

Abstract

Malaria, a parasitic infection, causes hundreds of millions of disease episodes and more than a million deaths every year, nearly all of them occurring in the poorer and more vulnerable sectors of the world's developing countries. In spite of the great burden of suffering caused by malaria, the human rights implications of this disease have not been well described. This article summarizes important associations between the spread of malaria and human rights abuses (such as those associated with slavery and armed conflict) and between poverty, socio-economic inequity, and access to malaria-control measures. The author concludes that malaria control merits inclusion as a core element in global strategies to achieve progressive realization of the right to health.

Le paludisme, infection parasitaire, est la cause de centaines de millions d'épisodes de maladie et de plus d'un million de décès chaque année, principalement dans les régions les plus pauvres et les plus vulnérables des pays en voie de développement. Malgré les grandes souffrances causées par le paludisme, les répercussions de cette maladie sur les droits de l'homme n'ont pas été amplement abordées. Cet article résume les associations importantes entre la propagation du paludisme et les abus des droits de l'homme (tels que ceux qui sont associés à l'esclavage et aux conflits armés) et entre la pauvreté, les inégalités socio-économiques et l'accès aux mesures de contrôle du paludisme. L'auteur conclut que le contrôle du paludisme mérite d'être inclus comme élément essentiel des stratégies mondiales en vue d'une prise de conscience progressive du droit à la santé.

El paludismo, una infección parasitaria, causa cientos de millones de episodios de enfermedad y más de un millón de muertes cada año, y casi todas ellas ocurren en los sectores más pobres y vulnerables de los países en vías de desarrollo del mundo. A pesar de la gran carga de morbilidad causado por el paludismo, no se han descrito bien las repercusiones de esta enfermedad sobre los derechos humanos. En este artículo se resumen relaciones importantes entre la propagación del paludismo y violaciones de los derechos humanos (como los relacionados con esclavitud y conflicto armado) y asimismo entre la pobreza e inequidad socioeconómica, y el acceso a medidas de control del paludismo. La autora concluye que el control del paludismo merece inclusión como un elemento central en las estrategias mundiales para conseguir la satisfacción progresiva del derecho a la salud.

HEALTH, HUMAN RIGHTS, AND MALARIA CONTROL: Historical Background and Current Challenges

Paula E. Brentlinger

This article seeks to define control of malaria—a mosquito-borne infectious disease caused by parasites from the *Plasmodium* family—as a human rights priority.

Unlike infection with the human immunodeficiency virus (HIV) or tuberculosis (TB), malaria has not been associated with systematic discrimination against individuals or groups assumed to be at high risk of infection. The history of malaria is entwined, however, with war, war crimes, slavery, and socio-economic inequity. Malaria was a topic of testimony at the world's first war crimes tribunal.¹ Malaria makes the world's poor and vulnerable even more so, thus making the elusive "right to health" ever more difficult to realize. Coverage of interventions for prevention and/or treatment of malaria is highly inequitable, with lesser access for persons of lower socio-economic status, thus leaving certain specific obligations of States parties, as defined by the International Covenant on Economic, Social and Cultural Rights (ICESCR), incompletely fulfilled.^{2,3} Still, the public health and development communities have not yet secured broad support from human rights advocates in the battle — now hundreds of years old — against this disease.

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Malaria: Burden of Disease

Snow et al. recently estimated that there were 515 million clinical episodes of *P. falciparum* malaria (the most malevolent of the four varieties affecting humans) in 2002, 365 million of them in Africa.⁴ More conservative estimates still place total cases at 300 million or more, with the clear majority of cases and deaths occurring in Africa.⁵

Although malaria is best known for causing an acute illness characterized by intermittent but intense fevers, its full burden is greater. Acute malaria is often rapidly fatal if untreated, particularly in young children, pregnant women, and persons whose immune systems are compromised by the acquired immunodeficiency syndrome (AIDS). Survivors of severe acute malaria attacks may not regain full function. The resulting deficits may affect hearing, speech, vision, strength, or cognition.⁶ Chronic malaria, though it does not cause the rigors and rapid mortality of the acute form, is also an important cause of morbidity. Both acute and chronic malaria destroy red blood cells and interfere with their replenishment, thus causing anemia. The consequences may include heart failure and death in pregnant women, low birth weight in infants born to anemic mothers, reduced work capacity, reduced cognitive function, and blood-borne infections resulting from emergency blood transfusions for the treatment of malaria-related anemia.⁷⁻¹⁰

Malaria infection may also increase the likelihood of HIV transmission and/or the likelihood that asymptomatic HIV infection will progress to AIDS. This is because malaria infection increases HIV viral load (the concentration of HIV virus in blood).¹¹ Because HIV-infected persons are also more likely to become infected with malaria, and because HIV infection is now widely present throughout the malarious regions of Africa and elsewhere, this association is of grave concern.¹²⁻¹⁴ Approximately 25% of pregnancy-related malaria infections in Kenya have already been attributed to maternal HIV co-infection.¹⁵

In Africa alone, in the year 2000, malaria is thought to have caused roughly 1.1 million deaths, 5,000 maternal deaths, and hundreds or thousands of cases each of paralysis, hearing impairment, visual impairment, behavioral difficulties, language deficits, and chronic seizures.¹⁶ The over-representation

of cases in Africa is caused both by local hospitability to the *Anopheles* mosquito vector and by inequities in access to malaria prevention and treatment services.

