INDUSTRIAL ANTI-MALARIA POLICIES

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INDUSTRIAL ANTI-MALARIA POLICIES ................................................................. 1

I. Recommendations – Anti-malaria Best Practices .............................................. 3

II. Introduction ........................................................................................................ 4

III. Traditional anti-malaria activities ....................................................................... 6

IV. Public service activities of industry in malaria-endemic countries .................. 7

V. Public-private collaborations ............................................................................... 9

VI. Economic burden ............................................................................................. 14

VII. Regulatory issues ........................................................................................... 19

VIII. Industrial interventions against malaria ....................................................... 22

IX. References ........................................................................................................ 29
I. Recommendations – Anti-malaria Best Practices

Industrial operations in malaria-endemic regions require a cogent plan for anti-malaria interventions.

Industrial anti-malaria interventions should conform to certain “Best Practice” guidelines, based on substantiated epidemiological evidence. Risk of infection of the residents of the region must be minimised, and non-immune visitors should be protected totally. The quality of the general environment in the vicinity of the industrial operation must be preserved and improved, as appropriate. An integrated program of anti-malaria interventions directed at appropriate components of the transmission cycle is critical. The program must be well administered, and the worker community must be educated in various facets of malariology and recruited into the anti-malaria effort.

With few exceptions, the level of funding allocated by industry for anti-malaria programs appears inadequate for the required health goals. Companies practice a false economy if they operate in malaria-endemic regions without comprehensive anti-malaria programmes.

A compelling business rationale requires companies operating in malarious regions to have programs that:

- Protect locally resident employees against malaria infection. Such programmes preserve worker productivity, reduce health-care costs, limit insurance costs and increase the companies’ ability to compete for workers of the best quality.

- Protect workers’ dependants. The business case rests on the worker absenteeism that results from caring for a sick dependent. In addition, programmatic effectiveness increases where worker families receive effective health care. Lastly, given the burden of malaria mortality on children, we believe that the responsibility is compelling ethically compelling.

- Protect nationals residing near the industrial operation. The concept of ‘local license to operate’ mandates corporate responsibility to protect the health of communities located close to sites of industrial activity.

- Protect expatriate employees to the greatest extent possible. Because expatriates lack anti-malaria immunity they are far more vulnerable to severe morbidity and mortality than are long-term residents of malaria-endemic sites. The health-care costs for expatriates, including the cost of evacuation and treatment, are particularly great. Liability, health and life insurance for such employees are also costly, but can be reduced by demonstrating effective protective measures.
• Protect the families of expatriate employees. Health-care and evacuation costs, medical and life insurance and liability provisions are required. Family anxiety is a particular concern because it impedes worker recruitment.

When a company becomes involved in a developing country, it assumes certain obligations to the host country, a requirement recognised in ethical investment terminology as “earning a local license to operate.” Regulatory processes may influence the nature of the formal or legal obligation. Beyond these negotiated commitments, companies have a responsibility not only to avoid damaging neighboring communities but to confer benefit on them to the greatest extent feasible. Indirectly, economic improvement in the host country will provide mutual benefit both to the company and the region in which it operates. Productivity of the work force will improve, and the company and the citizenry will come to share aspirations. Directly, meaningful philanthropic contributions to the host country contribute to the image of the company and potentially to its ability to market its product. Voluntary company-financed anti-malaria interventions can assist in building these important indirect relationships and advantages.

Successful anti-malaria interventions inadvertently reduce the immunity inherent in a community, thereby creating tension between a company engaged in a malaria-endemic region and the host-country. An extractive industry that withdraws after the resource becomes depleted, for example, may then terminate any anti-malaria programs that they had been conducting. The residents of the region, however, will then have become more vulnerable to the return of malaria.

Various kinds of industrial activities tend to promote risk of malaria due to deforestation, excavation and human movement. Investors, therefore, should endeavor to prevent environmental changes that might increase human exposure to vector insects and should identify and collaborate with local partners in order to increase sustainability by capacity building.

II. Introduction

Malaria became a special industrial concern at the beginning of the 20th Century soon after Laveran established its etiology and Ross and Grassi its mode of transmission. Before these seminal events, malaria posed an insuperable obstacle to development wherever it was endemic. Curtin’s (1998) recent analysis of 19th Century military activities in Africa demonstrated persuasively that malaria has impeded attempts by non-immune people to visit endemic sites. In a campaign in Benin in 1890, for example, malaria-attributed deaths were 18 times as numerous among European as among African troops in the British army while dysentery-related deaths were about as frequent in both groups of soldiers. Due to this disproportionate effect on visitors, endemic sites remain isolated from the outside world. Industrial activities in the world’s tropics, of course, remain vulnerable to health threats much like those that once immobilized foreign armies. Indeed, the first coordinated health-research activity designed to promote industrial activity in the tropics was stimulated by the malarialogical needs of the Assam tea estates and resulted in the formation of the Ross Institute at the London School of Tropical
Medicine. The impetus for industry to invest in malarious parts of the world is powerful due to the presence of oil and gas, diverse mining resources, unique agriculture products and tourist attractions. Manufacturing in such regions might be attractive because of the ready availability of abundant labour. Were it not for malaria, industrial development in the tropics might be far more intense than is the present level of activity.

Malarious countries generally are poor countries. A “bottom-up” microeconomic analysis of the burden of malaria in Africa indicates that malaria claims about one percent of the gross domestic product (GDP) of affected nations. In 1999, the burden exceeded a billion dollars. In contrast to this rational summing of measurable malaria-related burdens, a “top-down” macroeconomic analysis rests on cross-country regressions. The resulting loss of 1 GDP point of growth exceeds the macroeconomic estimate by an order of magnitude when summed over an appropriate span of time (in this case, 35 years). The difference between these estimates appears to derive from the isolating effects of malaria and implies that industry may avoid investing in malarious communities. The overall economic burden of malaria greatly exceeds the directly measurable “sum of its parts.”

The burden that malaria imposes on industrial development recently began to increase. Drug insusceptibility, which became established in much of the developing world during the 1970s, continues to spread and intensify. The drug that previously was our most satisfactory asset, chloroquine, has already lost its prophylactic and therapeutic value in much of the world’s tropics. Because the usefulness of the remainder of our armamentarium is deteriorating, drug combinations have been recommended for first-line status for therapeutic regimens where multi-drug resistant malaria exists (RBM 2001). Industry, therefore, has lost its most convenient measure for protecting non-immune people against infection, and case management increasingly is becoming difficult. Industry’s need for appropriate and effective anti-malaria doctrines promises to increase as the 21st Century progresses.

Malaria directly burdens industrial activities mainly by endangering the lives of non-immune employees. Protection of skilled expatriate workers employed in malarious sites is becoming increasingly difficult, and the problem becomes particularly acute if such workers are to be accompanied by their families. National employees may require similar levels of protection, particularly if they previously had been residents of non-endemic sites. Local residents, too, will require long-term protection if they have lost their natural immunity in the course of previous employment. Even the health of local residents, who have not been employed in the development effort, would demand attention. A rationale presented to the United States Congress in support of the worldwide malaria eradication campaign of 1958-1963 argued that malaria in foreign labourers imposed a hidden tax that increased the cost of imported goods. In addition to conventional business-related concerns, industrial operations in malarious regions assume diverse responsibilities.

The rapidly increasing burden that malaria places on industrial activities in endemic regions and the crucial role that industry plays in economic development in malarious parts of the world impels us to review the relationship between malaria and
industry. Toward this end, we shall describe the weight of malaria’s burden on industry and discuss illustrative cost-benefit data. We shall also review existing anti-malaria recommendations generated by industry and shall identify reasonable limits for corporate engagement and responsibility in anti-malaria activities.

III. Traditional anti-malaria activities

The anti-malaria effort that accompanied the construction of the Panama Canal represents the earliest major success in anti-malarial interventions. The earlier French-financed canal-building effort had been abandoned due to the toll taken by malaria among the work-force. Subsequent scientific discoveries prepared Gorgas to develop a malaria doctrine that facilitated the ultimate US-financed success, relying mainly on source-reduction but also quinine-based case-management. As a result, the 86% annual prevalence that was experienced in 1906 was reduced to 18% by 1912. Gorgas’ success demonstrated that industry could operate where malaria is endemic.

