and ultimately economic development, thus depleting the quality and quantity of country's labour force. This may result into lower national output in national income. Nigeria, like many developing countries, largely

operates a labour-intensive agricultural economy, which further explains the problem of labour force incapacitation due to malaria. Moreover, from a macro-economic perspective, malaria mortality has been observed to slow economic progress by reducing capacity and efficiency of labour force. Empirical evidence of the effects of malaria on national income concluded that countries with substantial level of malaria grew 1.3 % less per caput per year for the period 1965-1990 (Gallup and Sachs, 2001). The study also asserts that with a 10 percent reduction in malaria economy may grow by as much as 0.3 percent. Similarly, McCarthy *et al*. (2000) found a negative association between higher malaria morbidity and GDP per capita, and that most of the sub-Saharan African countries used in that study incurred an average annual growth reduction of 0.55 percent.

3.0 METHODOLOGY

In order to analyze the linkage between malaria illness and crop production among households in the farming communities of Yobe State, we stratified the sampling frame into five: (i) the entire state was divided into two agricultural zones I and II in accordance with the delineation by the Yobe Agricultural Development Program (YADP). Zones I and II comprised nine and eight local council areas, respectively (ii) identification and selection of local government council areas (LCAs) having standard hospital facilities. For the purpose of this study, two local council areas were purposively selected from each of the two agricultural zones, namely; Bade, Fika, Geidam and Nangere, (iii) Adoption of YADP enumeration units as “wards”. Accordingly, four wards were randomly selected in each of the four selected local council areas, (iv) random selection of 25 households whose heads were diagnosed to have malaria in each ward, and actually went down with malaria illness during the cropping season of 2012, and (v) selection of 25 (a near neighbor) households whose heads were not infected with malaria during the same cropping season, but who lived in proximity to the infected household and also engaged in comparable crop enterprises as the infected household. In developing the sampling frame efforts were made to include female household heads in the lists.

This stratification procedure was to enable the estimation of the direct and indirect impacts of malaria illness, on crop output as well as the susceptibility of households on the basis of selected key variables. By comparing crop outputs of infected households with that of uninfected households, we obtained an estimate of the opportunity foregone in respect of average days of incapacitation as an indirect impact of malaria illness on crop output.

3.1 Data Source and Description

The data consisted of patients hospitalized with malaria infection at Bade, Fika, Geidam, and Nangere Local Council Areas of the state, between March 1 and December 31, 2012 (this forms the period during which farmers in the areas begin preparations for farming activities, while actual operations begin with onset of rainy season from May/June to October. It is assumed that any health challenge during this period would likely have a negative effect on crop outputs of the farmers. Data on the patients were obtained by retrospective laboratory records reviewed by the nurses that compiled a list of malaria patients (both out- and in-patients) coming from the four LCAs selected. Information obtained on the patients included contact home addresses, which was also used to determine the selection of the near-neighbor malaria-uninfected households as the control unit.

The sample was restricted to those patients who survived to hospital discharge and engaged in farming during the cropping season of 2012. The sample also was restricted to household heads (including female household heads), and no other members of the households was involved. Of course, in most cases of malaria illness, care givers in the household equally lose their days of farm labor as the sick, but for this study only infected household heads were considered. The selected household heads with missing data on important covariates were excluded from the analysis, especially the PSM. In other words, only respondents whose covariates matched in the two groups were included in this analysis.

3.2 Data Analysis

3.2.1 Propensity score matching

There are three interrelated challenges that impede impact analysis, namely; finding a feasible counterfactual outcome (the predicted outcome in the absence of malaria illness, i.e., what would have happened to the outcome of malaria-infected households had the household heads not been exposed to malaria during the cropping season), linking the impact to malaria illness, and not any other interposition, and the difficulty of dealing with long and unpredictable lag times (Nkonya *et al*., 2007).

The problem of self-selection biases is the norm rather than the exception in most impact analyses, and which is often addressed using some matching model(s), our present study may be viewed along similar analytical lines by using quasi-experimental approach such as the propensity score matching (PSM). The malaria infected households and uninfected households constituted the two groups being assessed for their susceptibility to malaria illness, on the basis of the key socioeconomic variables common to the two groups.

Generally, from impact assessment literature, the average impact on households affected by a cause, referred to as average effect of the treatment on the treated (ATT), is defined as the difference between the expected outcome of the caouse and the expected outcome the same households would have received had they not been exposed to the cause (Starks and Garrido, 2014; Lanehart *et al*., 2012; Austin, 2011; Caliendo and Kopeinig, 2005).

In this study, malaria illness is an interference with ability of households to produce their optimal crops output levels in terms of indicators (D) for individual household (i). The potential outputs Y are therefore defined as Y_i (D_i) for each individual i^{th} household, where; i = 1,..., N, and N denotes the total population (Caliendo and Kopeinig, 2005). There are two possible treatments (e.g., malaria-infected and uninfected) and each individual, i, has a potential output for each condition, i.e., $Y_i(1)$ for infected and $Y_i(0)$ for uninfected. The treatment effect (τ) for an individual household (Y_i) is written as:

$$\tau_i = Y_i(1) - Y_i(0) \quad \text{... (1)}$$

$$\text{ATT} = E(Y_1 \mid M = 1) - E(Y_0 \mid M = 1) \quad \text{... (2)}$$

Where, ATT = average effect of the treatment (or malaria infection) on the treated (or infected), M = malaria infection (M = 1, if infected with malaria, and M = 0, if not infected with malaria). Y_1 = outcome (crop outputs) of households exposed to malaria illness; Y_0 = crop output of the same household, when not exposed to malaria illness.

The counterfactual crop output mean for malaria infected households, $E[Y(0) \mid M = 1]$, is not observed, which must be substituted for so that we can estimate the ATT, if not it would result in self-selection biases since malaria-infected households and the uninfected households can be very different in all essential indicators with or without malaria infection. For instance, it may be noted that:

$$\text{ATT} = [E(Y_1 \mid M = 1) - E(Y_0 \mid M = 0)] - [E(Y_0 \mid M = 1) - E(Y_0 \mid M = 0)] \quad \text{... (3)}$$

The expression in the first square bracket is observable – it is the difference of crop output of malaria infected households and uninfected households. The second expression is unobservable since $E(Y_0 \mid M = 1)$ is unobservable, and therefore represents the self-selection bias in the first expression. This bias results because the crop output that malaria uninfected households obtained may not be equal to the crop output that malaria infected households would have obtained without infection $E(Y_0 \mid M = 1)$ is not equal to $E(Y_0 \mid M = 0)$. The difference in the output between the two matched groups may be understood as the impact of malaria illness on the infected households.

Propensity score matching (PSM) was used to match malaria infected household heads and uninfected household heads in terms of observable and comparable covariates expected to impact crop output. PSM is the estimated probability of being infected with malaria illness, in this study the logistic model was used for the estimation.

3.2.2 Effects of Malaria Illness on Crop Production

Possible attribution of the reduction in crop output to malaria illness was attempted using R-regression package, version 3.1.3. The linear model was selected to fit the regression line for crop output Y on malaria indices, namely; days of incapacitation X_7, cost of malaria treatment X_8, frequency of malaria illness X_9, and distance to source of treatment X_{10}.

