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Economic Burden of Malaria in six Countries of Africa

Tuoyo Okorosobo (Corresponding author)
Independent Consultant, Lagos, Nigeria
E-mail: okorosobot@yahoo.com

Fola Okorosobo
Management Consultant, Lagos, Nigeria
E-mail: okorosobof@netscape.net

Germano Mwabu
School of Economics
University of Nairobi
Nairobi, Kenya
E-mail: gmwabu@gmail.com

Juliet Nabyonga Orem
World Health Organization, Country Office,
Kampala, Uganda
E-mail: nabyongaj@ug.afro.who.int

Joses Muthuri Kirigia
World Health Organization, Regional Office for Africa,
Brazzaville, Congo
E-mail: muthurijoses@yahoo.com

Abstract

Economic burden studies are important for use in advocating with Ministries of Finance and donors for increased investments in public health problems such as malaria. In September 2001, the authors convened a workshop at which a framework for the assessment of the economic burden of malaria in the African region was presented to health economists from 10 countries of the region. The framework document proposes the use of any one of three approaches – production function, cost of illness and willingness to pay – for the assessment of the burden of malaria to the economies of African countries. Between 2002 and 2005, six countries (Chad, Ghana, Mali, Nigeria, Rwanda and Uganda) undertook studies to assess the economic burden of malaria using the framework. The objective of this article is to report on the methodology, results and policy implications of the country economic burden studies.

Of the six countries whose results are presented in this report, Ghana and Nigeria used all three approaches to estimate the economic burden of malaria. Uganda, Rwanda and Chad implemented the production function and the cost of illness approaches, while Mali used only the cost of illness approach.

All countries implementing the cost of illness and willingness to pay approaches that required household surveys employed a multi-stage sampling methodology and used a structured questionnaire as the principal instrument for the collection of primary data from the households. Districts were selected to reflect the malaria epidemiological profile of the countries and a total of 5,498 households were sampled. Relevant secondary data on the institutional cost of malaria in the countries were obtained through checklists designed for the purpose, while other secondary data on the economy like the Gross Domestic Product (GDP), labour force, stock of capital, etc. were obtained from the National Statistical Services, Penn World Tables, World Bank Tables, African Development Bank, among others.

Malaria was found to be a significant explanatory variable for national income in Chad, Ghana, Nigeria and Uganda, countries that estimated macroeconomic models to assess the impact on malaria on the economy. In these countries, the incidence of malaria had a negative impact on aggregate national output, with the loss in growth of the economy or the "malaria penalty" ranging from 0.41% in Ghana to as high as 3.8% and 8.9% in Nigeria and Chad respectively. The loss in economic growth in Rwanda is much smaller at 0.08%. The studies reveal that the impact of malaria on the growth in real gross domestic product is negative and decreases for every increase in malaria morbidity rates.

The cost of illness approach results corroborate those obtained from the production function approach, indicating that malaria causes an enormous drain on the national economies. At the household level, the studies reveal a pattern of immense burden, particularly for the poorest households. In Ghana for example, the direct costs of malaria to the household is US$ 6.87, while it is US$ 11.84 and US$ 17.5 in Nigeria and Mali respectively. When the total cost of malaria was calculated, it was found that the countries were spending huge sums of resources for the control of malaria, resources that could have been devoted to other productive sectors, had the disease not been so prevalent.

There is need for more investment in malaria endemic countries to combat the disease to at least US$ 1.5 billion to US$ 2.2 billion annually, levels advocated by the WHO Commission on Macroeconomics and Health, as these investments would lead to lives saved, enhanced productivity and improved quality of life, particularly for the most vulnerable population.

Keywords: Africa, Malaria, Economic burden, Cost of illness, Direct costs, Indirect costs

1. Introduction

Malaria is a major public health problem in Africa. The disease is a significant contributor to the poor health situation in Africa, with the region having the greatest burden of malaria cases in the world as documented in several sources (Gallup and Sachs, 2001; WHO, 1999 and 2002; WHO/UNICEF, 2003 and 2005). Practically, the whole of the population of Sub-Saharan Africa (SSA) is exposed to malaria, with about 75% of its 650 million people, living in areas of stable malaria transmission. The region accounts for 60% of the world's 350 – 500 million clinical cases and 80% of the over 1 million deaths annually. The disease caused about 20% of the deaths of children under five years of age in 2000 (Malaria Consortium, 2002), and is also a significant indirect cause of death: malaria-related maternal anaemia in pregnancy, low birth weight and premature delivery are estimated to cause 75 000 – 200,000 infant deaths per year in sub-Saharan Africa (Steketee et al, 2001). Between 25% and 35% of outpatient visits and between 20% and 45% of hospital admissions are attributed to malaria (WHO and UNICEF, 2005). It is the leading cause of mortality in children under five years, a significant cause of adult morbidity, and the leading cause of workdays lost due to illness. This burden on the health system is significant for a single disease. An estimated 36 million Disability Adjusted Live Years (DALYs) were lost to malaria in 1999, making it one of the ten leading contributors to the global disease burden. The World Health Organization also estimated that the total cost of malaria to Africa was US$ 1.8 billion in 1995 and US$ 12 billion in 2000 (WHO/AFRO, 2003). Thus, Africa's malaria burden, now and into the future, is a heavy one.

The debilitating effects of malaria on its victims are immense. In addition to time and money spent on preventing and treating malaria, it causes considerable pain and weakness, and results in reduction in the working abilities of its victims. The adverse impact of the disease on household production and gross domestic product can be substantial. In much of sub-Saharan Africa, malaria represents not merely an illness, but a pandemic. The ubiquity of malaria in some regions leads not only to high prevention and treatment costs and loss of labour, but also to modifications of social and economic behaviour, with potentially serious consequences for economic growth and development. Malaria therefore is not only a public health problem but also a developmental problem.

Malaria illness imposes great burden on the society as it has adverse effects on the physical, mental and social wellbeing of the people as well as on the economic development of the nation. The economic burden attributable to malaria mortality arises from reduction in the available labour force that it causes as the death of a worker leads to a reduction in current full-employment national output. Further, once a worker dies, the total human capital investment in him and the rest of his productive work life are lost. However because adults seldom die of malaria in areas of stable transmission, the loss associated with human capital investment and loss of productive life is negligible. The mortality rate is however high among children below the age of 5 years. The death of a child also constitutes an economic burden in the sense that it reduces potential future population and labour force.