The scientific advances of the early 1900s facilitated agricultural investment in the world’s tropics. Hugely profitable rubber plantations were established in Malaya (now Malaysia) and Liberia and tea estates in Assam, each supported by research institutes that attracted many of the best minds of the day. As in the case of the Panama Canal, these industrial efforts generally served a limited work force that was employed in a defined site for a specified period of time. Health benefits generally included other residents of the site.

Before the mid-19th Century, anti-malaria programs focused mainly on environmental management (Utzinger et al. 2001). One copper mining program, implemented in 1929 and continuing for more than two decades in northern Rhodesia (now Zambia), proved to be one of the most effective industrial efforts of the era. An integrated approach was taken, beginning with an entomological survey of the designated region and a detailed study of larval habitats of the main vector mosquitoes. These observations resulted in a strategy that emphasized environmental management and source-reduction. Certain kinds of vegetation were removed, river margins modified, wetlands drained and oil applied to open bodies of water. Most interestingly, screens were fixed to the windows of well-constructed houses and mosquito nets distributed to the less privileged residents of the region. Prophylactic quinine was administered to short-term visitors. This drug, of course remained as the sole effective anti-malaria therapy until the amino-quinolones came into use in mid-century. As a result, the malaria caseload in the region declined by an increment of between 70 and 95% over a period of 3-5 years. Industry could operate even in an intensely malarious and environmentally disturbed site.

The Creole Petroleum Corp registered another early anti-malaria success in Venezuela during the mid-1900s (ref 4). The Company allied itself with the Venezuelan government and undertook a DDT house spraying campaign beginning in 1946. The government provided appropriately trained crews, and the company bore the costs of all materials, equipment and operations. In addition to residual applications of this recently developed insecticide, source-reduction efforts were undertaken. Paris green and oil
were applied to certain breeding sites while others were drained or filled. Although the intervention focused on the town of Caripito, the effort extended to neighbouring communities because introduced infections were seen as the cause of previous failures in attempts to interrupt transmission locally. Mosquito breeding sites were identified using detailed maps of the region specially modified for the purpose and mechanized truck-mounted sprayers for applying this material where mosquitoes were found. Residual insecticides were applied to the inside walls of houses. Malaria cases were reduced by more than half in this work-force of 12,772 people from 362 cases during August of 1946 to 91 in 1947. The intervention was considered to be exceedingly cost-effective. The availability of residual insecticides greatly facilitates industrial anti-malaria interventions.

**Summary comment**

The notable industrial anti-malaria successes of the early 19th Century derived from their close geographical definition and a reliance on well-reasoned source reduction efforts as well as housing improvement. Effective drugs and residual insecticides were not, then, readily available.

**IV. Public service activities of industry in malaria-endemic countries**

Industrial practice in developing countries frequently includes an important element of philanthropy. Although altruistic motivation plays an important part in such anti-malaria activities, these interventions generate good will and ultimately may aid marketing. If well conceived, such gifts will improve the health of the work-force.

Becton Dickinson and Company (B-D) engaged in a model malaria-related activity designed to develop diagnostic devices. The program began in 1988 when the Corporate Vice-President of the Company, Wilson Nolen, encouraged a group of academic scientists to modify a B-D device, the QBC or Quantitative Buffy Coat apparatus, toward this end. He explained that he regarded this activity in the spirit of a public service and indicated that no immediate return on the investment was expected (personal observation). The development effort was successful, and the device proved to be useful (Spielman et al. 1988). Many of these devices were distributed, and some continue to be used. A model atlas of blood parasite morphology was published (Anonymous 1990). The system is more sensitive than is standard microscopy. The test can be performed within five minutes as compared to 30 minutes or more for conventional blood-smear microscopy and does not require specialized personnel. These features are much appreciated by the private-health establishments. The technical requirements of the test and their cost, however, prohibits their use by the public sector, particularly in peripheral health systems. Until the QBC appeared on the market, the century-old practice of microscopy remained as the state of the art. More important than the development of QBC device itself, however, was the creation of an industry in tropical diagnostics. In the light of this advance, dipstick technology was harnessed by numerous academic and industrial concerns. The B-D Company formed a unit devoted to “Tropical Disease Diagnostics” and was first with its “Parasight-F” device in the late 1990s. Other companies soon followed this lead, and the resulting products soon
surpassed the original devices. Although B-D recently downgraded its tropical
diagnostics unit, an industry was born.

The main present drawback of the recently developed rapid diagnostic tests
(RDTs) is their lack of sensitivity at low levels of parasitaemia. The threshold of
detection by these tests is in the range of 40-100 parasites /ml of blood compared to 5-10
by microscopy. The RDTs which costs in the range of 4.60 to $ 2.50 per test are also
more expensive than microscopy. The RDTs, however, are cost effective where multi-
drug resistance mandates reliance on expensive drugs. These costs should decline as the
use of RDTs increases.

Insecticide companies have operated in a similarly low-profit fashion. The British
chemical company, ICI, led in the development of the pyrethroid family of insecticides.
The uniquely sorptive properties of permethrin and deltamethrin, which are the most
prominent of these exceedingly useful compounds, qualifies this unusually safe
insecticide as the prime impregnant for use in bednets and curtains (ITMs). ICON
(lambda-cyhalothrin) soon joined permethrin as an ICI anti-malaria asset. This
insecticide was well adapted for application as a residue to the inside walls of houses. It
soon became a crucial alternative to DDT. ICI then established a unit that was devoted to
the low-cost distribution of this compound. Little profit was sought, at least initially, and
a supply was donated to the World Health Organization for use against malaria. Other
companies that joined in this near-philanthropy include Aventis, the manufacturer of
bendiocarb and Bayer, the manufacturer of propoxur. These residual chemicals are
distributed for anti-malaria use at a price designed for markets in developing countries.
The new generation of insecticides, however, remains unaffordable in many endemic
countries and fails to provide effective anti-vector interventions.

Early diagnosis and treatment is a key element in the Global Malaria Control
Strategy adopted in 1993 by the World Health Assembly. The emergence and rapid
dissemination of resistance to the commonly used anti-malarial drugs by Plasmodium
falciparum challenges the effectiveness of case management. Although parasite
insusceptibility to chloroquine compromises the usefulness of this drug virtually
everywhere, insusceptibility to sulfadoxine/pyrimethamine is a particular problem in
Southeast Asia, South America and in a number of African countries. Mefloquine
insusceptibility is present in much of Thailand, Myanmar and Cambodia. The new
generation of anti-malaria drugs is too expensive for use by the residents of endemic
countries, and the international community urgently needs modalities for developing and
distributing these drugs free of charge.

Anthelminthics have similarly been distributed in developing countries gratis or at
a heavily discounted price. Ivermectin is the first and the best known of these drugs.
The North American company, Merck, donates this essential drug to the multilateral
Onchocerciasis Control Programme, and GSK distributes albendazole at no cost. Both
drugs produce an indirect effect on malaria by a collateral effect on hookworm infection
and hence reduce the intensity of anemia.
The market for goods directed towards tropical health remains limited, a circumstance that severely limits profitability. In an attempt to explore measures that might alleviate this marketing problem, a system for guaranteeing markets for anti-malaria vaccines was developed by Michael R. Kremer at the Center for International Development at Harvard University. USAID has established a similar five-year public-private programme designed to stimulate development of a commercial market for insecticide treated materials (ITMs) in selected African countries. Public moneys should be used in this indirect fashion to stimulate industrial research and development.

**Summary comment**

Where no market for their product exists, various industries have engaged in philanthropic activities that have facilitated important improvements in anti-malaria interventions. Their diagnostic, drug and insecticidal products constitute important anti-malaria assets. Required are strategies that promise to develop markets for sustaining and increasing the distribution of these products beyond the volume that would result from altruistic motivation. Philanthropic activities may not be sustainable.