3.2.3 Theoretical expectations of the results

The following theoretical assumptions were used to support the results of estimation, in terms of weight and direction of the estimates:

i) Days of incapacitation: The period of incapacitation in this study referred to complete absence of household head from farm work due to malaria illness. Days of incapacitation of the household heads would bring about decline in crop output (negative effect).

ii) Frequency of malaria illness: Directly reduces the streams of potential days of household labor. Consequently, high frequency of malaria illness would be accompanied by low crop production (negative effect).

iii) The out-of-pocket expenditure on malaria treatment: This would leave less cash for investment in crop production and their household needs. It therefore has a direct negative effect on the household crop production (negative effect).

iv) Distance to the source of malaria treatment: It is expected to reduce available cash for crop production, through the transportation fare and time taken to travel (negative effect).

v) Farm size: Normally farming would require labor, either from hired or/and household labor force. The high financial burden to meet the labor demand under lean financial situation could predispose a household head to stress, which in turn could make the household head susceptible to malaria illness. Therefore, the size of farm holding may have positive or negative effect on crop output, depending on the size (+/-).

vi) Household labor: In a rural agricultural setting household labor is expected to be less likely to predispose a household head to malaria illness. It is expected that large

amount of available labor force would ease the accomplishment of the farm tasks, thereby giving little room to stress and malaria illness (negative).

vii) Household size: Is expected to be less likely to predispose household heads to malaria illness. Large households in typical agricultural setting usually supply the labor force for farm activities, consequently making the work less rigorous and stressful. However, with greater emphasis on child education, the notion of large household having positive impact on agricultural production may no longer hold in most rural communities in the state (negative).

viii) Education: Educated household heads is expected to be less susceptible to malaria infection, having acquired better knowledge about malaria prevention and control methods, compared to uneducated household heads (negative).

ix) Age: The household head may be less likely to be predisposed to malaria illness, depending on the age. Older age may be less susceptible to the infection, compared to younger individuals (negative).

x) Farming experience: This would be less likely to predispose household heads to malaria illness (negative).

3.2.4 Economic loss approach

The monetary value of the production, as a function (f) of days of incapacitation was computed using the *Economic Los*s formula:

US$[1]-equivalent = $f(F_t.A_t)$ ... (4)

Where, F_t = average number of days of farm time lost due to malaria illness, A_t = average labor wage/man-day (in US$-equivalent). For the purpose of estimating the economic value of the average days of incapacitation (ADI), we established two benchmarks, namely; national daily minimum wage (NDMW), and average (Yobe State) daily labor wage (YDLW) rate. The NDMW of ₦591.78 (or US$3.65) in Nigeria was based on the 2011 approved national monthly minimum wage of ₦18,000 (or US$111.11) per capita, and YDLW (₦800 or US$4.93) per capita is the current daily labor wage rate in Yobe State. However, the daily labor wage rate can be different in time and space across the state depending on the demand and supply of labor.

[1]Exchange rate at the time of this study was ₦162 to US$1

4.0 EMPIRICAL RESULTS

4.1 Propensity Score Matching for Malaria-infected and -uninfected Households

This approach attempts to establish the susceptibility of human population to malaria illness on the basis of certain socio-economic variables. There seems to be an intricate relationship between malaria infection and a host of factors that define the living of the populace. Malaria parasites, especially *Plasmodium falciparum* are present in the human body of Africans, especially sub-Saharan African, but not everyone goes down with malaria illness because certain factors must predispose an individual to malaria illness, such as the functional immunity level and stress factors. This analysis attempted to establish a link between malaria illness and individual's socioeconomic characteristics

The logit model was used to analyse the propensity scores of the comparable variables between the infected and uninfected households, namely; age (X_1), household size (X_2), education (X_3), farm size (X_4), household labor (X_5), and farming experience (X_6). The object of this approach is the likelihood of malaria infection among the two groups, which is the dependent variable, and the observed covariates as independent variables. Only the infected and uninfected households with comparable propensity scores were used for estimation of ATT. Consequently, out 1145 original number of observations, only 762 observations were matched, and used for the analysis.

The overall effect, ATT estimate was negatively and statistically significant ($P<0.001$), implying that infected households could be less likely to be infected with malaria after match balancing between the two groups, in other word, the needed adjustments through balancing that would making infected households less susceptible to malaria illness (Table 1). Furthermore, Figs 3-8 indicate that the matching between infected and uninfected groups was generally good, except at higher levels of some of the covariates such as farm size, and farming experience.

Table 2 suggests that household heads with higher ages, household sizes, higher household labor, and farming experience were less likely to be infected with malaria, with only farming experience that was significant ($P<0.001$). The negative sign of the coefficients theoretically implied that susceptibility to malaria illness would decrease among household heads with every unit increase in age, household size, household labor and farming experience while malaria illness would likely increase with a unit increase in education and farm size. There is preponderance of evidence in literature that tend to suggest that individuals become less

predisposed to malaria illness as they grow older (Snow and Omumbo, 2006; Charlwood *et al*., 2001; Kahn *et al*., 1999). In other word, malaria infection has a defined age structure; for instance, age 0-5 years appears to be the most susceptible period to malaria infection. Independent estimates of malaria mortality among children under five years in Burundi, The Gambia, Ghana, Kenya, Senegal, Sierra Leone, and Tanzania gave a median of malaria-specific mortality rate of 9.33 per 1000 children per year (Jamison *et al*., 2006). Nwaorgu and Orajaka (2011) gave 0-4 years as most susceptible period to malaria infection in Nigeria. The WHR (2002) reported a daily loss of over 2000 children worldwide from malaria illness. Similar findings were reported by the US Embassy in Nigeria (2011), that malaria in Nigeria has accounted for an estimated 86% mortality of children less than 5 years of age in 2010. The median of malaria-specific mortality of older children, age 5-14, was 1.58 per 1000 per year. Among adults, age 15 years or older, the median malaria mortality rates were 0.6 per 1000 per year (Snow and Omumbo, 2006). Similarly, malaria infection during pregnancy was reported to have far reaching consequences, such as reduction of birth weights and infant survival rates, and expectant mothers who survive severe malaria illness may end up having children with epilepsy, behavioural disorders, or cognitive impairment (Holding and Snow, 2001). Women are considered as a vulnerable group, even to diseases attacks, and because malaria infection generally predisposes a person to other opportunistic infections coming from different diseases, women could be more easily susceptible to different forms of ailment, which could have serious implications for households' food situation in areas where women play leading role in food production. Todaro (2000) and FAO (1996) found that women accounted for about 70 percent of agricultural laborers, which also accounted for 60-80 percent of the food crop producers both for household consumption and sale. In malaria endemic areas such as sub-Saharan Africa, frequency of exposure to malaria can be a good determinant of the functional immunity to the disease from birth. Snow and Marsh (2002) noted "the speed with which a population acquires functional immunity to the severe consequences of *P. falciparium* infection depends on the frequency of parasite exposure from birth as measured by the intensity of parasite transition in a given locality". Therefore, children conceived, born and/or brought up in malaria endemic environment are more likely to survive malaria infections, since they tend to develop functional immunity early in life.

