WORLD
MALARIA
REPORT 2011

World Health Organization

WHO Global Malaria Programme

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Foreword

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The findings in the *World Malaria Report 2011* show that we are making significant and durable progress in battling a major public health problem. Coverage of at-risk populations with malaria prevention and control measures increased again in 2010, and resulted in a further decline in estimated malaria cases and deaths. And the malaria map continues to shrink. In 2011, I was pleased to be able to certify Armenia as being free of malaria, a tribute to this country's excellent surveillance and response capacity and attention to the public health basics. In a world starved of good news, these are welcome developments.

But worrisome signs suggest that progress might slow, especially in view of projected decreases in the funding needed to fi nance universal access to life-saving malaria prevention and control measure. International funding for malaria appears to have peaked at US$2 billion, well short of the US$ 5 to 6 billion that are required. While new commitments, such as those from the United Kingdom, have been indispensable for maintaining our current gains, they are not suffi cient to achieve the goals that the global malaria community has set. In endemic countries, domestic spending on malaria often remains inadequate. The implications of these funding shortfalls are far reaching, as success in malaria control is crucial for achievement of the health-related Millennium Development Goals, especially in Africa.

The next few years will be critical in the fight against malaria. We know from experience how fragile our gains are. While the distribution of hundreds of millions of long-lasting insecticidal mosquito nets over the past several years has been a remarkable achievement that has saved hundreds of thousands of lives, those nets now (or will soon) need replacing. Data in this report show that the vast majority of distributed nets are used, and that the primary barrier to universal coverage remains access. It is our responsibility to ensure that these and other life-saving commodities reach all who need them – before our hard-won progress slips away. Achieving this will require leadership at global, national, and local levels. It will also require innovation. If the mosquito nets can be made more durable, giving them a life of five years instead of three, the strain on fragile health systems could be greatly reduced, the risk of resurgences in malaria could be minimized, and hundreds of millions of dollars could be saved.

Parasite resistance to antimalarial medicines remains a real and ever-present danger to our continued success. While efforts to contain artemisinin resistance on the Cambodia–Thailand border appear to have dramatically reduced the burden of malaria due to *Plasmodium falciparum*, and the problem currently remains confined to the Mekong region, we are now seeing early evidence of artemisinin resistance in Myanmar and Viet Nam. There is an urgent need to develop an Asia-wide framework to ensure sustained and coordinated action against this public health threat, while at the same time continuing to press for the withdrawal from the market of oral artemisinin monotherapies, which are one of the major factors fostering the emergence and spread of artemisinin resistance. These monotherapies are still widely available despite repeated calls for action from the World Health Assembly.

One way to curb the continued emergence and spread of antimalarial drug resistance is to ensure that all patients with suspected malaria receive a diagnostic test, and that only those with confirmed *Plasmodium* infection receive antimalarial treatment. While we still have a long way to go, this report demonstrates continued progress with regard to diagnostic testing in Africa, and a doubling in the number of rapid diagnostic tests supplied by manufacturers, to 88 million in 2010, as well as notable increases in product performance.

To add to our list of worries, the threat of insecticide resistance appears to be growing rapidly. Currently, we are highly dependent on the pyrethroids, as they are the only class of insecticides used on insecticide-treated mosquito nets. Resistance to pyrethroids has now been identified in a wide variety of settings, many of those in the most highly malaria-endemic countries of Africa. In response to this threat, and as requested by the World Health Assembly, WHO is currently working with a wide variety of stakeholders to develop a Global Plan for Insecticide Resistance Management in malaria vectors, which will be released in early 2012.

In the face of economic uncertainties and potential threats from parasite resistance to antimalarial medicines and mosquito resistance to insecticides, we must remain determined. If we take full advantage of the malaria prevention and control tools we have today, while mitigating potential threats through constant vigilance and timely response, then we will sustain and extend the remarkable gains that have been made. The citizens of malaria-endemic countries are all counting on us. We must not let them down.

