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# The Malaria Gap

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**Introduction: Malaria And The World Twice Given**

Would an Africa free of malaria still be just as poor? If the continent were rich, would its malaria still be endemic? The scientist-philosopher Ernst Mach once remarked that "the world is given only once" in an effort to discourage undue effort spent on such counterfactuals. In the case of malaria, however, the planet can be divided into those regions that are malarious and those that are not, and from the point of view of both public health and economic development, these regions often resemble separate worlds.

The frequently cited case of sickle cell anemia is but the most dramatic example of the extent to which malaria changes the lives of those it afflicts: how better to evince the power of the parasite than with a potentially lethal modification of the genetic code as a desperate Darwinian defense against the even more deadly ravages of malaria? Accordingly, it may be expected that a force strong enough to rewrite our DNA will rewrite many of the lives and economies that it touches. It is no exaggeration to say that where malaria is present, it can be expected to affect diverse features of human existence including mobility, investment choices, and even fertility decisions.

We are not powerless to face this force of nature; from simple mosquito coils to investment in the development of a vaccine, there are numerous measures that may reduce or eliminate the threat posed by malaria. The economic dimension enters the picture precisely because these measures are not all equally effective, and none is without cost. It is in evaluating the appropriate level of resources that should be devoted toward anti-malaria interventions that the economist must ask "What would the sphere of economic behavior look like in the absence of malaria?" Answering this question provides the first step towards a comprehensive cost-benefit analysis.

Because the effects of malaria can pervade the fabric of human endeavor, however, it is not surprising that the current state of economic analysis has yet to provide a definitive accounting. To begin with, the state of the art for costing a disease like malaria has not progressed to the point where a dominant paradigm can be said to exist. Rather, there are competing schools of thought, each of which directly addresses some piece of the puzzle while leaving other aspects of the problem to alternative methodologies.

Recent attempts to assess the economic burden of malaria by means of cross-country regression analysis have found the disease to be a significant factor in long-term economic growth and development.[1,2] The nature of the macroeconomic approach, however, is such that it functions independently of chains of causation and so cannot shed much light on the underlying mechanisms through which these costs are incurred. As a first approximation, one might anticipate that the cost of malaria at a national level would be an aggregation of the burden borne

at the household level. Microeconomic analyses that seek to estimate the burden of malaria on households generally conclude that the effect of this disease is, in fact, quite large and particularly burdensome for the "poorest of the poor." The costs of prevention, treatment, and the loss of productivity as a result of malaria-related morbidity and mortality can represent a significant portion of the annual income of poor agricultural households. When aggregated to provide estimates of the burden of disease at a national level, however, the results are considerably smaller than those of cross-country estimates. Potentially large economic costs, therefore, appear to escape microeconomic analyses, implying that there are negative externalities that render the overall burden of malaria greater than its direct impact on individuals and on households.[3]

The extent of the economic burden imposed by malaria as well as the mechanisms through which these costs are imposed are relevant to health policy. The main reason for allocating resources towards malaria prevention and treatment is undoubtedly the significant cost that it represents in human terms. In trading off between equally deserving demands on health budgets, and more broadly, development budgets, however, an understanding of the extent of the economic impact of an investment in anti-malaria interventions becomes important. If intense malaria results in a considerable negative impact on economic growth, any reduction in this burden can ultimately promote a cycle of health and wealth that may improve standards of living. The very difference between the estimates of the economic burden deriving from microeconomic studies and from macroeconomic crosscountry regressions provides insight into the mechanisms through which malaria inhibits development. To the extent that malaria-related costs are external to the household unit, private expenditures allocated towards its reduction will be insufficient, and public support for anti-malaria interventions will be all the more critical.

The difference between the macroeconomic, or "topdown" approach and the microeconomic, or "bottom-up" approach for assessing the economic burden of malaria serves as the focus for the following analysis. Toward this end, we shall identify factors that may explain the apparent "malaria gap" that separates these estimates.

