The Economics of Malaria Control Interventions

Kara Hanson, Catherine Goodman, Jo Lines, Sylvia Meek,
David Bradley and Anne Mills
London School of Hygiene and Tropical Medicine

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Global Forum for Health Research
c/o World Health Organization
20 avenue Appia
1211 Geneva 27, Switzerland
T + 41 22/791 4260 F + 41 22/791 4394
E-mail info@globalforumhealth.org
www.globalforumhealth.org

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Executive summary

Uptake of malaria interventions remains woefully low, despite good evidence that they are both effective and highly cost-efficient. This publication uses economic analysis to review knowledge on why this is the case. Influences on patient behaviour (demand) and the range of public and private providers (supply) are assessed to identify factors that limit the availability and effective use of malaria interventions, and the opportunities to improve both treatment and prevention.

The economic rationale for government intervention in malaria control is based on arguments of equity and market failure. Poverty prevents access to effective interventions. The costs associated with complicated malaria can drive households into poverty, and the poorest households are likely to have access only to the most informal parts of the health sector where quality is lowest. Market failure is a problem for those malaria interventions with public goods characteristics or externalities; and where information problems are most severe.

Improving malaria treatment

Treatment in both the public and the private sectors is hampered by low quality of care, inefficiency in service delivery and low utilization of adequate care. Demand is influenced by prices (including travel and time costs of seeking treatment), income, lack of information about appropriate treatment and the difficulties patients have in assessing treatment quality.

Problems on the supply side are linked to the broader problems of health service delivery, such as inadequate resources, poorly trained staff and inappropriate incentives for health workers. Health workers also suffer from lack of information about appropriate treatment, especially in shops and commercial outlets where they are likely to be untrained, and following changes in drug policy.

Improving malaria case management will require measures to strengthen the health system as a whole, as in many places malaria cases make up a significant share of total utilization. Such measures must:

- Improve availability of effective antimalarial drugs in public health facilities.
- Address problems of quality from the users' perspective, including the attitudes of staff and availability of drugs.
- Increase accessibility of health services, since malaria can progress rapidly to severe or fatal disease, and many children die before they reach a health facility.
- Strengthen incentives for good performance by health workers.
- Strengthen information and management systems, to ensure drug supply and early detection of epidemics.
- Improve capacity to use economic analysis in decision-making.

As the majority of malaria episodes are treated at home with drugs purchased in private outlets, quality and availability in the private sector must also be improved

by taking into account the incentives and information that influence user and provider behaviour. These opportunities include:

- Giving care seekers better information about appropriate treatment, including the importance of early treatment with an effective drug and using the correct regimen.
- Modify provider incentives to encourage appropriate drug use, and provision of appropriate follow-up and supervision.
- Involving private providers in the design and implementation of interventions.
- Simplifying the process of dispensing and using drugs, e.g. by pre-packaging.

Several new technologies are becoming available, including artesunate suppositories to control the most dangerous symptoms of severe malaria, and rapid tests to improve diagnosis and reduce the costs of treating malaria where more expensive antimalarials are used as first-line drug. Further exploration is needed on how these new technologies can best be used in routine treatment practices.

Addressing the problem of drug resistance is high priority, particularly in Africa where the failure of chloroquine treatment is already common and the ability to pay for more expensive alternatives is limited. Implementation issues must include measures to prevent rapid growth of resistance to the replacement drug that take into account the negative externalities of uncontrolled drug use.

Increasing coverage of preventive interventions

Coverage of preventive interventions also remains low, due to many of the same problems of demand and supply. In addition, a number of effective preventive measures have public goods characteristics and will, consequently, be underprovided or not provided at all by the market. These include indoor residual spraying and insecticide treatment of mosquito nets, environmental management and chemical larviciding, health education, and epidemic surveillance and drug resistance monitoring. Government action and community cooperation are needed to increase the uptake of these interventions.

Coverage of chemoprophylaxis or intermittent presumptive treatment in pregnancy is constrained by health system factors, together with poor compliance and drug resistance. Insecticide-treated nets (ITNs) are a highly cost-effective means of preventing malaria, but the high cost of covering the entire population at risk suggests that innovative means of financing and delivering them are needed. Commercial markets for untreated nets exist in many places, but the coverage they currently provide is inadequate and there is little private sector provision of insecticide retreatment. Governments have an important role in introducing complementary interventions to encourage the development of commercial markets, such as large-scale promotion, tax and tariff reforms, and regulation. In parallel, governments have a critical role in ensuring access to ITNs for the poorest households through the provision of subsidies to these groups.

The value of economic analysis

Economics offers a powerful set of tools for understanding the various influences on the behaviour of consumers and suppliers, and through them, on coverage of effective interventions. In addition, through the method of economic evaluation, it offers a systematic way of comparing the costs and consequences of interventions in order to improve the allocation of resources. These tools should be used more widely to improve the uptake of existing effective malaria control measures, and ensure the maximum impact from the introduction of new technologies.

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Acronyms and abbreviations

CEA	cost-effectiveness analysis
CER	cost-effectiveness ratio
CQ	chloroquine
DALYs	disability-adjusted life years
DYLGs	discounted years of life gained
EPI	Expanded Programme on Immunization
GNP	gross national product
HIPC	Heavily Indebted Poor Countries
HIV	human immunodeficiency virus
IMCI	Integrated Management of Childhood Illness
IPT	intermittent presumptive treatment
ITNs	insecticide-treated nets
km	kilometre(s)
NGOs	nongovernmental organizations
RBM	Roll Back Malaria
SP	sulfadoxine-pyrimethamine
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VAT	value-added tax
VHWs	village health workers
WHO	World Health Organization

Chapter 1. Introduction

> *"Last week my 2-year-old daughter was unwell. She was feverish and vomiting, and could not sit up properly. I was worried about her and thought I should take her to the clinic, but it is a good two hours' walk from here, and I couldn't leave my other children at home. Besides, I needed to ask my husband for money for the clinic fees. I waited until the end of the day when my husband returned, but he said that it would be cheaper to go and buy some chloroquine from the village shop. He went out and returned with three tablets of chloroquine. I crushed one of these and mixed it up in a few spoonfuls of porridge, and gave it to the child. Within a few hours the fever seemed to go down, and the child slept through the night.*
>
> *The next morning the child was sick again. I agreed with my husband that I should take her to the clinic. We set off on foot and got to the clinic in the middle of the morning. By that time there were already many people queuing to see the nurse and we had to wait. We waited all morning, until almost everybody had left. But these nurses, they don't even look at the child before writing the prescription. They just hear 'fever' and write what you say. She said that the child needs this syrup and these tablets, but that they were not available in the clinic and I should buy them from the chemist. But I still had to pay the clinic fee even though there were no drugs. It is very frustrating when they tell you there is no medicine. With the rest of the money I went to the chemist. I had enough for the syrup, but not for the other items. So I just bought the syrup. Perhaps I will be able to save some of it for next time when the child is sick.*
>
> *Someone came to the house today and said I should get a mosquito net to protect the child from this illness. But I don't see how that could help much, and in any case where would I get the money?"*

This opening anecdote is fictional, but it is typical of the experiences of many people in much of the developing world. It also illustrates some of the key barriers faced by households in seeking treatment for malaria. Effective treatment is often inaccessible or costly for vulnerable groups. In many places, health services are of poor quality, with long waiting times, inaccurate diagnosis, and inappropriate prescription and advice. In addition, these services often do not have essential drugs in stock and, even if they are available, there are often high levels of parasite resistance to the drugs provided. People often resort to the private commercial sector, which may be poorly regulated and offer inappropriate treatment, but where access costs may be lower. The coverage of effective

prevention is very limited, especially in areas with the highest transmission. Most households rely on personal protection measures of limited effectiveness, such as burning mosquito coils or leaves. This situation persists despite the wide range of effective malaria control measures available (see Table 1 below).

There are many examples of health workers whose efforts and initiative produce good results in difficult conditions, and some examples of effective programmes run by governments and nongovernmental organizations. Sustained, systemwide success stories are, however, few and far between. This publication considers malaria treatment and prevention in turn, exploring the factors that currently limit the availability and effective use of malaria interventions, and using economic analysis to help assess how the current situation, which is wholly inadequate, can be improved.

Table 1. Interventions to control malaria

Principal goal	Interventions
Treatment	• Outpatient antimalarial treatment for uncomplicated malaria following active or passive case detection • Inpatient treatment for severe and complicated malaria • Home treatment
Prevention	
1. Inhibit mosquito breeding	• Source reduction, e.g. drainage, filling in ditches • Chemical larviciding • Management of agricultural, industrial and urban development to avoid the creation of breeding sites
2. Kill adult mosquitoes in order to reduce survival rate (and hence vectorial capacity) of adult mosquito population	• Indoor residual spraying • Insecticide-treated materials, e.g. bednets, curtains, in some circumstances
3. Isolate humans from biting by vector mosquitoes	• Insecticide-treated materials, e.g. bednets, curtains • Repellents and domestic insecticides, e.g. sprays, coils, burning traditional herbs
4. Reduce malaria infection and morbidity in humans	• Chemoprophylaxis for non-immune groups, e.g. children, pregnant women, migrants • Intermittent treatment of pregnant women

2. Current treatment situation

2.1 Background

The most widely used method of malaria control is the treatment of symptomatic cases with antimalarial drugs. People seek treatment from a wide range of sources, including modern health providers in the public, nongovernmental organization (NGO) and commercial private sectors, traditional healers, pharmacies, shops and markets. Most often, treatment is sought for "fever", a symptom that individuals associate closely with malaria. Recommended drug regimens vary regionally, and depend mainly on the parasite species, the pattern of antimalarial drug resistance and the availability of diagnostic and follow-up services.

The mix of formal facilities providing treatment for uncomplicated malaria varies greatly across the world in terms of the type of facility, the qualifications of staff and the services offered. In sub-Saharan Africa, treatment for uncomplicated cases of malaria is provided by clinics and dispensaries, where fever often accounts for between 20% and 40% of outpatient visits. Diagnosis is typically based on clinical symptoms alone. These facilities do not generally offer the life-saving emergency treatment required by cases of severe malaria (including cerebral malaria), which must be referred to the nearest hospital or health centre with inpatient facilities, where the share of admissions due to malaria ranges between 0.5% and 50%.[1]

Outside Africa, malaria normally affects only some parts of certain countries, and transmission rates are usually less intense. The burden on the health system, and especially on inpatient care, tends therefore to be much lower. In Asia and Latin America, people with malaria can seek treatment from general medical facilities, but in many places malaria-specific centres or staff also exist. Laboratory diagnosis is widely used. Where laboratory facilities are not available on-site, patients with suspected malaria are sometimes given presumptive treatment for their immediate symptoms. Only patients with positive results are given follow-up treatment later for a complete cure.

In some areas of low transmission, treatment is intended as a means of reducing transmission as well as curing symptomatic cases. Treatment services may then include searching actively for parasite-positive individuals or providing antimalarials to all those in close contact with a malaria-infected patient. In contrast, in much of sub-Saharan Africa where transmission levels are relatively high, most people spend much of the time in a state of chronic but asymptomatic infection, with occasional episodes of illness. In these circumstances, it is considered appropriate to treat only those with clinical symptoms.

Use of the informal sector for malaria treatment is very common throughout the world. Around 60% of all malaria episodes in sub-Saharan Africa are initially treated by private providers, mainly through the purchase of drugs from shops and drug peddlers.[2–6] Recourse to multiple providers is common, and patients often begin with self-treatment using drugs purchased through the commercial sector, and then seek care from health providers.[7] In Thailand, widespread use of *ya chud*, a mixture of medicines for malaria sold in private outlets, has been reported.

One study found that around 90% of respondents had used *ya chud* at least once in their lifetime.[7] Generally speaking, reported use of traditional healers and medicines for uncomplicated malaria is low,[7] though their use may be understated in surveys because of perceived disapproval. However, there is evidence from various parts of Africa of greater recourse to traditional healers for severe malaria.[8–10]

2.2 Weaknesses in the provision of malaria treatment

Treatment in both the public and private sectors is hampered by three key weaknesses: low quality of care, inefficiency in service delivery and low utilization of adequate care.

2.2.1 Low quality of care

Problems with quality of care exist in both the public and the private sectors. Two dimensions of quality can be distinguished. **Technical quality** is defined in terms of professional standards and the effectiveness of health care in improving health outcomes. **Perceived quality** is different, because patients are aware of a different set of information and have different priorities. For example, they are likely to attach more weight to interpersonal quality and staff attitude. The two concepts are clearly related: for example, good communication between patient and provider will influence the quality of the diagnosis and treatment, and the patient's adherence to the prescribed treatment.

Technical quality: Both formal and informal care providers present a range of problems with the technical quality of malaria treatment. Some of these are related to diagnosis. Even a very experienced physician may find it difficult to differentiate malaria from, for example, an acute respiratory infection on clinical grounds alone. Where clinical diagnosis is used, therefore, overdiagnosis rates tend to be high,[11–13] as an African child has on average four attacks of non-malarial fever each year. The availability of diagnostic equipment (microscopes, etc.) varies enormously. Even where microscopy is used, however, the equipment is often in poor repair and supplies are unreliable. Laboratory staff may have limited training and be poorly supervised, and health workers do not always use the results in their treatment choices.[14–15] In highly endemic areas, infection rates are high even in healthy people, so microscopy is of limited value in diagnosis.

Multidrug resistance is now common in South America and South-East Asia, necessitating several rounds of changes in policy in some countries. The process of changing first-line malaria treatment has proved difficult and confusing in some areas. Many countries in sub-Saharan Africa retain chloroquine as the first-line drug and it is sometimes the only antimalarial stocked in health centres and hospitals.[16] This remains the case even in countries where rates of parasite resistance to chloroquine are high. In the early 1990s, documented clinical failure rates with chloroquine were 31–48% in Zambia and 50% in Kenya.[17]

Essential drugs including antimalarials are frequently out of stock in health facilities[18] and in some countries, the malaria peak coincides with the end of the financial year, exacerbating the problem at a key time. Moreover, second- and third-line drugs may not be made available to lower-level health facilities, despite the high frequency of treatment failure with the first-line remedy. Inappropriate prescription and consumption are common. In addition to the immediate health effects of inadequate treatment, it has been argued that underdosing may contribute to the emergence and spread of resistant parasites.[19–20] In Malawi, 74% of febrile children attending a clinic were given chloroquine, but only 17% took the correct dose, so overall less than 10% of clinic attenders could be considered to have taken appropriate, timely treatment.[21] However, over-dosing is also frequently reported. In Accra (Ghana), more than 95% of cases of malaria in children aged 3–5 years were mismanaged, with 56–78% receiving doses of chloroquine in excess of the national guidelines.[22] While individual treatments are frequently inadequate, multiple treatment-seeking over the course of an illness episode may result in a cumulative over-dosing.

The bulk of care provided in the private commercial sector is from shops, where care seekers tend to purchase a "product" that they ask for by name, rather than a "service" including diagnosis and advice. Quality of care in these outlets may be particularly unsatisfactory. For instance, in a baseline survey in Kenya only 4% of children given store-bought chloroquine received an adequate dose and only 2% received this dose over the recommended three-day period. Aspirin was widely used and 22% of children received potentially toxic doses of aspirin over 24 hours.[23] Evidence of poor-quality drugs on sale in retail outlets and pharmacies was found in Thailand and Nigeria,[24–25] though the extent of this problem is as yet unclear. Poor drug quality was believed to be mainly due to lack of quality control in manufacture and degradation during storage. In parts of South-East Asia, the problem of fake drugs is a major concern.

Perceived quality: Patients' assessments of the quality of care in public and private facilities are often negative, though these appraisals depend on the type of illness and the level at which care is sought. Studies that take patients' views into account frequently find a range of problems with the quality of services they receive in the public sector.[5,16] Rude and insensitive staff and long waiting times are common complaints and, at the primary-care level, patients are concerned about the lack of diagnostic facilities and poor building conditions.[18] Lack of drugs is also a major shortcoming. For instance, a study of health services in Tanzania found that the most common reason for not using government services was that they had a poor drug supply. When asked about what improvements they would like to see in government services, the single most frequent response was that there should be more drugs.[26] Illegal charging for drugs during consultation and leakage in the form of the sale of drugs by health workers in their private clinics and sale to informal drug sellers or shops, are also widely reported. In a detailed study of ten health facilities in Uganda, leakage was found in all of them, informal charging in eight, and mismanagement of user charges in seven. The main mechanisms for drug leakage were "ghost" patients (where details of non-existent patients were registered in order to record associated prescriptions), recording of prescriptions for real patients who did not receive them, and simply taking drugs from available stocks.[27]

Patients frequently point to problems with private sector service delivery, even though they are often more satisfied with drug availability and the interpersonal quality of care in these facilities (shorter waiting times, more attentive staff, greater choice of provider). Studies from a number of countries note that the technical capacity of private clinics is perceived as inferior. If a person is very ill, he or she may prefer to be treated in the public sector because of the presence of more sophisticated equipment and a greater range of staff.[28–29] Patients may also perceive private providers as relying excessively on diagnostic tests and charging very high prices,[28] and they are often sceptical about the motivation of private providers, believing them to be primarily interested in generating income for themselves rather than in the welfare of their patients.[30]

2.2.2 Inefficiency in service delivery

The inefficiencies of developing countries' public health systems are widely acknowledged. Key inputs such as staff and drugs are inappropriately used. Polypharmacy, where providers prescribe additional unnecessary drugs, is widespread[31] and, as well as being wasteful, may also be detrimental to the quality of care because of increased risk of side-effects. Where patients have to pay for drugs, they may respond to polypharmacy by purchasing incomplete doses or only some of the prescribed products.[32]

Another example of inefficiency is the use of expensive drug formulations, such as injectables, when they are not clinically indicated. In Ghana, 42% of chloroquine prescribed to outpatients was administered by injection[31] with implications for safety as well as cost. Essential drugs are frequently out of stock in public facilities; this has consequences not only for quality of care, but also for the efficiency with which health workers are used: when drugs are unavailable, patients no longer seek care and much of the health workers' time is underutilized.

In many African countries, a substantial proportion of rural health care is provided by church (mission) organizations. It is generally believed that they are more efficient than government services, though evidence is somewhat patchy.[33,34] Certainly staff may be more motivated, and supply systems tend to be better. In Senegal, Catholic health posts had the highest labour productivity (measured as visits per health worker per day), but they also had higher staff costs, because they used more qualified doctors, and higher drug costs per patient.[35] Where output was low, these facilities had higher costs than public ones, but at higher output levels, their unit costs decreased significantly and were lower than those in public facilities.