Despite its multifaceted adverse effects, the importance of a malaria-free environment in promoting economic development and poverty reduction has not been fully appreciated in most countries of Africa. Perhaps the reason may be that the impact of the burden of malaria has not been demonstrated in economic terms to complement the existing epidemiological evidence to convince politicians, policy makers, programme managers and development partners to devote the needed attention to this disease. The objective of this article is to report on the methodology, results and policy implications of the country economic burden studies undertaken in Chad, Ghana, Mali, Nigeria, Rwanda and Uganda.

2. Rationale for the study

Available evidence strongly suggests that malaria impedes overall economic development particularly in the most endemic countries in the African Region. Short run costs - including lost work time, economic losses associated with infant and child morbidity and mortality, and the costs of treatment and prevention - are typically estimated to be higher than 1% of a country's Gross National Product. These short-run costs are likely to have risen in recent years due to increasing number and severity of cases in many countries. Moreover, the spread of drug-resistant *P. falciparum* malaria is substantially raising the costs of treatment in many countries as newer more expensive drugs and diagnostic technologies have been deployed. The annual loss of economic growth from malaria is estimated to range as high as 1.3 percentage points per year. This evidence comes from a global modelling study (Gallup and Sachs, 2001). The study used cross-country regression analysis with data for the period 1965 - 1990 to estimate the overall impact of the disease on economic development. The nature of this technique however is that it functions independently of the chains of causation and so cannot shed much light on the underlying mechanisms, and neither does the study in question provide the compelling evidence for the African Region.

Recognizing the need of countries for more accurate information on the magnitude of the economic burden and the impact on different sectors of the economy for advocacy purposes as well as to guide the efficient allocation of resources for control efforts, the authors developed a protocol for the conduct of country studies to assess the economic burden of malaria in 2001 (WHO, 2001). In collaboration with research institutions within countries, the protocol was utilized from 2002 to 2004 in multi-country studies to generate the desired evidence on the economic burden of malaria.

3. Methods

3.1 Conceptual Framework

Recognizing the methodological challenges in attempting to estimate the economic burden of any disease and the strengths and weaknesses of the individual methods, it was decided to use the three standard approaches for estimating the burden at country level – the production function, cost of illness and willingness to pay approaches. The conceptual framework of economic burden of malaria is presented schematically in *Figure 1*.

3.1.1 Production function approach

The production function approach has a macroeconomic perspective. In this approach, the Gross Domestic Product (GDP) of a country is specified as a function of gross investment, labour force participation, other exogenous variables, and malaria prevalence. This production function is then estimated.

Formally, the relationship between aggregate output and malaria can be expressed as follows:

$$Q = f(K, L, X, M) \qquad (1)$$

Where:
Q = Annual volume of goods and services (gross domestic product);
K = Capital stock or investment expenditure as a ratio of gross domestic product;
L = Labour input (workers age 15-65);
X = A vector of other factors affecting production such as trade openness, quality of public investment, political stability, epidemiological and initial conditions, etc; and
M = Malaria index (e.g., malaria morbidity per 100,000, intensity of malaria transmission etc).

Equation (1) shows the effect of malaria (M) on output (Q), holding constant the effect of other relevant variables (K, L and X). The effect of M on output in the literature so far has been shown to be negative. It is for this reason that malaria is said to be a burden on the economy. Different specifications of equation (1) have been used to calculate the effect of malaria on economic growth and on the level of gross domestic product in Africa (Gallup and Sachs, 2000; McCarthy et al, 1999).

The equation (1) shows that for given levels of K and L, M captures output-reducing effects of malaria such as diminished work capacity, work absenteeism, and low stocks of human capital (deficiencies in cognitive ability, literacy and numeracy skills due to malaria). Appropriate statistical methods can be used to estimate the effects of all these factors (embedded in M) on the economy.

The five countries (Chad, Ghana, Nigeria, Rwanda and Uganda) that implemented the production function approach started with a linear specification of the production function and proceeded to estimate a double-log form of the model, as this provided more robust results in all instances.

The double-log equation (2) estimated in Chad was follows:

$$\ln Q_i = \ln \alpha + \ln \beta_1 \ln K_i + \beta_2 \ln M_i + \varepsilon_i \qquad (2)$$

The four double-log equations (3-6) estimated in Ghana were specified as follows:

$$\ln Q_i = \ln \alpha + \ln \beta_1 \ln INC_i + \beta_2 \ln YRSEDU_i + \beta_3 \ln EXP + \beta_4 \ln M_i + \beta_5 \ln OPEN_i + \beta_6 \ln LAB_i + \varepsilon_i \qquad (3)$$

$$\ln Q_i = \ln \alpha + \ln \beta_1 \ln INC_i + \beta_2 \ln YRSEDU_i + \beta_3 \ln EXP + \beta_4 \ln M_i + \beta_5 \ln OPEN_i + \varepsilon_i \qquad (4)$$

$$\ln Q_i = \ln \alpha + \ln \beta_1 \ln INC_i + \beta_2 \ln YRSEDU_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \varepsilon_i \qquad (5)$$

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln INC_i + \beta_2 \ln YRSEDU_i + \beta_3 \ln EXP + \beta_4 \ln M_i + \beta_5 \ln OPEN_i + \beta_6 \ln TOT_i + \varepsilon_i \quad \text{......}(6)$$

In Nigeria the specification of the double-log equation (7) estimated was as follows:

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \beta_5 \ln NDR_i + \beta \ln POSTAR_6 + \beta_7 \ln WAR_7 + \varepsilon_i \quad \text{......}(7)$$

The four double-log equations (8-11) estimated in Rwanda were as follows:

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \beta_5 \ln T \; \beta_6 \ln EXP_i + \beta_7 \; Dummy96_6 + \beta_8 \; Dummy49_i + \varepsilon_i \quad \text{......}(8)$$

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \beta_5 \ln T \; \beta_6 \ln EXP_i + \beta_7 \; Dummy96_6 + \beta \; Dummy49 + \beta_8 \; Dummy49_i (\ln M_i) + \varepsilon_i \quad \text{......}(9)$$