## Economic Methodologies For Evaluating The Burden Of Malaria

Understanding the conditions that permit long-term economic growth is a central focus of economic research. There have been a number of attempts to explain the nearly hundred-fold difference in per capita incomes between the richest and the poorest countries. The many explanations for the difference that economists have explored include such factors as demographic structures, cultural practices, education, openness to trade, and legal and economic institutions.[4–7] Although economists favor diverse explanations, more recent explanations have included an increased focus on the role of health, and in particular of malaria. Indeed, poverty and malaria appear to go hand in hand, the world over. The per capita gross domestic product (GDP) (adjusted for differences in purchasing power) in highly malarious countries is on average one-fifth that of non-endemic countries.[2] In fact, recent macroeconomic studies have found that the growth rate of per capita GDP in malarious countries is 0.25–1.3% points lower per year than that of non-malarious countries, even after controlling for the impact of such factors as savings rates, economic and political institutions, and education levels of the population. Over a period of 25 years this can amount to almost half of the per capita GDP of poor countries.

Although macroeconomic studies suggest that malaria greatly inhibits economic growth, they cannot specify the mechanisms through which this happens. Their microeconomic counterparts attempt to provide national estimates by assessing the cost of malaria accrued by individual households and aggregating these estimates across households. This more conventional approach to assessing the burden of disease has been applied in numerous studies worldwide. An early 20th century calculation of the cost of malaria in the United States estimated the overall burden at US $100 million in 1917 dollars.[8] Since then, many area-specific studies ranging from South and Southeast Asia to Latin America and Africa have attempted to assess the costs imposed by malaria both on households and populations. The conclusions differ considerably, in part due to variations in methodology, but also to diverse patterns of endemicity and differences associated with the particular species of parasite involved. Of the several kinds of malaria parasites that infect people, Plasmodium falciparum produces a disease that is far more severe than that of the others, and the resulting costs reflect these differences. Similarly, the nature of the costs associated with the disease also change based on levels of endemicity. In highly endemic regions, mortality occurs mainly among infants and young children, while survival incrementally conveys diseasemodifying immunity. In addition to the unacceptable suffering associated with high infant and child mortality rates, they potentially have long-term effects on demographic and economic outcomes. Direct productivity losses, however, are less severe in such an environment than where transmission is less stable, where herd immunity is less, and where malariaassociated disease burdens people of all ages.

The most frequent approach toward evaluating the economic burden of malaria has been the cost-of-illness (COI) method. Such analyses attempt to account for the direct as well as indirect costs associated with an illness. Direct costs are private as well as non-private medical care costs. Private costs include private expenditures on prevention, diagnosis, treatment, and on case management. These could be such expenses as those required for bed nets, doctor's fees, the cost of anti-malaria drugs, the cost of transportation to medical facilities, and necessary support for the patient. Costs borne by an accompanying adult may be included, and these would be calculated over the duration of that person's stay at the facility. Non-private medical care costs include public expenditures on prevention and on treatment of the resulting disease and would be comprised of governmental expenditures on such measures as vector control, health facilities, education, and research.

Indirect cost calculations include productivity losses associated with malaria-attributed illness. Such costs are measured by estimating any income that may be foregone due to illness or death. In the case of mortality, foregone income is estimated by calculating the capitalized value of future earnings over the anticipated life-span of those who died prematurely as a result of malaria, based on projected incomes for different age groups, basic longevity estimates, and agespecific mortality rates. The indirect cost of morbidity is the value of lost workdays for each person with malaria and malaria- related illness, and this is calculated using similar methods. The standard formula for the COI method of calculating the cost of a disease is COI = Private Medical Costs + Non- Private Medical Costs + Foregone Income + Pain and Suffering.

The outcomes of previous COI studies on malaria have varied, based not only on such factors as the endemicity of the infection in the study locale, which actually does affect the cost of the disease, but also the particulars of the way in which the methodology was applied. A

comprehensive example of this is represented by a collection of case studies conducted within Africa, where the cost of malaria was estimated using the COI formula in Burkina Faso, Chad, the Republic of the Congo, and Rwanda. Each study used data available within the country, modifying the formula and components as necessary.[9] These studies indicated that a case of malaria in Africa cost $9.84 in 1987, of which $1.83 was direct and $8.01 was accrued indirectly as a result of foregone income associated with malaria morbidity and mortality. The total estimated cost of $0.8 billion represented 0.6% of the GDP of sub-Saharan African economies. An increase in this burden to 1% of the GDP in 1995 was predicted.