Very little evidence is available on the efficiency of the commercial private sector. This sector covers an enormous range of different types of facility, including full-time general practitioners, company clinics, small clinics run on a part-time basis by publicly employed staff, and clinics run by unlicensed "less than fully qualified" providers, which are common in India, for example.[36] Increasingly, clinics run by commercial companies are springing up in urban areas, offering a very standardized product (such companies are expanding fast in South Africa, for example). Because of this diversity in the nature and composition of the private

sector, comparisons of efficiency are very difficult to make. Moreover, since people themselves choose to use and pay for private care, inefficiencies have generated less concern. However, greater attention should be paid to the efficiency of the commercial private sector for several reasons. Firstly, even the poor pay for private care, and it is important that their limited funds are spent on cost-effective care. Secondly, some governments are interested in making use of commercial private providers to supplement public services. If governments are to act as purchasers, then they need to be sure that the services they purchase are provided efficiently.

2.2.3 Low utilization of adequate care

Prompt access to health-care providers is essential for effective malaria case management because *P. falciparum* malaria can progress rapidly to become a severe or fatal disease.[37] However, utilization rates are often low and treatment seeking is significantly delayed. Research in a demographic surveillance site in rural Tanzania found that 90% of deaths in children aged under 5 years from acute febrile illness with seizures occurred at home, and 48% of these occurred without prior contact with a formal health facility. Of this 48%, about 85% saw some kind of traditional healer.[38] The site was in an area with relatively good access to formal health services, where 85% of households lived within five kilometres (km) of a health facility. Problems of access to adequate care are much more pronounced where there is a low and/or more uneven distribution of health facilities and where the population is more sparsely distributed.

2.3 Understanding the causes of weaknesses in treatment

These problems of inefficiency, low quality and underutilization of care are the result of a range of influences on the behaviour of both providers ("suppliers" in economic terminology) and patients ("consumers"). Consumer behaviour – the "demand-side" – depends on a number of factors including prices of treatment alternatives, incomes, patient preferences for different characteristics of goods and services, and access to alternative providers. Demand is also influenced by the information that patients have at their disposal, including what they believe about the quality of the different alternatives available to them (and how well they are able to assess this), and by the advice and information they receive from health service providers. On the "supply-side", the behaviour of providers is influenced by their knowledge, financial incentives, competition, perceptions of patients' attitudes and any legal or regulatory sanctions for inappropriate behaviour. Understanding suppliers requires taking into account the effects of the whole supply chain including, for example, the ways in which drug wholesalers and pharmaceutical company detailers affect the prescribing patterns of doctors and pharmacists.

This economic framework, which uses the building blocks of supply and demand, offers a set of tools for clarifying some of the complex relationships in malaria treatment and control. It is employed in providing economic justifications for government intervention in response to equity concerns and market failures (see

Box 1, page 9). It can also add new insights into the opportunities for public action to improve the quality, efficiency and equity of access to services by intervening with care seekers and providers.

2.3.1 Constraints on demand

On the demand side, problems of access to information are crucial in explaining why the quality of treatment is so frequently poor. Patients often do not have the information needed to determine what course of treatment they require, so they hand over the responsibility for these choices to a provider, their "agent". The agents' knowledge may also be imperfect, however, and they may not advise patients correctly on which drugs to take or how to take them. A small-scale study in Tanzania reviewed 450 consultations at government and mission facilities. In only 16% did the doctor tell the patient the diagnosis or what medicine was being prescribed. In cases where the dispensing nurse gave out drugs, she or he checked to see if the patient knew how and when to take them in only 32% of consultations.[39] In a study of antimalarial treatment in Zambia, researchers found that parents appreciated having the research team show them how to give medication to their children, especially when the child was resisting or vomiting: such advice was not part of routine care.[40]

In the provision of health care, providers generally have considerably more information than patients. This "asymmetry of information", as it is called, may potentially lead to additional problems, particularly when combined with organizational factors which give providers financial incentives to prescribe more diagnostic tests and drugs than are medically warranted (called "demand inducement"). Even after receiving treatment, patients lack the ability to assess the quality of care received because multiple factors influence treatment outcomes. These include whether the condition really is malaria (especially where diagnostic facilities are in short supply), the levels of parasite resistance to the drug prescribed, whether the correct dosage of the antimalarial drug was prescribed, and the patient's adherence to the treatment. It may be difficult to disentangle which of these factors is responsible for a treatment failure, and therefore whether the failure can be attributed to poor quality of care. It is thus hard for consumers to make an informed decision on whether to revisit this provider in the event of a recurrence or future episode.

A related factor affecting patients' demand for treatment is their perception of what causes a disease and their understanding of how therapies work. Anthropological studies in a number of geographical areas have identified different perceived aetiologies for mild and severe disease. While severe forms of disease, such as convulsions, are linked with malaria, alternative explanations are also often identified, involving supernatural intervention such as spirit possession or magic spells.[8,9,41–43] One consequence of these beliefs is that individuals may seek treatment from traditional healers, rejecting western medicine, so that the most dangerous cases are least likely to get antimalarial treatment. A number of studies have reported that mothers believe that "modern" treatment, injections in particular, is dangerous for children with convulsions[8,41,44] even though injections are often perceived to be more effective than tablets for other conditions.

Box 1
Equity issues and market failures: The economic justification for government intervention in malaria control

There are two main justifications for government intervention in disease control. The first is equity. Lack of purchasing power is a fundamental constraint to effective malaria control interventions for much of the population. At the global level, poverty and malaria are highly correlated. The burden of disease can have important economic costs for very poor households, and complicated illness can drive households into poverty. Poor households are also likely to have access only to the more informal parts of the private sector, where quality is probably lowest. They may not be able to afford preventive measures at all. Hence, poverty and equity considerations provide powerful justifications for a strong public role.

As well as these concerns about equity, public intervention in malaria control can be justified on the basis of a range of market failures, which means that purely private delivery and financing of malaria control interventions would lead to inefficient outcomes from society's point of view. There are three main sources of market failure in malaria control:

- **Public goods:** These have benefits which cannot easily be provided to some and withheld from others, meaning that they are unlikely to be provided at all in the private sector. Malaria control examples include environmental management at the community level, indoor residual spraying, provision of health education to the general population and epidemic surveillance.
- **Externalities:** These arise when a service provides benefits to the community above and beyond those enjoyed by the individual. Examples include rational drug use, which provides positive externalities to future patients in the form of a reduction in the rate of growth of resistance. Insecticide-treated nets (ITNs) may also have positive externalities if they reduce malaria transmission. In making their choices, individuals will not take into account these additional positive effects and may consume less than the socially desirable quantity.
- **Information:** Free markets do not work well when buyers or sellers lack information, or when providers have significantly more information than consumers ("asymmetric information"). For instance, patients lacking information may purchase inappropriate drugs or consume subtherapeutic doses of antimalarials.

The identification of market failures points to a potential role for governments that could take a number of forms; it does not necessarily imply that governments should provide and finance the intervention. In some cases, it will be sufficient to provide information to consumers and providers, or to provide public financing to "contract out" a service to the private sector. In others, especially where competitive provider markets do not exist, it may be more efficient for governments to provide the service directly (e.g. health service provision in rural areas or epidemic surveillance activities).

While market failures are important, it must be recognized that governments also fail. Thus, it is not a simple choice between "bad" private markets and "good" public action, but rather a question of achieving an appropriate mix of public and private, and an appropriate structure of incentives for providers and consumers.

Alternatively, two parallel explanatory models of disease may coexist side by side, with both traditional and western medical providers consulted in turn.

Costs incurred by patients for treatment also influence utilization and quality. It may take some time for mothers to obtain the money and the approval necessary

to take their children to a health facility, leading to dangerous delays in care seeking. It also leads to the use of more informal but closer sources of care where quality may be lower. In addition to shorter travel time and costs, an important reason for the high levels of use of shopkeepers is that they are more likely to sell an incomplete dose of antimalarial drugs. This may be appreciated by the patient when cash is not available to buy a full course of treatment,[45] even though the price per tablet they pay may be higher.[2] Inadequate doses increase the risk of parasite recrudescence.

2.3.2 Constraints on supply

Many of the problems concerning the supply of malaria treatment are linked to broader problems of health services, such as inadequate resources, poorly trained staff and inappropriate incentives for health workers.

Public sector resource constraints are a major problem for the delivery of good-quality malaria treatment. In many countries, particularly in sub-Saharan Africa, expenditure on health has been constrained by very limited government revenues and restrictive macroeconomic policies. For instance, annual government health expenditure in Tanzania is approximately 2.50 US dollars per person.[46,47] Lack of resources is exacerbated by resource allocation patterns which tend to favour secondary and tertiary level facilities in urban areas. Such spending constraints contribute to shortages of trained staff (particularly in rural areas) and stockouts of essential drugs. They also lead to inadequate transport and communication facilities which seriously compromise the effective referral of severely ill patients. Part of the reluctance to change the first-line drug to a more effective but more expensive therapy can also be traced to concerns about the implications for already-strained drug budgets.

Information about appropriate treatment is also a problem for care providers in both public and private sectors. Limited information is likely to be most pronounced in shops and other commercial outlets where those selling drugs have minimal training, but is also surprisingly common in the more formal health sector. Health workers often have little training in malaria treatment, and changes in drug policy and therapeutic guidelines are not always well communicated, especially to those working in peripheral health facilities. For instance, a study in Accra (Ghana) found that less than 60% of doctors and health assistants knew the correct adult dose for chloroquine.[22]

Even with adequate information, providers face a complex set of incentives that influences their behaviour. In general, the incentive structures in public sector institutions do not encourage providers to deliver services efficiently or to be sensitive to patients' preferences. Health workers are often remunerated purely by salary, and salary levels are often very low. In some countries they do not provide a living wage, obliging health workers to find other sources of income, both related to their main job (e.g. illicit selling of drugs; charging informal fees) and involving other activities (e.g. farming). Effective performance assessment and supervision rarely exist and it is difficult to dismiss staff. Budgets for facilities are determined on a historical basis, and there are few rewards for improving quality

and attracting more patients, as this will simply mean having to treat a higher number of patients with the same resources. Introducing cost-recovery schemes that allow facilities to retain all or some of the revenue generated can create incentives to increase utilization by improving quality. The design of some schemes, however, encourages health workers to prescribe more items or more profitable items since extra money is generated either for the facility or for the workers themselves.[48] A study of prescribing practice in Ghana found that the introduction of a "cash and carry" system of charging for drugs resulted in less rational drug prescription: the proportion of patients treated for malaria receiving injections or three or more drugs rose from 56% to 89% following the policy change. This shift was attributed to the financial return received by the health centre; prescriptions containing only chloroquine and analgesics yielded a profit of 60% compared with between 120% and 200% profit on prescriptions with injections or more than three items.[49]

The degree of geographical variation in the burden of malaria means that control packages should be adapted to the local situation. For example, the quantity of antimalarials in drug kits for peripheral facilities should be flexible to reflect variations in disease incidence. This is often not achieved, however, because health-care managers in the public sector lack both the autonomy and the incentives to make such changes.[50] Locally responsive planning may also be undermined by the continued strong dependence on vertical malaria control programmes.[51]

Commercial private sector providers, on the other hand, face greater incentives to meet patients' expectations and achieve high levels of perceived quality. However, in general, private providers have stronger incentives to improve the easily observable dimensions of quality, such as equipment availability, as opposed to those that are harder to assess, such as diagnostic accuracy. This can lead to the use of more expensive drugs and drug formulations (e.g. injections) and of proprietary rather than generic drugs, as well as polypharmacy. Providers might also be under pressure from patients to prescribe or sell incomplete courses of antimalarials.

Regulation, which might be expected to support consistent quality in the private sector through its effects on incentives, is notoriously ineffective in developing countries. This is in part due to the lack of enforcement capability.[52,53] Furthermore, much of the private treatment takes place in the informal sector,[54] which by its nature is far more difficult to regulate and control.

Providers also work within other constraints that affect their treatment choices. For instance, in the absence of facilities for diagnosis and where patients' access to the formal health sector is limited, providers may prescribe for a range of different potential problems since patients may not return if their condition fails to improve. Such a "shotgun approach" may appear to be irrational and uninformed, but it may in fact reflect a greater sensitivity to local contextual factors. Health workers have also been observed to respond to drug shortages by reducing the amounts of antimalarial drugs given to patients for presumptive treatment.[55]

Chapter 3. What can be done to improve treatment?

Governments in developing countries have historically chosen to play a major role in the treatment of malaria and other common health problems in order to improve equity of access and to address the market failures that arise with private provision. However, as noted above, public treatment services are themselves frequently inefficient, of poor quality and underutilized. Moreover, to improve the quality of the majority of treatment episodes, the government has to address not only public sector services, but also the widely used services provided within the private sector.

This section begins by setting malaria treatment in the context of the broader health sector, highlighting general strategies that should improve the treatment of malaria and other health problems. A series of key planning decisions concerning public sector facilities and the services provided are then evaluated. Consideration is given to ways in which policy can be used to influence the behaviour of both care seekers and care providers, to ensure that these services are delivered and used in the most effective and efficient way. Finally, the government's potential role in improving the quality of care outside the public sector, by influencing the behaviour of private providers, is discussed.

3.1 Malaria treatment and health sector development

Efforts to improve malaria case management will benefit from coordinated sectorwide development, rather than an exclusive focus on malaria-specific programmes. The Roll Back Malaria (RBM) partnership has recognized this (see Box 2, page 13). Moreover, as malaria is responsible for such a large proportion of outpatient and inpatient diagnoses in endemic countries, sustainable improvements in access to high-quality malaria treatment are unlikely to be achieved without an overall strengthening of health services, at both health centre and hospital levels.

Indeed, in many ways it is not practical to separate malaria treatment from the management of other health problems. There is so much overlap in the signs and symptoms of common childhood diseases and conditions, such as acute respiratory infections, measles, malaria, diarrhoea and malnutrition, that a single diagnosis for a sick child is often inappropriate and may lead to other serious and potentially life-threatening conditions being overlooked. This issue is explicitly recognized in the development of a new approach to tackling the treatment of children, the Integrated Management of Childhood Illness (IMCI).

The IMCI approach involves the use of treatment guidelines, the training of health workers in integrated case management, strengthening drug supply, management and supervision systems, and addressing child health at community level. A multicountry study is under way to evaluate its efficacy and cost-effectiveness.[56] If IMCI is to be used on a sufficiently large scale to reach RBM's objectives, it will require substantial investment. At the same time, some modification will be

Box 2
Roll Back Malaria

Roll Back Malaria (RBM) is a global partnership founded in 1998 by the World Health Organization (WHO), the United Nations Development Programme (UNDP), the United Nations Children's Fund (UNICEF) and the World Bank. Its aim is to halve the world's malaria burden by 2010. The RBM partnership includes national governments, civil society and NGOs, research institutions, professional associations, United Nations and development agencies, development banks, the private sector and the media.

RBM was set up in response to growing concern of governments, particularly in Africa, about the continuing and increasing burden of disease and death due to malaria. RBM was built on the foundation of increasing efforts in malaria-affected countries and regions to improve and support capacity to scale up action against malaria. The partnership supports efforts to tackle malaria wherever it occurs, but particularly in sub-Saharan Africa, which accounts for 90% of the malaria burden, mainly in young children and pregnant women.

Political commitment is a key priority of RBM. In April 2000 in Abuja, Nigeria, leaders from 44 African nations endorsed RBM's goal for 2010 in the Abuja Declaration and set, as an interim target, the initiation of appropriate and sustainable action to strengthen health systems to ensure that by 2005:

- At least 60% of those suffering from malaria have prompt access to and are able to use correct, affordable and appropriate treatment within 24 hours of the onset of symptoms.
- At least 60% of those at risk of malaria, particularly pregnant women and children under 5 years of age, benefit from the most suitable combination of personal and community protective measures such as insecticide-treated mosquito nets and other interventions which are accessible and affordable to prevent infection and suffering.
- At least 60% of all pregnant women who are at risk of malaria, especially those in their first pregnancies, have access to chemoprophylaxis or presumptive intermittent treatment.

RBM is giving priority to four technical strategies: prompt access to effective treatment; promotion of ITNs and improved vector control; prevention and management of malaria in pregnancy; and improving the prevention of and response to malaria epidemics and malaria in complex emergencies. It seeks to expand the use of interventions which are already known to be effective in tackling malaria and to encourage the research necessary for better interventions to be developed and deployed in the future, including new and better drugs and insecticides, as well as malaria vaccines.

As well as the technical interventions, RBM highlights the importance of strengthening health systems and capacity development. The World Bank aims to play a lead role in the partnership to raise malaria on the overall development agenda and in national priority setting, to bring financing needs of malaria to the attention of Ministries of Finance and to ensure that poverty reduction strategy processes, debt relief to Heavily Indebted Poor Countries (HIPC) and sectorwide approaches give appropriate weight to malaria. Progress in this area is slow with limited release of resources in some countries, but has been substantial in others, such as Uganda. RBM has developed a strategic plan for capacity development, which emphasizes the importance of effective policies and systems to provide an enabling environment for using skills, and encourages linkages to other programmes and partnerships, and involvement of private and other sectors. This area still does not receive as much attention as it needs for sustainable malaria control. While progress in different countries is variable, the Country Strategic Plans developed for RBM have been valuable in moving beyond separate plans for each donor project within a country.

(See http://www.rbm.who.int *for further information.)*

needed to meet the technical requirements of malaria control. In particular, the IMCI algorithms do not currently include a specific malaria diagnosis. As more costly drugs become necessary, more specific diagnostic criteria will need to be considered.

Strengthening health service delivery will also require improvements to systems for supervision, monitoring and evaluation. Ensuring that adequate resources are devoted to these functions is critical, as is the development of capacity to collect and use this information in planning and managing health services.