Origins of Malaria: Human Rights Abuses and Spread of the Disease

Malaria almost certainly arose in Africa and spread within Africa as a nomadic lifestyle was abandoned for agriculture, accidentally creating favorable habitats for mosquitoes as fields were cleared for planting. Deforestation for agricultural purposes seems to promote the proliferation of malaria vectors.¹⁷

Trading and migration eventually brought malaria to China, India, and Europe. By the medieval era, malaria was endemic throughout Africa, in Europe from the Balkans to southern Sweden, and across southern Asia and parts of Russia.¹⁸

European colonization and the African slave trade brought malaria to the Americas, where various native species of *Anopheles* mosquitoes were available to serve as vectors for transmission.^{19,20} European colonists were the probable source of *P. vivax*, which could tolerate chilly European winters, and this strain flourished as far north as Vermont in the US and Ontario in Canada. African slaves, along with the traffickers who took them from Africa to the Americas, were the likely source of *P. falciparum*, which subsequently became established from the Amazon River basin to the mid-Atlantic colonies.²¹ African-born slaves had generally acquired some resistance to *P. falciparum* in their home countries, and common African blood types conferred immunity to *P. vivax*. Many colonists preferentially sought slaves from Africa because they appeared to be more resistant to local fevers.^{22,23}

Humphreys describes the social arrangements that supported high malaria prevalence in African slaves, and in their descendants, in North America.²⁴ Although they mistakenly attributed their intermittent fevers to damp air, rather than to mosquito-borne pathogens, the more prosperous colonists eventually opted to live on high ground, away from swamps and streams, and to travel away from the most malarious regions during the mosquito-ridden summer months. Quinine

(or its precursor, cinchona bark) was also available for treatment of fevers in those with financial means. Meanwhile, impoverished slaves and sharecroppers were more likely to live in crowded, substandard quarters in the swampy, malarious lowlands where cotton and rice were cultivated. Their houses often had apertures in the walls or floors allowing free passage of mosquitoes.²⁵

The resulting racial and geographic disparities in malaria incidence and prevalence in the US were quantified during the Civil War of the 1860s. Faust, quoting 19th century sources, reported that US Army troops stationed in North Carolina suffered 1,087.1 malaria cases per 1,000 men compared to 197.4 cases per 1,000 men in the Pacific region; infection rates among black soldiers were nearly twice as high as those among whites.²⁶ Other sources reported similar racial differentials among the Union troops; for example, "one-half of the white troops and four-fifths of the black troops" were said to have contracted malaria annually during the Civil War.²⁷ During the post-war period, Faust noted that ". . . the fertile bottom lands of the Atlantic seaboard, of the Gulf Coast, and the Mississippi Delta Region from New Orleans [in Louisiana] to Cairo [in Illinois] remained for the most part uncultivated and undrained and provided extensive breeding grounds for malaria-transmitting mosquitoes . . . the poorly nourished human population offered an increased opportunity for the disease to gain the ascendancy."²⁸

During the first decades of the 20th century, the earliest parasite surveys in the US again noted marked racial disparities. For example, a series of surveys conducted from 1912 to 1915 revealed a malaria prevalence of 20.6% in black subjects and 8.1% in white subjects; black schoolchildren surveyed in Georgia in 1930 had a parasite prevalence of 42.9% compared to 4.5% in their white counterparts.²⁹

Thus, two great human rights abuses—the enslavement of Africans and the race-based discrimination that succeeded it—contributed to the spread of malaria and to inequalities in the burden of suffering in North America. Indeed, the largely race-based disparities in living conditions that were partially determined by malaria risk in the 17th and 18th centuries were still visible in New Orleans, Louisiana, in the 21st century. Early descriptions of the damage caused by Hurricane Katrina in 2005 noted that the

population of the city's flood-destroyed lowlands was thought to be 76% black, with a median household income of US \$25,759; while the population of the city's unflooded (or minimally damaged), higher-altitude neighborhoods was 43% black, with a median household income of \$31,455.³⁰

Armed Conflict and Complex Humanitarian Emergencies

During armed conflicts, multiple mechanisms may increase malaria-related morbidity and mortality. They include forced migration of non-immune persons (or deployment of non-immune troops) to malaria-endemic areas (or, conversely, displacement or deployment of infected persons to a region where malaria is not endemic but hospitable *Anopheles* vectors exist); breakdown or destruction of health services; provision of poor-quality housing to displaced persons (for example, in refugee camps); and alteration of local vegetation in ways that favor the breeding of vectors. Discrimination against specific population groups, acute malnutrition related to reductions in food production or interference with food distribution, and diversion of human and material resources away from the health sector to military activities may also contribute to worsening malaria-related and all-cause morbidity and mortality.³¹⁻³⁴