V. Public-private collaborations

Various industrial concerns operating in malaria-endemic regions have established diverse collaborative links with national and multinational agencies. Such public-private interactions are designed to promote the health of the general population of a region as well as the work force employed by the company. RBM concepts form the central element in these collaborations.

A. Eni in Azerbaijan

Following the break-up of the Soviet Union, the malaria situation in Azerbaijan deteriorated sharply. More than 13,000 cases were recorded countrywide in 1996 following a low of 22 in 1990. The Ministry of Health then invited a number of potential partners to develop a coordinated intersectoral anti-malaria strategy for the country. Some 1.5 million people living in 40 districts were affected.

Eni, an Italian oil and natural gas company with interests in the region, became one of the major partners of a well-coordinated intersectoral plan of work designed to reverse the increasing trend of malaria in Azerbaijan. Eni worked closely with the Ministry of Health and other partners, beginning in 1996. It has donated USD $760,000 to support anti-malaria efforts there from 1999 to 2001 through the provision of drugs, insecticides, spraying equipment and the training of health workers in the management and implementation of appropriate activities. The Roll Back Malaria Programme (RBM) of the WHO and its partners joined in this effort along with the International Federation of Red Cross and Red Crescent Societies, Medicines Sans Frontiers Belgium, UNICEF and various other UN agencies. This public-private partnership resulted in a marked reduction in the frequency of malaria cases.
Their success in Azerbaijan encouraged Eni to participate in anti-malaria efforts in another of its operating regions, Bayelsa State in Nigeria. The Company volunteered to operate within the framework of the country’s strategic plan of activities. A memorandum of understanding for ENI’s participation is being finalised, and the programme is expected to start soon.

**B. Exxon Mobil in Africa**

Exxon Mobil Corporation is engaged in a number of African countries in the exploration and production of oil and natural gas. Many of the regions in which the Company operates are endemic for malaria and impose a considerable threat on expatriate and local immigrant employees. The company provides preventive and clinical care to its workers. Exxon’s anti-malaria program is designed mainly for its “upstream” exploration and drilling activities, and not for such “downstream” activities as marketing.

In 2001, Exxon Mobil became an active member of the RBM partnership in anti-malaria interventions in five African countries, including Angola, Chad, Cameroon, Nigeria and Equatorial Guinea. The corporation is presently working with the governments of each of these countries and other partners to define its role within each country’s strategic plan of anti-malaria action. Each program is the outcome of collaborative discussions with a number of partners, including Non-Governmental Organizations and is led by the ministries of health of the countries involved.

Exxon Mobil’s support is based on an assessment of local health status and needs and is guided by strategic health plans. In Angola, the initial commitment is to focus on planning and building organisational capacity and upgrading laboratory and diagnostic facilities. In Cameroon and Chad, the plan is based on a comprehensive programme of insecticide treated nets that includes education and training of health workers and participating community leaders; organisation of information campaign to sensitise communities; techniques for treatment of nets with insecticides; purchase and distribution of nets and development of evaluation tools to measure the impact of the programme’s effectiveness. In Equatorial Guinea, the involvement of Exxon Mobil includes construction of diagnostic and treatment centres and the purchase of mosquito nets as well as their distribution to local communities. In Nigeria, the Corporation, in collaboration with the New Nigerian Foundation, seeks to launch a community health services program in nine Niger Delta States. Thereby, Exxon Mobil hopes to enhance malaria diagnosis and treatment and training of health workers.

Exxon Mobil is also supporting research in the discovery and production of antimalarial drugs through the Medicine for Malaria Venture (MMV, a public private partnership) and the Harvard Malaria Initiative at the School of Public Health, Harvard University. The Corporation donated USD $300,000 to MMV and USD $1.3 million to the Harvard Malaria Initiative.
C. Mozal Aluminium Smelter in Mozambique

The Mozal Aluminium Processing plant is located in a malaria endemic site in the Maputo suburbs. The plant is a joint venture, uniting BHP-Billiton, an Australian based company, Mitsubishi and the government of Mozambique. Risk of malaria infection in the site is unusually great, resulting in unacceptably heavy morbidity and mortality. To safeguard its local and expatriate workers as well as the local residents, Mozal entered into partnership with the national malaria control programs of Mozambique and South Africa. Ameliorative measures included efforts to reduce transmission by means of indoor residual spraying with insecticides and early recognition and treatment of cases. The Medical Research Council of South Africa assumed overall responsibility for coordinating and implementing the anti-malaria effort.

D. Novartis

The rapid emergence and progressive loss of drug-susceptibility by *Plasmodium falciparum* crucially challenges the effectiveness of the “Global strategy for malaria control” that has been adapted by the RBM partnership. The elements of the strategy include: (a) early diagnosis and prompt treatment; (b) preventive measures (ITMs, intermitent presumptive treatment of pregnant women, environmental management and indoor residual spraying), (c) early detection and containment of epidemics and (d) strengthening basic and applied research. Decisions to employ these tactics will be evidence-based and will rely on sectoral and intersectoral coordination. WHO recognized the potential value of “combination-chemotherapy,” using combinations of drugs in place of traditional mono-therapy as an option for improving treatment efficacy and perhaps for delaying development of drug-insusceptible populations of malaria parasites.

Novartis has developed an artemisinin-based combination anti-malarial drug that is effective against multi-drug resistant *P. falciparum*. This co-formulation of artemether and lumefantrine is available as a fixed formulation, thereby increasing the likelihood that patients will comply with the full drug regimen. The drug is available as Coartem and as Riamet (identical formulations except for packaging) and is intended for markets in malaria endemic-countries and for developed economies respectively.

Novartis has made an agreement with WHO to make Coartem available at cost in developing countries. The Company intends to sell Coartem to WHO at USD $ 2.4 for a 24-tablet pack, which provides the 6-dose adult regimen of treatment. This compares with USD $40 for the price of the same drug, branded as RIAMET, in developed countries. The stated objective of this generous arrangement is to support endemic countries affected by multi-drug resistant malaria. More than 30 malaria endemic countries will benefit from the Novartis-WHO partnership.

E. Medicines for Malaria Venture (MMV)

Because of malaria’s wide-spread loss of susceptibility to many of the more useful anti-malarial drugs and the absence of a vaccine in the foreseeable future, new,
more affordable drugs are urgently needed. Toward this end, the Medicines for Malaria Venture was established as a public/private sector partnership, with the objective of bridging the gap caused by the shortage of effective anti-malarial drugs. MMV’s mission is to discover, develop and facilitate marketing of anti-malarial drugs at prices that are affordable to the people most affected by the disease at the rate of one new product every five years. To fulfil its goal, MMV will raise the necessary capital and apply these funds to a particularly promising drug discovery projects with in-kind support of a substantial nature from the pharmaceutical industry. Several projects are being conducted in collaboration with major pharmaceutical companies. Its partners include the World Health Organization (RBM and TDR), the International Federation of Pharmaceutical Manufacturers Associations (IFPMA), the World Bank, the Rockefeller Foundation, the Global Forum for Health Research, Exxon Mobil and a number of international donor agencies.

F. Global Collaboration for Development of Pesticides for Public Health (GCDPP)

The Global Collaboration for the Development of Pesticides for Public Health (GCDPP), a private/public sector partnership, serves as an advisory group to the WHO Pesticide Evaluation Scheme (WHOPES) on issues related to the development of safe and proper use of pesticides and application equipment for public health. The members of the group include pesticide industry representatives, national and government supported agencies, international organisations and research institutes. This initiative, which has the same objective as that of MMV, remains at an early stage of development. The GCDPP also seeks to collaborate with other public sector and commercial partners to build local capacity for more rational anti-vector interventions and the judicious use of pesticides. Additional details concerning WHOPES can be found on the WHO website at http://www.who.int/ctd/whopes

G. Improved access to anti-malarial drugs

A working group of the World Health Organization and the International Federation of Pharmaceutical Manufacturers Association (IFPMA) has produced a joint action paper on improving access to essential drugs in developing countries. The group undertook a situation analysis on access to anti-malarial drugs in a number of African countries including Ghana, Tanzania and Zambia. Subsequent country visits indicated the need for collaboration between the public and the private sectors for improving the quality of surveillance, public awareness and education in the rational use of anti-malarials, as well as user-friendly packaging and technical support for locally-based industry.

