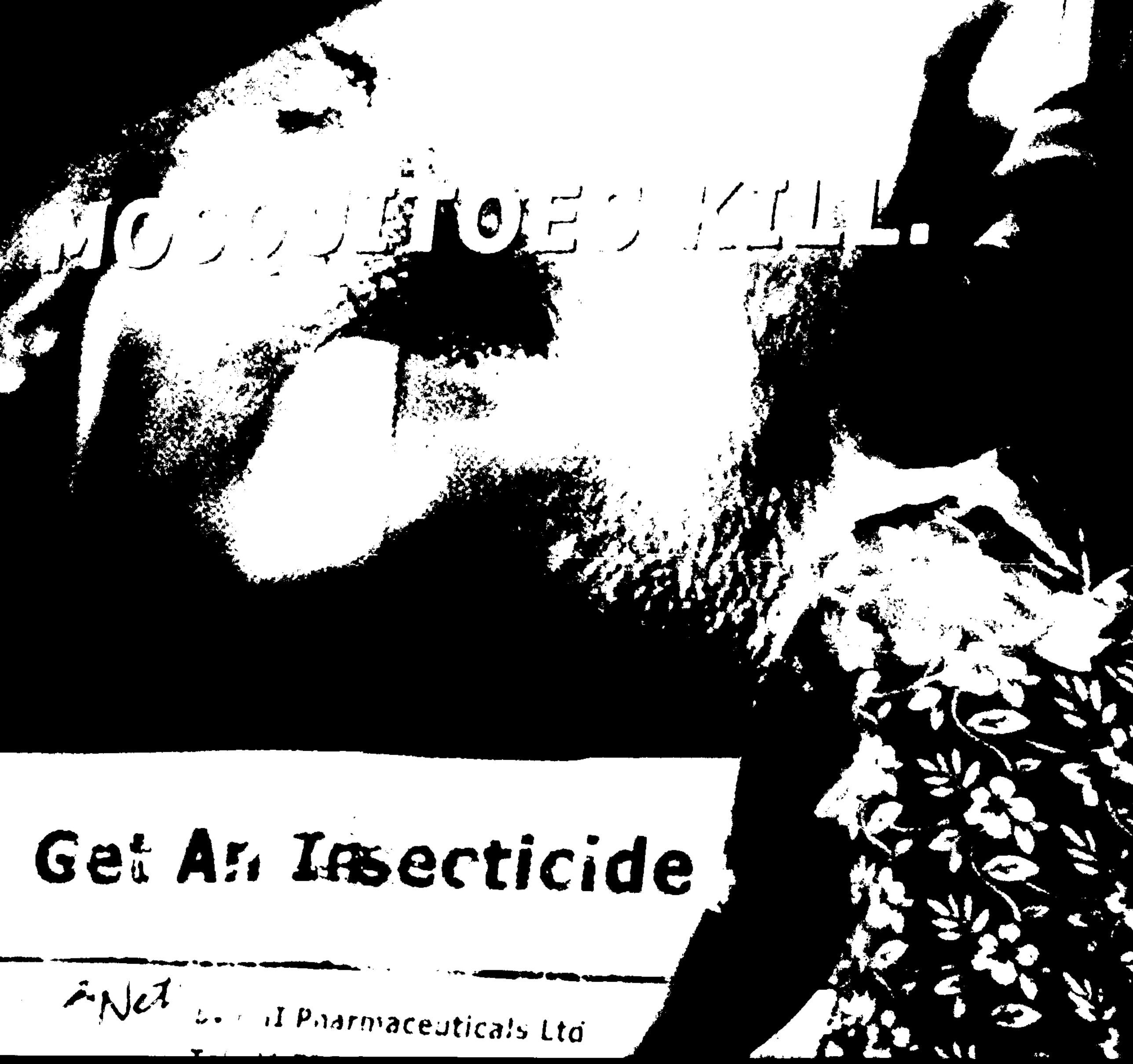

AP/WIDE WORLD PHOTOS

The Burden of Malaria

A SOBERING CALCULATION

By F. Desmond McCarthy, Holger Wolf and Yi Wu

Malaria ranks among the major health and development challenges primarily (but not exclusively) facing developing countries. Endemic in 91 countries that account for 40 percent of the world's population, malaria affects an estimated 300 million people. And though in most cases the disease is treatable, it is responsible for more than one million deaths annually. In sub-Saharan Africa, the most affected region, malaria-related illnesses claim the life of one out of every 20 children below the age of 5. Mortality rates are lower for adults, but frequent debilitating attacks reduce the quality of life for chronic sufferers.