Many of these circumstances are caused or exacerbated by violations of international humanitarian law—for example, deliberate attacks on health facilities and medical personnel, failure to protect civilians, and failure to provide adequate relief or to protect resources necessary to the survival of the civilian population.³⁵⁻³⁷

Malaria and Military Personnel

The Civil War in the US was not the only armed conflict in history complicated by malaria. Malaria is thought to have killed Alexander the Great and to have disrupted the military campaigns of Julius Caesar.³⁸

The recent burden of malaria in US troops has been well described. Between World War I and the war in Vietnam, US Naval forces alone reported 147,150 cases of malaria, resulting in over 3,800,000 sick days.³⁹ Malaria was an important strategic factor during World War II, when both Allied

and Axis troops were exposed to it in the Pacific, European, and North African theaters. Joy notes that malaria is thought to have been the cause of the US defeat at Bataan, where "Malaria and dysentery, coupled with starvation . . . led to the inevitable surrender on 9 April 1942 of a sick and starving army . . ."; casualties attributed to malaria outstripped those caused by combat by a factor of more than 3:1 in Papua, New Guinea; and malaria may have determined the outcome of the battle of Guadalcanal.⁴⁰

Malaria is also known to have affected troops in other more recent conflicts, particularly in Africa and Southeast Asia.⁴¹

Malaria and Civilian Victims of Complex Humanitarian Emergencies

Bloland et al. have recently reviewed the literature on malaria and complex humanitarian emergencies. They note that malaria was an important cause of morbidity and/or mortality in Cambodian refugees in Thailand, Karen refugees fleeing Myanmar, Mozambican refugees in Malawi, Ethiopian refugees in Sudan, Rwandan refugees in Goma, and in the civilian population of Tajikistan after the war-related collapse of the local health infrastructure.⁴² Other recent reports describe the following:

- **Mozambique.** In Mozambican refugees in Malawi, 16% of observed mortality was attributed to malaria, exceeded only by deaths from malnutrition (21%) and cholera (26%).⁴³
- **Burundi.** Female Burundian refugees in Tanzania had a significantly increased likelihood of poor pregnancy outcomes if they had suffered multiple episodes of malaria. In this population, malaria was the attributed cause of 41% of deaths, including one maternal death caused by cerebral malaria.⁴⁴
- **Angola.** In internally displaced Angolans, fever (presumed to be malaria) caused 24% of all deaths, second only to malnutrition (30%). It is probable that febrile illnesses such as malaria caused more deaths than war.⁴⁵
- **Afghanistan.** Before succumbing to the disruptions of armed conflict, Afghanistan had a successful national malaria control program. Consequently, Afghan refugees

(displaced by Soviet invasion, civil war, and/or US military intervention) lacked anti-malarial immunity. They were settled in refugee camps in a region where both *P. vivax* and *P. falciparum* were endemic and subsequently sustained as many as 150,000 cases of symptomatic malaria per year.^{46,47} Also, maternal mortality has been an immense problem among Afghan refugees in Pakistan, with an observed maternal mortality ratio of 291 maternal deaths per 100,000 live births in 1999–2000. Half of maternal deaths caused by indirect causes (14.8% of all maternal deaths) were attributed to cerebral malaria.⁴⁸

- **Uganda.** In camps for internally displaced Ugandans, malaria was the cause of 30–40% of all out-patient visits and up to 80% of all pediatric hospital admissions.⁴⁹ In the Gulu District of northern Uganda, malaria was the leading cause of hospital admissions between 1992 and 2002, during a time marked by civil war and the onset of the HIV/AIDS epidemic. Malaria admissions rose by 99.6% during this period, outstripping pneumonia, malnutrition, and war-related injuries.⁵⁰

In brief, where malaria is endemic or epidemic, malaria-related illness is an important link between complex humanitarian emergencies and the very high morbidity and mortality levels observed in affected civilians.

Malaria Prevalence, Poverty, and Economic Inequity

Although malaria could, in theory, become endemic wherever local climatic conditions are hospitable both to humans and to *Anopheles* mosquitoes, persistent malaria is more common where a third condition is met: the presence of poverty.