Several measures that fall under the broad heading of health sector reform can have a significant impact on the delivery of malaria treatment. These include structural changes, such as decentralization, separating service provision and purchasing functions, and promoting the delivery of health services through private for-profit and not-for-profit facilities. Financing reforms have been introduced, such as the introduction of user fees to increase the resources available to health facilities and provide incentives to improve quality and efficiency. Efforts to improve the policy process have involved the advocacy of burden-of-disease and cost-effectiveness analysis to determine "basic packages" of care to be provided at different levels of the health system. Finally, improvements in management processes have focused on planning and budgeting systems, information systems, drug distribution, financial management and accounting, management training and the introduction of controls over the supply of expensive technologies.[57] While the design and implementation of these reforms are based on broader health sector concerns, it has been suggested that the improvement of malaria treatment could act as a "pathfinder" or catalyst for change, focusing attention on key impediments to progress.[58]

It is also possible that some health sector reform initiatives have negative consequences for malaria case management. Decentralization of resources and authority to district and subdistrict levels should increase the ability of programmes to tailor interventions to the local epidemiological setting, allow greater intersectoral collaboration and increase local ownership and community involvement. However, poorly managed decentralization, unaccompanied by the development of technical capacity and increased resources at the peripheral level, may lead to a loss of focus and expertise, undermining programme effectiveness. There is strong evidence that introducing or increasing user fees dissuades the poor more than the rich from using services, delays care seeking and increases the use of self-medication and informal sources of care.[48] Given the importance of prompt treatment of febrile illness in reducing morbidity and mortality, any change which delays care seeking is a critical threat to effective case management. It may be possible to mitigate the impact on use by simultaneously improving quality, but fee revenues from poor communities are unlikely to be large enough to fund substantial improvements. This and other issues concerning the behaviour of providers and consumers are discussed in more depth below.

More recently, the adoption of new mechanisms for donor funding, such as Sector Wide Approaches and general budgetary support, have raised new issues for planning and implementing malaria control interventions. These include how to prioritize malaria in health sector plans and the relative importance that should be

accorded to health in Poverty Reduction Strategies and Medium Term Expenditure Frameworks. The magnitude of resources for malaria and other diseases promised by new funding bodies such as the Global Fund to Fight AIDS, Tuberculosis and Malaria has attracted the attention of central agencies such as the Ministry of Finance, which in some countries has raised concerns about the potential for such resource inflows to have adverse macroeconomic consequences.

3.2 Key planning decisions for the improvement of public sector malaria treatment

Attempts to improve public sector treatment services involve a series of key planning decisions concerning:

- The mix of facilities through which services are provided.
- The services offered at these facilities, such as diagnostic tools and choice of antimalarial drugs.

In addressing these decisions, policy-makers face the challenge of maximizing effectiveness and equity of access, while keeping within their severely constrained budgets. The economic techniques of cost and cost-effectiveness analysis are important tools for evaluating these key decisions, as described in Box 3 (see page 16).

3.2.1 Changing the mix of facilities for malaria case management

Public sector malaria treatment is frequently inaccessible to patients in need, particularly those living in remote rural areas. Governments need to establish the most cost-effective approach for extending coverage to these groups. Other key decisions concern whether treatment facilities should be malaria-specific or provide general health care, and whether they should rely purely on passive case-detection methods, where the patients take the initiative to seek treatment, or include active case detection as well, where blood samples are obtained from asymptomatic individuals in the community. These issues are more relevant to parts of Asia than to Africa, as in Africa malaria treatment is usually fully integrated in general health facilities.

Malaria-specific and integrated facilities were compared in Nepal.[59] The government cost per case detected was much higher in malaria-specific clinics, due to the economies of scope gained from sharing staff time with other activities in integrated facilities. This differential became much more pronounced in areas with relatively few malaria cases. It is likely, however, that the malaria-specific facilities detected and treated a higher proportion of total cases, so the lower cost per case in integrated facilities may have been offset to some extent by a less efficient detection system.

The same study also compared the cost per case of different case-detection mechanisms in malaria-specific facilities.[59] Active case detection had the highest government cost per case, followed by passive case detection by volunteers, with passive case detection through the malaria clinics being the cheapest. When

Box 3
Is malaria control good value for money?

A range of effective interventions are available to control malaria, but policy-makers face a series of complex choices. Firstly, the allocation of resources between malaria control and other health-care problems; secondly, the choice of interventions within malaria control; and thirdly, the choice of delivery method for each intervention. The fact that interventions are known to be effective is, on its own, not enough to justify provision, which requires consideration of a wide range of epidemiological, behavioural, economic and managerial factors. The economic tool of cost-effectiveness analysis (CEA) provides a framework to synthesize data on these diverse issues, and can help to identify the interventions representing the best use of public sector resources. CEA involves a comparison of the cost of interventions in terms of the value of resources used and their benefits in terms of units of health outcome.[186] The cost-effectiveness ratio (CER) for an intervention is calculated as the total incremental cost divided by the incremental number of units of health benefit. The most cost-effective strategy has the lowest CER. By comparing the CERs for a range of interventions, resources can be allocated to maximize the health gain from a given budget.

As it will never be possible to have up-to-date estimates of the cost-effectiveness of every intervention in every situation, policy-makers need to use results derived elsewhere and evaluate whether they are appropriate for their setting. Annex 1 (page 57) provides a comprehensive review of all malaria-related CEAs published up to and including 2002 using generic health outcome measures (deaths averted, disability-adjusted life years (DALYs) averted or discounted years of life gained (DYLGs)). The studies are not all strictly comparable because there are differences in methodology; they come from a wide variety of epidemiological and socio-economic settings and some are based on trial rather than operational settings, where compliance is likely to be higher.

A subset of the results quoted in Annex 1 is based on a standardized modelling framework, used to derive estimates for the cost-effectiveness of a range of interventions in sub-Saharan Africa which are as comparable as possible, given the data available.[82,91] These estimates are shown graphically in Figure 1 (page 19), which gives ranges for the cost per DALY averted by a selection of interventions to prevent malaria and improve treatment. The DALY is a measure of health gain which incorporates both disability and deaths prevented. The estimates are based on a sub-Saharan African operational setting, in countries with low income (gross national product (GNP) per capita under US$ 315) and moderate to high levels of malaria transmission, such as Malawi, Mozambique and Tanzania. To set these estimates in context, an intervention in a low-income country could be considered a “highly attractive” use of resources if the cost per DALY averted fell below US$ 25–30, and “attractive” if it fell below US$ 150.[187] All the interventions evaluated are an attractive use of resources in this setting, and some would be considered highly attractive. The cost per DALY averted for preventive interventions was between US$ 3 and US$ 93, and between US$ 1 and US$ 8 for strategies to improve case management (based on 1995 US dollars). It is possible to make rough comparisons with CERs for other health interventions, although the methodology used may not be strictly comparable. For example, the cost-effectiveness of measles vaccination is between US$ 2 and US$ 17 per DALY averted, onchocerciasis vector control between US$ 120 and US$ 230, and the medical management of hypertension greater than US$ 2000 (results converted to 1995 US dollars).[188]

Estimates for middle-ranking African countries (GNP per capita from US$ 315 to US$ 1000), such as Benin, Ghana and Zimbabwe, were very similar to those for very low-income countries, with the cost-effectiveness ranges only very slightly higher, and all continuing to fall clearly below US$ 150 per DALY averted. In higher-income African countries (GNP per capita greater than US$ 1000), such as Botswana and South Africa, some of the cost-effectiveness ranges for the preventive interventions no longer fell entirely below US$ 150, but the higher ability to pay for health-care interventions in these countries would mean that a higher CER cut-off would be appropriate. Cost-effectiveness

will also vary in settings with lower transmission or where the principal vectors and parasite species are different, and over time, due to changes in levels of drug and insecticide resistance, for example.

The modelling study evaluated individual interventions, rather than the packages of malaria control measures which would generally be implemented in practice. The total effects of interventions implemented together may be less than the sum of their incremental effectiveness when implemented alone. For example, separate chemoprophylaxis and ITN trials for Gambian children under 5 years of age found reductions in all-cause mortality of 49% and 42% respectively, but the addition of chemoprophylaxis to an ITN trial in the same setting did not avert any additional deaths.[189,190] The incremental cost of interventions could also be lower when implemented together if resources were shared and, therefore, used more efficiently. In Brazil, predictions were made about the likely incidence of cases and deaths if an improved malaria control programme had not been implemented. From these projections, it was estimated that the cost per DALY averted was US$ 132 for the combined prevention programme of residual spraying, fogging and source reduction, and US$ 17 for a package of measures to place greater emphasis on early diagnosis and prompt treatment. In combination, the prevention and treatment packages were estimated to have a cost per DALY averted of US$ 67 (1995 US dollars).[191]

The results from both the Brazilian and the sub-Saharan African modelling studies indicate that, on average, improving treatment is even more cost-effective than preventing malaria, although the cost-effectiveness ranges for treatment and prevention interventions overlap in the sensitivity analyses in both studies. It is difficult to obtain estimates for the cost-effectiveness of treatment compared with no treatment, because it is not ethically possible to measure the impact on health outcomes. However, rough estimates have been made by asking experts what they would expect case fatality rates to be without treatment. This method was used for children with uncomplicated malaria presenting at an outpatient facility in an African setting, for a selection of antimalarials and levels of drug resistance.[75] Combining these estimates with the drug costs of treatment, the drug cost per death averted was estimated to range from US$ 0.20 to US$ 6. It is evident that even if the cost and the cost-effectiveness ratio were to increase 10 or 20 times with the inclusion of the full costs of the outpatient visit, malaria treatment would still represent a highly cost-effective use of resources.

patient costs arising from expenditure on private treatment and inability to work were included, the relative costs of passive case detection increased markedly, but the ranking of the three alternatives did not change.

Several other studies have shown that extending the range of treatment outlets into the community to improve access increases accessibility and reduces patient costs, but tends to increase the government's cost per case.[60,61] In Maesot District in Thailand, the government cost per case detected was lowest in the large central clinic in the district town, followed by the peripheral clinic in the subdistrict town.[60] The periodic mobile clinic, whose staff travelled by motorcycle to five villages on a fixed weekly schedule, had the highest government cost per case. However, the community cost per case detected showed the opposite pattern, being highest at the central clinic and lowest at the periodic clinic, reflecting the increasing ease of access to the smaller community-based facilities. Combined government and community costs were minimized by a mixed strategy including all three types of clinic.

An alternative strategy for extending the reach of public health services is to use community-based agents to provide treatment within the patients' village, a common approach in Latin America[62] and in some countries in Asia. A range of agents have been used, such as paid and voluntary community health workers, officials managing community-based drug funds or traditional healers.[63] In Brazil, bar owners were trained to diagnose and treat malaria in villages far from formal facilities.[64] Although the care provided may be perceived to be of inferior quality because the volunteers have received limited training or do not have adequate drug supplies, these strategies should improve access for patients. When this approach was evaluated in Kenya, however, no impact on mortality was observed, even though more than 85% of patients sought treatment from the community volunteers.[65,66] In the Gambia, reductions in mortality were observed with a combined treatment and prophylaxis programme administered by village health workers, but there was no significant impact on mortality from the provision of treatment alone.[67] However, in 1997 in southern Tigray (Ethiopia), a 40% reduction in all-cause mortality in children aged under 5 years was achieved through a randomized community trial of an intervention to train mothers to recognize febrile illness and treat it appropriately with chloroquine, and to ensure chloroquine availability at community level. This dramatic result demonstrates the potential of such strategies, although some unusual features of this situation should be noted. These included low levels of chloroquine resistance, an absence of alternative sources of malaria treatment, strong community solidarity and a dynamic principal investigator.[68] Despite this evidence of the benefits of improving access to treatment, some experts remain cautious about this approach, because of concerns that allowing community-based workers to distribute antimalarials will increase the misuse of drugs and accelerate the development of antimalarial resistance.[63]

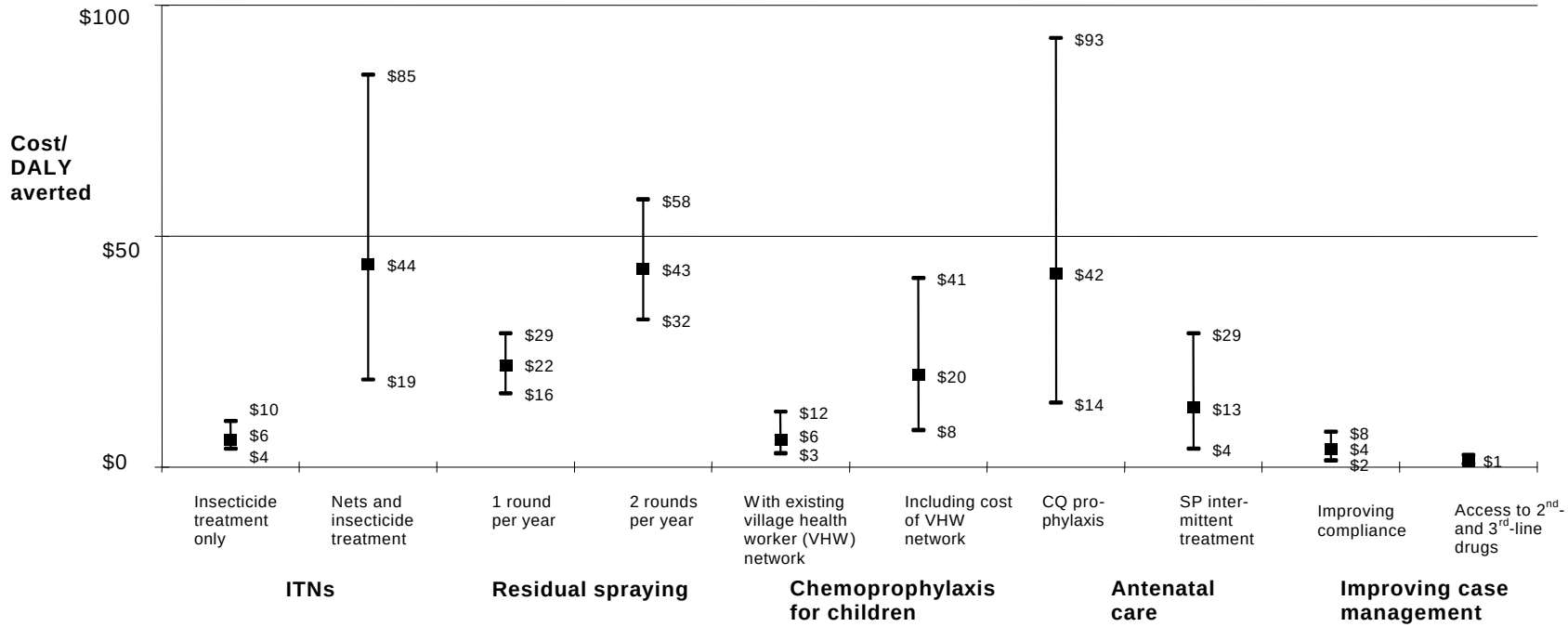
In conclusion, the most appropriate mix of facilities is highly dependent on the number of cases. Malaria-specific services will only be efficient where there is a sufficiently large number of cases to offset the high fixed costs. However, services need to extend into the community if they are to reach those most in need and reduce access costs, though the best way to do this effectively is still uncertain.

Finally, the distribution of costs among users and governments is important: what is cheapest for government will not necessarily be so for users.

3.2.2 Changing the diagnostic services offered

Efficiency and quality of care can also be improved by changing the diagnostic services offered at each level of the health-care system. The main diagnostic tool used has traditionally been microscopy, which is often of poor quality. Moreover microscopy is frequently not available at peripheral facilities, so if parasitological confirmation is required, samples must be sent to distant laboratories, leading to delays in diagnosis and appropriate treatment.

Figure 1.
Cost-effectiveness ranges and means in a very low-income sub-Saharan African country with moderate to high malaria transmission[91]



Notes: Figure shows mean and range within which 90% of cost-effectiveness estimates fall (all amounts are in 1995 US dollars)
ITNs (insecticide-treated nets): one treatment with deltamethrin a year, no insecticide resistance
Residual spraying: lambdacyhalothrin, no insecticide resistance
Chemoprophylaxis for children: Maloprim®, perennial transmission, no resistance to Maloprim®
Antenatal care: primigravidae only, 50% chloroquine (CQ) RII/RIII resistance, 10% sulfadoxine-pyrimethamine (SP) RII/RIII resistance
Improving case management: chloroquine as first-line drug with 30% clinical failure

Practical alternatives to microscopy are now becoming available in the form of rapid antigen tests on dipsticks or cards which require only a small blood sample, take a few minutes and do not require sophisticated laboratory skills or equipment, but are similar in accuracy to good-quality microscopy.[69] Some of the tests identify only *P. falciparum* malaria, but newer tests can distinguish between parasite species.[70] A key decision facing policy-makers is whether they should consider replacing more traditional diagnostic methods with these newer techniques. The kits cost between US$ 0.80 and US$ 3 per test, plus limited supplies and staff time, amounting to a total cost of between US$ 1 and US$ 3.50 per test. The cost of microscopy, on the other hand, has been estimated as around US$ 0.40 per test, so it seems that microscopy will normally be cheaper, except at very low volumes.[71]

However, dipstick tests have two important advantages: they provide instant results and can be used in peripheral facilities or even in the field. Thus, where blood samples are at present sent away for laboratory testing, dipstick tests could lead to substantial cost savings in transport, presumptive treatment and follow-up of parasite-positive patients. Reducing the delay in delivering radical treatment may also make case detection a more effective means of reducing the reservoir of infection. Costs to patients should also fall substantially from shorter waiting times, fewer repeat visits to health facilities and reduced illness duration due to the more rapid provision of a radical cure.[72] These cost savings may mean that the net costs of dipstick tests are much lower than their gross costs, and in some cases they could even save costs.

In much of sub-Saharan Africa, diagnosis is based on clinical symptoms alone. Rates of overdiagnosis are very high because it is so difficult to distinguish malaria from several other common causes of febrile illness. The potential to improve clinical diagnosis through training or simple algorithms to guide diagnosis and treatment is limited, as improving accuracy by excluding negative cases is usually accompanied by an increase in the number of positive cases missed.[73] This is unacceptably dangerous in settings where health facilities are relatively inaccessible and patients may not return if they subsequently develop severe disease. The introduction of diagnostic tools such as microscopy or dipsticks can improve diagnostic accuracy and reduce excessive prescription of antimalarials to negative cases, thus reducing drug costs. However, the extent of cost savings depends on the accuracy of both current practice and the new test, the cost of the drugs used and the behaviour of providers, as well as the local epidemiology of the disease.

In most of Africa where antimalarial monotherapies are used, cost savings from reduced drug use are unlikely to exceed the incremental cost of introducing diagnostic tests because the current range of commonly used monotherapies is so cheap. For example, treatment with chloroquine or sulfadoxine-pyrimethamine (SP) tablets costs around US$ 0.13 for an adult. For children under 5 years of age, who in high transmission settings account for around half of all cases, the cost is only US$ 0.02. Even if only half the clinically diagnosed cases are parasite positive, the average drug cost saving per case from using a diagnostic tool would be around US$ 0.04, much lower than the average cost per case of either laboratory or dipstick diagnosis. In low transmission areas, where the accuracy of

clinical diagnosis is even lower and a higher proportion of cases are adults, the drug cost saving per case would only be slightly higher, at US$ 0.09. The impact of drug savings on the net incremental cost of introducing the new tests would therefore be slight, and the total cost of introducing the tests would be beyond the means of most health services.