Although COI analyses generally find that the economic burden of malaria is less than macroeconomic results would suggest, they do demonstrate that the costs of malaria fall particularly heavily on the poor because the direct and indirect costs of a single case often represents a significant portion of a person's income. A household survey conducted in Malawi focused on the costs of malaria for low-income households.[10] In a sample of households with a mean annual household income of $115, the costs of malaria prevention and treatment, added to the foregone income from adult morbidity and caretaking for children with the disease, represent about 20% of annual income.

Although the COI approach theoretically includes the cost of pain and suffering, it is generally excluded from calculations because it is difficult to assess. An approach that is better designed to access these and other less tangible costs is the willingness-to-pay (WTP) approach, in which analysts attempt, by means of household surveys, to determine the value that a household would place on avoiding the disease. If it were possible to elicit such a dollar value, treatment costs and lost productivity would presumably be captured, as well as the value of lost leisure time, the cost of the pain and suffering associated with malaria, and other intangible costs that might be difficult to estimate. The WTP approach, which was developed originally to assign values to such public goods as environmental quality, has come under much criticism in the context of "existence" values, which do not derive from private consumption of a good.[11,12] Such values may be subject to personal interpretation and can be biased by respondents' desire to engage in strategic behavior. It is possible, however, to avoid some of these pitfalls through the use of a carefully constructed survey with closed-ended questions that place the issue in a market context. In one such study conducted in Tigray, Ethiopia, poor, agricultural households were found to be willing to pay about 16% of their annual income for a hypothetical malaria vaccine, or about two to three times as much as would be suggested by a COI calculation for the same sample.[13]

The COI approach also fails to account for lost productivity in the event that patients must return to work before they have fully recovered from a malaria episode and are therefore less effective. Indeed, in intensely endemic regions, many residents sustain chronic infection even though they appear to be non-symptomatic. It seems reasonable to expect that such a condition might actually reduce productive capacity. The production function approach attempts to take reduced productive capacity into account by assessing the change in output caused by a disease. The results of such studies vary considerably. One analysis in southern India estimated that households whose members suffered with malaria could clear only 40% as much cropland as those households without malaria,[14] suggesting a considerably greater burden than is indicated by COI analyses. A study conducted in Cameroon, however, which assessed the impact of parasitemia on rice production, found no significant effect.[15]

**The Malaria Gap**

Macroeconomic analyses indicate that malaria inhibits long-term growth and development to a degree that previously was unimagined. There are at least three potential explanations for the magnitude of this effect and for the discrepancy between these results and those of microeconomic studies. First, although our hypothesis states that malaria causes poverty, causation runs in the other direction as well. Many countries are too poor to afford the kinds of malaria interventions that enabled such wealthier countries as the United States and Italy to eliminate transmission of this infection from within their borders. The causal effect of malaria on poverty cannot readily be isolated from the effect of poverty on malaria. A second econometric problem lies in the effect of such confounding factors as climate that may drive both poverty and malaria. A third explanation for the gap lies with a failure of traditional microeconomic methods to incorporate broad costs of the disease.

The cost-of illness, WTP, and production-function methods for microeconomic analysis provide a broad range of estimates for the economic costs of malaria. Leaving aside fundamental data problems, each of these methods of analysis focus only on certain costs of the illness. The COI approach may miss costs that are not easily estimated numerically. The WTP approach incorporates household costs exclusively. The production-function approach makes no attempt to include direct costs of the disease. There are, moreover, other costs that malaria may impose that could represent a significant burden at a national level, which would not be captured by any conventional microeconomic analyses.

The COI methodology evolved in the developed world to evaluate the costs of a range of illnesses such as circulatory or respiratory diseases. These diseases tend to affect only a small segment of the population at any point in time. In much of sub-Saharan Africa, however, malaria represents not merely an illness, but a pandemic. The ubiquity of malaria in some regions leads not only to excessive costs for prevention and treatment and a loss of labor, but also to modifications of social and economic behavior that profoundly affect economic growth and development. Standard measures of direct and indirect costs generally used to classify the economic burden of disease are simply not designed to capture the full range of these impacts.