Poverty as a Cause of Malaria Morbidity

Communicable diseases caused 59% of all deaths in the poorest one-fifth of countries in 1990, but only 8% of deaths in the wealthiest one-fifth.⁵¹ Malaria itself was the 10th most common cause of death (3.6% of overall mortality—less than diarrhea or pneumonia, but more than HIV/AIDS or armed conflict) in countries in the lowest economic quintile in 1990, but caused fewer than 0.1% of deaths in the

wealthiest countries.⁵² In countries where malaria is highly prevalent, per capita gross domestic product (GDP) is only about one-fifth of the corresponding value for countries not plagued by malaria.⁵³

The causes of these associations are complex. Methods for quantifying the economic effects of many overlapping factors have not yet been solidified, and effect sizes probably vary among sites.⁵⁴ Still, data from several sites reveal that the poor are often more likely to be infected with malaria than those with more means, and less likely to receive adequate treatment in the event of illness.

Where housing is of poor quality, mosquitoes may find easy access to human sleeping quarters, and insecticides may not adhere well to interior walls. In Eritrea in 2000 and 2001, the prevalence of malaria parasitemia was significantly increased among residents of mud-walled houses.⁵⁵ In many countries, rural areas are poorer than cities. Housing may be of less robust construction and may be located nearer to such mosquito havens as riverbanks and irrigated croplands. In Malawi, malaria parasitemia was significantly more prevalent in rural children (relative risk 4.9–5.6), even after adjustment for parental education.⁵⁶

One analysis of health service utilization and health care spending, based on data from 1992 through 1995 in seven African countries (Côte d'Ivoire, Ghana, Guinea, Kenya, Madagascar, South Africa, and Tanzania), concluded that the poorest quintile of the population was less likely to use public- or private-sector health services than the wealthiest quintile in all seven countries.⁵⁷ In Guinea, for example, 73% of people in the poorest quintile used no health services at all during a recent illness compared to 35% of the wealthiest. In a separate study, conducted in Tanzania, the likelihood that a child received proper care for a febrile illness (under local norms, nearly all children with fever are presumed to have malaria) increased significantly with socio-economic status—from 31% of children in the poorest quintile to 62% of those in the highest quintile.⁵⁸

Malaria As a Cause of Poverty

In addition to the evidence that the prevalence of malaria is elevated and access to treatment diminished in the pres-

ence of poverty, there is also evidence that malaria can increase poverty and that malaria control is associated with poverty reduction. Again, the mechanisms of these associations are complex, and include the negative effects of both chronic and acute malarial illness on human productivity, the household-level costs of illness and medical attention, and malaria-related disincentives to foreign investment and tourism. Macroeconomists have recently estimated that malarious countries may lose up to 1.3% of GDP growth per year as a consequence of malaria infection; the cumulative effect of these losses over a quarter of a century could be equivalent to nearly half of a poor country's GDP.⁵⁹

Malaria and Human Productivity. Although young children, pregnant women, and HIV-infected people are often defined as the “target populations” for malaria control, economically active adult men and non-pregnant adult women are hardly unaffected by the infection. In Eritrea, for example, malaria prevalence was not substantially elevated in women and young children in 2000–2001; adult men bore a similar burden.⁶⁰ In Côte d'Ivoire between 1999 and 2002, a study of subsistence farming found that 58% of days lost from work were lost because of symptomatic malaria. Marketed vegetable (cabbage) yields were 47% lower for farmers who had lost two or more working days to malaria.⁶¹ In Mozambique, total malaria-related direct and indirect costs to a team constructing an aluminum smelter were estimated at US\$2.73 million in 2000.⁶² The negative effect of malaria on human productivity thus constitutes a hardship for the individual worker and a disincentive to investment.

Household-level Costs of Illness. Russell recently reviewed household-level costs of malaria episodes and estimated that each malaria episode in an adult results in up to five days of lost work time, with an economic cost of up to US\$7.63 per episode. The total cost of malaria to each household in sub-Saharan Africa may be the equivalent of 4.9% to 13% of annual household income, with proportionately greater costs in the poorest households.⁶³ In households surviving on US\$1 per day, these costs may be catastrophic.

Malaria as a Disincentive to Tourism. Revenues from tourism are now equivalent to those of over 11% of total exports in sub-Saharan Africa as a whole, even in such malaria-affected countries as Kenya (17.1% of export revenue), Tanzania (28.1%), and South Africa (11.5%).⁶⁴ However, prospective tourists must weigh the attractions of travel against its perceived risks. Malaria is the most common reported cause of systemic febrile syndromes (371 cases per 1,000 ill returning travelers, 62.2% of which are caused by malaria) in travelers returning from sub-Saharan Africa.⁶⁵ Since malaria developed widespread resistance to chloroquine (CQ — a very safe drug, even in pregnancy), and CQ's successor (sulfadoxine-pyrimethamine) caused well-publicized, fatal adverse reactions in a series of US and European travelers, the costs and perceived risks of both malaria and malaria prophylaxis have become more prominent in the prospective traveler's thinking.⁶⁶ The negative impact of malaria on tourism has not been fully quantified for sub-Saharan Africa but is thought to be substantial. Well-regarded travel guides for the region contain such chilling statements as, "Every year travellers die from malaria because they have taken insufficient precautions. Despite taking anti-malarial drugs and bite avoidance measures, it is still possible to contract malaria," and "Left untreated, malaria can cause anemia, kidney failure, coma, and death, and is an especially serious threat to pregnant women . . . malaria treatments can have very serious side effects, including slowed heart rate and nightmares. . . . They are also not 100% guaranteed to prevent malaria symptoms."^{67,68} Cautious travelers may thus choose to spend their hard currency in settings that appear less risky. Some governments, recognizing the negative economic impact of malaria (or perceived malaria risk) on tourism, have now defined increased tourism as a specific aim of malaria-control measures.⁶⁹