The logistic regression estimates for household size and household labor suggest that large household size and household labor may be less likely to predispose household heads to malaria illness. In traditional agricultural setting, household members often supply the needed labor force for farm work. Where sufficiently large amount of household labor is available, the

emotional pressure and stress household heads often go through in sourcing labor for the work would reduce, which would in turn make the household head less susceptible to malaria illness and many other diseases. Therefore, households may enjoy greater relief from pressure on labor, especially at the peak of farming operations, when most of the farm activities demands for labor. Perhaps, due to the drudgery nature of agriculture, as well as the practice of multiple wives in Muslim communities in the state, family system is structured in favour of large household size which also supplies farm labor that easies up stress that would predispose household heads to different types of illnesses.

However, viewed from perspective of impact on poverty, larger families could be associated with poverty and other vulnerability that may exclude such households from good quality living (Nkonya *et al*., 2007). The result also showed that Farming experience was significantly ($P<0.001$) less likely to predispose to malaria infection among household heads in the state. This may be possible because as people acquire more experience in growing of crops they are likely to be better able to manage agricultural activities, and such questions as "how" and "where" to source labor and finance for farming, etc., thereby reducing possible stress that would lead to malaria illness. The results further suggested that educated household heads may be more likely predisposed to malaria infection, contrary to the assumed expectation. Educated farmers may be resourceful and the reservoir of farming knowledge, and may be responsible for many spill-over agricultural technologies in his community, to the effect that the death of such key individual, perhaps, due to malaria illness, could have a serious negative impact on agricultural production in his area of his/her influence.

Table 2 further shows that households having larger farm size were more likely to be infected with malaria in accordance with the theoretical assumptions, with the farm size being significant ($P<0.05$). Perhaps, household heads with large farm size may be more susceptible to malaria illness because of the drudgery nature of crop farming in the state, which subjects farmers to a lot of emotional stress, thereby predisposing them to malaria. This may be compounded by poverty, in which most farm families in the state may be undernourished thereby become more vulnerable to many infections, including malaria. Moreover, the Muslim *pudder* system in which women, particularly wives are kept in seclusion further reduces labor force that would have come from women, thereby, putting the heads of households under emotional pressure.

4.2 Estimated Effects of Malaria Illness on Crop Output

The nature of the instrumented variables may suggest the presence of multicollinearity problem. Consequently, the Condition Number (CN) was analysed for the severity of multicollinearity (Wijekoon and Dissanayake, 2013). The estimated effects of the key malaria indices, namely; days of incapacitation, cost of malaria treatment, frequency of malaria illness, and distance to source of treatment, are presented on Table 3. In order to confirm the presence or otherwise of multicollinearity, a linear multicollinearity check was done, with Condition Number being 8.657672, which was not significant. Wijekoon and Dissanayake (2013) noted that the condition number in the interval (30, 100) indicates multicollineariy, and condition number of greater than 100 indicates severe multicollineariy. Furthermore, analysis of the Variance Inflation Factor (VIF) showed that: X_7 = 13.82192, X_8 = 8.03369, X_9 = 9.84882, and X_{10} = 3.920889. Figure 9 shows that the VIFs greater than 10 for all values indicate multicollinearity (Wijekoon and Dissanayake, 2013). From the above regression equation, only the days of incapacitation (X_7) has VIF greater than 10.

4.2.1 Days of malaria incapacitation

The days of incapacitation (DMI) constitute actual labor days lost from carrying out normal activities like farming as a result of malaria-specific ill-heath. During the period of malaria incapacitation, a typical farmer may stop work partially or completely due to debility arising from malaria infection. Consequently, labor availability and productivity may suffer a setback. Under severe malaria attack labor may not be available on the farm at all during the period of incapacitation while in a situation of mild malaria attack, the intensity or productivity of labor, which is measured by work done per unit time, may be reduced. The loss of workdays as a result of malaria-specific illness had accounted for the decline in farm outputs (Alaba and Alaba, 2009; Rwaheru, 2011). Table 3 shows the estimated effects of malaria indices on crop output in the rural communities of Yobe State. The coefficient of days of incapacitation was negatively significant ($P<0.001$), the negative sign supported the theoretical expectation, that malaria illness would cause real crop output reduction. This finding has implication for increased poverty among households in malaria endemic agricultural communities, which may give rise to a vicious circle of low crop output-low agricultural investment-high poverty continuum. Malaria-specific incapacitation therefore constitutes an important poverty dimension that cannot be ignored in malaria.

One of the cardinal goals of Millennium Development Gaols (MDGs) is halving extreme poverty by 2015. However, malaria-specific incapacitation has the capacity to reverse the

celebrated gains of MDG I in many endemic countries. The UN-MDG program, especially the goal of halving extreme poverty, has come to an end, but much socioeconomic evidence has shown the presence of extreme poverty in the state. Could it be that malaria infection is the factor behind the reversal trend? Threat to crop production in rural communities of the state also means threat to life, because life revolves around crop production among the farm families. Perhaps, malaria illness, and the combined effects of other factors, such as insurgency, especially the menace of Boko Haram, climate change impacts, etc, might have accounted for the state remaining as one of the poorest states in terms of economic development in Nigeria.

4.2.2 Cost of malaria treatment

The cost of malaria treatment may be viewed from two stand points of public spending and the out of pocket expenditure (OPE) of households. This study analysed only the OPE of households on malaria treatment. The results showed that the cost of malaria treatment negatively impacted ($P<0.05$) on households crop production, which may be interpreted from the OPE stand point to mean less money would be available to households in the state in terms of investment in crop production, education of household members, as well as saving to cushion future financial pressures on households. In other word, the OPE on malaria treatment constitutes a deprivation of households in terms of present and future development plans, such as investment in physical assets, agriculture, paying of schooling costs, and provision of adequate daily food needs. The combined effects of these costs would negatively impact households. Asenso-Okyere *et al*. (2009) observed that the cost of treating and preventing malaria could lead households to reduce farm area, planting of less labor intensive crops, changing cropping pattern, adoption of labor-scarce innovations that may be less productive. Asante (2009) further noted that expenditure on malaria, like any other treatment costs would reduce funds to hire casual laborers and to buy inputs like fertilizers and improved seeds. Furthermore, the use of personal savings for treatment of malaria illness may cause a financial dislocation of household's future plans. Chum (2005) noted that even when cash is readily available to pay for the cost of malaria treatment, this available cash is usually budgeted for other household needs, such as investment, including payment of school fees, buying of agricultural inputs, clothing, repairs, etc. The use of savings to finance cost of treatment would require adjusting the household's daily needs. In other word, the use of household cash savings for medical treatment is not an indication of cash availability, but some form of opportunity foregone. On the other hand, the increased spending by national governments, and international agencies on malaria prevention and control, such as distribution of mosquito treated bednets,

constitute opportunity foregone in the macroeconomic development of national economies. At the continental level, malaria costs Africa over US$12 billion annually and it is expected also to have slowed down economic development in the continent (WHO, 2010).