H. Public-private partnership for increasing bednet distribution

Anti-malaria measures, which effectively reduce malaria-attributed morbidity and mortality in the general population of endemic regions may also benefit industrial operations. Insecticide treated bednets and other ITMs, for example, have been adopted
by industry in collaboration with multilateral organizations for protecting indigenous people employed in many malaria-endemic regions. Rigorous WHO-conducted epidemiological studies on African children indicate that ITMs reduced overall incidence of mild malaria by 48%; severe malaria by 45% and mortality by as much as 23%. ITMs, therefore, are effective in many epidemiological settings. To render the manufacture and distribution of these materials profitable, USAID has established a five-year public-private program known as NetMark (http://www.netmarkafrica.org) designed to stimulate development of a commercial market for ITMs in selected African countries.

Diverse strategies now seek to encourage large-scale use of such ITNs in East Africa. In western and coastal parts of Kenya, Glaxo Wellcome has joined with the African Medical and Research Foundation (AMREF), the Kenyan Government, the UK aid agency, DfID, and with 14 local companies to make bednets available to the residents of selected communities. Toward this end, payroll-purchasing schemes were established and community bednet-sewing facilities organised. The companies involved in the initiative employ an average of 10,000 people and include a cement factory, a mining company, a hotel chain and several sugar cane plantations. The impact of the availability and extensive use of the insecticide treated nets was immediate. Malaria episodes in the communities involved diminished by as much as two-thirds, and significant savings in health care costs resulted.

Similar industrial collaborations are being conducted in Zimbabwe by a local bednet manufacturer, working with the management of a cotton plantation that is responsible for more than 10,000 people, including the work-force and their families.

The need to re-impregnate bednets semi-annually now constitutes the single most important obstacle to the successful deployment of ITMs. To resolve this difficulty, a Danish company has developed and is manufacturing long-lasting insecticide treated materials (ITMs). The insecticide is incorporated into the net at the time of manufacture and is released slowly over a period of many months.

I. Combating malaria epidemics in Burundi through partnership

The unusually heavy rainfalls in Burundi, which lasted for several months during 2001, brought about massive epidemics throughout the high land areas of the country. A total of 17 provinces were affected. The epidemics affected all age groups resulting in significant number of cases and deaths. The epidemic, which lasted from October 2000 to April 2001, was responsible for a total of 3,178,348 clinical cases of malaria.

The government collaborated with a number of humanitarian agencies including the Red Cross Associations, Christian Aid, Concern and MSF mobilised human and material resources to combat the epidemics. RBM provided anti-malarial drugs and technical support. The problem of arresting the epidemics was further complicated by the widespread distribution of chloroquine insusceptibility and reduced efficacy of sulfadoxine/pyrimethamine (fansidar) in the region.
Medecins Sans Frontieres (MSF), which led in containing malaria outbreaks on the ground, committed itself to purchase coartem, at the favourable price of USD $1 million from Novartis through WHO.

J. Assessing the quality of anti-malarial drugs

Diverse substandard and counterfeit drugs have been aggressively infused into the market in Africa. This development is of serious concern in many endemic countries where people generally self-treat using drugs purchased on the open market. Many of these countries lack the infrastructure required for quality assurance of imported drugs.

The German Pharma Health Fund (GPHF) donated a rapid-screening device to a number of countries including Gabon, Ghana, Kenya, Mali, Mozambique, Tanzania and Sudan, with the WHO (RBM, EDM) serving as intermediary. This device, known as “Mini-Lab” is intended for use by regulatory authorities to conduct on-the-spot quality evaluations. The objective of the survey is to determine how frequently poor-quality anti-malarials are distributed in the region and to verify the reliability of this rapid screening method. The Center for Quality Assurance of Medicines, University of Potchefstroom, South Africa has been identified as the central laboratory where the field findings will be validated.

K. Summary comment

The various public-private collaborations that support particular anti-malaria interventions demonstrate how different partners can synergise to produce an effect that exceeds the “sum of its parts.” Each of the participating partners, thereby, contributes its particular kinds of resource to the larger effort to “roll back malaria,” as appropriate. Such partnerships between industry and bilateral and multilateral organisations and the governments of endemic countries contribute to the profitability of industry as well as to the well-being of the residents of malarious parts of the world.

VI. Economic burden

Malaria can impose a substantial economic burden on firms operating in endemic regions due to direct health care costs as well as opportunity costs due to lost productivity. Anti-malaria interventions, therefore, can result in a direct economic benefit for firms by reducing absenteeism and increasing productivity. Furthermore, they can reduce the pain and suffering of people associated with the firm, thereby making it easier for the operation to attract workers of the highest quality. A net economic benefit may result, although measurement of this indirect benefit is difficult.

The magnitude of the benefit in terms of cost savings can be estimated by weighing the value of incomes foregone as a result of malaria morbidity and the cost of preventive measures and treatments that may be taken. The average cost for industry of malaria morbidity generally is determined using a formula such as the following:
Cost of malaria = number of cases \times \left\{\text{[workdays lost/case} \times \text{average wage]} + \text{[cost of health care/case]}\right\}

Although this general aggregation algorithm underlies many costing exercises, it generally will underestimate the industrial disease-associated costs because highly paid expatriate workers will be far more susceptible to malaria than are locally hired nationals, and the average wage will therefore be inappropriate as a measure of productivity loss. Furthermore, treatment costs can be considerably higher if expatriates require treatment in distant, more-developed health care facilities. It should also be noted that this analysis does not include the costs of productivity losses that occur when an unwell employee attends work. These losses also may be burdensome because many workers will come to work in preference to staying at home.

The costs of malaria mortality are considerably greater than that of morbidity. An economic evaluation of direct mortality-related costs can be derived from an assessment of the present discounted value of future lifetime earnings. The truly burdensome costs in such a situation, of course, would be those that are non-direct. The death of an employee represents a considerable human loss, as well as a long-term economic cost for the firm, for which the cost of drawing skilled labour is likely to increase sharply. The discussion that follows illustrates these costs for a diverse range of industries engaged in various malarious parts of the world.

Cost effectiveness studies on a range of interventions in low-income settings with high malaria transmission find that on average using insecticide treated bednets is equivalent to residual spraying, at USD $44 and USD $43 respectively per Disability Adjusted Life Year (DALY) saved. The range of costs for these interventions, however, is also burdensome. In the case of bednets the cost per DALY averted ranges from USD $19 to USD $85. Once the bednets are purchased, though, retreatment costs average USD $6 per DALY averted. In the case of residual spraying, the costs range from USD $32 to USD $58, with two rounds of spraying per year.

A. Exxon Mobil in Chad and Cameroon

Although few case studies analyse in depth the economics of industrial anti-malaria interventions, several such interventions indicate the likelihood of a considerable net economic benefit. Exxon Mobil, for example, has conducted a comprehensive economic analysis of their current anti-malaria program in Chad and Cameroon. Based on incidence rates faced by the corporation before the intervention was initiated, Exxon Mobil anticipates a loss of 63,000 worker days in the absence of the current intervention, or 16 project days of worker time. The daily cost of the oil pipeline construction project is calculated at USD $2.8 million dollars, of which thirty percent is expended on salary. The income foregone as a result of malaria morbidity therefore approaches USD $13.5 million. With the intervention program, malaria morbidity is expected to cost only 22,000 worker days, or 5.5 project days of worker time. This represents a cost of about USD $4.6 million. The prospective malaria intervention is thus expected to result in a savings of USD $8.9 million simply in terms of the productivity of the workforce. This calculation does not include the savings in health care expenditures that results from the intervention. Such treatment costs are relatively minor for non-severe episodes of
malaria among relatively immune national employees. The cost of a case of cerebral malaria in an expatriate worker would, however, be considerable because Exxon Mobil generally evacuates such people to a health facility in Holland at an estimated cost of about USD $100,000 per case. If the intervention prevents even ten such cases, it represents an additional savings of some million dollars. These savings are far greater than the estimated cost of USD $3 million for the intervention program, suggesting that investing in malaria suppression is extremely cost-effective for an oil company operating where transmission is intense.