However, if increasing resistance to low-cost drugs such as chloroquine and SP leads to the use of more expensive antimalarials, the savings in drug costs would be more significant. Assuming a cost per test for the dipstick of US$ 1, cost savings would occur in high transmission areas only at an average drug cost per treatment above US$ 2.33, which is greater than the average cost of either quinine or mefloquine. However, in low transmission areas the test would save costs if the average cost of any drug was more than US$ 1.50, implying potential overall cost savings if mefloquine or a combination containing an artemisinin derivative was the first-line treatment.[71]

Even if new diagnostic tools do not lead to overall cost savings, they may be considered cost-effective if they improve health outcomes. These improvements may arise through better management of non-malarial cases, a reduction in side-effects due to unnecessary treatment, increased utilization due to improved perceptions of quality of care, improvements in the identification of treatment failures and reduced selection pressure for resistance. Further analysis is needed to quantify these benefits and to model the potential impact on health outcomes so that value for money can be accurately assessed. It is also essential to take into account the behaviour of providers in operational settings. In practice, health workers may continue to prescribe antimalarials to negative cases if they are afraid of missing a severe case or in response to patient demand for drugs. This phenomenon was found to be common in Zambia, where 39% of health centre outpatients with negative blood slides were still prescribed antimalarials.[15] In Solomon Islands, however, patients have become unwilling to take treatment without a positive diagnosis (K. Palmer, personal communication).

3.2.3 Changing the first-line drug for treatment

The choice of first-line drug for the treatment of uncomplicated malaria is a key part of a national malaria control strategy, and needs to balance issues of actual and perceived drug efficacy, safety, simplicity of dosage and cost. In recent years the choice of an appropriate therapy has become increasingly constrained by the development of antimalarial resistance, which poses a crucial threat to the delivery of affordable and effective care. Resistance has necessitated changes in drug policy in many countries. In Thailand, SP replaced chloroquine as the first-line treatment for *P. falciparum* infections in 1973. Although morbidity and mortality fell over the next seven years, by 1981 there were reports of diminishing efficacy, and quinine and tetracycline were introduced. By 1985 it was felt necessary to change again to a combination of mefloquine and SP in some areas, and this was subsequently replaced by mefloquine alone, and then mefloquine plus artesunate.[74] Multidrug resistance is less common in Africa, where chloroquine remains the first-line drug in most countries. However, chloroquine resistance is now very common and is increasing rapidly, leading to considerable

debate over when the first-line drug should be changed and the choice of the replacement.[17] A number of sub-Saharan African countries, including Botswana, Burundi, Eritrea, Ethiopia, Kenya, Malawi, Rwanda, South Africa, Tanzania, Uganda, Zambia and Zimbabwe, have now abandoned chloroquine on its own, but many others continue to use it as their first-line drug. Several authors have attempted to provide guidelines on the level of resistance at which a change should take place.[19,75,76] In view of the South-East Asian experience, the potential growth of resistance to SP, if adopted as the first-line drug, is a major cause of concern. Although generic chloroquine and SP cost roughly the same per treatment, the currently available potential replacements for SP such as mefloquine or combination therapies are 20 to 40 times more expensive[77] and therefore unlikely to be readily affordable in most African countries.

Cost-effectiveness analysis provides a potentially valuable analytical tool for structuring the decision of whether to change the first-line drug. The assessment involves predicting how resistance to the alternative drugs will grow over time and how this will affect health outcomes. This requires the use of models combining data on resistance levels, treatment-seeking behaviour and case fatality rates, although information on all of these areas is very limited. The incremental cost per treatment and the costs of implementing the change in policy (e.g. consultation, revising guidelines, training, providing information, etc.) must be considered, as well as cost savings through reductions in the care required for treatment failures. The analysis involves complex trade-offs between higher drug costs, immediate reductions in morbidity and mortality, savings in treatment costs and increases in resistance to replacement drugs, which could lead to higher morbidity and mortality in the future, and potentially the high costs of another replacement drug. Therefore, the time period over which the costs and benefits are considered and the relative weight given to costs and benefits occurring now and in the future (the discount rate) have an important impact on the conclusions. Due to these complexities, it is not possible to summarize the intervention in a single cost-effectiveness ratio. However, cost-effectiveness analysis can make the trade-offs involved explicit and can pinpoint areas where further research would be beneficial to reduce parameter uncertainties.[78–80]

In light of the grave threat posed by increasing drug resistance, cost-effective strategies to reduce the growth of resistance are urgently needed. One strategy widely advocated is the use of combination drug regimens as the first-line therapy. The rationale is that if two drugs are taken together, the chance that a mutant will emerge, which is simultaneously resistant to both drugs, is likely to be much lower than if the drugs are used alone.[81] Ideally, the two drugs should be metabolized at an equal rate, so that the parasite is never exposed to one drug and not the other, and singly-resistant parasites have no advantage over fully susceptible ones. Estimating cost-effectiveness is complicated, because in addition to the many complexities of comparing single drug therapies, there is currently a stark lack of evidence on the likely impact of combination therapies on the growth of resistance.

Preliminary analysis with the best data currently available suggests that combination therapy would be highly cost-effective if it had a significant impact on the growth of resistance. Comparing the introduction of SP alone as the first-

line drug versus a combination regimen of SP and artesunate over a 10-year period, the cost-effectiveness range fell below US$ 150 per DALY averted if the reduction in the growth of resistance exceeded 14% and below US$ 25 per DALY averted if the growth of resistance was reduced by more than 58%.[82] The feasibility of achieving such reductions is unclear. In Thailand, a combination of SP and mefloquine was introduced in 1985 in an attempt to reduce the development of resistance, but the strategy met with little success because resistance to SP was already high and the pharmokinetic properties of the drugs were not well matched.[83] However, since 1992, mefloquine has been prescribed with artesunate in areas on the western Thai border with no decline in the efficacy of the combination regimen.[84]

Longitudinal studies to assess the impact of combination therapy on the development of resistance in Africa began in 2000.[85–87] Whether a significant impact is achievable in sub-Saharan Africa is at present unclear, as it depends on both epidemiological factors, such as the rate of transmission, and health-seeking behaviour, and on drug use.[88] However, if a combination regimen has much higher effectiveness than existing monotherapies at current levels of resistance, its adoption may be considered cost-effective even in the absence of a proven impact on resistance growth or transmission.

If it has been decided to change the first-line drug, it is important not to underestimate the implementation process for the new policy. Implementation requires substantial financial and human resources, expertise, political will and time. It also entails not only changes in public sector policy, but also interventions to influence the extensive provision of drugs through the private sector.[89] In Malawi, for example, the process of planning and implementing the training, education and monitoring required for the change from chloroquine to SP took two years. While the process is generally spearheaded by malaria and drug programme staff, it involves a wide set of stakeholders, ranging from senior Ministry of Health officials, health personnel, scientists, prescribers in the public and private sectors, and consumers. Successful implementation requires the development and distribution of therapeutic guidelines, training of health workers and timely procurement of adequate supplies of the new drug. Moreover, it is essential that a broad consensus behind the policy change is developed among policy-makers and health workers, which requires extensive provision of information to consumers and to public and private providers at all levels of the health system.[80]

3.2.4 Changing the range of available antimalarials

It is common for peripheral health facilities to stock a very limited number of antimalarials, often only chloroquine in some African countries. The effectiveness of treatment could be improved by increasing access to second- and third-line antimalarials for cases of treatment failure with the first-line drug. In Zambia, for example, SP was the official second-line drug, but was only available at referral hospitals if prescribed by a physician. In 1996 the Zambian Government decided to improve access to SP by making it available at health centres for people with persistent or recurrent symptoms after treatment with chloroquine.[90]

A study modelling the cost-effectiveness of malaria control interventions in sub-Saharan Africa is summarized in Box 3 (page 16). One of the interventions explored was increasing the availability of second-line drugs. A decision-tree model was used to provide estimates of the cost per DALY averted by moving from a situation where only chloroquine is available at outpatient facilities to one where SP and quinine are available as second- and third-line drugs for patients experiencing treatment failure.[91] The results (shown in Figure 1, page 19) demonstrate that the change is highly cost-effective, with a cost per DALY averted in the range of US$ 0.70–3.00. As chloroquine resistance increases, the intervention becomes more cost-effective, as it is even more important to have alternative drugs available. The cost-effectiveness range is under US$ 25 per DALY averted at any level of chloroquine resistance in high transmission areas, and at any level of resistance greater than 6% under low transmission.

Achieving these results in practice will require that health-care staff are provided with the necessary skills and incentives to identify treatment failures and implement the alternative regimens, and that both care seekers and care providers are prepared to accept the prescription of the first-line drug, even if they perceive the alternative available at the facility as more effective. Another possible cause for concern is that making second- and third-line drugs widely available might increase the growth of resistance to these drugs, potentially compromising the treatment of severe malaria and reducing the efficacy of potential replacements to chloroquine as first-line drug. It is, therefore, important that the intervention is combined with strategies to improve provider practice and patient compliance, in order to minimize this danger.

The range of therapies in peripheral facilities for patients with severe disease could also be expanded, in order to prevent or delay the development of more severe disease and complications, and thus increase survival, both en route to and after arrival in hospital. A basic package could contain a parenteral antimalarial, a parenteral antibiotic, an oral antimalarial and a rectal anticonvulsant.[92] Trials of the use of artesunate rectal suppositories are currently under way.[93] The suppositories are believed to be preferable to the use of parenteral injections because they can be given by minimally trained staff, do not entail the risk of HIV or hepatitis infection, and are less likely to be overused in situations where they are not indicated.[94] Preliminary investigation of their potential cost-effectiveness showed that, with a price per suppository of US$ 0.50, the intervention would have a cost per DALY averted of under US$ 4 if it led to a reduction of at least 5% in the case fatality rate for patients with severe disease.[82] If suppositories were available solely at health facilities, however, they would benefit only a subset of severely ill patients, as failure to receive prompt inpatient treatment arises from a variety of causes including reluctance to seek care for severe disease at formal health facilities, the inadequate knowledge of staff in health centres, lack of transport and financial barriers such as high fees charged at hospital facilities. None of these causes would be resolved by the introduction of this new technology alone. These issues could be tackled by introducing the suppositories as part of an intervention that also included in-service training for health-care staff on the recognition of cases requiring referral, the provision of additional transport and community education on appropriate treatment for severe disease. This technology also has the potential of being extended to community or household

level, and therefore of "buying" valuable time while the patient is being referred for formal care.[95]

The provision of more acceptable and effective therapies at peripheral levels may in itself draw people to the formal health-care system. For example in Tanzania, the introduction of IMCI, with its innovation of administering anticonvulsant therapy rectally instead of by injection, was observed to increase the utilization of peripheral dispensaries for the treatment of children with severe disease (Don de Savigny, personal communication).

In addition to selecting the range of antimalarials which should be provided, the government has a crucial role in ensuring that adequate stocks are available, both by the efficient management of the drug distribution system and by minimizing the leakage or sale of drugs that should be provided free. This issue is discussed below in the context of public sector provider behaviour.

3.3 Taking behaviour into account

The planning decisions explored above concerning the mix of facilities, services and drugs provided through the public sector are a vital part of a government's responsibilities. However, the public sector's role in malaria treatment goes beyond them. Firstly, to ensure high coverage of effective care in the public sector, it is also necessary to consider the determinants of the behaviour of care seekers and health workers. Secondly, the large actual and potential role played by the private sector in malaria case management and the need to target government interventions at changing the behaviour of providers in this sector as well must be recognized.

3.3.1 Changing the behaviour of care seekers

Even if efficient and high-quality services are offered, they will fail to have an impact on health outcomes if they are not utilized by care seekers, or if the drugs provided are inappropriately used. Policy measures are needed, firstly, to affect treatment-seeking behaviour, by encouraging timely visits to appropriate providers and appropriate requests for treatment for both uncomplicated and severe disease. Secondly, policies must encourage patients to take the correct dose of antimalarials at the correct time and to finish the course. Interventions to influence demand for treatment and appropriate use must recognize that these behaviours are affected by a wide range of factors, including the price and perceived quality of the treatment and its alternatives, income levels, accessibility, information and ease of use.

Attempts to influence behaviour have focused on education to improve the information given to care seekers, pre-packaging of drugs to improve recall of doses and ease of use, and subsidizing appropriate treatments to lower costs for consumers.

Education of care seekers

Care seekers need clear messages on how to recognize the symptoms of malaria, identify treatment failures and severe disease, and use drugs appropriately. Education may take place both at the community level, through channels such as mass media, schools, community groups or meetings, and on a one-to-one level during consultations. To be effective, messages must be made locally relevant by customizing them based on local illness classifications, explanatory models for malaria and patterns of seeking care.[40] As the symptoms of severe malaria, such as convulsions, are often perceived as a separate illness, it may be necessary to develop separate messages and materials that inform care providers on their management.[96] Messages should be targeted to household members who play a major role in the care of the sick and who control the resources for health-care expenditure. The decision-making role with regard to treatment-seeking for children may lie with men as well as with mothers, so that targeting women alone would not produce the intended results. For example, in Kilifi on the coast of Kenya, almost all mothers sought advice from other family members before taking their sick child to a health facility, most frequently consulting their husbands or other male household members.[8]

The impact of education on behaviour has rarely been measured in a systematic way. An exception is a health-education intervention in Cambodia, where an evaluation was done of the impact of education of community members, private practitioners and drug vendors on compliance with a seven-day quinine and tetracycline regimen.[97] For the purposes of the evaluation, the community's population was divided into two groups. Two options were compared: posters alone were distributed in both groups, while health education videos, involving Cambodian comic actors and music, were shown to the second group only in video parlours, restaurants and ceremonial gatherings. The impact on self-reported drug purchasing and compliance soon after the intervention was much greater in the second group, with a 28% increase in the number of patients who bought a full regimen and a 20% improvement in the number who completed the full course. The strategy of just providing posters was less than half as effective. The long-term impact was not evaluated.

Pre-packaging drugs

Pre-packaging drugs can improve patient compliance by helping patients understand and remember how to take their medication. Evidence suggests that although knowledge and understanding may improve drug use, simple technologies aimed at reminding patients to comply, such as the way the drugs are packaged, may have a greater impact.[98] In Burkina Faso, an intervention to train mothers and distribute chloroquine and paracetamol pre-packaged in simple plastic bags by village health workers (VHWs) led to the number of children taking an adequate dose of chloroquine increasing from 3% to 49% and the number following a treatment regimen of adequate length increasing from 21% to 72%.[99] Compliance was also found to increase following a similar pre-packaging intervention in Ghana, where chloroquine syrup was compared with pre-packaged tablets for children.[100] Only 42% of children prescribed syrup received at least the minimum dose compared with 91% of those receiving pre-packaged tablets. The tablets were also much cheaper, at a quarter of the cost of the syrup including the packaging costs.[101] Studies in South-East Asia showed positive results with blister

packaging of antimalarials compared to handing out drugs in simple envelopes, increasing compliance from 83% to 97% in China.[102] In Myanmar, compliance of 99% was achieved with blister packaging of artesunate and a combination of artesunate and mefloquine.[103] It is unclear, however, whether such results could be sustained outside of trial conditions.

In Burkina Faso, the cost of the simple plastic bags, labels and packing was US$ 0.015 per treatment and the total non-drug cost of the intervention per treatment was US$ 0.07 (which included the cost of training, health education, bags, labels and packaging of drugs, incentives to VHWs, supervision and distribution). Blister packs are much more expensive and were reported to add US$ 0.84 to the cost of a treatment course of chloroquine, although costs may fall if mass production is possible.[104] However, whereas pills packaged in loose plastic bags need to be used within 35 days, blister packs can last up to 13 months and should also be more difficult to forge than low-technology plastic bags.[105]

The sub-Saharan African modelling study used a decision-tree model to provide estimates of the cost per DALY averted, assuming that an intervention similar to that implemented in Burkina Faso, incorporating training, health education and pre-packaging of pills, would improve compliance with a full treatment dose by between 10% and 30%. The results (see Figure 1, page 19) demonstrate that improving compliance is highly cost-effective, with a range of US$ 2–8 per DALY averted in high transmission areas. The range remained under US$ 25 at any level of chloroquine resistance below 77%. In low transmission areas, the cost-effectiveness range fell under US$ 25 with up to 24% resistance, and under US$ 150 with up to 87% resistance. The results should be interpreted cautiously as the translation of the increased compliance into a reduction in morbidity and mortality has not been validated empirically, and the results are very sensitive to the cost per patient. If, for example, the incremental cost were as high as US$ 0.50 per outpatient, one could never be reasonably certain that the CER would be below US$ 25, even at zero resistance.

Choice of drugs

Different drugs have different implications for compliance and treatment-seeking behaviour. Drugs with a shorter or simpler dosage regimen would be expected to have higher compliance. For example, chloroquine and quinine, which are taken over several days and have more common, unpleasant side-effects, will have lower patient compliance than SP, which is taken in a single dose. In Thailand, a trial comparing the cost-effectiveness of a standard seven-day quinine + tetracyline course with a five-day artesunate course[106] found higher compliance with artesunate, which was attributed to its milder adverse effects, shorter course and once-a-day dosing. As the drugs had the same curative efficacy, this led to a significantly higher cure rate with artesunate (100% compared with 77%), but artesunate was considerably more expensive (the prevailing price was US$ 0.40 per 50mg tablet at 1994–95 prices). The cost per case cured would have been lower with artesunate at a cost per tablet under US$ 0.36.

The characteristics of drugs also influence consumer behaviour through their impact on perceived efficacy. There has been concern that the replacement of chloroquine by SP as first-line drug may have adverse effects on consumer

confidence and treatment-seeking behaviour because the new drug is less well known. In addition, despite SP's higher clinical efficacy, care providers might perceive it as less effective because it is has less of an antipyretic effect than chloroquine, lacks chloroquine's distinctively bitter taste and is not available in an injectable formulation. However, when care providers' perceptions were compared during a drug efficacy study in Zambia's Lundazi district, parents whose children were treated with SP, despite its unfamiliarity, readily accepted the new drug and reported higher perceived efficacy than those whose children were treated with chloroquine.[40]

Drug subsidies

An alternative approach to changing consumer behaviour is to alter the cost of drugs to be paid by care seekers through subsidizing drug prices. In many public health systems, essential drugs are officially provided free in a bid to increase utilization and improve equity of access to effective therapies. However, as noted above, patients often choose to pay for drugs at private outlets which are perceived to be more accessible and of higher quality, or are obliged to do so because of drug shortages at public facilities.

