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Burden of Malaria at Household Level: A Baseline Review in the Advent of Climate Change

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ABSTRACT

Malaria is the most serious public health problem in tropical and sub-tropical regions of the world. It has emerged one of the top three killers among the vector borne diseases in the world. Changes in climate factors greatly affect seasonal transmission and geographical distribution of malaria which causes great losses to the households in terms of costs of securing treatment as well as loss of output and income in endemic regions. This study aims to identify and review literature related to economic costs of malaria illness at household level. The study also focuses on the burden of the disease in terms of Disability-adjusted Life Years (DALYs) lost. Literatures were identified for review from various sources such as journals, reports, proceedings and other related documents by searching comprehensively both electronic and non-electronic databases. Websites of the organizations known to have undertaken research in this area were also searched to find related documents and reports. Based on the review of literature, it was found that costs of malaria vary by the socio-economic status of households and the poor spend a significantly higher proportion of their income on treatment and preventive measures for the disease. Direct cost of malaria consumed 28-34% of annual income of poor households and 1-2% of high income households. Studies revealed that indirect costs of malaria accounted for a significant portion of households' annual income ranging from 2 to 6%. It was found that even under minimal climate change scenario, some African countries may face their inpatient treatment cost of malaria increase more than 20%. It can be concluded that illness of malaria imposes greater burden on poor households than the better-off. Minimizing the burden of the disease could help people, especially the poor to get out from the worst economic situation. Therefore, further research is urgently needed to ensure interventions to control the malaria disease more effectively in the advent of climate change.

Key words: Malaria, illness costs, household, climate change

INTRODUCTION

Malaria has emerged one of the most serious public health problems in the tropical and sub-tropical regions (Lieshout *et al.*, 2004) which ranked major health and development challenges facing some of poorest countries of the world (McCarthy *et al.*, 2000). The disease is prevalent in about 90 countries and territories in the tropical and subtropical regions and almost one half of them are in Africa, South of Sahara (Kumar *et al.*, 2007). WHO (2010) revealed that 35 countries in African region are high-burden countries. It affects people of all ages, especially pregnant women and children as they have less immunity. Similarly, people from all income levels (e.g., rich and poor) within malaria-endemic regions suffer from morbidity and mortality of the disease. In all infectious diseases, malaria continues to be one of the biggest contributors to the global disease burden in terms of death and sufferings (Martens *et al.*, 1999). Egbendewe-Mondzozo *et al.* (2011) reported that 243 million malaria cases and 863,000 deaths occurred due to malaria in 2008 all over the world and 89% of the reported deaths were in Africa. The geographical distribution of the disease is uneven as approximately 85% of all deaths and incidences of malaria occur in Africa (Lieshout *et al.*, 2004). It is one of the most serious vector-borne diseases in the tropics. The vectors that harbor infectious diseases and transmit them to humans are directly modified by ecological and meteorological factors (Patz *et al.*, 2005). The ecological factors also affect biologically productive land and water resources and consequently humanity of a society (Begum *et al.*, 2009). Mosquito is a primary vector that infects human and can transmit diseases such as malaria, dengue fever, Rift Valley fever, yellow fever and West Nile virus (McMichael *et al.*, 2006). The female anopheles mosquitoes transmit the malaria parasites that cause malaria infection in humans. The disease is governed by a large number of climate factors, including temperature, rainfall and relative humidity which affect its reproduction, distribution, seasonality and transmission intensity (Snow *et al.*, 1999; Zhou *et al.*, 2004; Garg *et al.*, 2009; Halsnaes and Traerup, 2009; Wandiga *et al.*, 2010). Climate change is adversely affecting not only public health but also other sectors of the economy such as energy, industries, transport, forestry, agriculture, water and coastal resources and waste sector (Begum *et al.*, 2011a). The impacts of climate change may vary across different sectors of the economy and geographical location (Begum and Pereira, 2011). For example, the study conducted by Mwang`ombe *et al.* (2011) found that climate variability resulted in increased dry conditions, crop failures, reduced livestock productivity and increased livestock and human diseases, thereby complicating lives of communities in rural areas of Kenya. The study on Jeddah city, Soudi Arabia reported that environmental degradation affected adversely the water supply, air quality, health and safety which resulted in increased economic costs to the community of the city (Magram, 2009).