4.2.3 Frequency of malaria illness

An individual may suffer from malaria illness multiple times during a production season, depending on the functional malaria immunity of an individual, and the severity of malaria in the locality. Table 3 further shows that the frequency of malaria illness among the farm households had a significant ($P<0.001$) negative effect on crop output. This study further showed that, on the average, individual household received three bouts of malaria attacks during the cropping season, which could negatively impact food security. In a similar study on the impact of malaria on food production in Western Highlands of Cameroon, Endah and Ndambi (2006) noted that malaria posed a serious challenge to food security as a result of the vulnerability of farmers living in malaria prone areas. The high frequency of malaria illness, on the other hand, has implication for increased poverty among households in terms of OPE on malaria treatment, which in addition to indirect cost of crop output reduction, could bring a household under a serious economic burden.

4.2.4 Distance to source of treatment

The cost incurred in terms of transportation fares from one's location to another for the purpose of receiving medical treatment, and the time taken to reach the source of treatment, depend on the distance. The fare incurred and time lost in travelling to the source of treatment constitutes the opportunity cost of treatment. The results suggest that the opportunity cost of receiving malaria treatment was the decline in crop output, which was significant ($P<0.05$), implying that the value of the travelling time and fare paid to reach the treatment site – proxy for distance to source of malaria treatment – would impact negatively on crop production of malaria infected households. The cost incurred to reach sources of malaria treatment may be further compounded by the fact that often times, malaria infected individuals do not go to hospital alone, but in company of care-givers, which may further increase the economic burden and plunge households further into poverty by reducing their ability to expand crop production, which constituted the main source of livelihood among the rural households.

4.3 Estimated Value of Farm Labor Forgone

An average of 19.06 workdays was lost as a direct effect of malaria-specific illness during the cropping season, which also represented the actual wage and/or revenue foregone by malaria

infected households. Using Economic Loss approach, and the opportunity cost of labour, the economic implications of malaria illness was computed.

The proxy for opportunity cost of labour was benchmarked in the Nigerian national minimum wage (NMW) and the Yobe State average daily labour wage (YADW) rate. Using the NMW and YADW, the average days of incapacitation of 19.06 days translated to ₦11,279.32 (or US$69.44), and ₦15,248 (or US$94.12), respectively. The economic analysis of days of incapacitation recognises the methodological difficulties involved in the valuation of the opportunity cost of labor due to incapacitation. For many people, agriculture is not just the production of food for the households, or for commerce and industrial production, but it is also a way of life, around which the world revolves for many rural households. For this reason many elements of cost connected with opportunity cost of labor (as a result of illness or death) do not lend themselves for valuation in monetary terms, thereby complicating the methodological challenges involved in the valuation technique. In order to reduce this complexity, the opportunity cost of labor due to death of household heads as a result of malaria-specific illness was not assessed in this study; moreover, data for this study were collected from the cross-section of farmers following their discharge from hospitals.

The economic implication of farm labor foregone due to malaria illness brought to the fore the economic imperatives of malaria in household economy. In Yobe State, for instance, where extreme poverty ranks highest in Nigeria (C-GIDD, 2008), a loss of one workday or the opportunity cost of labor foregone, based on the NMW or YADW is equivalent to US$3.65 or US$4.93, respectively. This should be understood to represent the means of subsistence for the household, since many household subsisted on less than a dollar a day (Ochi *et al*., 2013). Therefore, the absoluteness of the value of days of incapacitation may mean little, unless it is viewed from the stand point of extreme poverty situation, in which much more than dollar and cent are at stake, such things as decent living, self-esteem, etc.

CONCLUSION

Malaria affects more people in the developing world, to the extent that many believe it is a disease of poor countries. Although the Italian “mal aria” means “foul air”, and the over 3 billion people in 106 countries and territories predisposed to malaria are largely in developing countries of Africa and Asia, malaria is a climatic phenomenon. Malaria is responsible for more deaths in the world than any other disease, including an estimated 100 million malaria cases with over 300,000 deaths per year in Nigeria.

This study attempted to analyse the farm-level direct and indirect effects of malaria on households. Using propensity score matching, the likelihood of malaria infection was evaluated in relation to age, household size, farm size, farm labor, education, and farming experience among infected and uninfected households. Similarly, the linear regression provided empirical evidence that the instrumented variables had significantly reduced crop out among malaria infected households. The economic loss approach, using the opportunity cost of labor foregone further stressed the economic imperative malaria among the infected households In all, the empirical analysis recommends a targeted malaria program for the safeguard of farmers as it were for pregnant women and children aged 0-5 years.

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Table 1: Mean treatment before and after match balancing

Variable	Before	After	P-value
Age (X_1)			
Mean infected	44.97	44.97	0.165
Mean uninfected	45.8.6	45.997	0.0399**
Household size (X_2)			
Mean infected	8.9304	8.9304	0.4644
Mean uninfected	9.0992	9.0397	0.5600
Education (X_3)			
Mean infected	1.9974	1.9974	0.1195
Mean uninfected	1.8198	1.95140.6277	0.6277
Farm size (X_4)			
Mean infected	2.4764	2.4764	0.2657
Mean uninfected	2.376	2.4727	0.9588
Farm labor (X_5)			
Mean infected	89.083	89.083	0.3981
Mean uninfected	91.084	90.292	0.5485
Farming experience (X_6)			
Mean infected	8.5866	8.5866	0.0000***
Mean uninfected	10.123	8.4032	0.090*

* p<0.1, **P<0.05, and ***P<0.001

Estimates are the mean effects before and after matching for each variable, indicating possible adjustments that could be made between infected and uninfected groups. Only the mean effect of uninfected age after matching was significant (P<0.05).

Table 2: Logistic regression coefficients using R package

Variable	**Coefficient**	Std. error	Z- value	Pr(>|z|)
Intercept	1.747733	0.401963	4.348	1.37e-05***
Age (X_1)	-0.007350	0.006534	-1.125	0.2606
Household size (X_2)	-0.029539	0.018820	-1.570	0.1165
Education (X_3)	0.059037	0.037415	1.578	0.1146
Farm size (X_4)	0.077976	0.044013	1.772	0.0765 *
Farm labor (X_5)	-0.000836	0.001508	-0.554	0.5794
Farming exp (X_6)	-0.073730	0.013892	-5.307	1.11e-07 ***
ATT	-242.51		-4.2276	2.3624e-05***

*** P<0.001, **P< 0.01, *P< 0.10, NS Not significant

Table 3: Effects of malaria indices on crop production in Yobe State

Variable	Estimate	Std. Error	t-value	Pr(>|t|)
Intercept	2354.15040	25.10832	93.760	2e-16 ***
X_7 Days of incapacitation	-77.89928	4.12910	-18.866	2e-16 ***
X_8 Cost of treatment	-64.73603	29.71890	-2.178	0.0297 *
X_9 Frequency of malaria illness	-0.07543	0.01651	-4.568	5.74e-06 ***
X_{10} Distance to source of treatment	-36.29820	19.07988	-1.902	0.0575*
R^2	0.823			