It would be possible to introduce targeted subsidies for particular drugs but as with general subsidies, a change in price alone may not be sufficient to change behaviour. In Myanmar, patients tended to use artemisinin derivatives on their own, rather than in combination with mefloquine as recommended, and this was believed to be because the addition of mefloquine increased the cost per treatment more than fivefold. A subsidy was introduced for mefloquine through the provision of a voucher, which was given to care seekers with the artemisinin prescription and redeemable at specific outlets. However, post intervention, only 3.6% of patients chose to redeem their voucher and all of those doing so were being treated at the hospital where both drugs were available. None of the other patients were prepared to put up with the inconvenience of going to another outlet to redeem the voucher.[103]

Lessons on influencing the behaviour of care seekers

The Myanmar study serves to emphasize that the costs to patients seeking care are not limited to the price of drugs alone but also include travel and time costs, and that acting on just one determinant of demand may not lead to behaviour change. The effectiveness of all strategies to change consumer demand and drug use will depend on the underlying reasons for existing behaviour. For example, pre-packaging is likely to be more effective if low compliance is due to care seekers misunderstanding or forgetting the correct regimen, but is less likely to be effective if patients buy a suboptimal dose because they cannot afford the full regimen, if drugs are frequently unavailable or if strong incentives remain for providers to deliberately over- or underprescribe. Full compliance with treatment has benefits not only for the individuals using the drugs (the increased cure rate) but to others as well. Improved compliance may reduce transmission where transmission is low and, it has been argued, may reduce the rate of growth of drug resistance. If a service exhibits such positive externalities, then relying purely on provision at the market price will result in a suboptimal level of consumption from a societal perspective, because individuals do not take account of the benefits to others when making their own treatment decisions (see Box 1 on page 9). This is

an important consideration for policy-makers planning to introduce a combination therapy. As in the Myanmar experience, if the two drugs are available separately individuals may not be willing to incur extra costs for a second drug when they perceive that they are adequately cured with one drug alone. While co-formulating the drugs would incur additional research and production costs, these need to be weighed against the potential benefits in terms of improved adherence to the drug regimen.

In addition to the factors discussed above, consumer treatment-seeking behaviour will be strongly influenced by the perceived quality of providers. This is affected both by the planning decisions made by policy-makers concerning the facilities, services and drugs offered at public facilities, and the behaviour of providers, discussed below.

3.3.2 Changing the behaviour of public sector and NGO providers

Public sector providers include the full range of facilities from hospitals to peripheral dispensaries and community-based workers. In a number of countries, non-profit NGOs are also important sources of care, often owned by religious missions. These may be integrated into the public health system (for example, by being included in district health plans), often receive at least some government funding and share many of the characteristics of public sector providers. They are therefore considered here together with public sector workers.

The behaviour of providers has a crucial impact on the effectiveness of the services provided, through the accuracy of diagnosis, the drugs recommended and the advice given to care seekers. In addition, the way providers handle drug supplies has an important influence on drug availability. As with consumers, a wide range of factors affect provider behaviour, including their knowledge, their perceptions of their patients' attitudes, financial incentives, competition among providers and any sanctions for inappropriate behaviour.

Most attention has focused on changing behaviour through training to improve knowledge and recall of appropriate care. Improvements in prescribing have been observed through the use of job aids such as fever treatment charts or simple treatment protocols.[107,108] Pre-packaging drugs can improve drug use by providers as well as patients, by simplifying dispensing. In Ghana pre-packaging was found to reduce overprescription, unnecessary use of injections and polypharmacy, in some cases halving the wastage and excessive costs caused by prescribing unnecessary drugs and in addition, reducing patients' waiting time.[109]

However, the evidence suggests that measures to improve knowledge and recall alone do not necessarily change provider practice in the long term. In Ghana, where the Ministry of Health established an in-service training programme for medical assistants, there was evidence of improved knowledge immediately after training but the gains had deteriorated within a year. There were also discrepancies between knowledge and practice, with persistent over- and underdosing, excessive use of injections and multiple prescriptions.[31] A key explanation of this behaviour was perceived patient demand for inappropriate

treatment, especially injections, because providers were concerned that leaving care seekers dissatisfied would diminish their reputation. Providers were also more likely to give injections if they believed that patients would not comply with the oral formulations.

This study highlights that, as with strategies to change consumer demand, the effectiveness of interventions to change provider behaviour will depend on the underlying reasons for existing conduct. Strategies to change behaviour must be based on a clear understanding of the bases for the decisions currently made by providers, with a particular focus on the incentives they face for inappropriate conduct. While inappropriate prescribing may appear to be "irrational" and the outcome of inadequate knowledge, it often has an underlying rationality related to provider incentives, perceived consumer preferences or the realities of operating in remote areas. In some circumstances, providers deliberately underprescribe to reduce the occurrence of drug stockouts. In other settings they have strong financial incentives to overprescribe deliberately.[48]

The lack of penalties for inappropriate or illegal actions is a key problem in ensuring a reliable drug supply at peripheral facilities. Leakage of publicly funded drugs is not specific to antimalarials[18,110] and is the result of deep-rooted problems in the health sector, such as the very low pay of some health-care staff and the lack of supervision or accountability of public health workers to the communities they serve. Addressing these issues requires reforms to the health-care system as a whole, emphasizing the need to analyse the problems of malaria treatment within the context of the broader health sector.

3.3.3 Changing the behaviour of commercial private sector providers

Malaria treatment policy has traditionally been made by and for the public health system, including NGO health facilities. Public policy towards the commercial private sector has generally been limited to the regulation and control of their activities and attempts to redirect consumers away from private providers through health education and improving the quality of public provision.[63] It is increasingly recognized that the private sector plays a major role in malaria treatment and could facilitate the expansion of access to effective care.[58] The accessibility of private providers, particularly those in the informal sector, makes them an important potential resource for ensuring prompt treatment. A study in Kenya found that mothers generally treated their children at home promptly (within 24 hours of onset of illness), but the time lag between onset of illness and being taken to a health facility was three days,[8] a difference that could be critical for the health outcome. The policy focus is therefore starting to shift towards partnerships with private providers at all levels from drug sellers to manufacturers, in order to provide training and positive incentives to improve the quality of private sector care.[111]

Factors affecting the behaviour of providers in the public sector, such as knowledge and perceived patient attitudes, are equally relevant in the private sector. In addition, private providers face sharper financial incentives in terms of the costs and revenue earned from different products and competition for patients

with other providers. The structure of control mechanisms is also different, with supervision by senior health-care staff being replaced by a limited regulatory framework. Designing interventions to influence the private sector is more difficult because the government has much less information about the way it operates.

Addressing inappropriate prescription and the sale of poor-quality drugs through strengthening regulatory control has posed great challenges to many low-income countries. While government agencies can improve the regulation of formal private sector outlets to some degree, the resources to monitor regularly the hundreds of informal outlets stocking antimalarials in many countries are simply not available. However, it may be possible to take steps at a higher level to control illegal and counterfeit drugs. This would include maintaining a legal and administrative framework vested with clear powers to revoke or amend licences, training customs officials, establishing laboratory facilities to test the quality of drugs and encouraging local manufacturers to devise anti-counterfeit measures, such as labelling or coding.[112] However, it will probably be impossible to monitor all drug imports as so many cross borders through unofficial channels.

Due to the problems of ensuring effective regulation, attention has increasingly focused on other methods for influencing provider behaviour. Strategies for improving the quality of provision in the private sector can be divided into those operating at the national policy level and at the local provider level.[113] At the national level, links can be strengthened between public and private systems through the flow of information and patient referrals, better access for private providers to essential resources such as drugs and diagnostic facilities, and improving the organization and monitoring of private providers through accreditation or self-regulation. Interventions targeting providers at the local level include the dissemination of evidence-based guidelines and in-service training to improve knowledge and reduce dependence on data provided by commercial drug distributors through their medical representatives.[114] In addition, alternative information can be supplied through "academic detailing" where non-commercial prescribing advisers make face-to-face visits to providers.[115]

Training patent medicine vendors in rural Nigeria on a range of common conditions, including malaria, led to an improvement in their knowledge, with increases in the proportion who listed generic chloroquine rather than brand-name drugs for the treatment of malaria,[116] but the impact on actual practices was not evaluated. As with training of public sector employees, this is a cause for concern. General training for drug retailers became well established during the 1980s in Nepal, where drug sellers offer the only access to modern medicine for much of the population. The training course, which had a recurrent cost of US$ 18 per trainee in the late 1980s, improved basic knowledge about drugs, but retailers often did not apply this knowledge in their actual dispensing practices. It was suggested that this may be explained by a mixture of customer demands, the influence of pharmaceutical company representatives, public advertising, practices of competing local prescribers and lack of educational materials to reinforce course messages during interactions with patients.[117]

Greater success was achieved with a project to train shopkeepers in coastal Kenya, which had a significant impact on both shopkeeper behaviour and patient compliance.[118] Shopkeepers from general stores were provided with work aids such as dosage charts and trained on correct treatment and indications for referral. The training was complemented by regular monitoring, refresher courses and community mobilization activities. The percentage of childhood fevers treated with an antimalarial drug rose from 26% to 42% and the percentage of fevers treated with a shop-bought antimalarial receiving an appropriate dose and regime rose from 8% to 33%. Both shopkeepers and community members were strongly supportive of the programme, with shopkeepers finding that it not only increased their knowledge, but also their confidence in selling drugs, their social status and their profits. Promising results have also been achieved in western Kenya, through a programme to train drugs wholesalers to communicate malaria guidelines to retailers during the course of their normal business, which is intended to provide a rapid and affordable method of covering a high number of dispersed retailers.[119]

The clear lesson from the experience of many different projects is that, as with public sector providers, training alone is not enough. Firstly, it should be reinforced by refresher courses and by well designed health education resources. Secondly, the practices advocated need to be compatible with providers' incentives, which are influenced by a diverse range of factors in addition to knowledge, including financial, professional and patient-imposed pressures. This is more likely to be achieved if the information flows in both directions, with private providers being actively involved in policy orientation and the design of interventions. Thirdly, it is important that such efforts are extended beyond the formal private sector to informal providers, such as chemists, shopkeepers and drug sellers, who are responsible for the majority of care. However, there are several important obstacles to reaching this group. Their large number, wide geographic spread and informal methods of work mean that information is not generally available on their operation, and organization and coordination is difficult. In addition, there may be political pressure militating against formal involvement of "unqualified providers". Powerful interest groups, such as the medical profession, may be suspicious of strategies that result in some sort of legal sanctioning or formal training for unqualified providers. Successful policy implementation will therefore require a sophisticated understanding of the different interests, concerns and priorities of all the groups involved.[120]

Chapter 4. Current status of preventive interventions

4.1 Preventive interventions

There is currently no effective malaria vaccine. The preventive interventions that are available can be classified into those that inhibit mosquito breeding, those that kill adult mosquitoes in order to reduce the survival rate of the adult mosquito population, those that isolate humans from biting and those that reduce malaria infection in humans (see Table 1, page 2).

The breeding of vector mosquitoes can be inhibited by environmental management to reduce breeding sources or by the destruction of mosquito larvae. This has proved successful in some areas. Because *Anopheles* mosquitoes can fly long distances, effective control in rural areas requires the elimination of virtually all the breeding sites within 2 or 3km of a settlement. This approach, therefore, tends to be successful only where breeding sites are well defined. For example, effective results have been achieved through marsh drainage and ditch clearing in Haiti, Italy and the United States, and the use of larvivorous fish and intermittent irrigation in certain rice-growing areas.[121–124] However, these methods are generally less effective in areas where breeding sites are small, numerous, scattered and shifting. In the African savannah, for example, *Anopheles* mosquitoes breed in such a wide variety of temporary water collections that it is practically impossible to eliminate breeding in the majority of sources over a sufficiently large area. The potential for environmental interventions also depends on the relative importance of man-made breeding sites. Environmental approaches to vector control must, therefore, be opportunistic and locally specific. Although they can make a minor contribution in a wide variety of conditions, they can only play a major role when the most important breeding sites are few in number, easy to locate and do not shift with the season. This is most often the case in urban areas.

Methods aimed against adult mosquitoes have focused on the use of synthetic insecticides and repellents. Residual house-spraying involves the treating of interior walls and ceilings using a handheld compression sprayer and is effective against mosquitoes that favour indoor resting before or after feeding. A variety of insecticides have been used for spraying, including organochlorine compounds such as DDT, organophosphates such as malathion and most recently, pyrethroids such as deltamethrin, lambdacyhalothrin and cyfluthrin. The first house-spraying campaigns, just after the Second World War, showed the capacity of this intervention to produce profound reductions in malaria transmission in a wide variety of circumstances. This was mainly due to the reduction in vector longevity, which greatly reduced the fraction of female mosquitoes surviving long enough to transmit malaria. The outstanding impact seen in these early trials was the inspiration for the global malaria eradication campaign of the late 1950s and 1960s. Although this campaign made little progress in Africa, and achieved permanent eradication only on the edge of malaria's global distribution, it greatly reduced the burden of disease in many parts of Asia and Latin America. In India, for example, the incidence of malaria was reduced from an estimated 75 million

cases in 1947 to 100,000 cases in 1965.[123] Spraying trials undertaken in Africa at that time found a reduction in the infant mortality rate of 41–59%.[125] However, sustained and large-scale spraying campaigns have never been regarded as feasible in most parts of equatorial Africa and so have not been attempted, partly because the target is so large – in many countries the entire rural population is at risk – and partly because financial and infrastructural resources are so weak.

Spraying is still widely used in Asia, Latin America and some parts of southern and north-eastern Africa. However, many countries have curtailed their spraying activities, primarily because of financial and logistical constraints, but also because of insecticide resistance, disillusionment over the failure to achieve eradication and concerns over the safety and environmental impact of some insecticides. Space spraying or fogging is also feasible, but has a low residual effect. It is only cost-effective as a means of malaria control in exceptional circumstances, such as epidemics in urban areas or refugee camps, when a prompt but temporary interruption in transmission can be decisive in halting an epidemic.

Residual spraying for malaria control is almost always financed and implemented by the government[92] and very rarely privately provided. Implementing effective house-spraying is expensive and requires specialized skills and efficient organization, though in reality, there are numerous examples of inefficiently implemented programmes. In India, for example, it was observed that a drive to increase coverage led to more cattlesheds being sprayed than houses, with limited impact on malaria transmission.[126] A study of spray-team behaviour in Thailand found that sprayers were more likely to use higher dosages of DDT powder in the morning than in the afternoon, in order to lighten the weight of the DDT powder that had to be carried from house to house. DDT was also given to villagers for agricultural use in return for food or as a courtesy. The observers estimated that up to one-third of the DDT carried by the spray team was misused each day.[127] Effectiveness may also be diminished if spray rounds are inappropriately timed in relation to the transmission season.[59,128]

Two further challenges are resistance of both the mosquitoes and the population. The main impact of resistance in the vector is to decrease efficacy (if the same compound is used despite resistance) or to increase the cost (if there is a switch to a more expensive compound). Vector resistance to DDT and to other residual insecticides is a major problem in South Asia and some parts of Latin America.[129] Of course, this does not mean that all vector populations throughout these regions are thoroughly resistant and many countries still rely on house-spraying as the mainstay of malaria vector control. Resistance is much less of a problem in highly endemic areas of Africa, mainly because there have been very few sustained and large-scale campaigns of house-spraying in these areas. House-spraying is, however, widely used in countries such as Ethiopia, Madagascar and South Africa, in the north and south of the continent. Growing concern about possible health and environmental hazards has sparked a debate on whether DDT should be completely banned for use in malaria control.[130,131] As a result, many countries (but not all) have switched to the use of more expensive but more biodegradable compounds for house-spraying. In several cases, this switch has been accompanied by a reduction in the proportion of the population at risk who are protected by spraying and by a progressive increase in malaria incidence.[132]

Resistance in the human population may be due to concerns about health, safety and convenience, with households refusing entry to spray teams, refusing to have certain rooms sprayed, or painting or replastering their walls immediately after spraying.[132] For instance, in Zimbabwe 21% of villagers refused to have some rooms in their homes sprayed.[133] In South Africa, over 48% of the homesteads replastered at least some of their walls before the end of the transmission season, rendering the insecticide ineffective.[134] One factor contributing to decreased acceptance of insecticide spraying is the development of resistance of other nuisance insects, such as bedbugs, to the insecticide. Spraying was unpopular in Papua New Guinea because it killed a useful predator and led to the premature destruction of thatched roofs by pests.[135] It has been suggested that the newer pyrethroid insecticides now increasingly being used will be better accepted because, unlike DDT, they do not leave an odour or a visible deposit on walls.

Methods for isolating humans from mosquito biting include insecticide-treated materials (bednets, curtains, hammocks and cloths) and domestic insecticides such as sprays, coils and repellents. In the case of insecticide-treated nets (ITNs), the net is dipped in a solution of pyrethroid insecticide which repels and kills mosquitoes. While nets normally last for several years, the efficacy of the insecticide gradually wears off over time, so it is necessary to retreat the nets regularly. A permanently treated net, with insecticide incorporated directly into the fibres, is now available, which eliminates the need for regular retreatment. It is still, however, only produced on a limited scale. The efficacy of ITNs in reducing mortality has been demonstrated by several large-scale African trials, which found reductions in all-cause mortality in children aged under 5 years ranging from 14% to 63%.[136]

Mosquito nets are not a new idea in most malarious areas, but levels of net coverage vary enormously from place to place. Vigorous commercial net markets exist in many parts of Asia. For instance, in 42 counties in the malarious areas of Sichuan province, China, there were 2.6 nets per household in the late 1980s.[137] Similarly, in some parts of Africa, net ownership is a well established social norm and nets are widely available and relatively cheap. For example in 1993, 62% of households in Dar es Salaam (Tanzania) owned a mosquito net[138] and around 35% of households were found to own a net in urban Burkina Faso.[139] In other parts of Africa, by contrast, net ownership is a rare exception and nets can only be bought for high prices in the big cities. In 1996 in Mozambique's capital Maputo, for instance, nets were available in only a dozen shops, at prices ranging from US$ 30 upwards. Most parts of Africa fall somewhere between these two extremes: there is a significant level of commercial activity, but it is concentrated in urban areas and coverage in rural areas falls well short of public health targets.