B. Creole Petroleum in Venezuela

A less detailed case study, which nevertheless suggests an economic benefit of such intervention programs for industry, is the experience of the Creole Petroleum Corp. in Venezuela. In the bush regions of Venezuela where oil has been discovered, malaria has always been a serious problem. In 1947, the Creole Petroleum Corp., an affiliate of the Standard Oil Company (New Jersey) chose a site in the bush to build a modern town, with water and sanitation systems, schools, stores and recreation facilities. Understanding the potential costs of malaria, they undertook, also, a vector control programme with residual spraying using DDT. At a cost of about USD $11,250, as many as 2,861 houses were treated, containing a minimum of 12,772 occupants. Malaria cases were reduced from 362 in the month of August 1946 to 91 in the month of August 1947. This reduction was due, at least in part, to the vector reduction programme. If the malaria season extended over about four months, the savings would correspond to a reduction of 1,084 cases per year. If this reduction were attributed directly to the intervention, it would imply that the cost of the intervention per case averted was USD $10.40. Although available estimates of health care costs and wages are inadequate for a comprehensive cost-benefit analysis, the minimum wages of a labourer in this plant approaches USD $3,000 a year. Assuming 250 workdays in a year, and a loss of 4 workdays per malaria episode, the minimum cost of lost labour as a result of malaria morbidity would approach USD $48 per episode. If even a third of the cases were amongst working age adults employed by the petroleum company the program would be cost-effective, saving about USD $17,000 a year in productivity losses at a cost of USD $11,250. Incorporating data on wage ranges and health costs would undoubtedly show an even greater productivity benefit and hence net economic benefit from the program.

C. Konkola Copper Mines in Zambia

A more recent example of a cost-effective anti-malaria program is the case of the Konkola copper mines in Zambia. Malaria rates in Zambia have tripled between 1976 and 2000. In the vicinity of Chingola and Chililabombwe, where the mines are located, malaria incidence rates were estimated at between 68/1000 and 158/1000 respectively. A comprehensive malaria program was initiated in 2000 that included indoor residual spraying, environmental controls such as larviciding and knowledge dissemination. Household spraying, the centrepiece of the initiative, cost USD $182,680 for the first year, or USD $6 per house. Fixed costs, such as equipment, vehicles and training accounted for USD $41,700 of this, while the insecticide costs were just at USD
$115,000, or USD $3.70 per house. This economy was realized, in large part, because the vector in this region did not become resistant to DDT, the most inexpensive and effective of insecticides. Resistance to DDT would likely have required the use of pyrethroids or other insecticides, and this would have raised the cost considerably. Although data is available only for the first five months of this program, malaria cases from January to May of 2001 were 57% less than for the same period in the year 2000. An incidence reduction of this magnitude can be expected to result in a reduction of 3,550 cases annually, at a cost of USD $51.50 per case averted in the first year. In subsequent years the costs will be lower as the fixed costs will already have been incurred. If the number of cases averted does not change, the cost per case will decline to some USD $39.70. This compares to a labour cost of about USD $30 per worker per shift, or about USD $60 per episode if each case results in an absence of two days. If about half of malaria cases averted were amongst working adults, productivity savings would be about USD $106,500. Furthermore, the cost of hospitalisation is USD $20 a day in those cases that are severe enough to require such measures. If we assume that, on average, half of those who become sick were hospitalised for two days, the direct treatment costs averted would be USD $71,000, to give a total savings of USD $177,500.

D. Bamburi Cement Plant in Kenya

In the case of the Bamburi cement plant in coastal Kenya the major intervention was a program whereby insecticide treated bednets were distributed to all employees and their families. The cost of bednets is estimated at USD $3.50 per net, plus an additional USD $1 for insecticide treatment annually. This program covered 715 employees and 2400 dependants at an estimated cost of USD $14,000 for the first year and an additional USD $3,200 every year after that for retreatment. Malaria episodes fell from 7800 in 1998 to 1674 in 1999, rising slightly to 2257 in the year 2000. Hospital admissions declined from 229 in 1998 to 148 in 2000 and worker absenteeism declined from 87 days a year to 34 days. Over two years, the program saved 90 days of worker time and 151 hospital admissions for a savings of USD $17,200. The cost per case averted was about USD $2.30 for the first year, and can be expected to decline in subsequent years as the fixed cost of the initial bednet purchase is distributed over time.

E. Freeport McMoRan Mining in Indonesia

The Freeport McMoRan mining company in Indonesia has undertaken a successful malaria control program for its workers. An integrated control program that includes drainage of swamps, larviciding and indoor residual spraying has virtually eliminated malaria from the lowland mining areas controlled by the mine. If the intensity of malaria transmission in this region were at the same level as in the surrounding area, in the absence of an intervention, the 8,000 local workers would experience about 200 – 300 cases of malaria a week, or about 13,000 episodes annually. The cost of the program in this region approaches USD $1.5 million annually, with a cost per case averted of approximately USD $115. The cost of lost productivity is estimated at USD $10 a day, based on an average wage of approximately $250/month or approximately USD $30 to USD $40 a case. Treatment costs are estimated at approximately USD $3 per case. The
cost of malaria to the firm in the absence of the intervention would, therefore, be about USD $500,000 a year. The differential between the direct economic benefits to the company and the costs suggests that there are either indirect or non-economic benefits from the intervention. This is supported by the fact that the company invests not only in malaria suppression in this region, but in a much larger surrounding area, at a total cost said to be about USD $3 million.

F. Mozal Aluminium Smelter in Mozambique

Another recent example of a decisive industrial anti-malaria program is that of the Mozal Aluminium smelter in Mozambique. This USD$1.4 billion joint venture between the Australian based mining and metals company BHP-Billiton PLC, Mitsubishi and the Mozambican government encountered extremely high rates of malaria, with 7,000 episodes in two years and the deaths of 13 expatriate employees. Malaria morbidity resulted in a loss that approaches 155,000 man-hours, or about 1% of the total man-hours of work. If the average wage were USD $20,000 per year, or about USD $80 per day, malaria related lost workdays alone would have cost the firm about USD $1.6 million. Furthermore, about 40 known episodes of severe malaria required medical evacuation, which might have cost another several hundred thousand dollars. Mozal has undertaken a comprehensive anti-malaria initiative, covering both the Mozal site and the surrounding area at a cost of USD $480,000 for the first year, with a reduction to USD $360,000 for the second year with the possibility of further reductions in successive years.

D. Summary comment

The cost of averting a case of malaria varies widely, depending on a number of factors including the specifics of the region, resistance of the vector to insecticides, resistance of the parasite to specific anti-malaria drugs as well as the time horizon of the intervention. Where the vector is susceptible to DDT, insecticide spraying is likely to be less costly than in other sites. Similarly, susceptibility of the parasite to such inexpensive drugs as chloroquine will likely increase the cost-effectiveness of prophylaxis and therapy. Interventions with large fixed costs, such as vector source reduction through environmental modification, are likely to be cost-effective for projects with a long time horizon. The set of interventions selected must be based, in part, on such considerations.

By reducing productivity losses due to worker morbidity, industrial anti-malaria interventions generally produce a net economic benefit. Certain companies, however, may choose to spend far more on such interventions than a simple cost-benefit analysis might justify. The burden of malaria to a firm may exceed that which a straight-forward tally of lost workdays would indicate. To the extent that the total absence of malaria transmission is perceived as a health imperative, firms must calculate the costs of such a rigorous program when investing in a malaria-endemic region. If the costs of an anti-malaria intervention comprise a substantial portion of the overall profit margin, the venture may not be worthwhile. If, however, the intervention represents only a relatively small portion of profits, as seems likely in the case of large industrial projects, the anti-malaria intervention will not burden the investment.
VII. Regulatory issues

Various national and multi-national agencies have generated policy instruments that may limit industrial practices in developing countries. Malaria is an important concern because of the prominence of worker health and environmental protection. These regulations may constrain industrial activities.