M. Chan

Acknowledgements

Abbreviations

ABER	Annual blood examination rate
ACD	Active case detection
ACT	Artemisinin-based combination therapy
AIDS	Acquired immunodeficiency syndrome
ALMA	African Leaders Malaria Alliance
AMI	Amazon Malaria Initiative
AMFm	Affordable Medicine Facility for malaria
AMP	Alliance for Malaria Prevention
CCM	Community case management
CDC	US Centers for Disease Control and Prevention
CHAI	Clinton Health Access Initiative
CRESIB	Barcelona Centre for International Health Research
DDT	Dichloro-diphenyl-trichloroethane
DFID	The United Kingdom Department for International Development
DHS	Demographic and health survey
DTP	Diphteria, tetanus, pertussis
FIND	Foundation for Innovative New Diagnostics
G-20	Group of 20 nations
G6PD	Glucose-6-dehydrogenase
GHG USF	Global Health Group, University of San Francisco
Global Fund	The Global Fund to fight Aids Tuberculosis and Malaria
GMAP	Global malaria action plan
GMP	Global Malaria Programme, WHO
GPARC	Global Plan for Artemisinin Resistance Containment
GPIRM	Global Plan for Insecticide Resistance Management in malaria vectors
HIV	Human immunodeficiency virus
HMIS	Health management information system
IAEG	Inter-Agency and Expert Group on MDG Indicators
iCCM	Integrated community case management
IDA	International Development Association
IEC	Information, education and communication
IHME	Institute for Health Metrics and Evaluation
IM	Intramuscular
IPT_i	Intermittent preventive treatment in infants
IPT_p	Intermittent preventive treatment in pregnancy
IRS	Indoor residual spraying
ITN	Insecticide-treated mosquito net
Kdr	Knock-down resistance
LSM	Larval Source Management
LLIN	Long-lasting insecticidal net
MDG	Millennium Development Goal
MERG	RBM Monitoring and evaluation reference group
MICS	Multiple indicator cluster survey
MIS	Malaria indicator survey
MPAC	Malaria Policy Advisory Committee
MVI	Malaria Vaccine Initiative
NGO	Nongovernmental organization
NMCP	National malaria control programme
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
OP	Organophosphate
PATH	Program for Appropriate Technology in Health
PCD	Passive case detection
PDS	Panel detection score
PMI	The US President's Malaria Initiative
PQR	The Global Fund's Price and Quality Reporting
QA	Quality assurance
RAVREDA	Amazon Network for the Surveillance of Antimalarial Drug Resistance
R4D	Results for Development
RBM	Roll Back Malaria Partnership
RDT	Rapid diagnostic test
RH	Relative humidity
SAGE	WHO Strategic Advisory Group of Experts on Immunization
SMC	Seasonal malaria chemoprevention
SPR	Slide positivity rate
TEG	Technical expert group
TDR	Special Programme for Research and Training in Tropical Diseases
UNICEF	United Nations Children's Fund
UNSE	Office of the United Nations Special Envoy for Malaria
USAID	United States Agency for International Development
WER	WHO *Weekly Epidemiological Report*
WHA	World Health Assembly
WHO	World Health Organization
WHOPES	WHO Pesticide Evaluation Scheme

Abbreviations of antimalarial medicines

AQ	Amodiaquine
AL	Artemether-lumefantrine
AM	Artemether
ART	Artemisinin
AS	Artesunate
CL	Clindamycin
CQ	Chloroquine
D	Doxycycline
DHA	Dihydroartemisinin
MQ	Mefloquine
NQ	Naphroquine
PG	Proguanil
PPQ	Piperaquine
PQ	Primaquine
PYR	Pyronaridine
QN	Quinine
SP	Sulfadoxine-pyrimethamine
T	Tetracycline
(d)	Days on treatment course