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \beta_7 \; Dummy96_6 + \beta_8 \; Dummy49_i + \beta \; Dummy49_i (\ln M) + \varepsilon_i \quad \text{......}(10)$$

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln L_i + \beta_2 \ln K_i + \beta_3 \ln M_i + \beta_4 \ln OPEN_i + \beta_5 \; Dummy96_6 + \beta_7 \; Dummy49_i (\ln M_i) + \beta_8 \; Dummy49_i (\ln L_i) + \varepsilon_i \quad \text{......}(11)$$

The double-log equations (12) estimated in Uganda was follows:

$$\ln Q_i = \ln\alpha + \ln\beta_1 \ln K_i + \beta_2 \ln L_i + \beta_3 \ln YRSEDU_i + \beta_4 \ln I + \beta_5 \ln T + \beta_6 \ln M_i + \beta_7 \ln A_i + \varepsilon_i \quad \text{......}(12)$$

where:

Q = National Income

K = Capital

GDP = Gross Domestic Product

INC = Initial income level, defined as GDP per capita

YRSEDC = Measure of the stock of human capital, defined as the average number of years of schooling in the total population over 15 years of age (secondary schooling).

EXP = Life expectancy at birth

LAB = Labour input (workers aged 15-65 years), proxied by the stock of agricultural labour force in Ghana.

NDR = the Naira- US dollar rate, a measure of the exchange rate

OPEN = the extent of openness to the rest of the world

TOT = Terms of trade

POSTAR = dollar price of the Nigerian crude oil per barrel

WAR = Dummy variable to capture the civil war years in Nigeria

K = physical capital stock

L = labour (persons economically active)

HK = human capital

I = inflation or general price changes

A = agriculture

T = openness to trade of the economy (terms of trade)

M = number of reported malaria cases per 100,000 individuals (malaria index).

Dummy96 = Dichotomous dummy variable capturing the year 1996 in Rwanda

Dummy49 = Dichotomous dummy variable capturing the period 1994-1999 in Rwanda

β_0 = the intercept or constant term, i.e. the expected value of the dependent variable (Q) when all the explanatory variables (and the error term) equal zero.

β_i = are slope coefficients, which show that if a specific explanatory variable changes by 1% while the other explanatory variables are held constant, then dependent variable will change by β_i percent.

3.1.2 Cost of illness approach

The cost of illness approach attempts to estimate the burden of malaria in an accounting sense using direct cost of malaria, indirect cost of malaria, and institutional cost of malaria care. The cost of malaria illness is a burden to the economy in three distinct respects. First, it shows the portion of gross domestic product that must be set aside to treat malaria. This portion represents a direct cost (burden) of treating malaria. Households and governments must pay this cost to treat malaria. Second, it shows the level of production benefits that are forgone by society when malaria causes absenteeism from work or death of workers. These forgone benefits constitute the productivity cost of malaria. This productivity cost is also known in the literature as the indirect cost (burden) of illness. Lastly, it shows the cost that households and governments are willing to bear to avoid the pain and suffering inflicted by malarial illnesses, termed intangible costs.

The sum of the above cost categories make up the cost of malaria to society. This cost of illness concept facilitates estimation of the disease burden at the level of microeconomic units before aggregating it to the level of society. The cost of illness (COI) formula is expressed as follows:

$$COI = (PMC + NPMC + LL + CBM + IL + CPS) \qquad (13)$$

Where:

- PMC (private medical costs) and NPMC (non private medical costs) are the direct cost of malaria treatment, which are borne by households and governments respectively;
- LL (labour loss) is the indirect cost or the productivity cost of malaria, i.e., the burden due to loss of labour via malaria mortality and morbidity;
- CBM (cost of behaviour modification) is the cost caused by modification of social and economic decisions in response to risks of contracting malaria, e.g., crop choice or migration decisions that are adversely affect land or labour productivity;
- IL (investment loss) is the cost of malaria on the long-term growth process because it negatively impacts accumulation of human and physical capital;
- CPS is the cost of pain and suffering and other intangible losses occasioned by malaria.

Application of the cost-of-illness approach entails inclusion of only PMC, NPMC and LL components, given the difficulties associated with attaching monetary values to the other costs.

3.1.3 Willingness-to-pay

It has been argued that the theoretically appropriate way to assess the true cost of malaria on the welfare of households is to determine the value that they would put on avoiding it. If it were possible to elicit a monetary value that the household would pay to prevent the disease, it would presumably capture the burden to the household of treatment costs and lost productivity, as well as the value of the leisure time given up and the cost of the pain and suffering associated with the disease, and other intangible costs which are difficult to price. The Willingness-To-Pay (WTP) approach, also known as "contingent valuation", attempts to elicit this value through the use of household surveys. Theoretically this approach has the advantage that it elicits the full range of personal costs associated with the illness. It has however been pointed out that the results are sometimes subject to personal interpretations of questions and can be biased by respondents' desire to engage in strategic behaviour.

3.2 Study Countries

This article documents the results of economic burden of malaria studies completed in 6 countries of the African region – Chad, Ghana, Mali, Nigeria, Rwanda and Uganda. The choice of the countries was based on participation in the workshop where the framework was presented and orientation on its use provided; availability of a local institution with relevant capacity in health economics to work with the national malaria programme on the study; and preparation and submission of a study proposal.

Of the six countries whose results are presented in this report, Ghana and Nigeria used all three approaches to estimate the economic burden of malaria. Uganda, Rwanda and Chad implemented the production function and the cost of illness approaches, while Mali used only the cost of illness approach.

3.3 Country Study Sites and Sampling Procedure

All countries implementing the cost of illness and willingness to pay approaches that required household surveys followed a multi-stage sampling methodology that permitted firstly, the selection of regions or districts taking into account the different malaria transmission profiles of the countries and secondly, the random selection of households within the selected communities.

Chad conducted the household surveys in six districts, i.e. Gounou-Gaya, Domo, Karal, Kinasséroum, Grédaya and Tidjani. Based on the agro-ecological zones in Ghana, three districts were selected for the study, namely: Bole District, in the savannah zone, Sekyere East District in the forest, and Awutu-Efutu-Senya District in the coastal zone. Mali with three malaria epidemiological zones had one district selected from each zone - Niono (zone de transmission permanente), Bougouni (zone de transmission longue), and Kolokani (zone de transmission courte).