A. International Labor Organization

Prominent among policy-instruments that may limit malaria-related industrial activities are the Conventions of the International Labour Organization (ILO). The ILO was established in 1919 to promote adoption of international standards for improved working conditions. The ILO's standards arise from international tripartite agreements that resemble international labour conventions and recommendations. The ILO's conventions are international treaties, subject to ratification by ILO member States. Its recommendations are non-binding instruments that promote guidelines for orienting national policies and actions. The goal is to improve global working conditions and practices.

Various ILO Conventions address occupational safety and health, including working conditions that might promote the transmission of endemic diseases or expose workers to infection. Convention C110, adopted in 1958, addresses the conditions of employment of plantation workers and states explicitly in its Article 91 that: “The appropriate authority, in consultation with the representatives of the employers’ and workers’ organisations concerned, where such exist, shall take steps in plantation areas to eradicate or control prevalent endemic diseases.”

Plantations are defined in this Convention as: “...any agricultural undertaking employing hired workers which is situated in the tropical or subtropical regions and which is mainly concerned with the cultivation or production for commercial purposes of coffee, tea, sugarcane, rubber, bananas, cocoa, coconuts, groundnuts, cotton, tobacco, fibres (sisal, jute and hemp), citrus, palm oil, cinchona or pineapple...”

Only 12 countries (Brazil, Cote d'Ivoire, Cuba, Ecuador, Guatemala, Liberia, Mexico, Nicaragua, Panama, Philippines, Sri Lanka and Uruguay) have ratified this convention since 1958. Two (Brazil and Liberia) have since renounced their earlier ratification.

In 2001, a Safety and Health in Agriculture Convention 184 was drafted that extended the scope of the Plantations Convention to include such activities as “...forestry activities, animal husbandry and insect raising...” as well as “...primary processing of agricultural and animal products.” Under the general topic of preventive and protective measures, Article 7 of this Convention states: “...the employer shall...adopt preventive and protective measures to ensure that under all conditions of their intended use, all agricultural activities, workplaces, machinery, equipment, chemicals, tools and processes under the control of the employer are safe and comply with prescribed safety and health standrds.”
Also drafted in 2001, Recommendation 192 associated with the Safety and Health in Agriculture Convention further states that: “The competent authority...should...prescribe measures for the prevention and control of occupational hazards in agriculture...taking into account the need to protect the general environment from the impact of agricultural activities...” and “...specifying the steps to be taken to prevent or control the risk of work-related endemic diseases for workers in agriculture...”

These relatively specific health obligations of the agricultural industries operating in ratifying countries are joined by the somewhat less specific, but more widely ratified, health provisions found in the 1995 Safety and Health in Mines Convention, and the 1985 Occupational Health Services Convention.

The Safety and Health in Mines Convention covers extractive industries and activities including mineral exploration and extraction (excluding oil and gas) and processing. This Convention recognises the need to “…prevent any fatalities, injuries or ill health affecting workers or members of the public, or damage to the environment arising from mining operations...”. It specifically mentions biological hazards in addition to chemical and physical risks and obligates employers in ratifying nations to: “…ensure that the mine is commissioned, operated, maintained and decommissioned in such a way that workers can perform the work assigned to them without endangering their safety and health or that of other persons.” Ratifying nations include Botswana, Zambia and South Africa.

The 1985 Occupational Health Services Convention applies to all industries and services and requires its ratifiers to ensure that workers are protected “against sickness, disease and injury arising out of his employment...”. Considerable flexibility is allowed in specifying the kind of surveillance and response required to deal with threats to health. In general, this Convention requires employers to undertake an active program of assessment and prevention of Occupational Health threats, which in such industries as those described above, might be interpreted as including malaria.

Enforcement of these conventions is stipulated through a well-defined though cumbersome process that begins with a report of an infraction (a “representation”) by a national or international workers’ or employers’ organization and may lead ultimately to the hearing of charges in an international court. The International Labour Office acknowledges receipt of such a report, informs the government concerned and puts the matter before its Officers of the Governing Body. The Governing Body may then turn the “representation” into an official “complaint”, which then is heard by a commission of inquiry appointed specifically to examine the case. These three “prominent” people convene “quasi-judicial” proceedings that result in a report with recommendations concerning what should be done in response to the complaint. The governments concerned can then either accept these recommendations or refer the complaint to the International Court of Justice for further deliberation. Although the effectiveness of these enforcement policies is not clear, the relatively low level of ratification makes this irrelevant. The Conventions of the ILO, however, provide a useful benchmark of international consensus for the responsibilities of industries in protecting the health of workers and affected communities.
B. United States Agency for International Development

Bilateral agencies may also operate under regulatory constraints. The United States government implemented in 1970 the “22 Code of Federal Regulations Part 216” that required USAID and other federal programs to consider potential environmental consequences prior to making decisions. This legislation was implemented in 1979 by Policy Act and Executive Order 12114. Thereby, “USAID views environmental impact assessment as not just a legal requirement, but as one of the most essential and basic tools for designing sustainable activities.” (J. Hestin, USAID Environmental Coordinator). Under the terms of these rules, Environmental Health Assessments have become an essential precondition for federal investments that may result in environmental change. Such an Assessment would be required in the event that a privately funded project includes commitment of USAID resources.

C. World Bank “Safeguard” rules

Under certain conditions, such multinational institutions as the World Bank may regulate how industry invests in developing countries. This indirect effect is illustrated by Exxon Mobil’s experience in obtaining World Bank financing for their USD $3.5 billion oil-extraction project in Chad and Cameroon during the late 1990’s. When the Exxon Mobil first considered the prospects for developing the landlocked oil fields of southern Chad, the company recognised the requirement to address the imposing socio-economic conditions of the region’s poor as well as environmental quality and public health. Malaria was prominent among these considerations. The Company, therefore, developed a proposal for the project that included the private sector, the governments of Chad and Cameroon, and the World Bank. Exxon Mobil indicated that “The Bank’s decision is an important validation of the project’s environmental and socioeconomic assessment and mitigation plans” (ExxonMobil website). The World Bank’s involvement also was critical to the governments of Chad and Cameroon, because “World Bank involvement will ensure greater public consultation, local participation and attention to environmental and other socio-economic issues” (World Bank website #1). The World Bank’s financial commitment to the project included loans totaling about USD $95 million to the governments of Chad and Cameroon (through the International Bank for Reconstruction and Development) and another $100 million to the pipeline companies (through the International Finance Corporation) (World Bank website #1). For a project to receive World Bank approval, however, the effort must be in compliance with a set of “Safeguard Policies” dealing with the environmental and social issues surrounding the project’s possible implementation. These safeguard policies, “…give project sponsors a powerful tool for avoiding mistakes, reducing development costs, and improving project sustainability” (World Bank website #2). By accepting World Bank investment, Exxon Mobil imposed on itself a compliance requirement with the Bank’s safeguard policies. Negotiation over the details of the health components of the resulting Environmental Assessment Evaluation, such as malaria, may have delayed implementation of the project.
D. United Nations Environmental Programme

Industrial activities in malaria-endemic regions may be subject to oversight by the United Nations Environmental Programme (UNEP), which created in 1975 the Industry and Environment Center (UNEP IE). This Center is concerned that “...industrial development will only be truly sustainable if it is built on firm ecological foundations”. Agenda 21, adopted at the Rio de Janeiro Earth Summit provided a plan of action based on promoting “...cleaner and safer industrial production and consumption patterns”, presumably inclusive of those that avoid exacerbating the transmission of malaria. Environmental impact assessments and “sound” management of chemicals are particularly encouraged. The Technology, Economics and Industry (TIE) Division aims to work closely with decision-makers in national and local governments, businesses and industries to further these objectives. The regulatory constraints that these initiatives may impose on industry remain unclear.