Governments in many malarious countries now include the promotion of ITN use as one of their malaria control objectives. Some, such as the Philippines, Solomon Islands and Vanuatu, are involved in large-scale and effective efforts to promote and distribute treated mosquito nets.[140] However, the most successful and sustained public sector programmes exist in places such as China and Viet Nam, where mosquito net coverage is already very high, so that the government's role in provision has been largely restricted to offering a regular net treatment service. In Africa, there have been many local projects, mostly run by NGOs, that have

sold nets and insecticide at subsidized prices, often with the aim of setting up local revolving funds. Unfortunately, very few of these projects have proved sustainable. This experience has shown that it is relatively easy to sell subsidized nets, but much harder to sell the retreatment, with less than 20% of nets being regularly retreated in most cases.[141,142] The only exceptions are programmes in which retreatment has been provided free of charge (e.g. China and Viet Nam). In such cases, coverage has usually been high (over 95% in China).[137]

Households also prevent malaria and avoid nuisance insect biting through the extensive use of insect repellents and domestic insecticides, such as aerosol sprays, repellent coils and mats, and traditional herbs, all of which are privately provided. There is growing recognition of the potential importance of these household practices, given that much more money is spent on household-based methods of personal protection than on publicly organized vector control. For instance, an estimated 29 billion mosquito coils are sold each year, 95% of them in Asia.[143] Household expenditure on these antimosquito measures can be substantial, although there is evidence of large rural–urban disparities in spending.[139,144–146] In Dar es Salaam, Tanzania, it is estimated that up to US$ 1 million per month is spent on coils and sprays (D. Chavasse and J. Lines, unpublished data). The global retail market for coils, sprays and mats is estimated to be worth US$ 2 billion.[143] High-income households have access to other private options for mosquito control, including air conditioning and screening on windows and doors.

Malaria infection and morbidity in humans can be prevented through the provision of chemoprophylaxis using antimalarial drugs and through intermittent presumptive treatment. Mass chemoprophylaxis can lead to a rapid increase in drug resistance and is therefore not recommended.[67,147] Instead, it is recommended that prophylaxis be targeted to vulnerable groups, such as non-immune travellers and pregnant women. Prophylaxis provided through the private sector is limited and primarily used by high-income households in urban areas. Public sector programmes have been targeted at young children, pregnant women and specific populations such as refugees and the military. Although large-scale programmes of chemoprophylaxis for children have been implemented in the past, for example, in Senegal and Ghana,[67,148] they have suffered from low compliance and the logistical difficulties of ensuring a regular supply of drugs.[149]

Pregnant women are particularly vulnerable to malaria. Infection may cause harmful effects for the mother, and placental parasitaemia retards the growth of the fetus and increases the probability of low birth weight.[150] This is of particular concern because low birth weight is associated with increased neonatal and infant mortality.[151] Chemoprophylaxis or presumptive intermittent treatment with antimalarials during pregnancy has been shown to reduce the risk of malaria infection in all pregnant women and to increase significantly the birth weight of babies born to women in their first pregnancy.[152] The most commonly used regimen was weekly prophylactic doses of chloroquine, but more recently an intermittent presumptive treatment (IPT) regimen with sulfadoxine-pyrimethamine (SP) has been advocated.[153] Prophylaxis was generally recommended by WHO as a component of antenatal care for all pregnant women, but this was rarely achieved in practice. For example, in a survey of four African

countries, only 1–18% of women reported taking adequate weekly doses.[153] Where it is provided, effectiveness is often compromised by both high levels of resistance to chloroquine and low compliance with the weekly chloroquine regimen. IPT of pregnant women has already been endorsed in high transmission areas and implementation is beginning in several countries. There is increasing interest in using IPT for children and studies are currently under way of its effectiveness.

An effective surveillance system to monitor changes in transmission and the incidence and prevalence of disease also forms an important part of control programmes. In particular, epidemic risk surveillance is appropriate in many regions, involving the identification of epidemic-prone areas and the monitoring of risk factors through the use of data on meteorological variables, population movements, environmental modifications and social disturbance.

In sum, a range of effective preventive interventions exist, although they need to be carefully targeted to meet local epidemiological conditions. Coverage remains woefully low, however, and the services provided suffer from technical inefficiency and low quality.

4.2 Understanding the weaknesses of malaria prevention

The demand and supply framework used earlier to explore weaknesses in treatment can also be used to highlight the factors underpinning the low coverage of effective preventive measures.

4.2.1 Constraints on demand

Lack of information on the part of consumers severely limits the demand for preventive services. For instance, while in many places there is demand for untreated mosquito nets, there is not yet demand for insecticide (re)treatment because of lack of knowledge about its effectiveness. The information problem is more pronounced for insecticide than for nets, as it is not immediately obvious to consumers how the insecticide retreatment improves the effectiveness of the net. Consumers are also often unaware that pregnant women and young children are particularly vulnerable to malaria and will therefore benefit most from the use of ITNs. This lack of information, combined with the intra-household allocation of power and authority, means that the household members most in need are sometimes the least protected. Lack of knowledge about the benefits from chemoprophylaxis in pregnancy similarly limits demand, as does concern amongst women in a number of countries that chloroquine may pose health risks to the unborn child.

Effective environmental management requires good information on the suitability of different measures to specific vector breeding patterns, but this is often not locally available. Misinformation about what measures are effective is also common. For instance, in Africa the suggestion that malaria-carrying mosquitoes can be controlled by cutting grass and bush around houses has had widespread and

persistent appeal,[154] despite being clearly refuted in an article published over 60 years ago:

> *"…As for DESTRUCTION OF SHELTERS, we know of no instance where a small radius of clearing about houses or inhabited centres has done any good, but many instances where it has done great harm. Nevertheless, the cutting of underbrush and trees around dwellings is an obligatory measure in many tropical settlements"* (emphasis in original).[155]

Unfortunately, such methods continue to be promoted, even in health education materials.[156,157]

Costs faced by consumers are also a factor influencing the coverage of effective prevention. Mosquito nets are relatively expensive items, costing US$ 5–10 or more in many countries, and the average household will need to purchase more than one net to cover all beds/sleeping mats. The expense involved in regularly retreating a number of nets can also mount rapidly.

Limited physical access to preventive measures also restricts their demand. Households may have to travel long distances to get to health facilities where antimalarial care is available, incurring both time and travel costs. The distance to places where mosquito nets are sold may also be considerable. Low retreatment rates of nets may also be due to the inaccessibility of retreatment points and the inconvenience associated with communal retreatment, where villagers are asked to bring their net to a central location for retreatment. In addition, many people seem to be uncomfortable about bringing their dirty nets to a public place.[158]

The nature of the benefits provided has an important impact on the demand for preventive interventions. This is influenced by their mode of action. With the exception of ITNs, methods of mosquito control can be clearly divided into two categories of economic goods: those that are "public goods" and those that are predominantly or wholly "private goods". Public goods have benefits which cannot easily be provided to some and withheld from others. They are therefore subject to "market failures", which means that they are unlikely to be provided in the private sector (see Box 1, page 9). Methods that are primarily intended to reduce either the abundance of the local vector population or its overall ability to transmit disease (i.e. its vectorial capacity) have public goods characteristics. This category includes residual house-spraying and all forms of attack on breeding sites, including environmental management and chemical larviciding. Such methods are only effective if they are carried out on a moderately large scale: the minimum area that must be covered depends on the flight range of the local mosquitoes, but is usually at least a few kilometres across. As a consequence, it is not normally effective for one family within a village to act alone and in isolation, either to control breeding around the family house or to pay for their own house to be sprayed with residual insecticide. Conversely, if almost all the houses are sprayed or if almost all the breeding sites are removed, then everyone in the village benefits, whether or not they have contributed to the intervention. As a result, private markets are unlikely to undertake environmental management or

residual house spraying in the socially desired quantities, and community-level cooperation or public intervention is required.

In contrast, methods aimed at providing personal protection against biting, i.e. untreated bednets, mosquito coils, aerosol sprays and repellents of all kinds, are aimed at isolating the individual user from mosquitoes. They are therefore primarily private goods and markets will tend to exist for them, although there may still be concerns over equity, affordability and market failures due to inadequate information.

Insecticide-treated nets are the only widely practised method of mosquito control that does not fit easily into this categorization, having some characteristics of both public and private goods. Treating an untreated net greatly improves the personal protection against biting enjoyed by the net user, whether or not the other people in the village are also protected. However, in some circumstances, community-wide use of treated nets can also have an overall impact on the vectorial capacity of the local mosquito population. This "mass effect", which can be observed as a reduction in the sporozoite rate (the proportion of the local mosquitoes that are infected and ready to transmit malaria), benefits both users and non-users in a village.[159] Treated nets are therefore best described as a private good with a positive externality (see Box 1, page 9). The relative importance of the "mass effect" is hard to assess at present: for reasons which remain obscure, it appears to be very important in some places, e.g. Tanzania,[160,161] of some importance in others, such as Ghana, where distance from a household with an ITN was positively related to mortality risk,[162] but of little or no importance in, for example, the Gambia.[163,164] Where the mass effect is an important part of the total benefit from using ITNs, even well informed private demand will fall short of the socially desired level.

4.2.2 Constraints on supply

The key constraints on public sector supply are the lack of financial resources and technical and logistic capacity.

Severely constrained public sector health budgets in most malarious countries mean that it is difficult for governments to implement even those interventions which are clearly public goods. Preventive interventions are particularly expensive because the whole population at risk must be protected, while treatment interventions are needed only for those who fall ill. As described in Box 4 below, the cost of achieving high coverage with a preventive intervention such as residual house spraying or ITNs would consume a substantial part of a poor country's total health allocation.

In addition to the problems of financial feasibility, the implementation of interventions presents many operational and logistical challenges. For example, the strong management capacity required to run an effective and well timed spraying programme or to supervise and support a village health worker (VHW) network to deliver prophylaxis is often lacking.

Box 4.
Can the public sector afford malaria control?

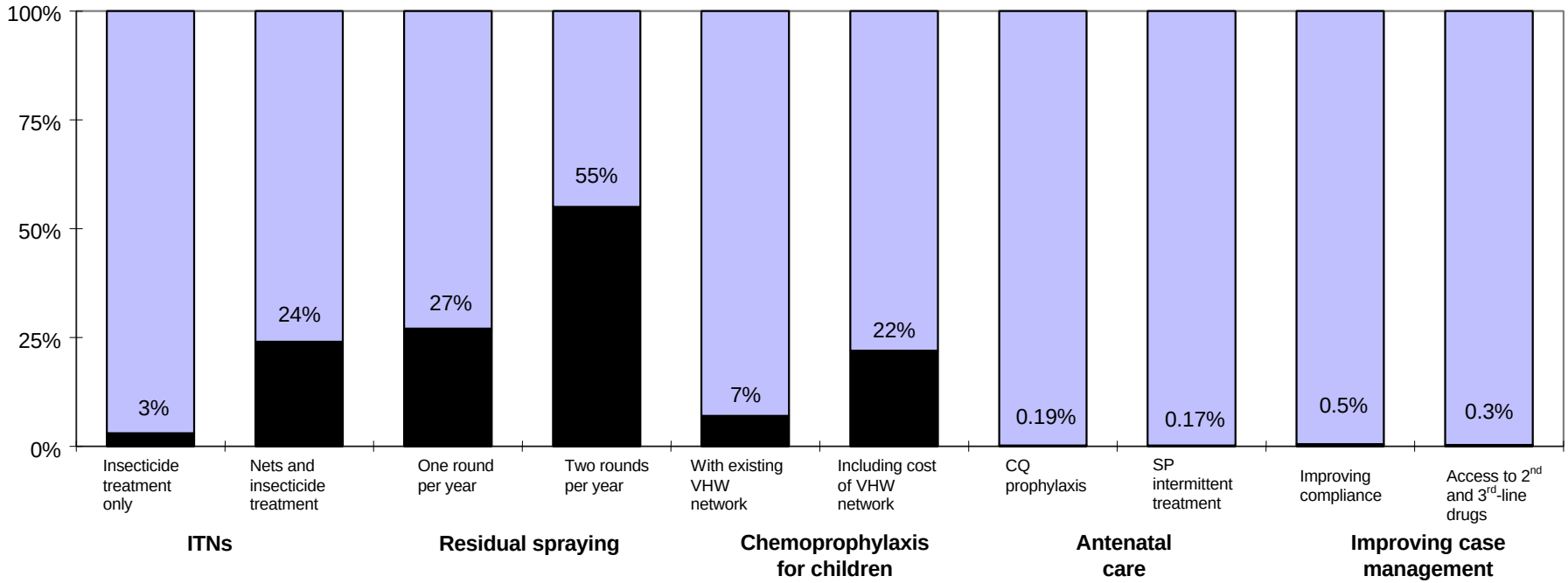
Interventions funded by the public sector must not only be highly cost-effective but also affordable. Figure 2 (page 41) shows the estimated total cost of full coverage of selected interventions as a percentage of the existing public sector health budget for a typical very low-income country. Some measures are relatively inexpensive: prevention in pregnancy, improving compliance with treatment (through training and pre-packaging of drugs) and improving the availability of second- and third-line drugs would each absorb less than 1% of the existing budget. However, achieving high coverage with an intervention to prevent childhood malaria could have an extremely high total cost. In this example, full coverage of children under 5 years of age with ITNs would cost US$ 22.5 million or the equivalent of 24% of the existing health-care budget. Reaching the same coverage with residual spraying would be even more expensive, costing the equivalent of around 27% of the existing budget with one spraying round per year and 55% with two rounds**.**

In the face of many pressing priorities and limited resources, very low-income countries would obviously not be able to afford at current levels of public sector expenditure a package of interventions which would significantly reduce the bulk of the malaria burden. There is scope for increased private sector involvement, but if the most vulnerable and impoverished groups in Africa are to be reached, substantial additional government and external donor resources will be required. This should not be impossible: to give just one example, one Hawk fighter jet costs in the region of US$ 29 million,[192] more than enough to cover all children under 5 with ITNs for a year in the country example.

The problems of public sector inefficiency constraining the delivery of effective treatment are an equally important handicap in providing high coverage of effective prevention. These include weak incentives, lack of management and planning capabilities and hierarchical management structures which restrict the operations of local managers.

Although a private market would be expected to develop for ITN products with private goods characteristics, the private sector has not yet developed a mass-market insecticide product for home use. Until now, the major transnational chemical manufacturers have been the main suppliers of insecticide for nets. These large companies make finished products mainly for the agricultural and institutional public health markets, and have only limited knowledge of the domestic insecticide market, especially in poor countries. The companies that are more familiar with this market are those that focus on manufacturing aerosol sprays, buying and repackaging bulk chemicals from the primary manufacturers. They have not yet become involved in products for treating nets. This may be because it is not yet clear whether this will be a profitable undertaking due to low levels of consumer information and purchasing power.

Figure 2.
Total cost of full coverage of target population as a percentage of a typical public sector health-care budget in a very low-income country[91]



Notes: Based on Tanzanian population[196] and health sector budget data[197] (combined donor and government funds); assumes no cost recovery
ITNs (insecticide treated nets): one treatment of deltamethrin a year
Residual spraying: lambdacyhalothrin
Chemoprophylaxis for children: Maloprim®, perennial transmission
Antenatal care: primigravidae only
Improving case management: chloroquine as first-line drug

Chapter 5. Improving the delivery of measures to prevent malaria

Evidence on the cost-effectiveness of a number of preventive interventions clearly demonstrates that they are good value for money (see Box 3, page 16). Chemoprophylaxis for children and pregnant women, indoor residual spraying and the use of insecticide-treated mosquito nets are all "attractive" or "highly attractive" interventions from a resource allocation point of view in a low-income country with moderate to high malaria transmission. All their cost-effectiveness ranges fall under US$ 100 per DALY averted and many are under US$ 25. This section takes a closer look at the cost-effectiveness results and considers how the delivery of, firstly, chemoprophylaxis and, secondly, vector control could be improved. Chemoprophylaxis is considered separately, because it is delivered as part of the health-care system and has many issues in common with improving the provision of treatment.

5.1 Chemoprophylaxis

The cost-effectiveness of chemoprophylaxis for children aged 6–59 months was examined in the sub-Saharan Africa modelling study.[82,91] Estimates were made on the basis of fortnightly distribution by village health workers (VHWs) of pyrimethamine and dapsone (Maloprim®). One scenario assumed that the VHWs existed already and the intervention was merely added to their existing activities. The second scenario included the costs of setting up such a network.

The results suggest that chemoprophylaxis for children is highly cost-effective, with a cost-effectiveness ratio (CER) of US$ 3–12 per DALY averted if an existing network of VHWs is used, and US$ 8–41 if the costs of establishing the VHW network are included. There are concerns, however, that provision of chemoprophylaxis on such a wide scale could significantly increase the growth of drug resistance,[67] which would reduce the cost-effectiveness of the intervention itself and potentially threaten the provision of effective case management. On the other hand, current plans to introduce intermittent presumptive treatment (IPT) as part of routine Expanded Programme on Immunization (EPI) visits may be a relatively cost-effective way to deliver this intervention.

Because it is targeted at a smaller group of people, chemoprophylaxis for pregnant women is a more appealing preventive option. The effectiveness of chemoprophylaxis in reducing low birth weight has been examined directly, but the cost-effectiveness analysis (CEA) had to use a model to extrapolate from this reduction in low birth weight to decreased neonatal mortality, because the sample size in the trials was too small to show an effect on mortality.

CEA was undertaken in the sub-Saharan Africa modelling study for two alternative drug regimens for women in their first pregnancy, the most vulnerable group (see Box 3, page 16). Both regimens were assumed to be delivered as part of the routine antenatal care package in public health facilities. Figure 1 (page 19) showed that a regimen of two intermittent presumptive treatments with

sulfadoxine-pyrimethamine (SP) was more cost-effective than weekly chloroquine chemoprophylaxis (US$ 4–29 per DALY averted, compared with US$ 14–93). The SP regimen performed better because it was cheaper and was assumed to have higher adherence as it involved only two doses per pregnancy, and because resistance is lower to SP. The SP regimen's CER remained under US$ 150 per DALY averted even if coverage were extended to all pregnant women or if three, rather than two, treatments were provided per pregnancy.

An important influence on cost-effectiveness is the level of drug resistance. Figures 3a and 3b (page 44) show the relationship between the cost-effectiveness range and the level of drug resistance for very low-income countries. The range for the chloroquine regimen remains under US$ 150 with up to 69% parasitological resistance, and for the SP regimen with up to 83% resistance.[91] Cost-effectiveness could also decrease through reductions in compliance as women lose faith in the effectiveness of the intervention.