In Nigeria, the selection of the study sites was based both on the malaria epidemiological zones, namely, the forest, the savannah and the grass-land zones, and the geo-political zones. At least one State was selected to represent each of the major malaria zones, namely, Lagos State (the equatorial forest zones), Kwara and Kogi States (Savanna zone), Katsina State (Grass lands) and two eastern States (Eastern forest zones). The Ugandan study stratified districts by malaria endemicity into Hyper, Meso, and Hypo endemic. Four districts- Kabale (Hypo), Kamuli (Hyper), Mubende (Meso), and Tororo (Hyper) - were then selected randomly from these strata, and included in the survey. Districts from the North were not included in the study due to insecurity in that region at the time. Following stratification by level of endemicity, Rwanda randomly selected six districts namely – Murunda, Ruhengeri, Rwinkwavu, Kabuga, Bugesera and Kabutare, for inclusion in the study.

Both primary and secondary data were collected for the studies. Field surveys were conducted in the selected districts in all the countries. Secondary data were obtained from a variety of sources in each of the countries, typically from the Ministries of Health, health facilities, National Statistical Services and published macroeconomic data from the World Bank (World Bank Database).

The field studies were organized at two levels in order to obtain the relevant data for the cost estimation. At the micro level, district based cross-sectional surveys of households were conducted. The population was made up of households with malaria episodes during the last one month of the survey in the selected districts. The household therefore was the unit of analysis.

A structured questionnaire was the main research instrument for the collection of primary data from the households. The questionnaire sought to gather the following data: demographic and socio-economic characteristics of households, direct cost of a malaria episode to the household (out-of-pocket expenses), indirect cost in the form of productivity lost by malaria patients, caretakers and substitute labour, protection strategies of households against malaria attack and the cost involved as well as households' standard of living. In addition, in Ghana and Nigeria that implemented the willingness to pay approach, households' willingness to pay for malaria prevention and control was solicited through contingent valuation.

Checklists were designed and used to gather the relevant secondary data on the institutional cost of malaria in the countries. The checklist broadly sought to find the cost of malaria surveillance, detection, treatment, control and prevention to the Ministries of Health and other government departments. In the study districts, the main health facilities were also contacted for data. Apart from data on various costs at the facility level, morbidity and mortality figures were collected. National data were collected from the office of National Malaria Control Programmes, the Central Medical Stores, Health Management Information System offices, and the Policy, Planning, Monitoring and Evaluation Units all of the Ministries of Health. In addition, official documents of the Ministry of Health, the principal partners supporting malaria control efforts in the countries, including the major NGOs and CBOs were also reviewed. Other secondary data on the economy like the Gross Domestic Product (GDP), labour force, stock of capital, etc. were obtained from the National Statistical Services, Penn World Tables, and World Bank Database.

3.4 Data Analysis

For the cost of illness approach, data entry formats were developed in each country to capture data obtained from the household surveys. Analyses were carried out using either the SPSS or Microsoft Excel Spreadsheets or a combination of both. Given the wide country differences there is no attempt here to collate, harmonize and perform a meta-analysis of the data collected.

Under the production function approach, countries specified and estimated a linear as well as a log-linear (double-log) aggregate production function. The method of Ordinary Least Squares (OLS) was used to estimate the model, with a number of tests were undertaken to validate the regression results. Misspecification tests undertaken included: tests for seasonality - since in some countries the data was interpolated into a quarterly series, and tests for normality. The method of Instrumental Variables (IV) to see if possible simultaneity between output (the dependent variable) and capital stock employed would affect OLS estimates adversely. In addition, tests for multicolinearity are carried out using the variance inflation factor (VIF) procedure. Finally, the estimated regressions were tested and corrected for serial autocorrelation.

The two countries that implemented the willingness to pay approach estimated their models through a multivariate ordered probit procedure with the dependent variable being the qualitative choice of amount an individual is willing to pay and the explanatory variables being a selected set of variables denoting demand for malaria control/eradication and other socio-economic factors.

4. Results

4.1 Impact of Malaria on Macro-economy

4.1.1 Chad

Table 1 presents the percentage loss in GDP attributable to malaria in Chad. The evidence is that malaria is a major cause of economic loss to the Chadian economy. For the period under review (1990-1998), the annual loss of GDP ranged between 15% and 27%, with the average annual loss being 20.54%.

4.1.2 Ghana

Table 2 shows the effects of various explanatory variables (including malaria) on GDP growth in Ghana. Model 1 was estimated with explanatory variables INC, YRSEDU, EXP, MALARIA, OPEN and LAB. The R-squared was 0.57 implying that 57% of the variations in GDP of Ghana were explained by the regression equation. The coefficient of the malaria index (lnM) had the expected negative sign and was statistically significant at the 10% level. The ln(M) coefficient was -0.435, which means that when malaria morbidity increases by 1% while the other explanatory variables are held constant, growth in annual real GDP will decrease by 0.435%.

Model 2 also shows the coefficient for ln(M) with the expected negative sign implying that when malaria morbidity increases while the other explanatory variables are held constant, growth in annual real GDP decreases. In model 3 none of the coefficients were statistically significant. Model 4 results show that when malaria morbidity increases by 1% while the other explanatory variables are held constant, growth in annual real GDP decreases by 0.455%.

Therefore, Ghana results reveal that malaria morbidity erodes the growth in real GDP by at least 0.40% per year. The significant negative association between malaria and economic growth confirms earlier studies by Gallup and Sachs (2001) and McCarthy et al. (2000). The study also shows that the impact was smaller than that found by Gallup and Sachs (2001) of 1.3% but closer to the average of 0.55% for sub-Saharan Africa reported in McCarthy et al (2000).

4.1.3 Nigeria

Table 3 portrays the impact of malaria on growth in real GDP in Nigeria. The adjusted R-squared was 0.968, which indicates that the explanatory variables included in the model explained 96.8% of the variations in the growth in real GDP in Nigeria. It is clear that all the variables coefficients were statistically significant at either 5% or 10% confidence level and had the expected signs. The ln(M) coefficient assumed a value of -0.038, meaning that when malaria morbidity increases by 1% while the other explanatory variables are held constant, growth in annual real GDP decreases by 0.038% per annum.