Long-term chimate changes, especially rising in temperature play a vital role in determining the geographical distribution and severity of malaria, since both vector and parasite of the disease are sensitive to temperature. Generally, in warmer temperature, the anopheles mosquito develops more rapidly and feeds more frequently and earlier in its life cycle and consequently the malaria parasite within the mosquito develops and multiples more rapidly (National Research Council, 2001). The major malaria parasite, *Plasmodium falciparum*, can complete its development in most anopheline vectors at room temperature (Ambu *et al.*, 2003). Rainfall also contributes significantly to malaria epidemiology. Malaria vectors e.g., mosquitoes breed in standing water such as mud-pools, marshes and natural ponds. Therefore, rainfall not only affects malaria transmission by increasing breeding sites for mosquitoes but also increases the relative humidity which helps in survival and longevity of adult mosquitoes (Martens *et al.*, 1995; Garg *et al.*, 2009). Floods associated with increased El Nino rainfalls have contributed to epidemics of malaria in Africa (Brown *et al.*, 1998; Greenwood and Mutabingwa, 2002). In Iran, malaria transmission depends on seasonal and temperature variation and reaches a peak in Autumn (November-December) when temperature increases (Basseri *et al.*, 2005). Another study assessing the impact of climate change in Iran reported that malaria is prevalent in different provinces of the country and the trend of incidence of the disease is on the rise (Amiri and Eslamian, 2010). Similarly, in Uttaranchal, India, malaria transmission is significantly correlated with climatic variables (especially rainfall) and reaches its peak during monsoon and post-monsoon seasons (June to September) (Devi and Jauhari, 2006). A small seasonal change in host or pathogen factors may create large seasonal surges in malaria incidences which may be important particularly in the context of global climate change (Fisman, 2007).

Climate change increases the outbreak of malaria which places enormous burden on humanity causing a lot of economic losses to the vulnerable people living in endemic regions, in terms of costs of securing treatment as well as loss of output and income. The poor and hardcore poor who have relatively larger household members suffer most by the adverse impacts of climate change (Begum *et al.*, 2011b). Incidences of malaria also have huge welfare cost and other impacts for individuals in the endemic countries (Halsnaes and Traerup, 2009). In addition, the disease may impede the socio-economic development of a country by imposing long-term negative impacts on trade, savings, investment, tourism and human capital accumulation of the country. This study aims to review studies that have measured the economic costs of malaria at the household level. The study also focuses on the burden of the disease in terms of Disability-adjusted Life Years (DALYs) lost. A number of studies have been carried out mostly in low and middle income countries focusing on the economic impacts of malaria for the patients and their families. Majority of them attempted to measure direct and indirect costs of malaria illness to estimate the economic impact of the disease at the household level. The Cost-of-illness (COI) method is the most widely used approach for estimating direct and indirect costs. In a few studies, a third category of costs of malaria illness has been described as intangible cost. But it is the most controversial and not generally valued (Chima *et al.*, 2003). Recently some studies have given effort to measure the burden of the disease in terms of Disability-adjusted life years (DALYs) lost. However, this study does not focus on the macroeconomic costs of malaria while a few studies have attempted to measure macroeconomic impacts of the disease.

Technique of identifying and collecting literature: This study identified and selected literatures (for review) focusing on climate change and economic impacts of malaria at household level. Literatures were identified from various sources such as journals, reports, proceedings and other related documents by searching comprehensively both electronic and non-electronic databases. Literature searches from electronic databases were conducted mainly on Science Direct, Springer Link, Blackwell, Science Citation Index, Social Science Citation Index, Medline, PubMed, PubMed Central and WHOLIS using a range of key words relating to climate change and economic impacts of malaria illness. References cited in the literatures were searched and important studies were collected in full text. Websites of the organizations known to have undertaken research in this area were also searched to find related documents and reports. In addition, both electronic and non-electronic searches were also supplemented by a network of colleagues who provided related literatures and documents. In the review process, only the documents written in English were considered and there was no country restriction. This study reviewed the literatures that included discussion and demonstrated findings and evidences related to climate change, costing of malaria illness and its impacts on the household economy.

Assessing economic impacts of malaria at household level: This review is based on data, information and findings from published literatures and documents that focus on and discuss economic costs of malaria at the household level either or not from the view of climate change, depending on the availability of literatures and documents. Costing of malaria at the household level includes the direct, indirect, intangible and total costs that are discussed below.