Although it is highly cost-effective and has been recommended by WHO since the late 1980s, only a small proportion of women actually receive chemoprophylaxis in pregnancy. Improving coverage of pregnant women requires action on two fronts. Firstly, there are technical issues around the choice of drug regimen. Several countries in Africa have recently changed their official policy from weekly chloroquine to IPT with SP. Given the spread of SP resistance in Africa, identification of an alternative effective drug, which is sufficiently safe to use in pregnancy, is a high priority. Once a decision has been taken to change to another regimen, a wide range of concerns come into play, similar to those discussed earlier in relation to changing the first-line drug for treatment, to ensure widespread implementation through the reproductive health services.

Secondly, action is needed to change behaviour. On the supply side, it is unclear why prophylaxis is not offered in many facilities, despite frequently being part of the official antenatal care package. The attitudes of health workers towards chemoprophylaxis in pregnancy need to be explored and action taken to influence their behaviour through the provision of information, appropriate incentives and structured supervision, requiring improvements in the performance of the health system in general.

As with treatment, changing the behaviour of consumers is also critical: merely making a cost-effective intervention available is not sufficient to ensure its regular use. Attendance, especially early attendance, at antenatal clinics needs to be improved. Preventive therapy should begin at the start of the second trimester, but many women make their first visit well into the third trimester. Compliance by pregnant women with the drug regime is also a critical issue, particularly for weekly prophylaxis. In Malawi, where a study found that women were not taking chloroquine because of the bitter taste that recalled a local abortifacient, improving health education and coating the pills with sugar significantly improved compliance.[165,166] Patient factors are likely to be less important for IPT with SP, as its administration can be directly observed by health workers.

Figure 3.
Cost-effectiveness of chloroquine chemoprophylaxis (Figure 3a) and SP intermittent treatment (Figure 3b) as a function of RII/RIII drug resistance, for very low-income countries, showing the mean CER (- – -) and 90% range (——) (in 1995 US dollars) [91]

Figure 3a. Chloroquine chemoprophylaxis

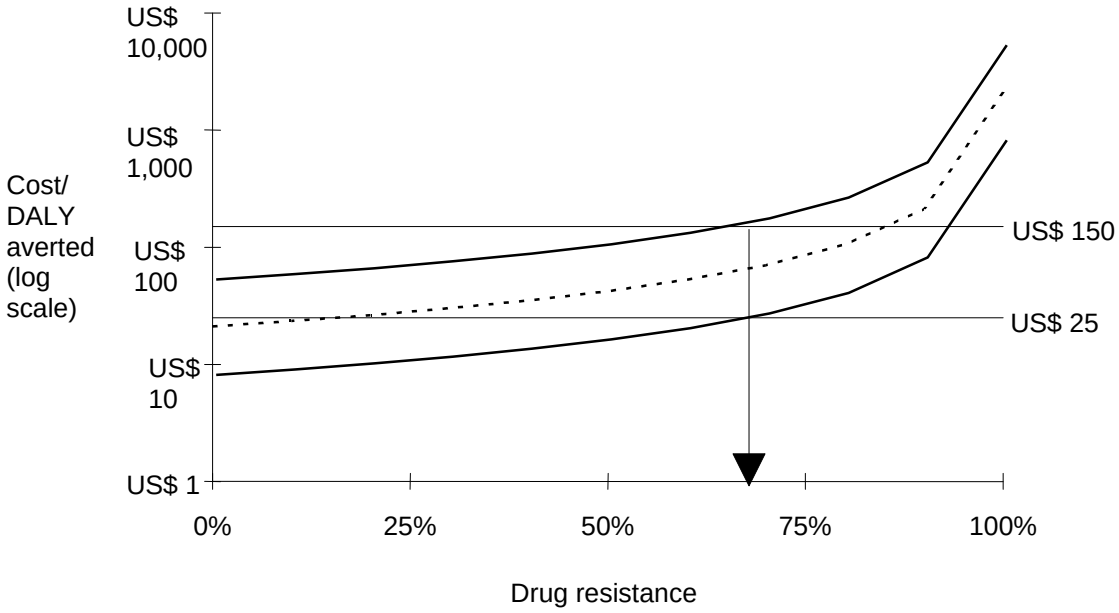
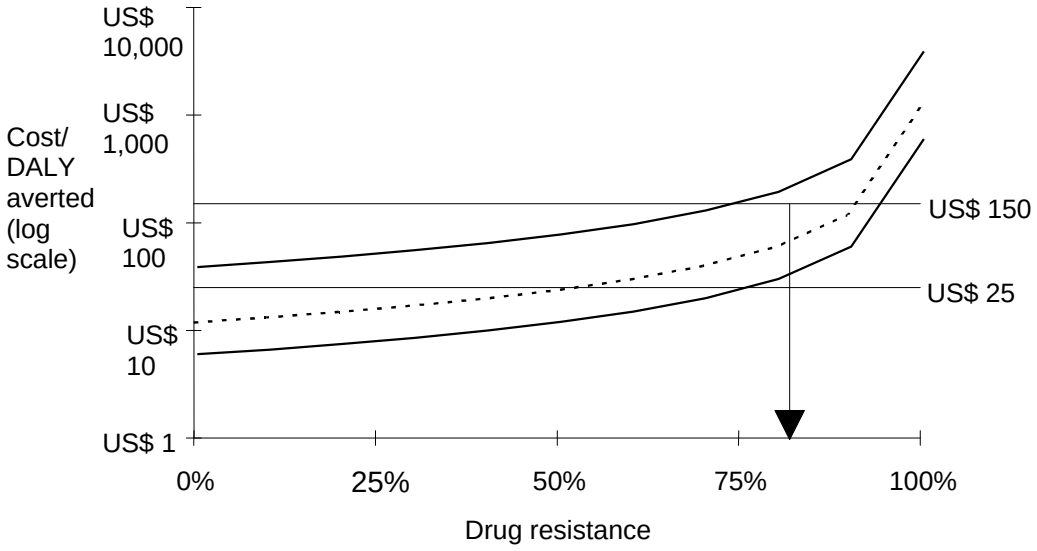


Figure 3b. Sulfadoxine-pyrimethamine (SP) intermittent treatment



5.2 Vector control interventions

5.2.1 Cost-effectiveness of vector control

Cost-effectiveness results for ITNs are shown in Box 3 (see page 16). The estimates from the modelling study are based on annual communal treatment of nets with a pyrethroid insecticide. Two scenarios were considered. Firstly, that nets are distributed by the public programme; costs are therefore included in the annualized cost of the mosquito nets. This scenario would apply in most countries where levels of net ownership are currently low. Secondly, that household ownership of mosquito nets is already high and the intervention costs were limited to the retreatment of existing mosquito nets. This is the case in the Gambia, and would apply in a few other places.

The results indicate that both of these scenarios are cost-effective, with the ranges falling into the "attractive" or "highly attractive" categories. The data for very low-income countries are shown in Figure 1 (see page 19). The cost-effectiveness range for insecticide treatment of existing nets is US$ 4–10 per DALY averted, but if both provision of nets and retreatment are required, it rises to US$ 19–85. If two insecticide treatments are required per year, due, for example, to the use of an insecticide with a shorter duration or more frequent net washing, the cost-effectiveness range increases to US$ 9–23 for insecticide retreatment of existing nets and US$ 25–96 for provision of nets and insecticide treatment. Recent evidence indicates that an untreated net in good condition (i.e. without holes or tears) provides about half the personal protection of an ITN[167,168] at a cost which has been estimated to be about half of an ITN.[169]

CEA of residual spraying in this modelling study was based on a government-run programme of residual spraying with a pyrethroid insecticide. The cost per DALY averted is US$ 16–19 with one spraying round per year and US$ 32–58 with two rounds. There is little difference between the costs per house sprayed with different insecticides; DDT is the cheapest, but is only around 20–30% cheaper than pyrethroids.

The CERs for ITNs and residual spraying overlap, despite the fact that the costs of spraying (measured as cost per child covered) are higher than for ITNs, particularly if more than one round per year is required. The overlap occurs because behavioural factors are an important influence on the relative cost-effectiveness of the two interventions. Even in situations where the interventions are of comparable efficacy, their effectiveness is likely to be significantly different in practice because of the influence of non-compliance in an operational setting. In the case of spraying, some proportion of households may deny entry to spray teams because of the inconvenience, the residue left on walls, the smell or fears about the health effects of inhaling the fumes. For ITNs, non-compliance is due either to children not sleeping under a net or to failure to retreat a net. There is a significant difference in the levels of non-compliance that are expected with the two interventions. For spraying, a "high" level of non-compliance would be 20–30% of households; the CEA used a range of 5–30%. In contrast, even under trial conditions, non-compliance for ITNs was 35% on average and could be considerably higher under operational conditions.

A range of other factors that are not fully captured in the CEA, such as affordability and feasibility, need to be considered in making the choice between the two interventions. Important considerations are whether mosquito nets are already in widespread use and whether the government has the capacity to mount an effective spraying programme.

In addition, some caution is needed in interpreting the cost-effectiveness evidence for malaria prevention interventions. Firstly, there are important gaps in the epidemiological information currently available. For instance, the data on the health impact of spraying are very old, being drawn from studies undertaken in the 1950s and 1960s. In addition, most of the studies of the effectiveness of ITNs have involved community-wide coverage with ITNs. There is much less evidence as to whether individual use of treated nets (while living among non-users) has the same epidemiological benefits for the user as community-wide use. This may have important implications for the health impact of strategies to expand net use. However, studies in the Gambia[164,170] and Tanzania[168] suggest that individual children using ITNs enjoy substantially better protection than children with no net (or an untreated net) in the same community.

Secondly, the CERs presented here have been calculated for specific delivery modes. They do not address alternative strategies for residual spraying such as spraying in focal areas or in special circumstances, such as control of epidemics, refugee camps and initial protection of non-immune settlers in development areas. However, a recent study in Kenya's highlands compared ITNs and spraying by an international relief agency in an epidemic-prone setting and found the economic cost per infection prevented was much lower for spraying at US$ 9 compared with US$ 29 for ITNs (US dollars at 1999–2000 value).[171] The data on costs and effectiveness of ITNs assume a public programme established to purchase insecticide and organize net retreatment, and where necessary, to distribute nets. It is assumed that no charges are made to users who provide only limited amounts of labour and resources such as water and detergent. However, it is unlikely that such a delivery mode can be used on a wide scale. Most ITN programmes to date have been organized on a much smaller scale and many countries in malaria endemic areas are unlikely to have the resources and capacity to operate a national programme for nets and insecticide. The cost-effectiveness of a social marketing approach to ITN distribution was investigated in Tanzania.[172] The cost per DALY averted was found to range from US$ 22–57, depending on the assumptions made about the effectiveness of untreated nets and the coverage levels achieved. Under these "programme conditions", using community effectiveness as the outcome measure,[173] distribution of ITNs through social marketing was found to be in the same range of cost-effectiveness as the more controlled systems used in the randomized controlled trials. However, no evidence is available for other delivery modes such as the involvement of the private sector, the use of other types of material or the individual treatment of nets at home.

Thirdly, data are lacking on the costs and/or effectiveness of a number of interventions. For instance, very few studies have been undertaken on the cost-effectiveness of other personal protection measures such as sprays and mosquito coils. There is a dearth of up-to-date data on the cost-effectiveness of environmental management interventions. A recent study used historical data

from Zambia's copper mines between 1929 and 1950 to argue that a malaria control programme primarily composed of environmental management was highly effective and cost-effective, with a cost per death averted of US$ 858 (see Annex 1, page 57).[174] This should be interpreted with caution, however, since the circumstances in these mines were clearly unusual in many respects (for example, the financial and logistical resources available and the degree of discipline imposed on the life of the mineworkers).[174] The costs and effectiveness of environmental interventions are likely to vary enormously from location to location, according to the nature of the water bodies preferred by the local vector. These interventions also pose particular challenges for cost-effectiveness studies because their malaria impact may be only one of a wide range of health and economic benefits.

Finally, even where the analysis indicates that an intervention is cost-effective, the available evidence does not guide programme managers about how to achieve high levels of coverage of the population at risk and ensure adequate quality and compliance levels. This is considered in the next section.

5.2.2 Increasing coverage with vector control measures

While vector control interventions are highly cost-effective, they are also very expensive and the costs of covering the entire population at risk of malaria would be substantial (see Box 4, page 40). However, the presence of market failures hampers the private provision and finance of many of these interventions (see Box 1, page 9). In determining the optimal role for government, the importance of affordability concerns, market failures and potential government failures in delivery need to be carefully weighed. Market failures are likely to arise with all three vector control interventions, though to varying extents.

Because environmental management is primarily a public good, such activities will only be implemented where there is public intervention or community cooperation. The latter requires extensive efforts to educate communities on the potential benefits in order to overcome the information problem. In addition, it will probably work well only where there is a strong local government with substantial resources or where communities are accustomed to joining together and organizing collective activities that benefit all.

Indoor residual spraying also has public goods characteristics, which means that it is likely to remain the responsibility of government. However, the countries in Africa where it is practised on a wide scale are those at the northern and southern limits of the malaria distribution, e.g. Ethiopia, Namibia, South Africa and Zimbabwe. With the exception of Ethiopia, these countries are richer than most in Africa but more importantly, malaria is concentrated in limited areas, with much or most of the country remaining free of malaria. This makes spraying both more affordable and less of a logistical burden. Such geographical targeting is not possible in the more equatorial countries, where malaria is highly endemic throughout most of the country, with only city centres and mountainous areas being malaria free.

Since an effective spraying programme requires strong managerial capacity, especially in relation to the timing of the spraying round relative to the transmission cycle, governments will need to be realistic about their capacity to mount an intervention of this organizational complexity. Both Namibia and Zimbabwe have reported decreasing efficiency and effectiveness of spraying programmes due to constraints in planning and management.[175] Any expansion of coverage would have to address the range of issues relating to public sector organization and incentives.

Although there is some potential for positive externalities from ITN use, the public health community in Africa mostly sees them as a commodity which could be at least partly financed by users. This is because there is also a significant private benefit from ITNs, because ITNs are expensive and cost-recovery is seen as a way of extending project benefits, and because in some places there is already a moderately active commercial market in untreated nets.[176] In the face of the severe resource constraints hampering the public sector, mobilizing private resources to finance and distribute ITNs is an attractive option. However, expanding the private market is far from straightforward, in view of the cost of mosquito nets and retreatment and the very low levels of knowledge and awareness of retreatment.

It is helpful to distinguish between the mosquito nets and the insecticide for retreating them, as they have a number of different characteristics, which mean that different mechanisms may be appropriate for their financing and delivery. Nets are a well known product, and it is easy to understand how they work. In some countries, a commercial market exists for nets and they are produced in-country on a large scale by manufacturers or on a small scale by local tailors. They are relatively expensive and can constitute a major investment for a household. They do, however, last quite a long time (from three to five years).

Insecticide for the treatment of nets and other fabrics is a comparatively new product. Its effectiveness is less easily observed and understood by ordinary people until they have used ITNs. Commercial availability outside projects is as yet extremely limited. Retreatment needs to be done regularly (minimum every 12 months, more often if nets are washed frequently or where transmission is perennial). The costs vary depending on whether retreatment is “dip-it-yourself” or organized at community level. The chemical is a pesticide and so must be regulated, and a monitoring system to ensure that effective dosages are being provided may also be necessary.

Four models of public sector or NGO involvement in delivering nets and insecticides can be distinguished: purely public sector delivery, community-based projects, social marketing and encouraging the development of the private sector.

Public sector models have been implemented for the retreatment of existing nets. In China and Viet Nam, retreatment is provided and financed publicly, and nets are purchased by households in the private market. The Gambian National Impregnated Bednet Programme also provides communal retreatment, for which there is some cost-recovery through sales by community workers.

Community-based ITN projects have been implemented in a number of countries. Typically the cost of the nets is shared, with users paying a contribution and a donor agency providing a significant subsidy. Retreatment also tends to be subsidized and is often provided communally. A community-based project in Zambia involved volunteer "malaria agents" to promote and sell ITNs. While the project succeeded in selling a considerable number of nets and insecticide treatments (with half the households owning a net within two years and 81% of the nets having been treated at least once), the project serves to illustrate the variety of problems frequently observed with such activities. Net retreatment rates were fairly low, with only 47% of treated nets being retreated. Introducing a charge for retreatment in one village further reduced retreatment rates. A barter system was used to purchase 19% of the nets; difficulties were encountered, however, with storing agricultural products until they could be marketed and with spoilage. There were also costs associated with the sale of the produce, such as transport and the purchase of sacks. The revenue from sales of nets and grain was supposed to be used to restock nets, but problems of financial management and unanticipated costs meant that the revenue was less than expected in all of the communities. Exchange rate depreciation and real increases in the price of nets limited the extent to which the fund could "revolve". Furthermore, the mechanism for using the funds generated to buy more nets was not specified at the outset of the project. An external evaluation concluded that continued external support would be needed.[177]

Similar problems were encountered by the Bagamoyo Bed Net Project in Tanzania, which used village net committees to distribute nets and provide insecticide retreatment, with the aim of establishing a revolving fund. While coverage reached 77–100% after four years, the fund did not revolve as planned and retreatment rates were low. At the end of the project, the structure for net procurement collapsed.[140]

Community-based projects are often promoted to donors on the basis that as coverage increases, the need for subsidy will decline and the project will become self-sustaining. However, some interesting financial simulations from a project in Mozambique demonstrate that this logic can be flawed. If the subsidy is attached to a variable cost (such as the cost of a net), then expanding coverage merely expands the total subsidy required (and with it, the "loss" attached to the project).[178]

Social marketing, involving the application of commercial marketing methods to influence demand for public health commodities or services, is a promising approach to increasing ITN coverage. In order to increase retreatment rates, social marketing projects have adopted home treatment, "dip-it-yourself" insecticide products, to reduce some of the barriers to retreatment and make net retreatment as accessible as other methods for mosquito protection such as coils and sprays. Retreatment kits include insecticide (e.g. a sachet or tablet), gloves and an instruction sheet. Social marketing projects typically involve the development of a branded product with attractive packaging, use a range of distribution channels including shops, kiosks and health facilities, and elaborate promotion activities.[140] While charges usually cover the factory cost of the net, the insecticide is often subsidized, as are the costs of promotion and distribution. Social marketing

projects have been implemented in a range of countries in sub-Saharan Africa and preliminary results suggest that demand can be created for both mosquito nets and insecticide retreatment.