D. Summary comments

Various national and multinational agencies potentially regulate industrial activities in malaria-endemic regions. Instruments of the International Labor Organization would regulate investment if related activities were to increase risk of malaria morbidity and mortality among agricultural workers under Convention C110, various other kinds of workers under Convention 184 or mine workers under Convention 192. USAID would regulate environment-related activities if its monetary assets were involved under the 22 Code of Federal Regulations. The World Bank would regulate activities deriving from any of its investments under its Safeguard Rules. The regulatory powers of UNEP would be engaged under Agenda 21 of the Rio de Janeiro Earth Summit if industry activities threatened environmental quality.

VIII. Industrial interventions against malaria

Malaria remains as a crucial obstacle to industrial activities throughout much of the world’s tropics. The burden appears to be increasing, mainly due to a loss of drug susceptibility by the various malaria pathogens, increasing insecticide resistance by vector populations and a general deterioration of anti-malaria programs. By disturbing drainage and encouraging immigration, mining operations tend to exacerbate malaria transmission. As a result, industrial activity in endemic regions depends increasingly on the development of appropriate anti-malaria interventions. Certain industrial operations involved in oil and gas production, mining, agriculture, tourism and manufacturing already have contributed substantial resources to confront the obstacle of malaria.

A. Oil and gas production

1. Exxon Mobil in Chad and Cameroon

The Exxon Mobil Company recently generated a model anti-malaria program and a system for its implementation in western Africa. This scheme was implemented in
response to an outbreak of infection among workers employed in the vicinity of Mondou in southern Chad since 1988. About 12 expatriate employees experienced malaria episodes each month over a period of more than 10 months (Spielman 1989). More than 100 residents of the United States and Europe were employed there at any one time, and the costs of evacuation and clinical care burdened the company. These infections appeared to derive from intense cycles of transmission in this sahelian region that were maintained in villages that happened to be located near the oil-exploration drill-rigs operated by Exxon Mobil and its contractors. Although the expatriate employees were quartered in air-conditioned vans and regularly received prophylactic regimens of chloroquine and amodiquine, preventive measures failed. Employees appeared to be infected nocturnally when they worked on the drill rigs and during the early evening hours when they engaged in outdoor recreational activities in the vicinity of their camps. Subsequent protective measures included intensive applications of insecticidal residues and aerosols as well as source reduction efforts where practical. Patios were screened to provide recreational spaces for the expatriate employees. National employees were protected by distributing bednets, impregnated clothing and repellent creams and by applying insecticidal aerosols.

Exxon Mobil’s (Exxon at the time) intensified anti-malaria system of interventions proved to be effective. The malaria incidence rate among expatriate employees, which exceeded 20% in 1993, declined 5-fold during the following year, following implementation of the anti-malaria effort.

The current anti-malaria program developed by Exxon Mobil for personnel employed working where malaria is endemic is detailed and extensive (ref 3). The general program identifies four main categories of intervention, which comprise:

1. Risk assessment.
   A malaria matrix has been developed based on a GIS analysis of the operating region, which will assist in determining the health burden of the disease in the various regions in which the Company operates.

2. Implementation.
   Procedures for directing the application of appropriate anti-malaria interventions have been developed. Strong emphasis has been given to clinical management of the disease as well as source reduction through environmental measures.

3. Training.
   An educational program has been developed which seeks to inform employees of the malaria risk in each region and to help them to implement preventive measures.

4. Environmental management.
   Source reduction efforts, directed against vector anophelines, include draining or filling of potential breeding sites as well as insecticidal applications.

The malaria-related activities of all non-immune employees are monitored closely beginning at the time of arrival and continuing to their departure from an endemic region. Maximum effort is taken to prevent malaria in non-immune employees and to minimize risk among semi-immune employees. For the latter purpose, early detection of cases and reducing host/vector interactions are targeted.
Exxon Mobil has developed an elaborate system for administering its anti-malaria program that includes well-enforced regulations. An “intra-net” program is being implemented that specifies the programmatic duties of its various employees and officers and disseminates specific information regarding anti-malaria measures. The program specifies site-specific risks as well as procedures for self-protection.

B. Mining

1. Freeport MacMorAn Copper and Gold in Indonesia

The PT Freeport Indonesia (PTFI) mine, operated in Indonesia by Freeport MacMorAn Copper and Gold (based in New Orleans) is the world’s largest gold mine. The mine itself and the nearby small city that serves it are located high in the mountains of Irian Jaya, where malaria cannot be transmitted. Another small city was constructed near the coast to support the mine, however, and it lies in an intensely endemic region.

The PTFI Company cultivates a close working relationship with government health authorities. They also seek to encourage the government to build health services in non-PTFI sites and to offer support and training whenever possible. These anti-malaria activities, described in the year 2000 Annual Report of the Company, remain central in the regional effort to reduce vector abundance and parasite prevalence in the local community.

A protocol has been developed for managing complicated as well as uncomplicated malaria, and anti-malaria drug resistance is being closely monitored. Emphasis has also been given to diagnosing episodes of disease by microscopic examination of blood slides. Directly observed therapy and follow-up of patients are recommended strongly. House to house surveys are conducted in order to identify possible malaria cases actively and to provide appropriate treatment at home.

Source reduction is achieved by extensive drainage of “swamp-land,” a measure that is said to have been successful in the past. Bodies of water that cannot be drained are treated with insecticide. These measures appear to have eliminated mosquito breeding sites throughout the region of concern. Biodegradable herbicides are used to eliminate certain stands of water hyacinth as a malaria suppressive measure.

In addition to this program of draining and filling, the company has instituted a system for entomological surveillance and response. Potential breeding sites are, thereby, monitored systematically and insecticides applied when larval vector anophelines are discovered. The program includes residual applications of insecticide to all homes in the vicinity of the operation and the use of bednets. Space spraying is carried out sparingly using thermal fog generators with diesel carriers or ultra low volume aerosol generators in the vicinity of the airport and when outbreaks of malaria or dengue are detected. Overall, the company strives to achieve an integrated approach in designing their program of anti-malaria interventions.
2. Konkola Copper Mines in Zambia

The Konkola Copper Mines operating in Chililabombwe and Chingola in Zambia, recognising the adverse economic effects of malaria to the company, embarked on an anti-malaria programme covering these “copper-belt” towns. The program mainly focuses on anti-vector measures by means of DDT or pyrethroid house spraying and has continued over a period of two years. Scheduled interventions covered a region that extended ten kilometres beyond the boundaries of both towns.

Before implementing the Spray program, a committee that included representatives of the local community as well as Company employees was established, and an extensive publicity and education campaign was conducted to ensure maximum participation of interested parties. The Company also conducted a systematic effort to ascertain the pre-intervention parasite prevalence rate and to monitor changes in prevalence.

A study addressing the knowledge level and beliefs of the community was conducted before the intervention and an education program was formulated on the basis of the outcome. In preparation for the program, the density of vector anophelines was monitored by means of a system of traps, and an assay system was implemented to monitor for possible loss of insecticide susceptibility. A training program was set up to prepare employees as sprayer applicators. Laboratory personnel from the local hospitals and health care centres were given a refresher course in malaria diagnostics, and a similar refresher course on case management was provided for the nurses. One year after the intervention was implemented, malaria incidence in the region fell by 57%.

D. Agriculture

The managers of the Igara Growers Tea Factory in the Bushenyi District of Southwestern Uganda have acknowledged that malaria-related expenses constitute the single most important operating cost that impedes their business. Despite this perception, the company has, until recently, limited itself to providing reimbursement for medical care to permanent workers or their dependents experiencing symptoms of malaria. More pro-active anti-malaria measures are under consideration. Although a bednet distribution program has recently been implemented for the Company’s workers, its efficacy has not been monitored closely.

The Igara Company is mainly a tea processing facility that manages a few of its own fields but receives virtually all of its supplies from independent growers. The Company also maintains a forest from which wood is harvested to run their boilers.