Direct costs of malaria at the household level: Evidences demonstrate that households in malaria endemic regions face a substantial amount of direct cash expenses which can be classified into two broad categories: expenditures on malaria prevention and expenditures on treatment. With respect to malaria prevention, households in endemic countries rely largely on insecticide treated (mosquito) nets and indoor residual (house) spraying though they also use mosquito coils and mosquito repellent lotions (Yukich *et al*., 2008). Treatment seeking and usage of preventive measures for malaria vary to different degrees across geographic and seasonal differences and accordingly the costs for malaria prevention and treatment vary by different degrees (Ewing *et al*., 2011). Table 1 summarizes household's expenses on malaria prevention and treatment from the different parts of the world. The differences in expenditures for malaria prevention among households might be due to epidemiological factors, e.g., the prevalence of different malaria species and immunity levels and socio-economic factors, e.g., income levels. For example, in Malawi, only 4% of very low income households spent resources on malaria preventive measures compared to 16% of low to high income households (Ettling *et al*., 1994). In the republic of Benin, estimated annual expenditure on malaria prevention constituted 1.6% of rural and 2.1% of urban household income (Rashed *et al*., 2000). But there is still inadequate relevant data and information on this. Moreover, most of the studies avoided estimating prevention expenditures on annual basis and its consequent economic impact on households due to lack of good information and data on seasonal distribution of malaria, households' economic activities and availability of cash throughout the year (Chima *et al*., 2003).

Table 1: Summary of household's is direct costs of malaria

	Direct costs per capita per month (US$)			
Country/Province	Prevention	Treatment	Total	References
Malawi (nationwide)	0.05	0.41	0.46	Ettling *et al*. (1994)
Burkina Faso (urban)	0.93	1.18	2.11	Guiguemde *et al*. (1994)
Ghana (rural)	-	0.65	0.65	Asenso-Okyere and Dzator (1997)
Tanzania	-	1.55	1.55	Jowett and Miller (2005)
Ethiopia (rural)	0.09	1.60	1.69	Deressa *et al*. (2007)
Nigeria, Enugu State	0.94	2.90	3.84	Uguru *et al*., 2009)
North-Eastern Tanzania	0.82	-	0.82	McElroy *et al*. (2009)
Per case/per episode				
Republic of Beuin	-	1.74	1.74	Rashed *et al*. (2000)
Northern Ghana	-	2.71	2.71	Akazili *et al*. (2007)
South Africa	-	2.30	2.30	Castillo-Riquelme *et al*. (2008)
Mozambique	-	6.50	6.50	Castillo-Riquelme *et al*. (2008)
Per household per mouth				
Sri Lanka (rural)	-	1.91	1.91	Attanayake *et al*. (2000)
Nigeria (rural)	-	1.84	1.84	Onwujekwe *et al*. (2000)
Sudan, Khartoum State	-	1.70	1.70	Mustafa and Babiker (2007)

Source: Adapted from Chima *et al*. (2003), Russell (2004), Chuma *et al*. (2006)

Household expenditures on malaria related treatment include direct medical and non-medical costs. Direct medical costs are the cash expenditures for doctor's fees, laboratory tests and drugs. On the other hand, direct non-medical costs include direct payments for food, lodging, transport charges to and from health care facilities or drug stores and miscellaneous expenses associated with seeking and obtaining medical care as well as household members visiting patients at hospital or clinic. Furthermore, Attanayake *et al.* (2000) demonstrated 'complementary cost of treatment' for malaria which included cost of vitamins, nutritional food, special foods and drinks and constituted a significant portion of the total treatment costs. Like prevention costs, household expenditures on malaria treatment vary by different degrees in different areas and households (Table 1). This difference is due to user fees in public health care facilities, costs of drugs and laboratory tests and so on. For example, in Sri Lanka (rural) households' direct costs for malaria treatment found much lower due to free treatment at public hospitals. Free hospital treatment is a core component of the Sri Lankan government's universal coverage policy that aims to protect the majority, particularly the poor, from catastrophic illness costs (Russell, 2004). It is also noticed that malaria treatment costs vary from rural to urban areas in the same country or region.