Putting a dollar figure on the human cost of this terrible disease is very hard. But it is possible to calculate the far smaller tangible costs associated with reduced productivity in the countries affected. And these estimates, in turn, offer a sense of just how valuable a vaccine (or other measures for eradicating malaria) would be. Our back-of-the-envelope calculations imply that the cost of delaying the eradication of the disease by even a few years could run to tens of billions of dollars.

THE DISEASE

Malaria is a parasitic disease transmitted by anopheles mosquitoes. Risk of infection is partly driven by factors outside individual control, such as the fraction of the mosquito population that carries the parasite, the life expectancy of the mosquito relative to the parasite's incubation period, and average ambient temperature. Individual risk can be reduced, however, through a variety of measures – for example, using bed netting (most mosquito bites occur between sunset and sunrise) and staying two miles (the insect's range) from mosquito breeding grounds.

The fact that infection risk depends on both environmental conditions and behavioral responses translates into a wide variation in exposure from place to place. The average number of infective bites per person per year ranges from zero in nontropical areas to the low single digits in the subtropics, but the number jumps to between 40 and more than 100 bites in some tropical areas. Among regions, sub-Saharan Africa suffers the highest exposure rates, followed by parts of Asia and Latin America.

Over time the human immune system adjusts to the parasite, resulting in fairly low adult mortality in endemic areas. Mortality is concentrated among (a) children between the age of six months (the age at which immunity endowed by the mother wanes) and five years (the age at which children develop their own immunity), (b) travelers and migrants from nonmalarial regions, (c) populations in previously nonmalarial regions undergoing climate change and (d) populations with repressed immune systems, including pregnant women and people with HIV.

A typical bout of malaria lasts about 10 to 14 days, with four to six days of incapacitation and recuperation periods of four to eight days characterized by fatigue and weakness. Mild malaria usually leads to one or two episodes of fever per year, coupled with headache, nausea, fatigue and diarrhea, with relatively few side effects between episodes. Severe malaria results in impaired consciousness, weakness, jaundice and, in some cases, death.

COMBATING MALARIA

The human and economic costs of malaria have been recognized for centuries. The discovery of the transmission mechanism in the late 19th century opened the way to systematic anti-malarial efforts. Attempts at defeating malaria have followed four distinct routes: reducing the mosquito population, minimizing the number of infective bites for a given mosquito population, developing anti-malarial drugs and developing an effective vaccine.

Early post-World War II efforts focused on eradicating mosquitoes. Widespread use of DDT coupled with the coating and draining of breeding grounds resulted in a substantial reduction in malaria morbidity in the subtropics, notably southern Europe and parts of Asia (Malaysia, Singapore) from 1940 to the late 1960s. This fueled optimism that malaria could be rapidly eradicated.

Alas, these successes did not extend to areas with higher incidence, notably sub-

DESMOND MCCARTHY is a consultant to the World Bank. **HOLGER WOLF** and **YI WU** teach at Georgetown University. This paper draws from their World Bank working paper, "The Growth Effects of Malaria." The views expressed herein are not necessarily those of the World Bank.

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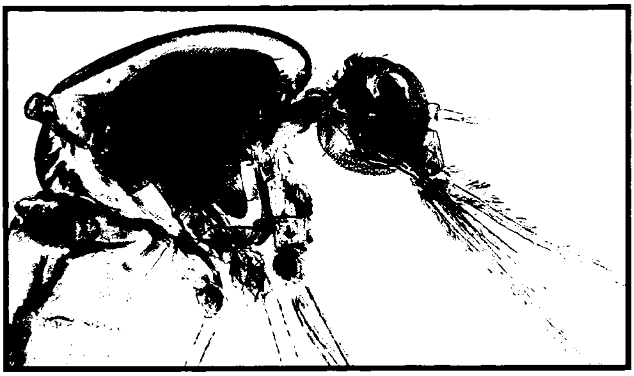

Saharan Africa. And as the environmental side effects became better understood in the late 1960s, they were largely terminated. Subsequent efforts focused on the reduction of human exposure to mosquitos – notably through the use of insecticide-impregnated bed nets and reduction of local breeding grounds.

Better medical treatment provides the second pillar of current anti-malarial efforts. Progress on the medical side has been problematic, however. Effective anti-malarials capable of eliminating parasites in the blood (though not in the liver) have been developed. Most are both effective and relatively cheap ($1 to $5 per bout). However, the disease has not stood still. Premature termination of treatment cycles by patients and partial mosquito eradication efforts have allowed the parasite and the mosquito to evolve, leading to greater resistance to commonly used drugs and insecticides.