Some of the costs deriving from the ubiquitous nature of malaria are such that they are external to individual households. In such a situation, the very existence of malaria in a community imposes a cost on the entire community by modifying social and economic decisions taken in response to the perceived risk of infection. It has been widely observed in the descriptive literature that decision making in such diverse areas as crop choice, trade, investment, and fertility is affected by the risk of acquiring malaria, with a potentially sizeable negative effect on economic productivity and growth. Standard household-based studies naturally fail to capture these effects.

One example of such a cost is the effect that fear of malaria may have on discouraging foreign trade and investment. International corporations that seek to extract natural resources may be willing to invest in intensive anti-malaria measures to protect their workers from infection because the value of the natural resources that they extract would justify the cost. In Zambia, for example,

such investments by mining corporations greatly increased in-migration of labor and the output from copper mines. Indeed, it has been suggested that “effective malaria control was a principle driving force behind Northern Rhodesian economic development.”[16] To encourage investment in the kinds of manufacturing industries that have formed the basis of growth in many newly industrializing countries, however, it is necessary to provide an environment that can compete with other such opportunities. Malariaendemic sites are inimical to foreign experts and their families. In such a market, investors are less likely to invest in a region requiring costly health interventions when they can choose instead to invest in malaria-free zones. In a rapidly globalizing economy, malaria can prove excessively burdensome in the long run.

Malaria can also affect trade within an economy because visitors to endemic sites generally lack appropriate immunity, and this may inhibit local traders from travel within and between malarious regions. This would limit the development of markets that form the building blocks of economic growth. Tourism, which can constitute a highly profitable industry, would similarly be affected by the perception of malaria risk. One approach to understanding the magnitude of some of these factors is to examine the impact of malaria control strategies on small island economies. For example, the emerging oil economies of the West African islands of Sao Tome, Principe, and Bioko are planning widespread control programs to control intense endemic malaria that could provide an opportunity to examine such macroeconomic impacts.

The risk of acquiring malaria can also affect population mobility. Adult residents of highly endemic sites generally benefit from an acquired non-sterilizing immunity to the malaria parasite that protects them from the intense illness that otherwise would result from this infection. Migrants from non-malarious regions, on the other hand, are exquisitely vulnerable to infection. Acquired partial immunity, moreover, dissipates within a few years in the absence of reinfection, as for example during a period of schooling or a job assignment away from home. The considerable risk of illness or death upon return may depress the extent of short-term migration for schooling or temporary job opportunities in other locations. By limiting the movement of labor to regions where it is most productive, malaria can interfere with skill-matching and generally depress worker productivity.

More fundamentally, malaria profoundly affects the demographic structure of a society. Where this infection is endemic, its mortality burden generally falls most heavily on children less than five years of age. High rates of infant and child mortality slow the pace of a country’s demographic transition, wherein fertility rates decrease in response to a decrease in mortality. A high fertility/high mortality environment can be especially detrimental to a nation’s long-term economic growth. In such an environment, women devote a major part of their productive life to child-rearing activities. Not only does this exclude them from the workforce, it often discourages investment in human capital through education of women because such an investment is less likely to produce economic returns. Such a cost is particularly inefficient when relatively few of the children a family has invested in survive to adulthood.

Malaria can also slow the long-term economic growth process through its impact on the accumulation of human and physical capital. High rates of saving and investments in physical and human capital have formed the engine of growth in many of today’s most advanced and rapidly developing economies. The drain that malaria imposes on family resources through its direct and indirect costs limits the ability of households to save and to invest in physical and financial capital.

Moreover, malaria tends to reduce the funds that might be available for education limits the human capital represented by children.