Studies suggested that the direct medical costs constitute a higher proportion of total treatment costs borne by households (Table 2). The choice of households to use health care facilities is determined by many factors such as accessibility to health services, availability of drugs, quality of care, distance to the health care facilities from household, travel time, household size and user fee policy (Rutebemberwa *et al.*, 2009). In Ghana, the comparatively high medical cost of malaria was linked to drug costs at public health care facilities and private drug stores. On the other hand, in Sri Lanka, the relatively low direct cost of treating malaria (Table 1) was due to low medical costs. The low level of medical costs was due to free treatment in public hospitals in Sri Lanka.

Evidences indicate that the direct costs of malaria consume a significant portion of households' income, monthly or annually, as shown in Table 3. Households have to pay in full the expenses for treatment at the time of illness when income may be lower than usual due to inability of carrying out normal activities or attending the sick person for treatment. In addition, households have to make informal payments (e.g., illegal payments) in public health care facilities which contribute to the high cost of malaria treatment (Onwujekwe *et al.*, 2010). Household's direct costs are also inflated by people's widespread preference to use private doctors and pharmacies for outpatient treatment, particularly in urban areas and even by the poorest. For example, In Ghana, malaria patients had to pay quite a significant amount of money to purchase drugs from private drug stores as public health care facilities could not provide all the drugs prescribed (Asenso-Okyere and Dzator, 1997). Similarly, patients receiving treatment only from private clinics had significantly larger average cost of treatment in Vietnam (Morel *et al.*, 2008). Ettling and Shepard (1991) observed comparatively high treatment costs from private health care facilities in Rwanda where households' direct expenses, on the average, were \$0.39 in public health centers and \$3.36 in private facilities (which is almost six times of expenses occurred at public facilities). The factors that

Table 2: Direct medical cost as a proportion of household is total treatment cost

Country	Direct medical cost as a % of household's total treatment cost	References
Ghana	49.00	Asenso-Okyere and Dzator (1997)
Sri Lanka	31.00	Attanayake *et al.* (2000)
Ghana	81.56	Asante and Asenso-Okyere (2003)

Table 3: Direct costs of malaria to households

Country/Province	Direct costs as % of household income	References
Malawi	28% of annual income among very low income households and 2% among low to high income households	Ettling *et al*. (1994)
Republic of Benin	3.3% of annual income of rural and 2.4% of urban households	Rashed *et al*. (2000)
Nigeria, Enugu State	2.9% of monthly income	Onwujekwe *et al*. (2000)
Sri Lanka	2% of monthly income	Attanayake *et al*. (2000)
Kenya	18% of annual income	Leighton and Foster (1993)
Nigeria	13% of annual income	Leighton and Foster (1993)
Northern Ghana	34% of annual income of poor households and 1% of annual income of rich households	Akazili *et al*. (2007)
Kenya, Ganze State	7.1% of monthly income in wet season and 5.9% in dry season	Chuma *et al*. (2006)
Mozambique, Maputo Province	18% of monthly income	Castillo-Riquelme *et al*. (2008)
South Africa, KZN Province	2.1% of monthly income	Castillo-Riquelme *et al*. (2008)
South Africa, Mpumalanga Province	1% of monthly income	Castillo-Riquelme *et al*. (2008)
Tanzania	0.7% of annual income	Jowett and Miller (2005)
Guyana	10-20% of average monthly income	Booth and MacLean (2001)
Sudan, Khartoum State	5.3% of average monthly income	Mustafa and Babiker (2007)

Source: Adapted from Mia *et al*. (2011)

make people reluctant to use public health facilities are limited resources, inadequate staff and lack of essential drugs (Hopkins *et al*., 2007). Other factors are poor quality of care and lack of services after working hour at public hospitals as well as better attention to the patients at private clinics. Inadequate health-care infrastructure is a major barrier for malaria treatment in many African countries (Moerman *et al*., 2003). In coastal India, a higher proportion of malaria patients did self medication usually with antimalarials and did not seek medical attention (Unnikrishnan *et al*., 2008). A study conducted in Nepal found that almost 50% of the respondents did not have information on availability of free treatment of malaria though it is available in Nepal (Joshi and Banjara, 2008).

Few studies compared how cost burdens vary by socio-economic status of households and found that costs of malaria treatment were highly regressive, imposing a greater burden on poor families than the better-off families (Table 3). For example, direct cost of malaria consumed 34% of annual income of poor households and 1% of annual income of rich households in Northern Ghana (Akazili *et al*., 2007). In the republic of Benin, the direct cost of malaria among the rural households was 3.3% of annual income while it was 2.4% of annual income of the urban households (Rashed *et al*., 2000). The study conducted by Leighton and Foster (1993) found that the typical rural households in Kenya and lower income urban households in Nigeria were the hardest hit by the economic impacts of malaria. The poor households have to meet the treatment costs and purchase preventive measures for malaria out of their scarce cash reserves which push them into vulnerable situation.