4.1.4 Rwanda

Table 4 provides a summary of the impact of malaria on the economy in Rwanda. The explanatory variables included in all the four models explain over 99% of variations in the logarithm of GDP. The ln(M) coefficients in equations 1, 2 and 3 are negative as expected and statistically significant at either 5% or 10% significance level. As shown in equations 1, 2 and 3, an increase of 1% in malaria morbidity results reduces GDP growth rate by 0.017, 0.013 and -0.012 per cent respectively.

4.1.5 Uganda

The impact of malaria on log of per capita GDP in Uganda is presented in Table 5. The overall performance of the model is very good with the adjusted coefficient of determination (R^2) of 92%. Both the variable coefficients (elasticities) and the marginal effects are presented in the table. The marginal effects coefficient for malaria measures the loss in GDP as a result of malaria related morbidity. The malaria coefficient *(ln M)* had a negative sign and was statistically significant at 95% level of significance. The coefficient *ln(M)* was -0.178, implying that a 1% increase in malaria morbidity reduces GDP by 0.178% per year. This reduction in GDP takes a variety of forms such as: reduced labour performance and school attendance; reduced household ability to save and invest; modification of household economic decisions in response to the risk of contracting malaria; and increased government expenditures on control and treatment of the disease.

4.2 Cost of Malaria Illness

4.2.1 Direct costs of treatment in Chad

The direct cost of treating a case of uncomplicated malaria in Chad ranges from US$ 9.7 to US$ 17.5. In the case of severe malaria where admission is required, the direct cost rises to US$ 82. When the result from the study sample is extrapolated to the total population, the direct cost of treating the estimated 370,000 uncomplicated and severe malaria cases in Chad is US$ 7.2 million.

4.2.2 Direct costs of treatment in Ghana

The relative share of the cost components of malaria treatment in Ghana is shown in Figure 2. It costs US$ 5.73 on average, to treat a single case of malaria, with the treatment cost varying according to the type of treatment sought. The average cost of treatment from the orthodox health care providers was US$6.87 per malaria episode. The cost of drugs formed a significant proportion of the total treatment cost, approximately 36%. Transportation cost to the facility represented 10.79% of the total treatment cost. Costs of registration and consultation were relatively low in all the districts surveyed. The cost of laboratory test in the districts represented between 16.91% and 20.65% of the total treatment cost. Few patients incurred several other costs in the process of seeking further treatment after the first course of action. These costs related to costs incurred during referrals, reviews, extra medication and food among others.

4.2.3 Direct costs of treatment in Mali

In Mali, the direct cost of malaria treatment is US$ 4.7. As in the other countries, drugs take the largest share of the costs, accounting for 36% of the total costs, followed by hospitalization (23%) and consultations (16%).

4.2.4 Direct costs of treatment in Nigeria

The results of the study to ascertain the average total cost of treatment by major healthcare providers in Nigeria shows that it costs, on the average, about US$ 1.2 to treat an episode of malaria by self-medication, about US$ 2.5 by the use of herbalist/spiritualist and about US$ 9.7 by the use of orthodox health care provider when admission is involved. When admission is not involved, this comes to about US$ 8. It is no wonder then, that in a low-income country like Nigeria, self-medication for malaria treatment is widespread. The distribution of the cost across the different components is very similar to the Ghana scenario.

Using the study's estimated parameters, the estimated cost of treating all the observed cases of malaria by self-medication in the studied population per annum is about N3.8 million, while the corresponding estimates for herbal/spiritual and clinic/hospital treatments are N7.9 million and N35.2 million respectively. Extrapolating these findings to the total population, with 53% of malaria cases being treated by self-medication, with 7% and 40% treated by herbalist/spiritualists and clinics/hospitals respectively, the total cost of treating malaria cases in Nigeria per annum is estimated to be N284,992 million (US$ 2,374.9m). This represents about 3.9 per cent of the Nigerian GDP at current market prices for year 2003. Thus, the direct cost of treating malaria cases in Nigeria is significant.

4.2.5 Direct costs of treatment in Rwanda

In Rwanda, the cost of treating a single episode of malaria in a public facility, where no hospitalization is involved, in 2003 was estimated to be US$ 2.8, a cost which rises significantly when the private sector provider is used. For in patient malaria cases, the cost in public facilities averages US$ 13 and US$ 18.7 in the private facilities. The study computed that in the year 2003, the total direct costs of treating all malaria cases in the country amounted to US$ 6 million.

4.2.6 Direct costs of treatment in Uganda

The average expenditure per person on self-medication for an episode of malaria in Uganda was US$ 1, with the greatest expenditure on medication. The average cost of treating a case of malaria in a clinic or hospital, when admission was not required was found to be US$ 4.8, with drug costs being the highest contributor. When admission occurs, the cost of malaria treatment rises to US$ 5.73. When the treatment seeking behaviour of the households with respect to malaria episodes is taken into account, it is estimated that the total annual direct cost of malaria treatment in Uganda is US$ 41.6 million.

4.2.7 Indirect Cost of Malaria in Ghana, Mali, Nigeria, Rwanda and Uganda

The indirect cost is estimated by quantifying in monetary terms, the opportunity cost of the time that was spent by households seeking treatment from the different health care providers. In addition, during the days of complete incapacitation and the period of convalescence, the productive time that was lost by the malaria patients, their caretakers as well as substitute labourers were valued as far as possible by the countries. The average number of productive days lost for an episode of malaria was 10.79 days in Ghana, 4.8 days in Nigeria, 6 days in Rwanda, and 8.4 days in Uganda.

In Mali, the indirect cost to households for an episode of malaria was calculated in the sample to be US$ 2.73, but the study did not impute a cost for the lost productive days, due to ill health as do the other studies. This amount compares with the US$ 5.82 in Ghana, US$7.74 in Uganda and US $ 15.63 in Nigeria. Figure 3 displays the total cost of an episode of malaria to households in Ghana, Mali, Nigeria, Rwanda and Uganda. The total costs range from US$ 6.5 in Rwanda to US$ 16.3 in Nigeria.