Abbreviations of WHO Regions / Offices

AFR	WHO African Region
AFRO	WHO Regional Office for Africa
AMR	WHO Region of the Americas
AMRO	WHO Regional Office for the Americas
EMR	WHO Eastern Mediterranean Region
EMRO	WHO Regional Office for the Eastern Mediterranean
EUR	WHO European Region
EURO	WHO Regional Office for Europe
SEAR	WHO South-East Asia Region
SEARO	WHO Regional Office for South-East Asia
WPR	WHO Western Pacific Region
WPRO	WHO Regional Office for the Western Pacific

Summary and Key Points

The *World Malaria Report 2011* summarizes information received from 106 malaria-endemic countries and other sources and updates the analyses presented in the 2010 report. It highlights continued progress made towards meeting the international targets for malaria control set for 2010 and 2015.

International funding for malaria control has continued to rise, to a peak of US$ 2 billion in 2011. The amounts committed to malaria, while substantial, still fall short of the resources required to reach malaria control targets, estimated at more than US$ 5 billion per year for the years 2010–2015. Moreover, funding is projected to remain at these levels or decrease before 2015 unless new sources of funds are identified.

The financing provided for malaria control has enabled endemic countries to greatly increase access to insecticide-treated mosquito nets (ITNs); the percentage of households owning at least one ITN in sub-Saharan Africa is estimated to have risen from 3% in 2000 to 50% in 2011 while the percentage protected by indoor residual spraying (IRS) rose from less than 5% in 2005 to 11% in 2010. Household surveys indicate that 96% of persons with access to an ITN within the household actually use it. The number of rapid diagnostic tests (RDTs) and artemisinin-based combination therapies (ACTs) procured is increasing, and the percentage of reported suspected cases receiving a parasitological test has also increased, from 67% globally in 2005 to 76% in 2010, with the largest increase in sub-Saharan Africa. Despite this significant progress, however, more work is needed before the target of universal access is attained.

Reductions in reported malaria cases of more than 50% have been recorded between 2000 and 2010 in 43 of the 99 countries with ongoing transmission, while downward trends of 25%–50% were seen in 8 other countries. There were an estimated 216 million episodes of malaria in 2010, of which approximately 81%, or 174 million cases, were in the African Region. There were an estimated 655 000 malaria deaths in 2010, of which 91% were in Africa. Approximately 86% of malaria deaths globally were of children under 5 years of age. The estimated incidence of malaria globally has reduced by 17% since 2000 and malaria-specific mortality rates by 26%. These rates of decline are lower than internationally agreed targets for 2010 (reductions of 50%) but nonetheless, they represent a major achievement.

Resistance to artemisinins – a vital component of drugs used in the treatment of *P. falciparum* malaria – has been reported in a growing number of countries in South-East Asia. Resistance to pyrethroids, the insecticides used in ITNs – and most commonly used in IRS – has been reported in 27 countries in Africa and 41 countries worldwide. Unless properly managed, such resistance potentially threatens future progress in malaria control.

Internationally agreed targets and goals for malaria control

The year 2010 was an important milestone on the way to achievement of internationally agreed goals and targets for malaria control. In the light of progress made by 2010, targets for the Global Malaria Action Plan (GMAP) of the Roll Back Malaria Partnership were updated in June 2011.

1. The year 2010 was the date set to achieve universal coverage for all populations at risk of malaria using locally appropriate interventions for prevention and case management, and to reduce the malaria burden by at least 50% compared to the levels in the year 2000.

2. In the light of progress made by 2010, the Roll Back Malaria (RBM) targets were updated in June 2011. The targets are now to: (i) reduce global malaria deaths to near zero by end-2015; (ii) reduce global malaria cases by 75% from 2000 levels by end-2015; and (iii) eliminate malaria by end-2015 in 10 new countries since 2008, including in the WHO European Region. These targets will be met by: achieving and sustaining universal access to, and utilization of, preventive measures; achieving universal access to case management in the public and private sectors and in the community (including appropriate referral); and accelerating the development of surveillance systems.