However, some studies also focused on the impact of seasonal variations in the cost burdens of malaria. For example, a study in Kenya reported significantly higher malaria transmissions in the wet season (64%) than in the dry season (37%) (Chuma *et al*., 2006). The same study showed that mean direct cost burdens of malaria were 7.1% of total household expenditure in the wet season and 5.9% in the dry season. Present study also reported that people were keen to avoid public health care facilities in the wet season and were better able to meet relatively high private clinic costs. In Assam, India, Baruah *et al*. (2007) recorded the highest overall density of malaria vectors

Table 4: Indirect cost of malaria morbidity as a proportion of households' total cost

Country	Indirect cost as a % of households total cost	References
Rwanda	75.0	Ettling and Shaperd (1991)
Ghana	79.0	Asenso-Okyere and Dzator (1997)
Sri Lanka	76.0	Attanayake *et al*. (2000)

Table 5: Indirect costs of malaria as a proportion of household income

Country	Indirect costs as % of households annual income	References
Malawi	2.6	Ettling *et al*. (1994)
Sri Lanka	4.9	Attanayake *et al*. (2000)
Nigeria	2.0	Onwujekwe *et al*. (2000)
Sri Lanka	6.0	Konradsen *et al*. (1997)

during the monsoon period (June-August) followed by post-monsoon (September-November) and pre-monsoon (March-May) and lowest in winter season (December-February). This study also revealed that the densities of malaria vectors were influenced by rainfall pattern. Unfortunately, this study did not explore the impact of seasonal variations on direct costs of malaria treatment.

Households' indirect costs for morbidity and mortality of malaria: Evidences show that households loss productivity due to morbidity and mortality of malaria which can be termed as indirect cost of the disease. It is an important determinant of economic costs of malaria. Households incur indirect costs in terms of income or wage lost, school days missed and reduced productivity and output due to morbidity of malaria. The scope of indirect cost measurement varies considerably across studies: some only include economically active individuals but others include children and the elderly; mostly measure the time spent seeking treatment by the patient and caregiver and their loss of productive labour time due to illness (Russell, 2004). Key variables are thus the amount of productive labour time lost and the assumed value of that time. But, there is a great variation between studies in the methods used for valuation of productive labour time lost of the patient and caregiver. The method used in most of the studies is the wage rate method which relies on the relationship between wage and the value of labour. Some studies used age specific average wage while others applied economic activity or gender specific average wage to value the time lost. Other methods include mean daily income, average daily output per adult, average income per day, average agricultural wage and market value of average output.

Studies reveal that the indirect cost of malaria morbidity constitutes a significant proportion of total malaria costs borne by households (Table 4). Indirect cost due to malaria illness may be lower in settings where young children are affected by the disease than in settings where both adults and children are equally vulnerable to the disease (Chuma *et al*., 2010). Evidences also showed that indirect cost of malaria imposed a greater burden on the households, especially the poor. Table 5 shows indirect costs of malaria that contributed to the proportion of households' annual income ranging from 2 to 6% for the Nigeria, Malawi and Sri Lanka. It can be noticed that income losses due to illness of malaria can be of great economic significance to households and poor families experience higher burden than better-off families. For example, In Malawi, Indirect costs among the very low income households were accounted to be 3% of the total annual household income and 2% of the annual income among the low to high income households (Ettling *et al*., 1994).

Households in malaria endemic regions are also affected by the disease through its effects on their children's attendance and performance at school. Repeated illness of the school-age children from malaria causes high rates of absenteeism which result in children's poor educational performance, increased failure rates, repetition of school years and drop-out from school (Malaney *et al.*, 2004). Holding and Kitsao-Wekulo (2004) revealed that school-age children in endemic areas face 15% of health-related absenteeism from school due to illness of malaria. For example, the study conducted by Leighton and Foster (1993) in Kenya found that primary school children missed an estimated 20 school days, on the average, per year due to malaria which amounts to over 10% of the total school days. The study also estimated that secondary school students missed 8 school days per year. In Sri Lanka, children lost 10% of school days due to malaria during the high transmission season (Konradsen *et al.*, 1997). Similarly, in Ghana, school children lost, on the average, 4 school days due to malaria illness (Asante and Asenso-Okyere, 2003).