4.3 Cost of Malaria Prevention to Households

Households in Ghana on the average spend US$ 1.3 a month on products such as aerosol sprays, mosquito coils and bed nets to protect themselves against mosquito bites. In Chad, mosquito nets are the most widely used form of personal and household protection from malaria. Each net costs US$ 11.4. Households in Mali and Rwanda spend an average of US$ 4.5 and US$ 2.9 on preventive measures monthly respectively. The results from the study in Nigeria and Uganda showed that households spend US$ 2.2 and US$ 8.4 on preventive measures every month.

4.4 Total Cost of Malaria

The study in Ghana found that the total cost of malaria control in 2002 was US$ 50.05 million by applying the various average costs per case obtained from the survey results to the total malaria cases recorded in 2002. The direct cost of treatment and prevention amounted to US$26.16 million which represented 52% of the total cost. The indirect cost of illness in the form of workdays lost to the illness is estimated at US$ 23.89 million. While households accounted for 85% of the total cost of malaria, 15% was incurred by the government. In Rwanda, the total cost of controlling malaria in 2003 was estimated at US$ 32.6 million, with the direct, indirect and institutional costs respectively comprising 22%, 23% and 55% of this total.

The studies showed that malaria drains US$ 658 million and US$ 8.1 billion respectively from Uganda and Nigeria annually. In Mali, the total annual cost of malaria was estimated in the study to be US$10.6 million or US$ 12.7 per capita. This amount translates to 3.36% of the GDP in the country. Households contribute a disproportionately larger share of the funds for malaria control in African countries, typified by the values of 92% in Mali and 85% in Ghana.

4.5 Willingness to Pay for Malaria Control

In Ghana, the household survey revealed that about one-quarter of the respondents were willing to pay US$ 10.03 per illness episode while 18.3% stated their willingness to pay US$17.96 for malaria control. Significantly, it was observed that there is a 0.23% chance that 1% increase in households' income is likely to result in household's willingness to pay as much as US$47.13 for malaria control.

Nigerian households are willing to pay, an average of US$ 9.3 per month for the treatment of malaria in adults and a slightly higher figure of US$ 9.4 for a child-victim. The study also found that households are willingness to pay an average US$ 11 for a bednet and about US$ 8.9 for spraying of neighbourhoods. Finally the average sum that households are willing to pay for the total control of malaria is US$ 61. These WTP values are significantly above the current actual values committed by the households to malaria control services and might be looked upon as representing the household valuation of the intangible costs of malaria. This is about US$ 22.6 per month per household.

5. Discussion

The economic cost of malaria to the six countries is enormous. The malaria morbidity coefficients in the econometrics models were negative sign and were statistically significant in Chad, Ghana, Nigeria, Rwanda and Uganda. If malaria morbidity increases by 1% while the other explanatory variables are held constant, growth in real GDP decreases by between 0.017% in Rwanda and 26.8% in Chad.

The cost of illness approach results corroborate those obtained from the production function approach, indicating that malaria causes an enormous drain on the national economies. The significant negative association between malaria and economic growth confirms earlier studies by Gallup and Sachs (2001) and McCarthy et al. (2000).

At the household level, the studies reveal a pattern of immense burden, particularly for the poorest households. In Ghana for example, the direct costs of malaria to the household is US $ 6.87, while it is US $ 11.84 and US$ 17.5 in Nigeria and Mali respectively. Although these amounts are well beyond the capacity of the majority of households in these countries, when the indirect costs are computed, they come to even higher values. The studies thus show that the direct cost of malaria to the households in Africa is high and imposes a harsh burden, bordering on catastrophic expenditures for the poorest households.

It is instructive that households bear a disproportionately high share of the total cost of malaria in all the countries, as exemplified by Ghana and Mali, where, households contribute about 90% of the total cost. This large share has implications for such a ubiquitous cause of ill health and the impact on the impoverishment of already poor households. The findings on household contributions are corroborated by the results obtained from the willingness to pay results from Ghana and Nigeria that reveal a high level of willingness to pay for malaria control in the countries.

What are the policy implications? At the programmatic level, given that a significant number of malaria cases are treated at home by self-medication, efforts need to be intensified to improve the quality of care at home, in accordance with national treatment guidelines, particularly in making the Artemisinin-based Combination Therapies (ACTs) close to the households. This will reduce both transport costs and travel time needed to access sources of care. In addition, considering the high levels of expenditure on preventive measures, mainly on coils and aerosol sprays, more should be done on targeted IEC actions to channel these household resources to the more cost effective ITNs.

In all countries, the cost of malaria treatment is well beyond the means of the poorest households and given the reality of repeated bouts of malaria and its contribution to the impoverishment of the households, there is a need for policies to make access to effective treatment a priority for the most vulnerable groups. This is particularly urgent with the deployment of the more expensive ACTs in countries of Africa.

The significant macroeconomic burden of malaria, in terms of lost productivity and growth potential highlights the fact that the disease is not just a public health problem but also a developmental issue that requires multisectoral action. Its inclusion in the poverty reduction strategies of governments as well as its explicit consideration in policies to achieve the MDGs is imperative.

6. Conclusion

Malaria is not only a health problem but also a developmental problem in countries of the African Region. It places significant financial hardships on both households and the economy. The burden of malaria is therefore a challenge to human development manifesting itself as a cause and consequence of under-development.

From the macroeconomic perspective, the estimated econometric models in Chad, Ghana, Nigeria and Uganda found malaria to have negative effect on real GDP growth. Malaria endemic African countries suffer significant loss in economic growth because of the prevalence of the disease. The burden of malaria in the countries obtained through the cost of illness approach is also excruciating for the poorest households, with the high treatment cost forcing households to devise appropriate coping strategies for economic viability.

The Abuja Summit called for US$ 1 billion a year to help Africa tackle malaria; however, this request may underestimate the actual resources needed to address this disease effectively. The WHO Commission on Macroeconomics and Health (WHO, 2001) estimates, which sought to cost fully the provision of a package of malaria control measures, estimated that to achieve high levels of malaria interventions coverage by 2015, US$1.5-2.2 billion would be needed a year for prevention and treatment of malaria in adults, and a further US$3.3-4.2 billion for a child treatment package which included malaria.