Malaria Control and Economic Growth. Fortunately, malaria's contribution to poverty appears to be at least partially reversible. In the early 20th century, public health reformers in the US successfully convinced some businesses to fund local malaria-control initiatives. Cotton mill owners reported that worker efficiency rose as a result of malaria control; southern railroads estimated that malaria

reduction led to a 20% increase in lumber shipped; and an Alabama health lobbyist calculated that a \$3,000 malaria-control initiative saved local townspeople \$25,724 in medical expenditures.⁷⁰

In Vietnam, aggressive malaria control led to a 68% decline in reported malaria cases between 1993 and 1998, with a concurrent 91% decline in malaria death rates. Each case of malaria was thought to result in costs of about US\$11 to the health services, with additional costs to affected households. Household economic consumption rose during the period of malaria's decline. The reduction in malaria incidence was thought to create US\$183 million per year in economic benefits (for a \$28 million investment in malaria control).⁷¹

Most famously, in Zambia (formerly northern Rhodesia) endemic malaria threatened the production of four copper mines established in the late 1920s and early 1930s. An intensive, 20-year-long malaria control program was instituted, involving window screens, mosquito nets, quinine, destruction of mosquito larval habitats, and (in the later years of the program) spraying with DDT. Utzinger et al. recently calculated that, for an investment of about US\$11 million, malaria-related mortality dropped from 10.3 deaths per 1,000 persons per year to less than 0.5 per 1,000 persons per year; approximately 900,000 work shift losses were prevented; and both employment and copper production boomed (from 0.5% to 12.7% of world copper output) in spite of a worldwide economic recession.⁷²

Because persistent malaria is therefore likely to increase socio-economic inequities within affected societies, progressive realization of the right to health in Africa and other regions where malaria is endemic may depend on adequate control of malaria infection.

Malaria and Inequities in Access to Prevention and Treatment: Historical and Human Rights Considerations in Malaria Control

The "Peruvian Bark"

The first effective anti-malarial medicine was cinchona, or "Peruvian bark."⁷³ European colonists in Peru learned of it during the early 17th century; it soon found its way to Europe and North America, transported by priests, soldiers, mer-

chants, the nobility (who thought Peruvian bark a suitable gift for empresses, popes, and ambassadors), and pirates.⁷⁴ During the early 19th century, quinine was isolated from the bark, and its commercial extraction began. The market for quinine was so great in Europe that plantations of cinchona trees were established in Java, India, Ceylon, and elsewhere. Widespread availability of quinine is thought to have contributed to the decline of malaria in Europe and the Americas during the late 19th and early 20th centuries; although (as noted above) some of the most vulnerable populations had little access to this remedy.^{75,76}

Malaria Control and Human Experimentation in World War II

During World War II, the world's supply of quinine was decimated by Japanese control of Java. Similarly, there was a shortage of pyrethrum, the pre-war mainstay of anti-mosquito spraying programs. Widespread spraying of houses with pyrethrum was conducted as early as 1932 in South Africa.⁷⁷ However, a combination of bad weather and wartime interference with shipping later reduced the supply of pyrethrum flowers, which were cultivated in Kenya.⁷⁸

Malaria infection was such a threat to both Axis and Allied troops that both sides moved rapidly to test new prevention and treatment measures. This effort involved both military and civilian personnel and drew resources away from malaria control in civilian populations. For example, the Rockefeller Foundation supported malaria control programs in sites as disparate as the state of Mississippi in the US, Italy, Bulgaria, and Mexico between 1915 and 1942. But in 1942, the Rockefeller malaria-control staff were re-assigned to the Malaria Control in War Areas program, with the aim of controlling malaria in US military personnel.⁷⁹

Dichloro-diphenyl-trichloroethane, or DDT, was discovered in 1874 but was not in widespread use before World War II. The US Department of Agriculture tested it in 1942 as a larvicide and mosquito killer.⁸⁰ The Rockefeller Foundation tested several candidate insecticides for control of lice (the vector for typhus) on conscientious objectors in New Hampshire and eventually moved on to testing DDT (again

with the primary aim of typhus control) on German and Italian prisoners of war and on Algerian jail inmates.⁸¹ The DDT tests were successful (its potential ecological side effects were not of concern at the time) and are thought to have helped avert wartime outbreaks of typhus in Naples and malaria near Rome. DDT was being supplied to the US military by 1944.^{82,83}