***P< 0.001, ** P<0.01, *P<0.05

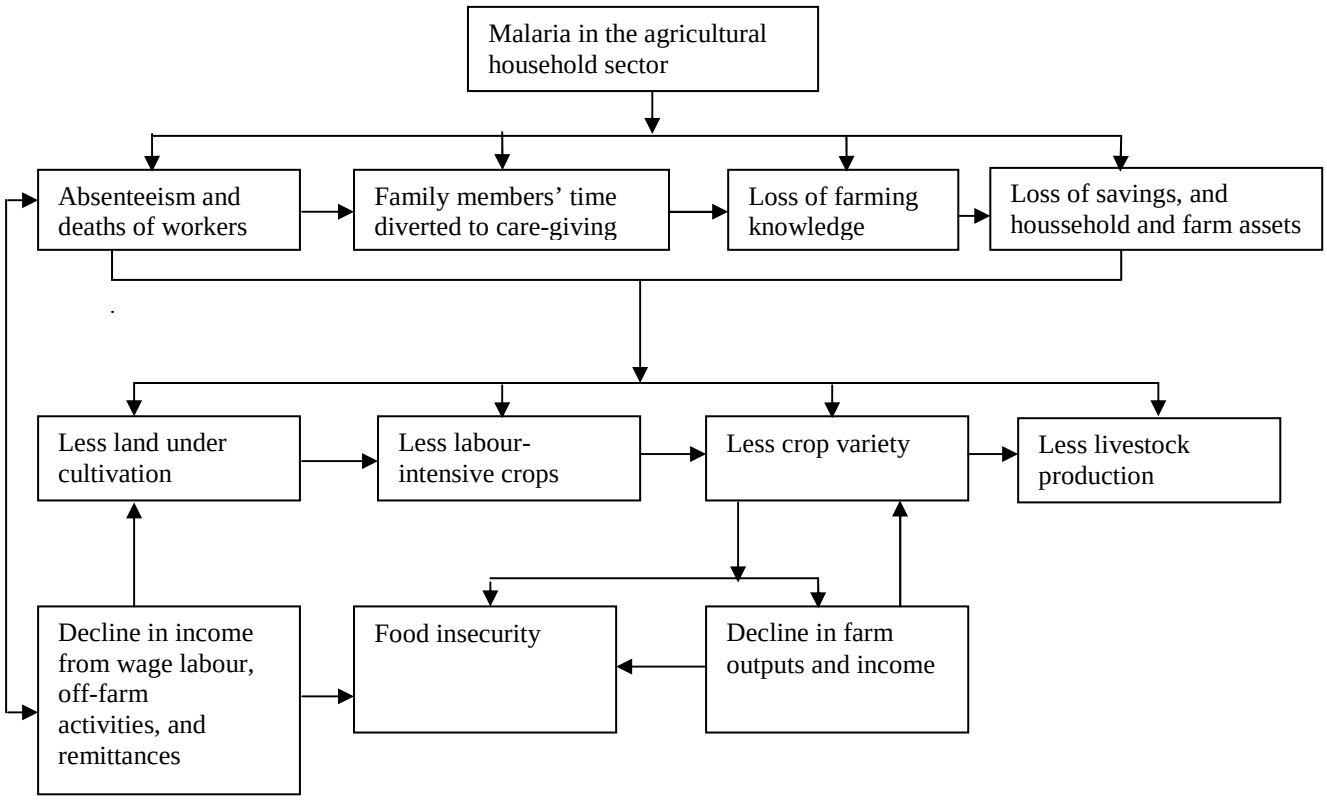

Fig. 1: Conceptual framework for malaria and agriculture linkages, culled from Asenso-Okyere *et al*. (2009)

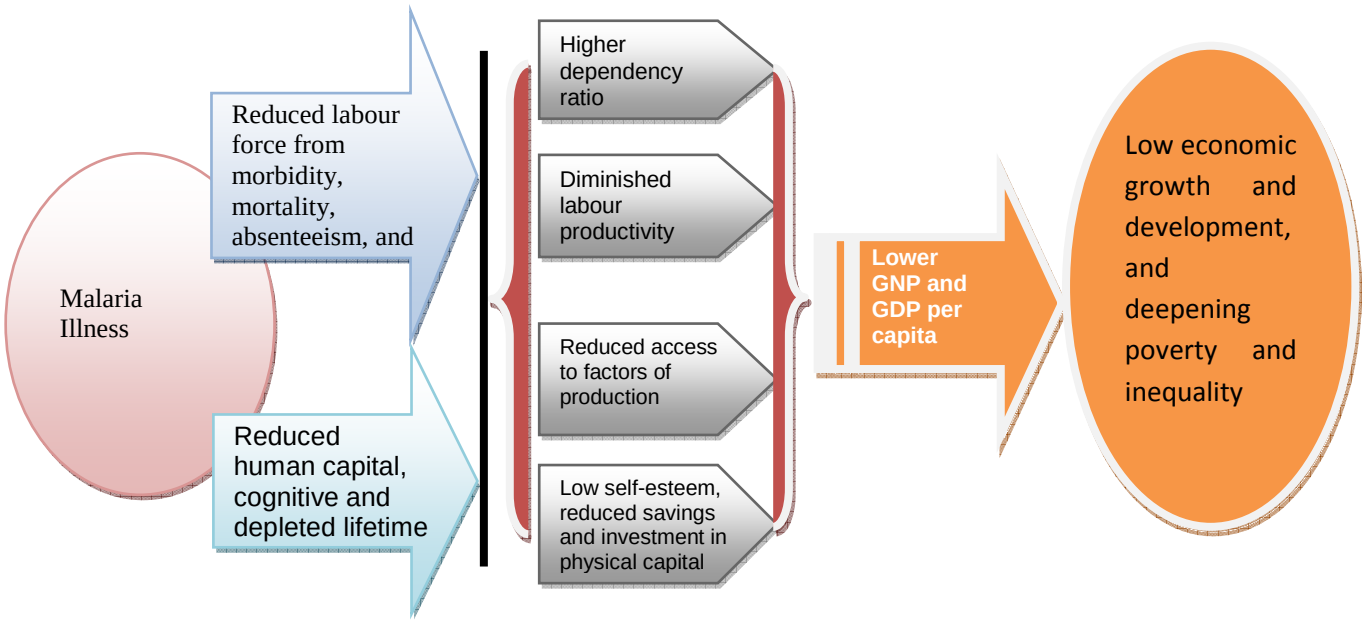

Fig. 2: Linkages between malaria illness and the economic growth development, with input from Abegunde and Stanciole (2006).