The Company currently is reviewing its labour policies in the face of mounting expenses related to malaria. The current mix of permanent and casual employees may be replaced by a total casual work force that would allow it to circumvent medical benefits required for permanent workers and dependents by the National Union of Plantation Workers. Administration of medical benefits is complicated by a nebulous definition of ‘dependents’ in workers with large, extended families. Factory policy provides free
malaria treatment to workers and their immediate families, including as many as 4 children less than 18 years old. A problem arises in identifying children who are qualified to receive such care. As an alternative to the restructuring of labour policies, the company is investing in an expensive photo-identification program that is intended to help limit medical reimbursements to a predefined population.

In the year 2000, a total of 400,000 Uganda shillings were paid for referral fees of malaria patients to private clinics. As of October 2001, this expense had increased to 1,300,000 Ush (~1,700 Ush per USD$ 1). In addition, the company expends about 800,000 Ush per month on anti-malarial drugs. In a typical month, the company covers medical care for about 50 malaria cases. Thirty percent of these cases occur in workers and about 70% in their dependents.

Workers lose an average of about two days of work in the course of an episode of uncomplicated malaria affecting either themselves or their dependents. The rate of tea production generally is not affected during malaria outbreaks because of the ready availability of labour and the relatively minimal demands for skill that allow the company to replace sick workers with temporary casual hires. Side-effects of quinine treatment lead to additional lost time or lost efficiency because workers complain of hearing loss and are unwilling to risk working near heavy machinery. Extreme cases are awarded additional paid sick days.

Although the Company conducts no deliberate environmental interventions, management as well as workers perceive that malaria transmission is less intense in the vicinity of the plant than in the surrounding community. This might be explained by industrial pollution in the runoff created by the cleaning machines. Lubricants are permitted to run off in gullies down the hillside to where they contaminate standing water below. Pollution due to waste tea leaves might also inhibit transmission by polluting breeding sites that would otherwise be suitable as breeding sites for the vector population.

The experience of the Igara Tea Company illustrates the malaria-related problems that face diverse industries operating where malaria is endemic. Other such industries face the problem in different ways. Sugar producers in the Rift Valley of Ethiopia, for example, rigorously modify the landscape in the vicinity of their operations and apply residual insecticides to the homes of their workers. Risk of infection is thereby rendered virtually nil. Plantations devoted to the production of palm oil, rubber, fruit and even cinchona, face similarly ill-defined problems.

E. Manufacturing

An apparent reluctance on the part of the manufacturing industries to invest in malarious countries was demonstrated at a meeting of the World Bank in 2001 when the Chief Executive Officer of Daimler-Chrysler, Jurgen Schremp described a recent action by his company (personal communication by Ok Pannenbour, who attended this meeting). Construction of an automobile assembly plant in Zimbabwe was rejected mainly because the region of concern was malarious. The company calculated that worker productivity as well as the costs of life and health insurance would be so
unfavourable as to render the investment nonviable. The presence of human immunodeficiency virus, which is also heavily endemic in the region, contributed to the calculation. The burden of malaria falls on industry as well as on the nations that are directly affected.

F. Tourism

Tourism frequently contributes importantly to the economies of nations. In certain developing countries, tourism may contribute disproportionately to the total economy in relation to other industries, and thus may be especially sensitive to the impediments or disruptions imposed by malaria transmission. In Kenya, for example, tourism serves as the primary source of foreign exchange. In South Africa, tourism contributes an estimated $7 billion per year, rivalling manufacturing and mining in its contribution to the Gross Domestic Product (South Africa Department of Environmental Affairs and Tourism Annual Report, 1999/2000). In such cases, malaria may profoundly limit nations’ economies by disrupting their potential for developing tourism industries.

Unfortunate experiences with *P. falciparum* malaria among western travellers may impede the full development of the tourism industry in affected regions. Imported malaria is routinely reported in Europe and the Americas, although it is not always efficiently diagnosed and treated (Lackritz et al 1991, Lobel et al 1990). This often results in dangerous complications in non-immune travellers, perhaps further dampening the initiative of potential tourists who become aware of these risks. For example, a recent promotional campaign offered inexpensive air travel to the Gambia from various European destinations (TropNetEurop 2001). Physicians were struck by the relatively high incidence of severe disease among returnees who contracted *P. falciparum* malaria including respiratory distress, coma and other syndromes requiring intensive care support. A similar spate of imported malaria cases was reported among European travellers to the Dominican Republic (Jelinek et al. 2000, Richter et al 2001), although the incidence of complicated cases was less. Media reports of severe malaria complications in unprotected tourists are certain to have profound reverberations in the potential travel market.

The Lubombo Spatial Development Initiative (LSDI) was formed to encourage new investment and development in a huge swath of land with unrealised potential extending across much of southern Africa that includes segments of Mozambique, Swaziland and South Africa. The LSDI recognizes the importance of malaria in affecting development in this region and thus has initiated a comprehensive anti-malaria program in the region with the aim of sharply reducing malaria’s impact. LSDI also recognized the potential importance of the tourism industry in this area and has initiated a study that aims to determine the influence of malaria on tourism in a region that includes Kruger National Park and other major tourist attractions. Preliminary results of this study indicate that the owners of various tourist facilities in the region perceive malaria to be the primary negative influence on bed occupancy. During the year 2000, facility cancellations were reported in all LSDI districts during the malaria season with an average cancellation rate of 44% in southern Mozambique (LSDI 2001).
A similar, though more limited effort focussed on tourism is underway in Zambia. Sun International has maintained a presence in Livingstone, Zambia since 1998, trying to develop the tourism industry. The company has been directly affected by malaria with a resulting loss of productivity. Furthermore, a very large negative perception regarding risk of malaria has been built that is detrimental to the tourist industry in Zambia. An in-house spraying program has been installed with the consultancy services of the South African medical services. Sun International, in partnership with Roll Back Malaria, is in the process of formulating a viable anti-malaria interventions in Livingstone.

The 2001 dengue outbreak in Hawaii illustrates the extreme sensitivity of the tourist industry to vector-borne infection. During the first two weeks after the first human infection was diagnosed in October of 2001, the Maui News, included at least one dengue-related article among the five or six feature articles that it published each day. When the Governor of Hawaii, Ben Cayetano, visited Maui, he said “We are going to Hana [the epicentre site] to see firsthand what the consequences of dengue fever and our state of war [on terrorism] have had [on the tourist industry].” A day later, he announced that “Hana is safe, and the word needs to get out to the visitor industry.” A similar perception of a threat to visitors’ health caused the tourism authorities to ask the Pan American Health Organization for an analysis of malaria risk of Barbados Island (Spielman and Nathan 1990). A casual report of the presence of Anopheles aquasalis had previously caused great concern on this reportedly malaria-free tourist destination because no anopheline mosquitoes were thought to be present there. The PAHO report reassured the Ministry that these mosquitoes posed no risk. Perceived risks to health may destroy local tourist industries.

G. Summary comments

The extractive industries operating in malaria-endemic regions (oil and gas producers and mining operations) focus first on personal protection, including chemoprophylaxis and reduction of host-vector contact by means of repellents, screening and ITMs. Prompt diagnosis and clinical case management are crucially important, particularly in non-immune personnel. Application of insecticidal aerosols protects personnel who are out-of-doors at night, either for work or recreation. Source reduction would be designed to remediate the environmental disturbance created by these industries and to reduce the force of malaria transmission in adjacent communities. Drug as well as insecticide resistance should systematically be monitored.

Agricultural operations in endemic regions pursue goals that appear to be less well-defined. Where feasible, source reduction efforts virtually eliminate transmission in confined sites. Case management is a prominent component of such an activity. Where malaria continues to be endemic and the vectors are nocturnal and indoor-biting, ITMs should be distributed to all workers and their dependents.

No general recommendations appear to be available for the manufacturing industries. Housing improvement, including installation of window screens, may translate into greater worker health and productivity.
Tourists require virtually complete protection against malaria. Case management with an effective evacuation plan is required. The perception of malaria-risk, however unlikely, may severely inhibit tourism.

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