These results from the studies on the economic burden cost of malaria in African countries provide a compelling case for increased investment at all levels for the control of the disease, to reach the levels recommended by the Commission on Macroeconomics and Health. Investment in the control of malaria will provide good return, saving lives, enhancing productivity and improving the economic wellbeing of the poorest households in African countries.

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Table 1: Yearly percentage loss in GDP attributable to Malaria in Chad (1990 – 1999)

YEAR	% Loss of GDP
1990	18.29
1991	16.43
1992	17.26
1993	15.75
1994	21.14
1995	23.18
1996	26.81
1997	23.26
1998	22.70
Average annual GDP Loss	20.54

Table 2: Impact of malaria on growth in real GDP in Ghana

	Regression Results			
Variable	Model 1	Model 2	Model 3	Model 4
CONSTANT	-1.437 (-0.143)	4.892 (2.019) **	1.456 (0.723)	5.987 (1.651)
ln(INC)	-0.720 (-0.524)	0.086 (0.148)	-0.558 (-0.996)	0.017 (0.018)
ln(YRSEDU)	1.614 (2.349) *	1.601 (2.396) *	1.101 (1.560)	1.691 (2.325) *
ln(EXP)	-3.286 (-2.037) **	-3.280 (-2.089) **	-	-3.628 (-1.981) **
ln(M)	-0.435 (-1.961) **	-0.412 (-1.933) **	-0.354 (-1.480)	-0.455 (-1.865) *
ln(OPEN)	0.426 (1.110)	0.593 (2.140) **	0.388 (1.323)	0.689 (1.878) *
ln(TOT)	-	-	-	-0.167 (-0.420)
ln(LAB)	1.313 (0.651)	-	-	-
R-Square Durbin Watson (DW)	0.57 2.83	0.55 2.77	0.38 2.28	0.56 2.82

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( ) t-statistics in parenthesis * Significant at 5% level ** Significant at 10 % level				

Table 3: Impact of malaria on growth in real GDP in Nigeria

Variables	**Coefficients**
Constant	10.187* (21.663)
ln(L)	0.085** (1.822)
ln(K*)	0.051* (3.637)
ln(M)	-0.038* (-2.246)
ln(Open)	0.126* (3.487)
ln(NDR)	0.070* (7.304)
ln(POSTAR)	0.043* (2.117)
War Dummy	-0.149* (-3.165)
Other Statistics: Adjusted R^2 = 0.968; DW = 1.593 t – values in parentheses * Implies coefficient is significant at 5% ** Implies coefficient is significant at 10%	

Table 4: Impact of malaria on real GDP in Rwanda

Variables	**Dependent Variable: Log (Real GDP)**			
	Equation 1	**Equation 2**	**Equation 3**	**Equation 4**
Constant	-12.53917	-12.53905	-12.23478	-10.8612
	(-14.905)**	(-40.779)**	(-41.402)**	(-47.003)**
ln(K)	1.07580	1.18829	1.14486	0.9763
	(25.817)**	(32.476)**	(21.294)**	(21.000)**
ln(L)	0.91567	0.90085	0.90678	0.86054
	(20.981)**	(51.672)**	(73.417)**	(71.152)**
ln**(M)**	**-0.01742**	**-0.01256**	**-0.01219**	**-0.00532**
	(-1.841)*	**(-3.240)****	**(-2.891)****	**(-1.4662)**
ln(open)	-0.07790	-0.05437	-0.03461	-0.02701
	(-2.239)**	(-3.702)**	(-2.762)**	(-1.8592)*
ln(TOT)	0.00841	0.02163	….	….
	(0.3020)	(0.9838)		
ln(EXP)	0.11883	0.04730	….	….
	(1.339)	(1.3940)		
Dummy96	0.17980	0.19076	0.1810	0.1611
	(8.821)**	(25.814)**	(27.222)**	(32.134)**
Dummy49	-0.08839	0.3076	0.3024	….
	(-3.951)**	(5.811)**	(5.922)**	
Dummy49xLog (M)	**….**	**-0.07641**	**-0.0750**	**-0.08415**
		(-8.406)**	**(-9.011)****	**(-5.7947)****
Dummy49 x ln(open)	….	….	….	0.11635
				(4.695)**
Dummy49 x ln(L)	….	….	…	-0.00285
				(-4.068)**
R^2 Adjusted	0.9932	0.9977	0.9977	0.9981
F-Statistic	422.56	1095.84	1442.696	1513.337
Durbin-Watson	2.568	1.983	1.942	1.5263
Number of Observations	24	24	24	24
NB :				
(.): t-statistic values in parentheses				
*: statistically significant (10%)				
**: statistically significant (5%)				
Dummy 49 : For the period 1994-1999				

Table 5: Impact of malaria on the log of per capita GDP in Uganda

Variable	Model		
	Coefficient	T-statistic	Marginal Effects
Ln(K)	0.0008	0.04	0.010
Ln(L)	0.8373	3.21*	4.1284
Ln(YRSEDC)	0.9118	5.43*	0.0037
Ln(I)	-0.411	-0.6	-0.908
Ln(T)	-0.104	-8.3*	-1.328
Ln(A)	-0.165	-2.8*	-0.980
Ln(M)	-0.178	-2.0*	-0.0078
Constant	-38.85	-2.5*	
DW Stat		1.75	
R^2		0.941	
Adjusted R^2		0.921	
VIF		1.67	
Observations		28	

Note: *Means that the variable has a statistically significant impact on GDP per capita at 95% level of significance.