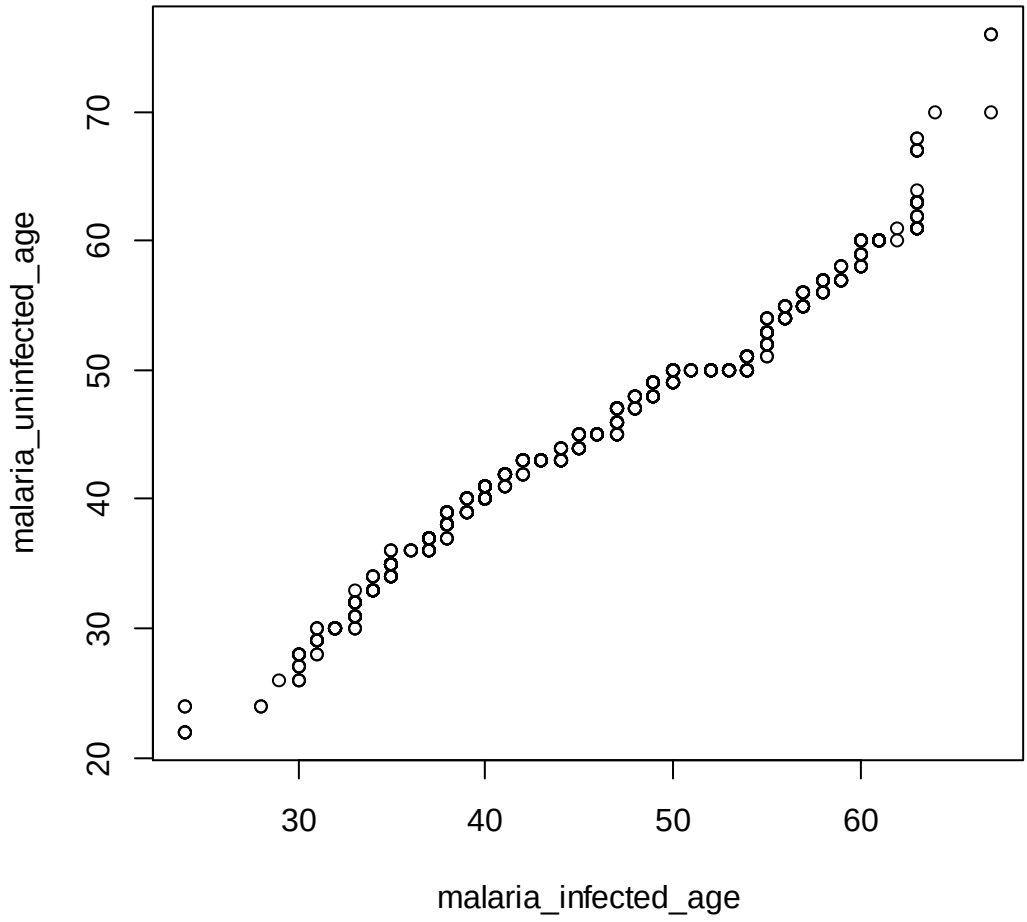

Fig. 3: Graph of uninfected age vs. infected age after matching

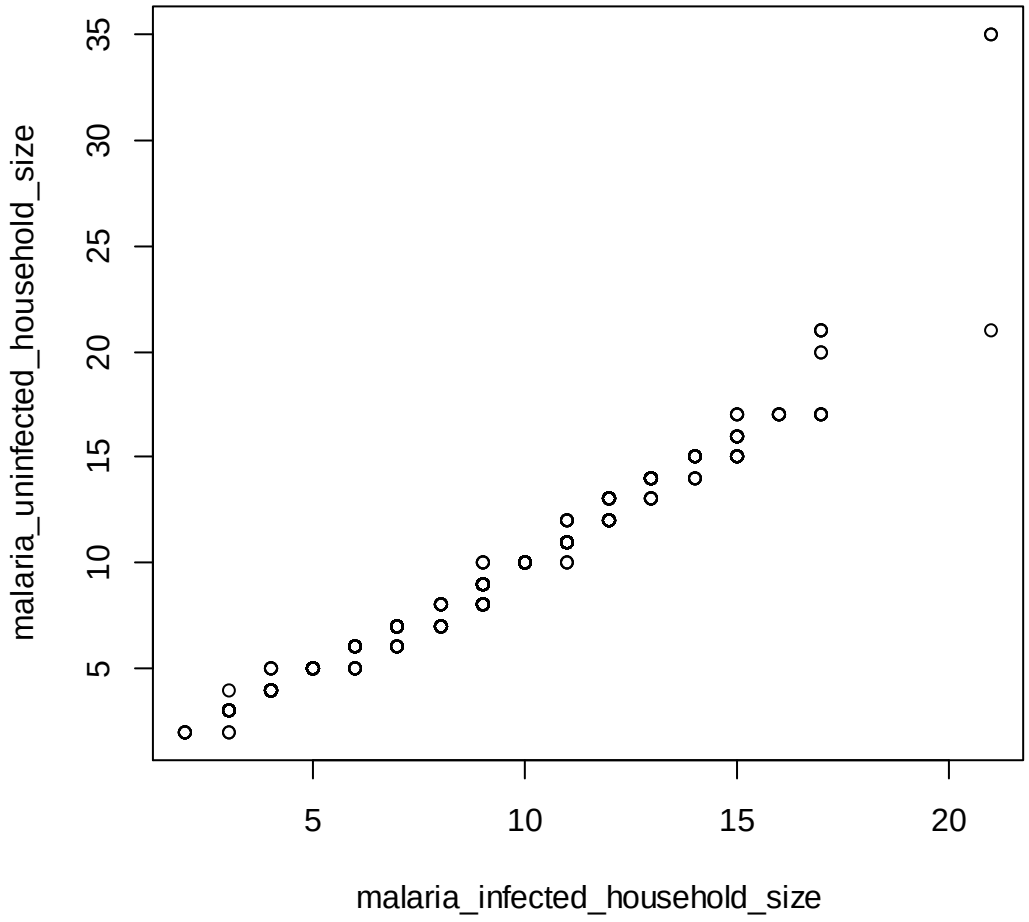

Fig. 4: Graph of uninfected family size vs. infected family size after matching

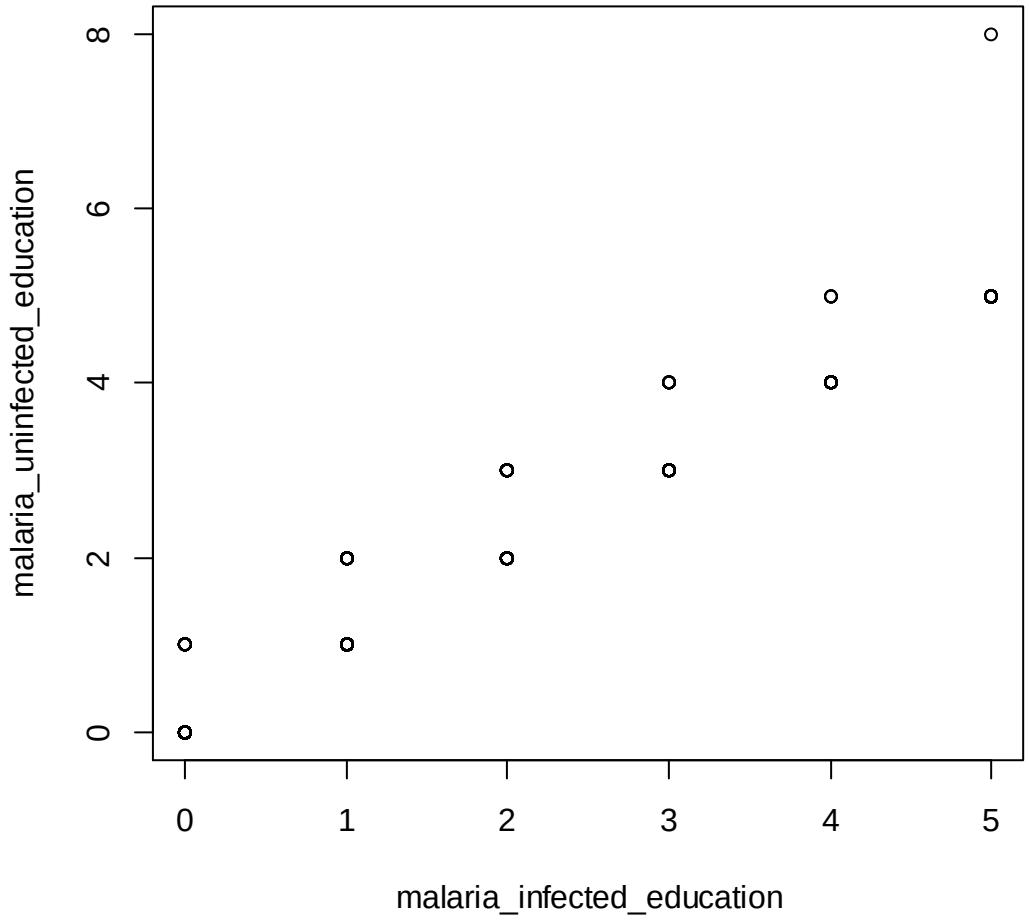

Fig. 5: Graph of uninfected education vs. infected education after matching

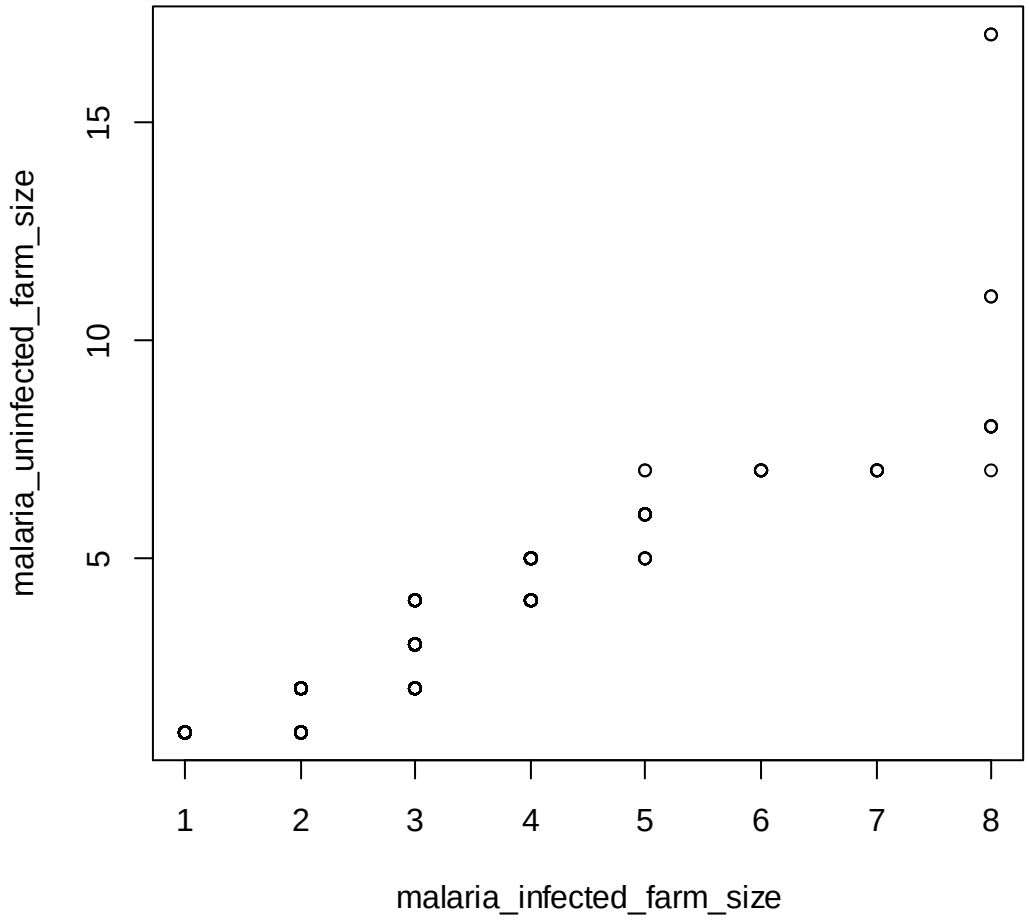

Fig. 6: Graph of uninfected farm size vs. infected farm size after matching