Malaria also imposes significant economic burden to households by causing the permanent loss of productive labour time through premature death. With regard to work output and earnings, life lost to disease through premature death is an indirect cost to households and society in general (Asenso-Okyere and Dzator, 1997). Premature death of an economically active workforce destroys permanently the potential output to household. At the same time, his/her contribution to the Gross Domestic Product (GDP) is lost to society. However, the estimation of indirect cost due to premature death is difficult as it requires sophisticated methods to value the stream of future earnings. In this case, the lost income can be estimated by calculating the capitalized value of future lifetime earnings that would have been gained by those who died prematurely from malaria (Halsnaes and Traerup, 2009). Evidence on mortality costs of malaria found very limited due to lack of adequate data on age and sex-specific causes of death. In Rwanda, Ettling and Shaperd (1991) have attempted to estimate the mortality cost of malaria by calculating present value of the stream of future earnings lost due to premature death. Present study showed that mortality cost accounted for 74% of total indirect costs of malaria in Rwanda. Approximately 50% of all reported malaria deaths were in adults. The significant proportion of malaria mortality among adults in Rwanda made extremely high cost of premature death. Perhaps, most of the studies avoided the estimation of economic costs of malaria mortality, paying attention to the effects of morbidity only. Therefore, it is necessary to focus more on the mortality consequences of malaria especially in areas where adults are at risk of malaria.

Total costs of malaria: The direct and indirect costs of malaria have been summed in order to get estimates of total economic costs. Several studies estimated total economic costs of malaria in terms of the proportion of households' income as shown in Table 6. It is found that households suffer greatly from the burden of malaria because the direct and indirect costs of a single case/episoded deplete a significant portion of a household's income. For example, In Kenya, total cost due to illness of malaria consumed, on average, 28% of monthly income of the households (Chuma *et al.*, 2010). In Vietnam, households' expenditure on malaria constitutes, on average, 13%

Table 6: Total costs of malaria as a proportion of household income

Country	Total costs as % of households income	References
Malawi	7.2% of annual income	Ettling *et al.* (1994)
Nigeria	4.9% of monthly income	Onwujekwe *et al.* (2000)
Sri Lanka	6.7% of monthly income	Attanayake *et al.* (2000)
Kenya	18.0% of annual income	Leighton and Foster (1993)
Nigeria	13.0% of annual income	Leighton and Foster (1993)

of their income per month (Morel *et al.*, 2008). It is also found that the poor households bear the greatest burden of malaria as they have to spend a significantly higher proportion of their income on treatment and preventive measures for the disease and loss income due to ill health or attending the sick person for treatment. For example, the average total cost of malaria among the very low income households was 32% of annual income compared to 4.7% among the low to high income households in Malawi (Ettling *et al.*, 1994). A brief period of illness cause catastrophic consequences for families which may push them into poverty or force into deeper poverty (McIntyre *et al.*, 2006). On the other hand, poverty can contribute to high transmissions of malaria in the poor countries. For example, malaria is widely prevalent in the poor countries of Africa and Asia. But malaria is not a direct consequence of poverty. The incidence and severity of the disease are mostly determined by climate and ecology (Gallup and Sachs, 2001). This study was conducted by McCarthy *et al.* (2000) also confirmed that climate played a dominant role in accounting for cross-country differences in malaria morbidity. Recently, Egbendewe-Mondzozo *et al.* (2011) conducted a study in 25 African countries to assess the relationship between climate change and malaria incidences and attempted to estimate the potential economic consequences from climate change. The study was found that even under minimal climate change scenario, some countries, e.g., Burundi, Cote D'Ivoire, Malawi, Rwanda and Sudan may face their inpatient treatment cost of malaria increase more than 20%. The subsistence farmers in rural tropical areas, especially in Africa shoulder the greatest burden of the disease because they are mainly dependent on agriculture and their margin of survival is so fragile (Mia *et al.*, 2011).