US forces experimented with the anti-malarial medication atabrine in the Pacific, where medical officers invented and tested their own regimens for malaria prophylaxis and treatment. Later, more controlled trials were conducted in the US and in Australia, some of them using prisoners, conscientious objectors, and soldiers as experimental subjects. By 1943, a successful regimen for prevention of *P. falciparum* had been defined.⁸⁴ It was used not only to prevent malaria from incapacitating combat troops but also to prevent the spread of malaria from returned military personnel to the domestic civilian population.⁸⁵

German desperation to control malaria (on the Russian and Balkan fronts and in North Africa) was such that experimental drugs were tested on concentration-camp inmates and prisoners of war (some mentally ill) at Dachau and Buchenwald and in a psychiatric clinic in Thuringia.⁸⁶ In the Dachau experiments alone, about 400 prisoners of war died after being deliberately infected with malaria by Nazi vaccine researchers.⁸⁷

In the aftermath of the war, the Dachau malaria experiments were the basis for Count 2 of Case 1, Military Tribunal 1, at Nuremberg; some of those found guilty were condemned to death.⁸⁸ In response to contemporary revelations about Nazi medical experimentation in the war, the concept of the "medical war crime" was developed, and the Nuremberg Code defined new standards for protection of human medical research subjects.⁸⁹ Experimentation by Allied forces did not come under equivalent scrutiny during the immediate post-war period, probably because their side was victorious and their experiments more benign, but the ethical foundation of Allied trials was questioned decades later.⁹⁰

The strategic importance of malaria is such that the military forces of the US and other countries continue, even now, to be important funders of malaria research.⁹¹

Malaria Control after World War II

Taking advantage of the new post-war availability of DDT and chloroquine, aggressive malaria-control campaigns (combined with rising prosperity) essentially eradicated malaria from the US, Europe, and portions of the Soviet Union by the 1960s. Drastic reductions in malaria prevalence were achieved in India, Sri Lanka (then Ceylon), China, and Madagascar. But for the majority of sub-Saharan Africa, vector-control campaigns were of limited scope. Local *P. falciparum* rapidly acquired resistance to chloroquine, and the AIDS epidemic was soon to reduce population-level immunity to many infections, including malaria. Thus, little long-term relief was gained. According to Carter and Mendis, “Much as they were at the beginning of the 20th century, 5 to 10% of all those born in tropical Africa today are destined to die from malaria before they reach the age of five years.”⁹² The early malaria campaigns, though impressive, failed to achieve equity on the global level.

Current Initiatives against Malaria

At the end of the 20th century, efforts to control malaria were revived through the efforts of the World Health Organization, the Roll Back Malaria initiative, the Global Fund to Fight AIDS, Tuberculosis and Malaria, and others. The principal tools of the current efforts include: insecticide-treated bednets (ITNs), indoor residual spraying of houses, prompt treatment of illness with effective anti-malarial medications (preferably two drugs with different mechanisms given in combination), and preventive treatment of malaria in vulnerable pregnant women. In some settings, other environmental controls—such as larvicides—are also promoted. Equity issues related to use of bednets and anti-malarial medications are discussed below.

Insecticide-treated Bednets

The ITN provides dual protection against malaria. If properly deployed and maintained, the net creates a mechanical barrier against mosquitoes, while its insecticide repels and even kills nearby insects. A recent study from Kenya reported that use of ITNs reduced all-cause mortality by 22–24% in post-neonatal infants and that the

ITN-related survival advantage was sustained through age 59 months.⁹³

Newer, long-lasting nets are made of fiber to which insecticide has been bonded prior to net manufacture. The insecticide incorporated into the core of the net fibers steadily replenishes the surface insecticide as it is lost to washing or weather. The durability of the resultant insecticidal protection has been remarkable in some studies. In camps for displaced persons in Uganda, one brand of long-lasting net retained significant protection against malaria parasitemia even in the face of "severe" physical damage from rats, fire, and other causes.⁹⁴

ITNs and Poverty. Although ITNs have been shown to be an effective, relatively inexpensive means of malaria prevention, multiple studies have shown that ITN ownership and use are disproportionately concentrated among the wealthier segments of different societies. Some examples follow:

- **Malawi.** In Malawi in 2000, ITN ownership was significantly more common in households whose heads had higher levels of education, where walls of house were constructed of brick (compared to mud walls), where roofs were made of metal (compared to grass roofing materials), and in urban households (compared to rural households).⁹⁵
- **Kenya.** In two urban sites in Kenya studied in 2001, ITN ownership was also significantly associated with higher levels of education (highest levels of education compared to lowest, depending on site) and wealth.⁹⁶
- **The Gambia.** In an early bednet trial conducted in The Gambia in 1994, 85% of bednets were found to have been re-treated with insecticide when insecticide for re-treatment was distributed without charge. After user fees were instituted, insecticide coverage of nets dropped to 14%, and the majority of household heads and health workers declared that cost was the primary obstacle to re-treatment.⁹⁷
- **Kenya.** In Kenya, in a study conducted between 1998 and 1999, low levels of parental education and higher levels of poverty were significantly associated with

lower hemoglobin levels in children under five years of age who did not use bednets. However, no such relationship was observed in children from ITN households — suggesting that the association between poverty and anemia can be attenuated by effective malaria prevention in malaria-endemic settings.⁹⁸