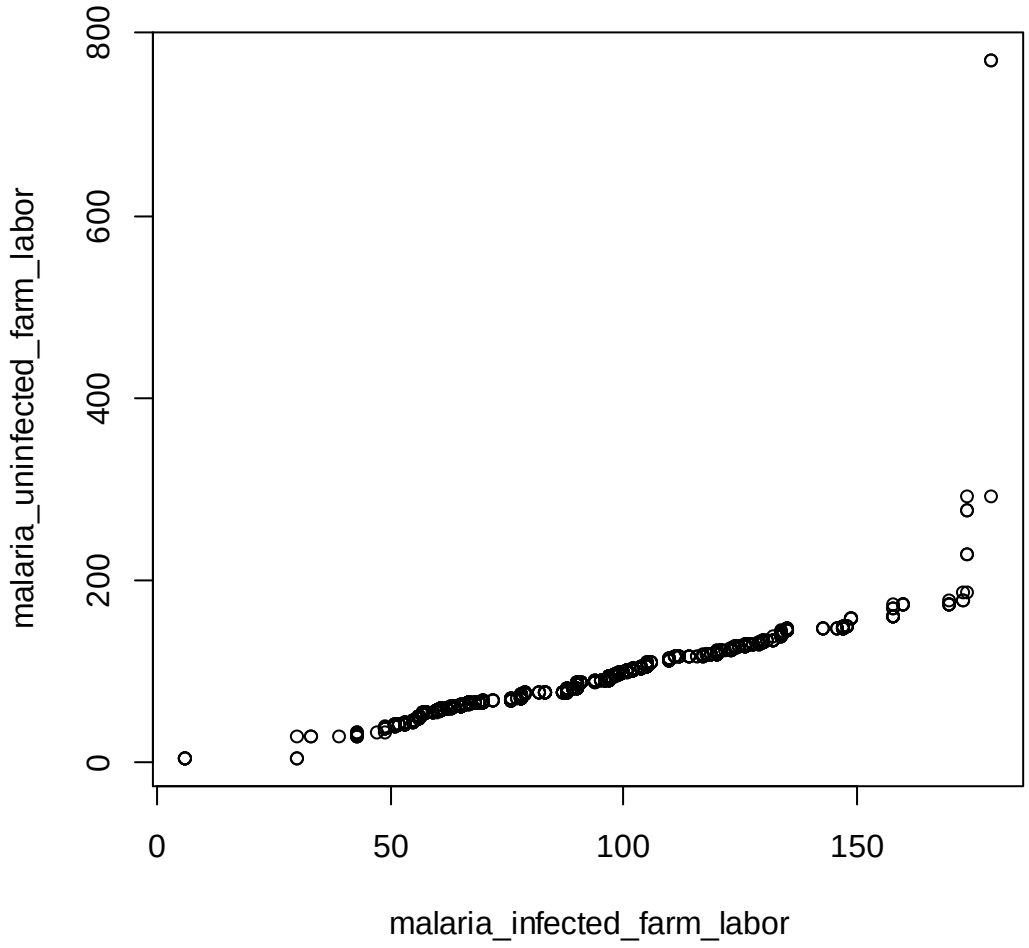

Fig. 7: Graph of uninfected farm labor vs. infected farm labor after matching

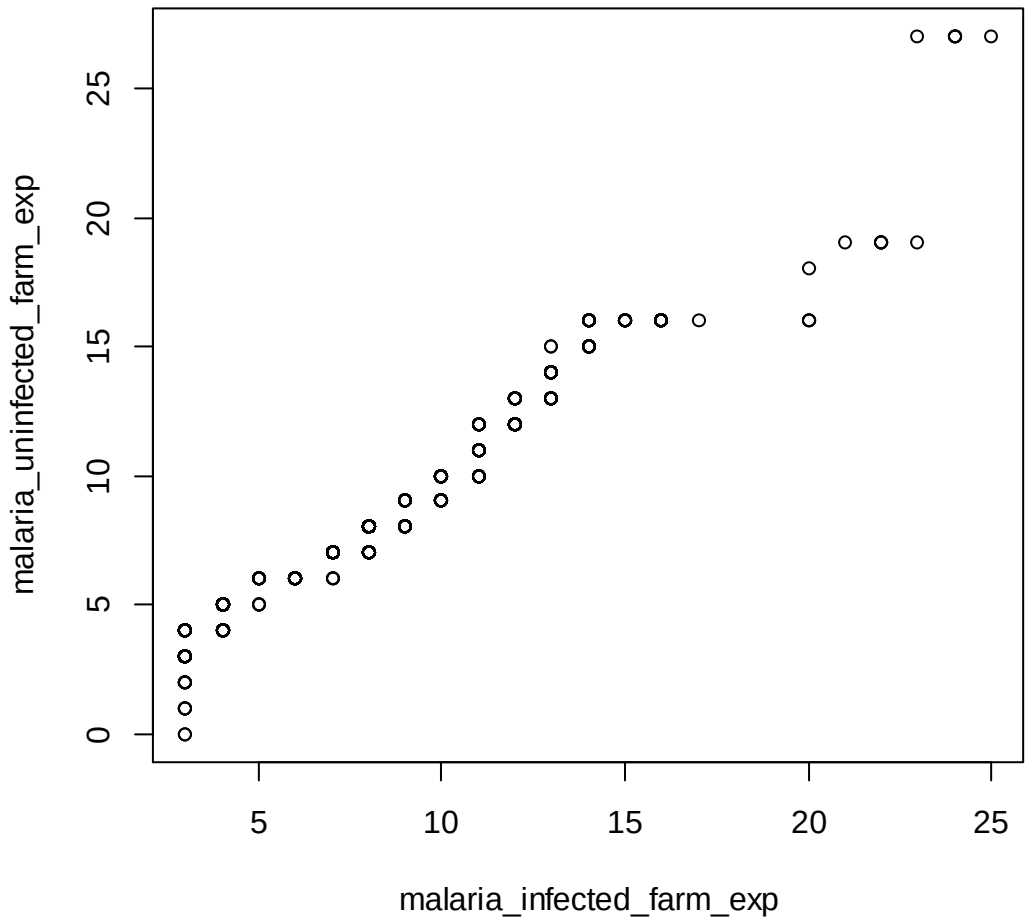

Fig. 8: Graph of uninfected farming experience vs. infected farming experience after matching

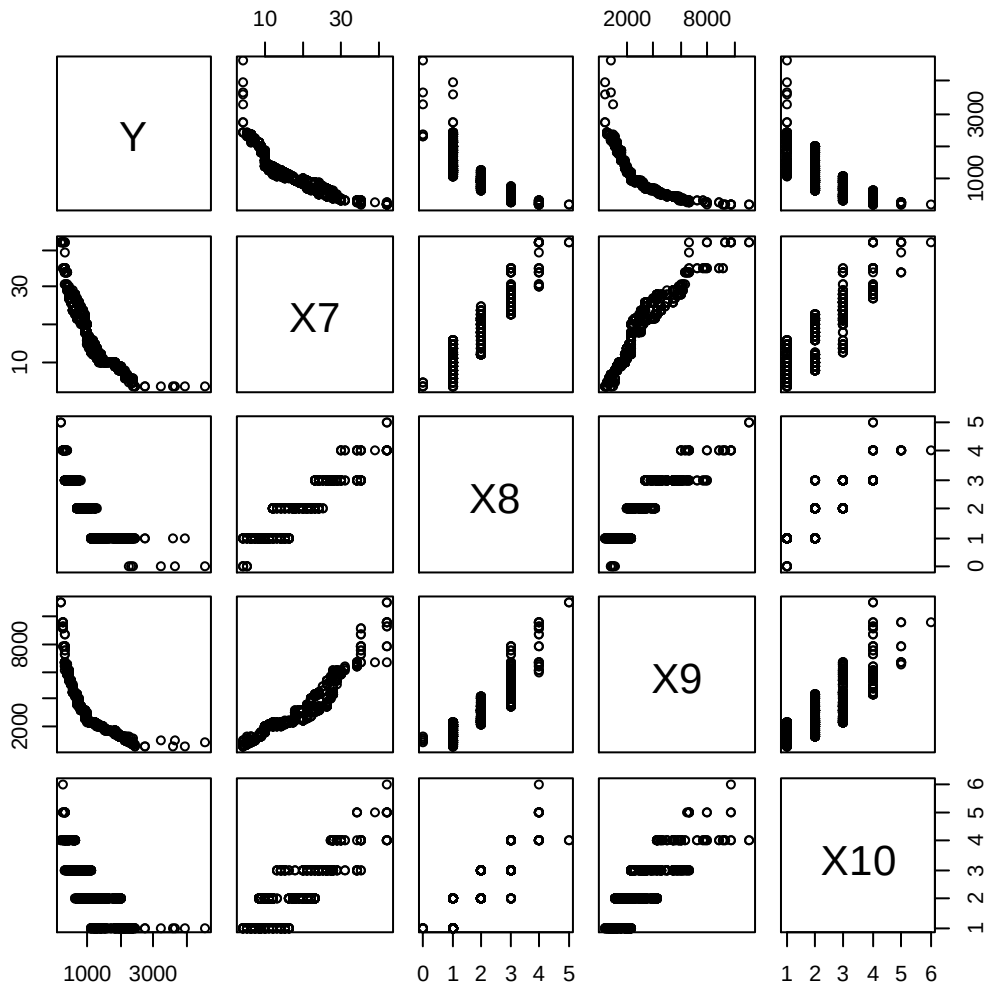

Fig. 9: Graph showing linear relationship among the variables X_7, X_8, X_9 and X_{10}

	Y	X_7	X_8	X_9	X_{10}
Y	1.0000000	-0.9040762	-0.8377732	-0.8341376	-0.7469149
X_7	-0.9040762	1.0000000	0.9214103	0.9458558	0.8367236
X_8	-0.8377732	0.9214103	1.0000000	0.8936291	0.8519008
X_9	-0.8341376	0.9458558	0.8936291	1.0000000	0.7910187
X_{10}	-0.7469149	0.8367236	0.8519008	0.7910187	1.0000000

Where, Y=crop output, X_7=days of incapacitation, X_8=cost of treatment, X_9=frequency of illness and X_{10}=distance to source of treatment.