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Figure 1: Conceptual Framework of Economic Burden of Malaria

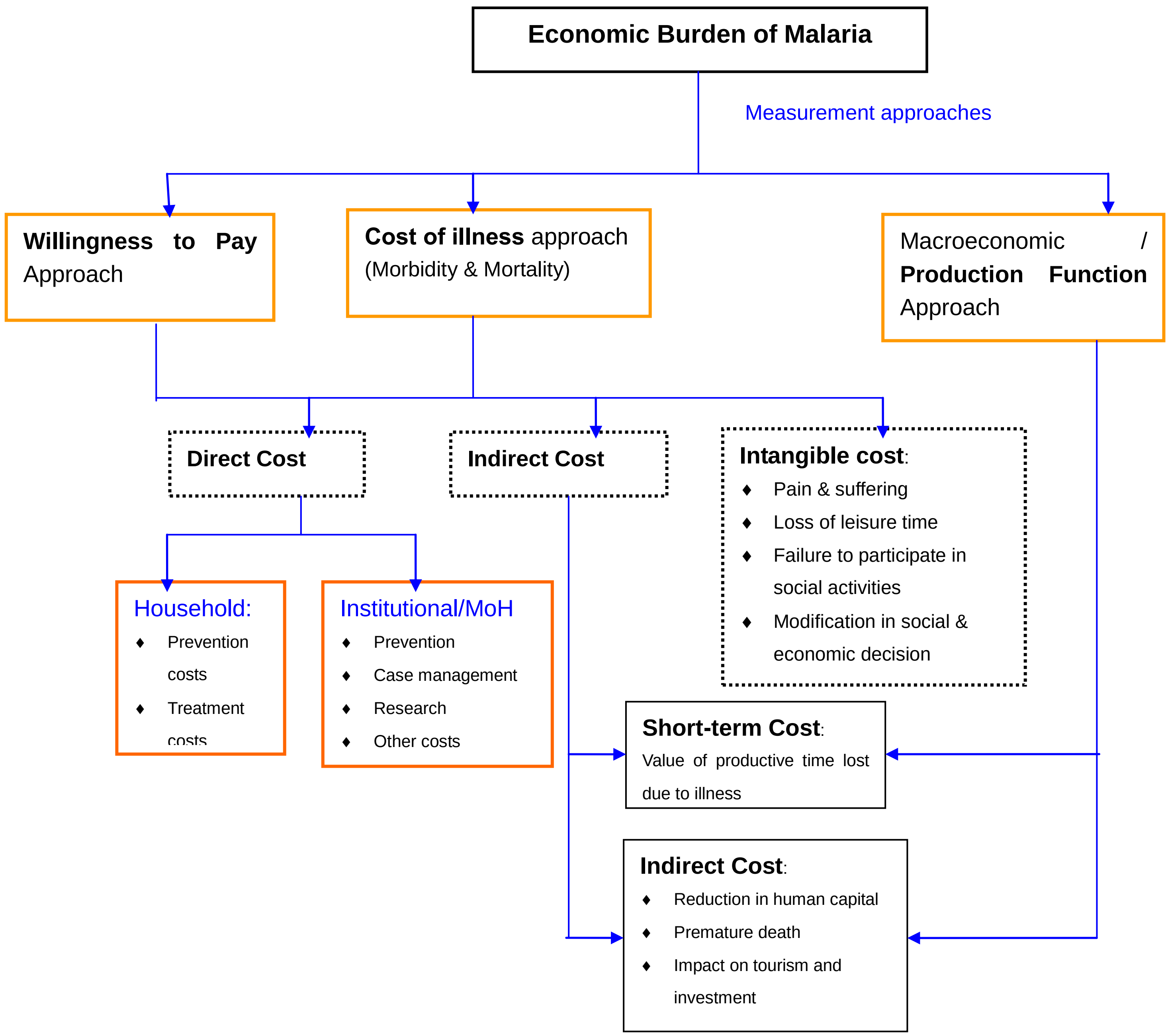

Figure 2: Percentage share of direct costs of malaria in Ghana

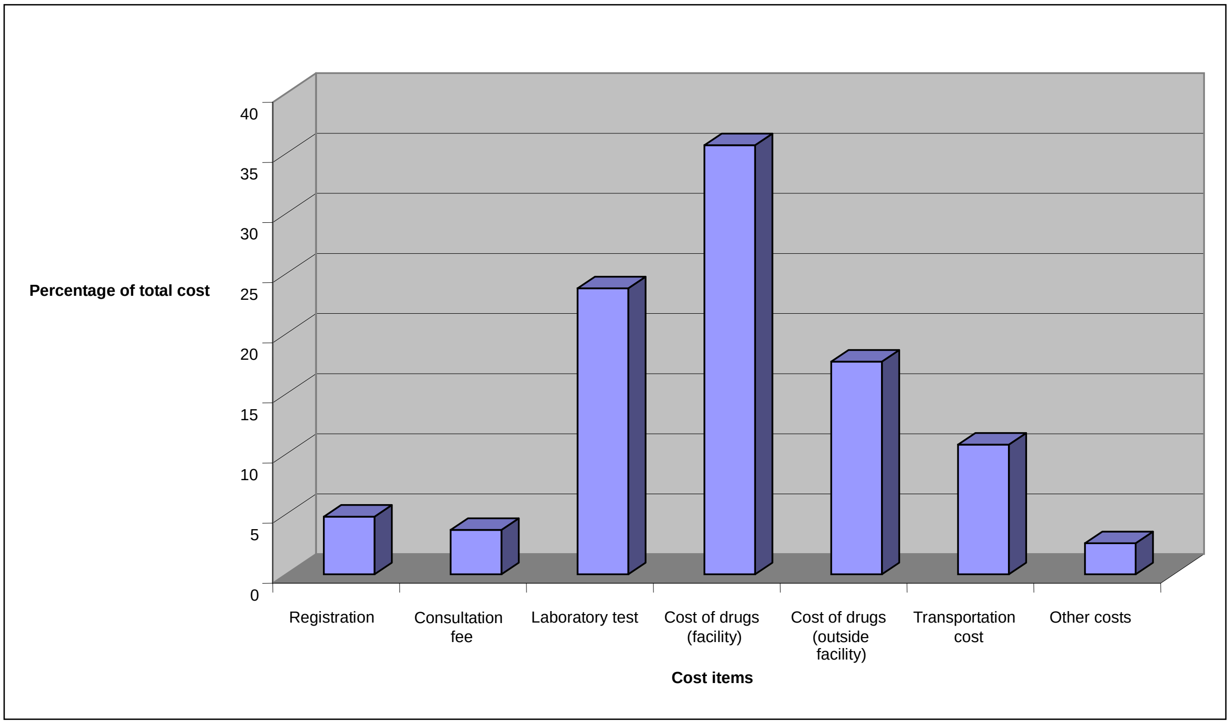

Figure 3: Total Cost of Malaria Treatment to Households