- **Nigeria.** In Nigeria, a baseline ITN survey showed that 35.8% of persons lived in bednet-owning households in the wealthiest quintile of socio-economic status compared to 5.8% in the poorest quintile. During the subsequent month, 21.1% of the wealthiest households bought new ITNs compared to 14.9% of the poorest households. Both differences were statistically significant.⁹⁹
- **Afghanistan.** In Afghanistan and among Afghan refugees in Pakistan, ITN social marketing among displaced persons raised overall ITN coverage from somewhere below 2% to about 30% between 1993 and 2002 — but ITN purchase was over four times as frequent in households from the wealthiest quartile, as compared to the two poorest quartiles.¹⁰⁰

Again, it appears that progressive realization of the right to health through malaria prevention is occurring in disproportionate fashion, with faster gains occurring among less needy populations.

Characteristics and Costs of Different ITN Distribution Schemes. Although the benefits of ITN use for reduction of mortality and control of anemia have been well demonstrated, there is considerable debate about the best mechanisms for ITN distribution. The leading policy options might be called “social marketing” and “public good.” Social marketing programs are designed to encourage purchase of ITNs (and/or bednet re-treatment materials) at market or somewhat subsidized prices. “Public-good” programs are designed to deliver large quantities of nets at very little or no cost to the users. The difference is both operational and ideological: some proponents of the social-marketing approach believe that stimulation of ITN manufacturing capacity and consumer demand is the best way to achieve high levels of coverage over the long term, while some proponents of mass dis-

tribution believe that nets, like childhood immunizations and ante-natal care, are a public good that should be made available at no charge by the public sector.¹⁰¹⁻¹⁰³ A middle ground also exists, often involving both social marketing and voucher systems to enable the most vulnerable to receive nets at no or very little cost.¹⁰⁴ Published studies have described very different results for the two types of programs, although different methods for cost calculations limit comparability.

In two districts in Tanzania, ITNs were promoted through social marketing between 1996 and 2000. The price to the consumer was approximately US\$5.00 per net, in addition to US\$0.42 to \$0.50 per re-treatment packet. Overall program economic costs were estimated to be US\$13.38 per treated net-year, based on sales of 65,111 nets and 24,393 bednet re-treatment kits; 30% of the costs were borne by the ITN users and their communities in the form of cash paid for nets and/or other non-financial costs. Total project financial cost was estimated at US\$8.30 per net delivered.¹⁰⁵ Between 1997 and 2000, ITN coverage increased from 37% to 73% of households. Among the poorest quintile of households, coverage rose from 20% to 54%; among the wealthiest quintile, coverage rose from 63% to 92%.¹⁰⁶

In contrast, mass distribution of free ITNs was recently linked to population-wide measles immunization in Ghana (2002) and Zambia (2003). The campaigns, which lasted one week each, raised household bednet ownership from 4.4% to 94.4% in Ghana and from 16.7% to 81.1% in Zambia — at a financial cost of US\$4.66 per net (exclusive of the costs of the measles immunization campaign).¹⁰⁷

Similarly, the United Nations Children's Fund (UNICEF) and the government of Kenya distributed free bednets to 37,206 pregnant women during a 12-week period in 2001 at an estimated cost of US\$5.26 per net.¹⁰⁸ In Vietnam, free distribution of ITNs to all households, coupled with free diagnosis and treatment of malaria infection, dropped malaria parasitemia prevalence from 37% to 4% in children under two years of age and from 56% to 7% in children from two to ten years of age.¹⁰⁹

The disproportionately higher levels of bednet ownership observed among the least needy seem to confirm Victora's observation that "new interventions will tend to

increase inequity since they will initially reach those who are already better off.”¹¹⁰ However, the results of some public-good distribution programs suggest that equitable gains in coverage of this life-saving intervention can be achieved rapidly and at low cost.