There are grounds for optimism that the behavior- and treatment-focused pillars will soon be complemented by vaccines. Currently, active programs include the World Health Organization's Medicines for Malaria Venture (a joint public-private initiative that aims to develop anti-malarial drugs), the Malaria Vaccine Initiative (financed by the Bill & Melinda Gates Foundation with the objective of accelerating the clinical development of candidates), and the P. Falciparum Genome Sequencing Consortium of the Sanger Center, the Institute for Genomic Research/Naval Medical Research Institute, and Stanford University.

WHERE WE STAND TODAY

In much of the world, the threat from malaria has faded: outside sub-Saharan Africa and some areas in Asia and Latin America, mortality rates have plummeted to near zero. But the parasite's foothold in the tropical parts of Africa was barely disturbed in the first half of the 20th century, with mortality declining only moderately before rebounding in recent decades. In some countries, one-quarter of the population is thought to be infected.

Equally worrisome, the sustainability of the decline outside sub-Saharan Africa is now in question. While medical advances, notably an effective vaccine, promise further reductions, climate changes combined with the increasing mobility of both mosquito and human populations threatens to increase the susceptible area. "Airport malaria," the infection of individuals living close to airports, is perhaps the best known instance of the mobility effect, though the number of cases is thus far small.

MALARIA AND DEVELOPMENT

In the last few years, the links between disease and economic development have attracted increased research attention from, among others, a group of researchers around Jeffrey Sachs at Columbia University. These linkages are two-directional.

An important link runs from development to improved health. Economic development is likely to reduce the incidence of a variety of easily preventable diseases by funding public investment in sanitation and public health care, and by giving households the resources to invest in preventive measures and to obtain medical treatment. Poorer countries also tend to suffer from a relatively higher incidence of conflict, economic crises and administrative disorganization, which disrupt health services.

A second causal chain runs into the opposite direction: reductions in malaria increase productivity, creating a positive feedback effect. How important are these linkages? On the most direct level, malaria incapacitates part of the labor force. This loss of labor input has been the primary focus of the classic studies of malaria's economic impact dating to before World War II, and the approach has been refined in several careful case studies since.

The estimates suggest that attacks entail a loss of four or more working days, followed by additional days with reduced work capacity. The output effect of the lost work time depends both on the degree to which other family members can temporarily fill in and on the overlap between malaria episodes and harvest periods when labor is most productive. A second effect operates longer term: malaria is a major cause of school absenteeism. Furthermore, malaria appears to impair learning capacity, reducing the accumulation of human capital.

The incapacitation of the labor force in turn affects the attractiveness of a locality as an investment site, leading to reduced capital accumulation. Endemic malaria also reduces the growth potential for some industries – notably tourism – and sharply raises the cost of infrastructure projects and other collective enterprises.

Indeed, early anti-malaria measures in Panama were partly motivated by the need to protect workers building the canal. Malaria has also been cited as a major obstacle in building the trans-Amazonian highway, as well as major dams and tourism projects.

These direct effects on labor and capital are augmented by a range of indirect effects on productivity. Frequent absenteeism reduces the efficiency of the informal networks organized around work activities, requiring greater redundancy and reducing the scope for specialization.

Malaria-motivated limits on mobility (both domestic and international) make it more difficult to match skills to work demands. Changes in planting patterns to minimize the overlap between malaria episodes and peak agricultural work times reduce agricultural productivity.

Areas with high malaria incidence may thus experience lower trend growth. While the simple correlation between growth rates and malaria incidence does not establish causal direction, the presence of a linkage is evident. As the table shows, the third of countries with the highest malaria morbidity rates has the lowest median GDP per capita, the

lowest growth rate, the lowest investment rate and the lowest school enrollment ratios.

While the individual costs of malaria in terms of days of work lost and treatment costs can be measured fairly accurately, estimating the aggregate economic costs is more difficult, as it requires assessing indirect costs – education never received, tourism and infrastructure forgone, industrial specialization patterns never pursued. They can, however, be indirectly captured in cross-country studies. If malaria exerts an adverse effect on growth, one would expect to find an explanatory role for malaria in statistical analyses that estimate the impact of various factors affecting growth.

Jeffrey Sachs and his colleagues have pursued this approach. Their measure of malaria is an exposure index, defined as the fraction of the population at risk multiplied by the fraction of malaria cases of the most serious type. Their results reveal both a significant negative correlation between malaria exposure and income per person, and a significant positive association between declines in malaria exposure from 1965 to 1994 and the 1965–1990 per capita growth rate. They estimate that malaria may reduce growth by more than 1 percentage point a year.