Intangible costs of malaria: There is another type of cost of malaria illness, for example cost of pain, suffering and loss of leisure time due to illness, that cannot be easily quantified monetarily and is known as intangible cost (Massad *et al.*, 2011). Although the Cost-of-illness (COI) approach theoretically includes the cost of pain and suffering, it is generally excluded from calculations because it is difficult to assess (Malaney *et al.*, 2004). An alternative approach that is capable of measuring the intangible cost is the Willingness-to-pay (WTP) approach. This approach was originally developed to assess the value of intangible items in the environmental field such as clean air or improved water quality. However, WTP approach is now frequently used in health, social and environmental programs for price setting and cost-benefit analyses (Uzochukwu *et al.*, 2010).

There are very limited studies focused on intangible cost of malaria. In Nigeria, one study applied the WTP approach to evaluate the burden of malaria on households through the contingent valuation method based on a cross-sectional household survey (Jimoh *et al.*, 2007). The study assumed that the difference between the amount people are willing to pay to malaria eradication and control and the current costs for malaria treatment and prevention would be taken as the household valuation of the intangible costs of malaria illness. The results of this study showed that households would be willing to pay $3.6 in excess of the average current expenditure on malaria treatment per month and $22.6 in excess of the current costs for protection and control of malaria. The average valuation of households' intangible costs represented $5.1 per head per month, $61.2 per year. Asante and Asenso-Okyere (2003) applied the WTP technique in Ghana, reported that households would be willing to pay, on the average, $14.1 to avoid malaria. They also found that, in general, as people's income increase they would be willing to pay more for the control/eradication of malaria in their household. However, the application of WTP approach is limited due to difficulties in obtaining relevant data for valuation. Moreover, there are many criticisms against this type of studies for being too hypothetical and generating results with low validity, as the results depend completely on the choice of the respondents (Saulo *et al.*, 2008). Since, a respondent in this situation does not have to pay the amount he/she states, he/she may not provide accurate answers or may respond technically to influence the outcome of the study.

Burden of malaria in terms of Disability-adjusted Life Years (DALY) lost: Recently a few studies have attempted to estimate the burden of malaria in terms of DALYs lost. DALY is a new indicator of the burden of disease which estimates the amount of time, ability or activity lost by an individual from disability or death because of disease (Murray, 1994). It is calculated as the sum of: (1) years of life lost due to premature death (YLL) and (2) years of life lived with disability (YLD). In DALY approach, effort has been provided to better define disease-specific mortality rates (Snow *et al.*, 2003). Internationally this method has gained popularity in the last decade. It offers a standardized measure of morbidity and mortality that is comparable across various conditions and geographic regions, serves as a useful tool for resource allocation, cost-effectiveness analyses as well as assessment of the burden of disease (Clark *et al.*, 2005). In Africa, it was estimated that 39 million DALYs were lost due to malaria in 1998 and 36 million DALYs in 1999 (World Health Report, 1999). Present study by Dash *et al.* (2008) reported that malaria might be responsible for loss of about 2.3-2.5 million DALYs in the Southeast Asia region in 1998. Kumar *et al.* (2007) computed DALYs lost because of malaria in India for 1997. It was estimated that DALYs lost were 0.786 million years among females versus 1.074 million years in males. In Sudan, malaria related morbidity and mortality caused loss of 2,877,000 DALYs in 2002 (Abdalla *et al.*, 2007). Present study also found males having the highest incidence and mortality but females losing more DALYs. Unlike the Cost-of-illness (COI) approach, however the DALY method does not provide any monetary value of the burden of disease.

CONCLUSION

The fact is that there is very limited study on costing and economic impacts of malaria at household level, particularly in the advent of climate change. This is partly attributable to the limited availability of suitable data and information of malaria morbidity and mortality due to climate change as well as variation in methods and approaches to estimate and quantify the costing and impacts of the disease. The comparison of results and findings from different studies cannot be done directly due to lack of common methodology. In particular, there is limited study on economic impact of malaria by socio-economic status of households and especially its impact on the poorest. Poor families are the hardest hit by the disease due to climate change because they are not financially sound enough to purchase preventive measures and to seek prompt effective treatment. To select the suitable approach that meets the needs of the research and study is also difficult due to limitation of existing data, assumptions and estimates. Therefore, future research is very much needed for understanding the impact of climate factors on malaria and monetary valuation of economic burdens of the disease in order to set target and control efforts in a more effective manner to minimize the burdens of the disease. More cooperation and collaboration between biophysical scientists and economists is also necessary for a clear understanding of economic impacts of malaria due to climate change.

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