A fourth model is to encourage deliberately private sector development. There is one instance where a sluggish net market has recently undergone a dramatic transformation. In the mid-1990s, the net market in Tanzania began to enjoy a sudden and sustained boom, and now over 1.5 million locally manufactured nets are sold in the country each year. Over the period from 1994 to 2000, there was an average annual growth of more than 30% per year. That these sales are reflected in increased coverage at the household level can be seen by comparing the household coverage from the 1999 Demographic and Health Survey with the 2000–01 Household Budget Survey. The latter indicated that 37% of households in Tanzania (28% in rural areas, 71% in urban areas) owned at least one net. These figures imply an annual increase of 20% in the number of households with at least one net, showing that sales volumes continue to grow and that the market shows little sign of saturation. This growth was partly triggered by a change in the tax levied on net sales, but other less well understood factors (such as the contributions of a number of small-scale projects to raise public awareness of ITNs, a fall in factory prices and retail margins, and increased product quality and diversity) were almost certainly involved. What is clear is that this boom was not initiated through deliberate and detailed planning by health authorities (although more recently it has received significant support from public health interventions, including demand-creation campaigns), yet the large-scale, unsubsidized provision of untreated nets by the commercial sector has almost certainly prevented more child deaths than all of the subsidized projects together.[179]

The prospects for triggering such an expansion of the local market in other countries are unknown, but a variety of forms of public-private partnership have been proposed as a way to encourage the development of mass market insecticide and net products. One approach is being implemented under USAID's Netmark project, the aim of which is to work with commercial firms and private retail outlets to develop mass market nets and insecticide (see http://www.netmarkafrica.org). Another approach adopted in Uganda is the creation of an "ITN Business Association", which has mobilized donor funds to match private manufacturers' expenditures on advertising and promotion.[180] Over 100,000 ITNs (a net plus an insecticide sachet) were sold in the first nine months of the project. A number of lessons have emerged from the Uganda experience (J. Quigley, personal communication). First, the private sector will tend to focus on those areas where they can earn the greatest profit: poor and rural populations are less likely to benefit. Second, private sector partners have less incentive to report on their outputs, making it more difficult to monitor and evaluate project outcomes. Third, private sector advertising alone is not enough to promote the whole public health message: generic advertising is required, focusing on the public health issues and especially on retreatment.

None of the approaches described above is ideal and all have limitations. Balancing the challenges of equity and sustainability requires a more strategic approach to public and private collaboration as national ITN programmes consider how to increase ITN coverage. Roll Back Malaria has recently proposed a

strategic framework setting out a number of principles on which the design of scaling-up activities should be based and a way of allocating responsibilities to the public sector (including donor partners), the commercial sector and NGOs so as to maximize impact.[181] The two main components of the strategy are to provide subsidies to well defined vulnerable groups to ensure equity and to encourage the development of the private sector to ensure that ITNs are widely available at the lowest unsubsidized price. To minimize the conflict between these two strategies, any subsidies that are used to increase coverage among vulnerable groups should be designed so as to reinforce or complement the private sector, but not compete with it. This will require them to be targeted appropriately to minimize the negative impact on the private sector (see Box 5 below).

There are three essential roles that the public sector should play in encouraging the development of the commercial sector: providing information and promoting demand, reducing taxes and tariffs, and regulating standards and quality.

Providing information and promoting demand: Lack of information has already been identified as a cause of inadequate demand for preventive measures, particularly ITNs. Because information is a public good (in the sense that the benefits cannot all be captured by the providing firm), the private sector alone will not provide adequate information. Furthermore, a private firm will generally promote its own brand of net or insecticide in an effort to capture a larger share of the benefits of the advertising. Governments should therefore engage in "generic" advertising to inform people about the benefits of ITN use and to promote demand.

Advocacy to reduce taxes and tariffs: Developing the commercial sector for ITNs may also require intervention to encourage supply. One area for government action is to reduce taxes and tariffs on mosquito nets. Tariff levels on imported nets and netting in sub-Saharan Africa vary enormously. Fourteen countries apply tariffs of 30% or more.[182] In addition to tariffs, countries levy a range of domestic taxes such as VAT (value- added tax) or sales tax, which apply to both locally produced and imported goods. The combined effect of taxes and tariffs on mosquito nets amounts to as much as 57% in Kenya, 52% in Ethiopia and 45% in Nigeria and Zambia.[183] Tariff rates on insecticides are lower and they can be imported duty free in a number of countries. Reducing taxes and tariffs would reduce costs and, potentially, stimulate entry by producers and importers. It could also increase demand for ITNs by lowering the price. The precise effects of tax and tariff reduction will depend on the responsiveness of both demand and supply to prices (the relative price elasticities of demand and supply), about which there is currently little information. An important concern about tax and tariff reform is that it should promote a "level playing field" for domestic producers and imported products. For instance, if finished mosquito nets are imported tax free, but the polyester yarn for knitting nets is subject to import duties, domestic producers will not be able to compete with imports. This raises a host of other practical concerns such as how to ensure that yarn that is imported duty free is used for mosquito nets and not for other textiles.

Regulating standards and quality: Where the quality of a product is difficult to observe, there may be a role for public intervention in the form of standards and

Box 5.
How do projects affect the private commercial sector?

The private sector is involved in the production of mosquito nets in a range of countries. In eastern and southern Africa and in Asia, this is in the form of large-scale commercial manufacture; in west Africa, nets are made by small-scale tailors and sold in local markets.

Because nets are a relatively expensive household item, NGOs and donor-funded projects have tended to provide them at a subsidized price. They have often been unconcerned about the way their activities affect the development of sustainable commercial sources of supply.

One possibility is that by creating demand, projects can "crowd in" the private sector, encouraging entry into the market. There is some evidence that small-scale community and social marketing projects contributed to the expansion of the net market in Tanzania. Small-scale promotion activities, larger-scale advertising and guarantees of project sales encouraged existing factories to expand their output and a third factory entered the market. However, the presence of projects can also "crowd out" the commercial sector by selling subsidized products to those who would otherwise have bought them at the full price. The impact of subsidized social marketing brands on the commercial sector has been examined at the local level in two Tanzanian projects. In both, the commercial sector market share became smaller as the social marketing project expanded.[193,194] This has also been a problem in some places for contraceptives.[195] Subsidies must, therefore, be carefully targeted in order to resolve the potential conflict between providing subsidies to vulnerable groups and encouraging a sustainable commercial sector.

It is also important that monitoring and evaluation activities address this issue. Before starting activities, projects should assess the existing state of the market, for example, the extent of mosquito net coverage and their availability in the commercial sector. Funders should encourage projects to monitor their impact not just by measuring the sales of their own products but also the size of the market as a whole, to ensure that project activities complement rather than replace private sector initiatives. "Exit strategies" should include the definition and monitoring of indicators for withdrawal of subsidized products.

regulation of quality. This is likely to be a much greater issue with insecticide than with nets. Nets vary enormously in quality (e.g. strength and durability), but consumers are used to assessing the quality of textiles. When insecticide is sold as a "dip-it-yourself" product for home use, it may be subject to dilution or other degradation which is difficult for consumers to detect. A regulatory framework which includes effective monitoring mechanisms would be helpful in such cases.

5.2.3 Ensuring access to ITNs for poor people

The commercial sector will not be accessible to all, either because poor people cannot afford to buy nets and insecticide at commercial prices or because they do not have access to markets where ITNs are sold. Ensuring that poor people living in malarious areas have access to ITNs will be an important role for governments and NGOs.

One method is to provide subsidized products. The challenge is to target the subsidy at those who would not otherwise buy a net. Efficient targeting mechanisms will maximize coverage of the target group and minimize leakage of the subsidy to those who do not need it. Operationally, this raises the question of whether subsidies should be targeted on the basis of ability to pay or of vulnerability to malaria. Community-based NGOs in many countries appear to have been able to identify the poor and provide them with a free or subsidized net. This is probably facilitated by the small scale at which they operate and their knowledge of the community, built up over many years. It is difficult to see how such targeting can be undertaken at a larger scale.

An alternative mechanism for delivering subsidies is to use vouchers or coupons. The vouchers are distributed to the target group (e.g. pregnant women at antenatal clinics) and the recipients are able to purchase a net from a shop at a reduced price. The retailer exchanges the vouchers either for cash or for more stock. Such a system has the advantage of reinforcing the commercial sector at the same time as it improves affordability for vulnerable groups. The KINET project in Tanzania has experimented with distributing vouchers for pregnant women and children under 5 years through maternal and child health clinics.[184] An assessment of the scheme identified a number of useful lessons.[185] First, while the rate of redemption by women who received a voucher was extremely high (97% of vouchers were used to purchase a net), community awareness of the scheme and the qualifying criteria was poor (only 43% of the target group were aware of the scheme after two years of operation) and uptake among the eligible population was relatively low. In addition, there was evidence that the less poor were more likely to use a voucher than the most poor. As countries consider the feasibility of such schemes at national level, a number of critical areas need further refinement. These include how to minimize fraud and misuse of the scheme; how to ensure the smooth flow of vouchers, nets and money through the system and maximum population awareness of the scheme; and how to make certain that the increased demand provided by the voucher is met by a ready supply of nets in the retail sector.

A major problem with targeted subsidies is the definition of the target group. If it is too large, the subsidy available per net may be so small as to be negligible. However, targeting a more restricted group raises the problem of how to identify them and minimize cheating. In addition, there continues to be confusion about the extent to which health vulnerability coincides with economic vulnerability: not all households with a pregnant woman are poor. Designing effective ways to target subsidies for maximum health impact is a critical issue for public health authorities in countries where public-private partnerships are being encouraged.

Chapter 6. Key messages and conclusions

This publication has demonstrated that a number of cost-effective interventions are available to improve the prevention and treatment of malaria, including:

- Interventions to improve case management, such as pre-packaging of drugs and improving access to second- and third-line drugs for treatment failures.
- Chemoprophylaxis or intermittent presumptive treatment during pregnancy.
- Vector control through insecticide-treated mosquito nets and indoor residual spraying.

All have been demonstrated in general terms to be excellent value for money in terms of the health gains achieved per dollar spent, though choice of intervention and packages of interventions need to be tailored to the local situation.

There are good reasons for governments to intervene in malaria control, related to affordability and equity concerns, and the presence of market failures. But government failure also needs to be addressed. Improving malaria case management will require measures to strengthen the health system as a whole. In many places, malaria cases make up a significant share of total utilization of health facilities. Initiatives to improve the quality and efficiency of health service delivery must address some of the general weaknesses of the health service provision by:

- Increasing the availability of effective antimalarial drugs in public health facilities.
- Addressing the problems of quality from the user's perspective, including the attitudes of staff and availability of drugs.
- Identifying ways to improve the accessibility of health services to the population, since malaria can progress very rapidly to severe or fatal disease, and many children die before they reach a health facility.
- Addressing the weak incentives facing health workers, such as low salaries and poor supervision, which can undermine their motivation.
- Improving information and management systems, for example, to ensure the continuity of antimalarial drug supply and the early detection of epidemics.
- Improving the capacity to use economic analysis in decision-making.

Improving treatment in the public sector is very important, but the majority of malaria episodes are treated at home with drugs purchased in a variety of private outlets. There are opportunities to improve the quality of treatment by taking into account the incentives and information that influence user and provider behaviour, for example:

- Giving care seekers better information about appropriate treatment, including the importance of early treatment with an effective drug, using the correct regimen.
- Recognizing the incentives facing providers and looking for opportunities to modify these to encourage appropriate drug use and provide appropriate follow-up and supervision.
- Involving private providers in the design and implementation of interventions.

- Simplifying the process of dispensing and using drugs, e.g. by pre-packaging drugs.

In these ways, existing drugs and technologies can be much more effectively employed.

In addition, several promising new technologies are becoming available:
- Artesunate suppositories can help to control the most dangerous symptoms of severe malaria while the patient is transported for further care.
- New, rapid malaria tests can expand access to accurate diagnosis and should help reduce the costs of treating malaria where more expensive antimalarials (such as artemisinin-based combination therapy) are used as the first-line drug. They may also improve health outcomes and potentially reduce the selection pressure for resistance.

Addressing the problem of drug resistance is a high priority, particularly in Africa where failure of chloroquine treatment is already common and where health systems and individuals have limited ability to pay for more expensive alternatives. Replacing an ineffective first-line drug brings substantial and immediate health benefits, but strategies must be put in place to prevent resistance growing rapidly to the replacement, as there are few effective, safe and affordable antimalarials available. A range of implementation issues should be considered, such as the effects on compliance of changing drug regimens and the need to inform public and private providers about the new policy. Combination therapy, which may help to protect new drugs from becoming resistant, is a promising new development, but needs to be introduced together with strategies to promote rational drug use in the public and private sectors.

A substantial expansion of preventive interventions is required. A number of effective preventive measures have “public goods” characteristics and will be underprovided, or not provided at all, if left to the market. Government action or community cooperation are needed. These measures include:
- Indoor residual spraying
- Environmental management and chemical larviciding
- Health education about effective means of prevention and appropriate treatment
- Epidemic surveillance and drug resistance monitoring

The same applies to a lesser extent to insecticide for nets, which has both public and private goods characteristics.

Chemoprophylaxis or intermittent presumptive treatment in pregnancy is highly cost-effective, but wider use is constrained by a number of obstacles, including limited provision in government health facilities, inadequate attendance at antenatal care clinics, poor compliance with therapy and resistance to the most widely used drug (chloroquine). These must be addressed if coverage is to be improved.

Insecticide-treated mosquito nets (ITNs) are a highly cost-effective means of preventing malaria, but covering the entire population at risk will be expensive.

Innovative mechanisms for financing and providing ITNs are needed to increase their use. Commercial markets for nets exist in many places, but the coverage they achieve is often inadequate, and the commercial market for insecticide retreatment is currently almost negligible. It is essential to find ways to expand the markets for both products in a sustainable way, for example:

- A variety of strategies for expanding access to nets and insecticide are being developed, such as social marketing and public/private partnerships, and the development of "dip-it-yourself" insecticide retreatment kits as a mass market product.
- Governments should introduce complementary interventions to encourage the development of commercial markets, such as large-scale promotion activities and tax and tariff reforms that reduce prices and create a level playing field for domestic producers attempting to compete with international firms.

Access to ITNs through commercial markets could be expanded, but the poorest households will not be able to afford to purchase nets and insecticide at commercial prices. Mechanisms are needed to provide subsidized ITNs to these groups. Examples of such mechanisms include:

- Voucher schemes, which can help direct subsidies to needy mothers and children.
- Providing nets and insecticide through maternal and child health clinics.
- Social marketing to raise awareness of the value of ITNs and encourage their appropriate use.

This paper has adopted an economic perspective in analysing the characteristics of the demand for and supply of malaria control interventions. Such an approach offers a set of tools for understanding the various influences on the behaviour of consumers and suppliers, and through them, on the coverage of effective interventions. In addition, through the method of economic evaluation, it offers a systematic way of comparing the costs and consequences of interventions in order to improve the allocation of resources. A wider application of these economic tools offers an important opportunity for improving the uptake of existing effective malaria control measures and ensuring the maximum impact from the introduction of new technologies. This will require the strengthening of health economics capacity at country level in cost-effectiveness analysis and the application of economics to understanding the behaviour of providers and consumers.

Annex 1.
Review of cost-effectiveness studies
(costs in 1995 US dollars)

Intervention	Area studied	Cost per death averted	Cost per DALY averted or DYLG	Reference
Prevention				
Insecticide treatment of bednets	The Gambia	US$ 219 (US$ 167–243)	US$ 9 (US$ 9–14)	Picard et al., 1993[190]
		Net CER* US$ 494 (US$ 326–805)	Net CER* US$ 21 (US$ 14–35)	Aikins et al., 1998[198]
		US$ 829 (US$ 447–2117)	–	Graves, 1998[199]
	Sub-Saharan Africa	–	US$ 4–10	Goodman et al., 1999[91]
Provision and insecticide treatment of bednets	Ghana	US$ 2112 (US$ 992–2289)	US$ 77 (US$ 37–84)	Binka et al., 1997[200]
	Kenya	US$ 2958 (US$ 2838–3120)	–	Some, 1999[201]
	Africa	–	US$ 10–118	Evans et al., 1997[202]
	Sub-Saharan Africa	–	US$ 19–85	Goodman et al., 1999[91]
Residual spraying	Sub-Saharan Africa	–	US$ 16–58	Goodman et al., 1999[91]
Chemoprophylaxis for children	The Gambia	US$ 167	–	Picard et al., 1992[189]
	Sub-Saharan Africa	–	US$ 3–41	Goodman et al., 1999[91]

Intervention	Area studied	Cost per death averted	Cost per DALY averted or DYLG	Reference
Antenatal chloroquine chemoprophylaxis	Malawi (drug costs only)	US$ 950 (US$ 317–951)	–	Schultz et al, 1995[203]
	Sub-Saharan Africa	–	US$ 14–93	Goodman et al., 1999[91]
Antenatal SP intermittent treatment	Malawi (drug costs only)	US$ 81 (US$ 79–352)	–	Schultz et al., 1995[203]
	Sub-Saharan Africa	–	US$ 4–29	Goodman et al., 1999[91]
Combined prevention interventions				
Insecticide treatment of bednets and chemoprophylaxis	The Gambia	US$ 300 (US$ 246–333)	US$13 (US$13–20)	Picard et al., 1993[190]
Residual spraying, fogging and source reduction	Brazil	US$ 5072 (US$ 785–10,427)	US$ 132	Akhavan et al., 1999[191]
Environmental management with DDT residual spraying in later years	Zambia (1929-1950)	US$ 858	US$ 22–591	Utzinger et al., 2001[174]
Treatment				
Treatment versus no treatment	Africa (drug costs only)	US$ 0.20–6	–	Sudre et al., 1992[75]
Improving compliance	Sub-Saharan Africa	–	US$ 2–8	Goodman et al., 1999[91]
Improving access to second- and third-line drugs	Sub-Saharan Africa	–	US$ 1–3	Goodman et al., 1999[91]
Package of measures to place greater emphasis on early diagnosis and prompt treatment	Brazil	US$ 677 (US$ 271–1355)	US$ 17	Akhavan et al., 1999[191]

Intervention	Area studied	Cost per death averted	Cost per DALY averted or DYLG	Reference
Combined prevention and treatment programme				
Residual spraying, fogging and source reduction, and a package of measures placing greater emphasis on early diagnosis and prompt treatment	Brazil	US$ 2596 (US$ 1093–5193)	US$ 67	Akhavan et al., 1999[191]
Case detection and treatment, and residual spraying	Nepal	Net CER* US$ 109–17,650	Net CER* US$ 12–1803	Mills, 1993[204]

* Results labelled “Net CER” incorporate potential cost savings to government and households from reducing malaria incidence.

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