GROWTH DETERMINANTS FOR COUNTRIES WITH LOW, MEDIUM AND HIGH MALARIA MORBIDITY

	Low	Medium	High
Malaria morbidity (per 100,000)	30	574	6,697
GDP per capita (Start of Period)	3,595	2,193	1,267
Average GDP p.c. growth rate (5Y)	1.45	1.51	0.22
Investment ratio	22.7	20.0	18.3
Primary school enrollment index	104	99	76
Secondary enrollment index	49	35	16

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We pursued a related approach, but use World Health Organization data for malaria morbidity. Our estimates suggest that eliminating malaria could increase growth by more than 0.25 percentage points per year for about a quarter of the sample countries. These findings are more conservative than earlier GDP growth loss estimates of between 0.6 percentage points and 1.3 percentage points. But by any absolute measure, the numbers are frightfully high.

COST PER DISABILITY-ADJUSTED-LIFE-YEAR SAVED (IN $)

INTERVENTION	COST PER DALY SAVED	PERCENT INCREASE OF HEALTH BUDGET
Better access to 2nd and 3rd line drugs	$1.4	0.3%
Better compliance with drug therapy	4.0	0.5
Insecticide treatment of existing nets	6.0	3.0
One spraying round per year	22.0	27.0
Chloroquine prophylaxis	43.0	0.2
Distribution and treatment of nets	44.0	24.0

SOURCE: WHO (1999:57). DALY: Disability Adjusted Life Year. The health budget baseline is the public sector health budget for a typical low-income sub-Saharan country.

It is notoriously difficult to put a dollar figure on the "cost" of disease. Illness has many aspects, ranging from the psychological to the economic. If one restricts attention to direct economic effects, though, it is possible to provide a rough estimate of the cost of malaria.

If we take our estimated growth reduction of 0.25 percent and the median income level of the high malaria group of $1,267, the annual cost per individual (in the sense of forgone income growth) comes to $3.17. As long as malaria persists, these annual costs must be added to the previous years' costs, leading to a large cumulative effect. Taking the current trend rate of economic growth – a wretched 0.22 percent – GDP per capita can be expected to grow to $1,339 over 25 years. Raising this growth rate by 0.25 percentage points – the estimated gain from eradicated malaria – would raise the GDP per capita over 25 years to $1,425. While this amounts to only a 6.4 percent income gain, an increase of $86 per person multiplied by a conservative 500 million individuals living in malaria endemic areas implies that the failure to eradicate malaria today means that the GDP of the most affected area will be $43 billion smaller in a quarter-century than it would have been.

These are, of course, very rough calculations abstracting from a range of other factors. But they do provide a sense of the magnitudes involved. Note, too, that this estimate is conservative: increasing the population assumed to live in affected areas or raising the assumed growth cost could lift the forgone output substantially.

Moreover, these cost measures do not include the resources spent on combating malaria. Anne Mills has estimated these costs at more than 1 percent of income in six sub-Saharan countries. Were these resources instead to be devoted to human and physical capital accumulation, the growth effect would be further enlarged.

COPING WITH CATASTROPHE

Over the course of the 20th century, humankind succeeded in beating back a number of previously pervasive diseases. The success in combating malaria has to date been more mixed, with near complete success in some areas, but slow progress in others – in particular, those climatically best suited to the transmission of the disease.

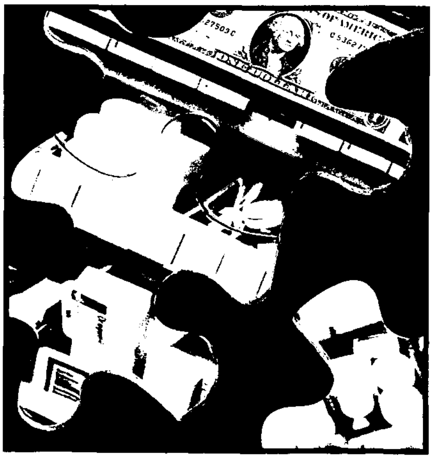
The not-impossible dream of virtually eliminating malaria lies in finding effective vaccines. The figures reported above establish that even on the most narrow economic cost calculations, the payoff to a vaccine would be astronomically high.

Drug Distribution

Putting the Pieces Together

BY LAWTON BURNS
AND PATRICIA DANZON

This selection from *The Health Care Value Chain** is more technical than most book excerpts published in the *Milken Institute Review.* The authors, Lawton Burns and Patricia Danzon of the University of Pennsylvania's Wharton School, are specialists in health care economics and management, and have assembled detailed portraits of how the business works. The point of excerpting their nuts-and-bolts analysis of the complex relationships between pharmaceutical makers and their biggest clients is to give readers an idea of the forces driving supply, demand and innovation in the $100 billion-plus market for drugs. With medical technology and medical care changing rapidly, the capacity of workaday institutions to support the rapid diffusion of life-saving technologies is becoming increasingly problematic.



— *Peter Passell*

MICHAEL SIPE

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