Human capital accumulation is affected even more directly by malaria through its effects on school attendance and performance. High rates of school absenteeism as a result of this disease increase repetition and dropout rates. An increasing body of research also points toward ways in which malaria in childhood may permanently affect development and cognitive performance.[17–21] Parasitemic children, for example, score lower on certain tests than do non-parasitemic children. The in utero experience of a fetus in a malaria-infected mother may also inhibit the long term cognitive performance of the resulting child

To the extent that malaria contributes to the burden on societies of other illnesses, the entire range of direct and indirect costs that result should be included in the economic calculation. Acute or chronic malaria infection may alter the immune response to certain other infections while also changing the response to vaccines. Malaria is causally associated with hyper-reactive splenomegaly, chronic renal damage, the nephrotic syndrome, and Burkitt's lymphoma. Malaria suppresses appetite and growth in children and infants.[22,23] Acute malaria infection, furthermore, can have chronic health consequences; cerebral malaria appears to cause long-term neurologic damage in many of those who survive. Perhaps most tellingly, endemic malaria has produced such a heavy disease burden through the ages that it has led to a potentially deadly genetic modification causing sickle cell disease in approximately 130,000 African infants each year.

A particularly burdensome consequence of chronic malaria is the anemia that directly results from this infection, particularly in children.[24–26] In adults, such anemia markedly reduces worker productivity.[27,28] In children, malaria-related anemia may be severe and potentially fatal, frequently requiring blood transfusions. Transfusion screening systems remain rudimentary in many sub-Saharan African countries, resulting in the iatrogenic transmission of such blood-borne pathogens as hepatitis B virus, hepatitis C virus, cytomegalovirus, parvovirus, and others. An increasingly deadly consequence is the transmission of human immunodeficiency virus (HIV) through infected blood supplies. Ten to fifteen percent of overall HIV infections and as much as 25% of pediatric infections in sub-Saharan Africa result from blood transfusions, mainly for the treatment of severe malaria and sickle cell anemia.[29,30] Recent studies have also shown that malaria infection in pregnant mothers carrying the HIV virus can increase the rate of transmission to the unborn child.[31] The economic burden of HIV is extremely high, and the role that malaria plays in increasing risk of infection represents a particularly costly consequence in both human and economic terms.

## Conclusion

Economic estimates of the burden imposed by malaria are essential for guiding the effective allocation of resources within tightly constrained health or development budgets. Different methodologic approaches, however, have produced drastically different results, with consequent implications for resource allocation. If indeed macroeconomic estimates of the impact of malaria, which suggest that the disease could account for a reduction of almost half the annual per capita GDP of some countries, are correct, then by economic considerations this disease should receive a much larger share of available resources than is currently devoted toward this end.

Microeconomic estimates, on the other hand, find that the cost is closer to one percent of per capita GDP, with very different implications for resource allocation.

An enormous gap separates the various available estimates of the costs exacted by malaria, with certain research methodologies producing far larger estimates than do others. A careful examination of each approach suggests that the malaria gap could, in fact, convey a critical piece of information. If the studies undertaken using the different approaches successfully answer the question that they set out to explore, then the difference between these estimates most likely reflects a difference in the kinds of costs that each research approach seeks to assess. At the broadest level, this gap suggests that malaria imposes important economic externalities, i.e., costs that are borne not by each individual household, but by the community as a whole. These would include such costs as diminished tourism or foreign direct investment. Another difference between the questions posed by these methodologies is the time horizon of the effects. Microeconomic studies focus on the short-term effect of malaria on households. The magnitude of the impact of malaria on economic growth found by macroeconomic regressions, in contrast, suggests that the accumulation of the effects of malaria on standards of living may be far more serious over the long term. If malaria affects peoples' decisions about schooling and their ability to learn or their decisions to save, this infection could potentially change long-term income streams in a far more remarkable fashion than is indicated by a case by case analysis of costs borne by households.

Although macroeconomic analyses of the cost of malaria cannot identify individual elements in the chain of causation, they do encompass all possible malaria-related causes of poverty, including any that microeconomic analyses might miss. The apparent magnitude of the gap that separates these estimates suggests that certain economic externalities may be vastly more important than are the direct effects of malaria on public health. Our present challenge requires that we verify the magnitude of the economic burden of malaria, understand the channels through which these costs are imposed, and devise anti-malaria interventions that will most effectively contribute to human betterment in malaria-endemic parts of the world.

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