Poverty and Access to Effective Anti-malarial Treatment

During the latter half of the 20th century, chloroquine — a product of wartime malaria trials — was the mainstay of anti-malarial treatment. It was inexpensive, well-tolerated, and effective both in reducing malaria parasitemia and in reducing fever. However, widespread use eventually led to very high levels of resistance in most of Africa, Southeast Asia, and Latin America (except Central America and the Caribbean).¹¹¹ It is now clear that combinations of two or more effective anti-malarial medications will be required for cure of malaria at the individual level and for prevention of anti-malarial drug resistance at the population level.^{112,113}

The most effective current combinations — many of which are based on artemisinin-family drugs, such as artesunate and artemether — may cost more than 10 times the price of chloroquine or other cheap monotherapies. In consequence, wealthier individuals and countries, such as South Africa, have switched to artemisinin-based combination therapies (ACT) with good results. Poorer countries, such as Mozambique (where annual per capita expenditure on health is approximately US\$28 compared to \$770 in South Africa), are still trying (or were until recently) to make do with combinations of cheaper agents, such as sulfadoxine-pyrimethamine and amodiaquine, or with monotherapy.¹¹⁴ Although some of the less expensive non-artemisinin combinations have been highly effective in recent clinical trials and may be equivalent to ACT, there is concern that their effectiveness may be short-lived where high levels of drug resistance to individual components of these regimens already exist or where health systems are unable to manage simultaneous system-wide transitions to combination therapy.^{115–117}

A US Institute of Medicine (IOM) committee recently concluded that widespread provision of ACTs should be guaranteed through global subsidies, because “a ‘global

public good' results from the reduced risk of early development of resistance to this class of drug."¹¹⁸ The IOM committee argues that artemisinin-family drugs are the only class of effective anti-malarials to which widespread resistance has not yet developed; that resistance is inevitable unless they are systematically combined with other effective agents in the form of ACT; and that countries whose need for effective anti-malarials is greatest are the least able to afford them. In consequence, unless access to ACTs can be extended to all populations at risk of death or disability from malaria (the "humanitarian" decision), the use of artemisinin or other monotherapies in poorer populations will create transmissible drug resistance that will eventually render ACTs useless in wealthier populations (the "economic" justification for a global subsidy).¹¹⁹

Conclusion: The Human Rights Challenges of Malaria Control

Malaria is one of the most important causes of death and disability in the world. Currently, the burden of malaria is borne disproportionately by the most vulnerable population subgroups, including residents of sub-Saharan Africa, very young children, pregnant women, HIV-infected persons (especially those with compromised immune systems), and victims of war and other humanitarian catastrophes. Not only does poverty elevate risk of malaria infection, but malaria also exacerbates poverty through its effects on productivity and household economics.

Effective means of prevention and control of malaria now exist, but access to them is also disproportionately distributed, reflecting the same pattern of socio-economic inequity that influences the distribution of infection. In some sites, poorer families must now save for months or years to afford a socially-marketed bednet, while wealthier families (whose houses may have sturdy walls and window screens) can buy "luxury" nets (some are now king-sized, with ruffles) without making sacrifices. Similarly, prosperous citizens, visiting tourists, and malaria researchers may have ready access to ACT for treatment of malaria, while impoverished subsistence farmers may be lucky to receive sulfadoxine-pyrimethamine (or, worse yet, chloroquine) monotherapy.

Gwatkin has observed that the health-related Millennium Development Goals call only for changes in overall health statistics—not a reduction in the gap between the health indicators of the wealthy and those of the very poor. At present, approximately 1.76 deaths occur in children who live below the US\$1/day poverty line for each child death occurring in wealthier populations, and Gwatkin further observes that this gap will only widen if slower progress is made toward mortality reduction in poorer populations. This is very possible given the lack of health infrastructure designed to serve the poorest of the poor.¹²⁰

Fortunately, some strategies for achieving malaria control with equity have already been defined and/or successfully piloted. Mass distribution of free or highly subsidized ITNs has achieved high and equitable levels of coverage very rapidly in multiple sites and settings in Africa and Asia. Province-wide indoor residual spraying, combined with public-sector use of ACT, has resulted in dramatic reductions in malaria incidence in KwaZulu-Natal, South Africa; the benefits of this program have recently been extended to southern Mozambique.¹²¹ The IOM has laid out the case for broad subsidy of ACT. The Medicines for Malaria Venture is mobilizing funds for development of new anti-malarial medications through a public-private partnership in an attempt to uncouple drug development from the search for financial gain.¹²²

Policy-makers are increasingly engaged in explicit discussions of the links between malaria, poverty, and inequity. In 2002, a panel convened on behalf of the Roll Back Malaria partnership concluded that the partnership's goals and monitoring strategy should encompass equity concerns, particularly gender equity and equity based on socio-economic status and other characteristics of vulnerable populations.¹²³ The Millennium Development strategy explicitly links health and poverty reduction.^{124,125}

Provision of widespread, equitable access to interventions for prevention and treatment of malaria would be an enormous contribution to realization of the right to health for some of the world's most vulnerable groups. This, however, will require the political will and financial resources of governments, major donors, and implementing agencies.

Scattered voices have already declared that effective control of malaria in the most vulnerable populations is a human rights concern.¹²⁶ Health and human rights activists should take up this cause, in the interest of securing the right to health for the hundreds of millions who are now destined to become victims of malaria this year, and every succeeding year, until malaria control is achieved for all.

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