Financing malaria control

The funds committed to malaria control from international sources are expected to peak in 2011 at US$ 2 billion and remain substantially lower than the resources required to achieve global targets, estimated at > US$ 5 billion for the years 2010–2015.

3. International funding is expected to peak in at US$ 2 billion 2011. From 2012 to 2013 it is projected to remain relatively stable, but then decrease to US$ 1.5 billion in 2015. A reduction in commitments from the Global Fund is partly offset by increased commitments from the United Kingdom's Department for International Development (DFID) of up to US$ 800 million by 2015. Information on domestic government funding for malaria control is less complete. Available information suggests that domestic funding is generally less than US$ 1 per person at risk and represents a small proportion of the total financing of malaria control in the most highly endemic countries.

4. Cost savings within vector control programmes may be possible but are likely to be modest, for several reasons: (i) the price of an ITN, which represents the largest component of the cost of ITN programmes, has decreased by 29% between 2007 and 2011, but the reductions may not be maintained if manufacturers cut their manufacturing capacity; (ii) large purchasers usually obtain the lowest prices, leaving little room for efficiencies through improved procurement; (iii) the costs of the two main strategies for delivering ITNs, via mass campaigns or health services, are similar and typically comprise only 5%–10% of the total cost of delivery; moreover delivery costs may increase when programmes need to deliver only to households requiring replacement nets rather than to all households; (v) there is scope for reducing the cost per person protected by IRS by expanding IRS programmes, but the cost per person

protected per year is US$ 2.62 in large programmes, compared to approximately US$ 1.39 for ITNs.

5. Expenditure on treatment is expected to decrease as parasitological testing is expanded to all suspected cases of malaria. With current prices of RDTs and ACTs (US$ 0.50 for RDT and US$ 1.40 for AL), and perfect compliance with test results, savings on commodities could amount to US$ 68 million in the public sector in the WHO African Region. However, expanding the use of RDTs may not lead to overall cost savings because of the possible added costs due to increased staff time to perform tests, establishing quality control systems, alternative therapies for patients with negative test results, and the start-up costs of changing malaria case management policy. Any additional costs would need to be balanced against the improved quality of care provided to patients, better health outcomes, the potential reduction in the risk of emergence and spread of antimalarial drug resistance, and improved malaria surveillance.

6. Improved malaria control should result in lower numbers of malaria cases and lead to reductions in the cost of treating patients; attainment of universal access to ITNs in the WHO African Region in 2015 could reduce the number malaria cases attending public health facilities by 31 million to 48 million. The savings on commodities alone (ACTs and RDTs) would amount to more than US$ 59 million per year in the African Region. However the full potential of these savings will not be realized if all fever cases are treated presumptively as malaria, without confirmation by a diagnostic test.

7. Potentially large savings could be made through new technologies. The development and deployment of ITNs lasting 5 years could reduce the total number of ITNs required between 2011 and 2020 from 1.25 billion to 750 million. If the unit cost of delivering both types of ITNs were similar, at US$ 7.66, a total of US$ 3.8 billion could be saved from a financing requirement of US$ 9.6 billion. The price of RDTs has fallen by 11%–15% annually from 2008 to 2010. The development of still cheaper tests could lead to considerable cost reductions; even if RDTs were used for only half the suspected malaria cases attending public health facilities in the WHO African Region, halving the price from the current US$ 0.50 to US$ 0.25 would save US$ 45 million per year.

8. Malaria programmes accounted for approximately 8% of Official Development Assistance (ODA) for health and population in 2009, increasing from 3% in 2005. Overall financing for health and population remained stable between 2008 and 2009, and is likely to do so thereafter. Given stable total funding, and that malaria programmes already receive a significant proportion of health and population financing, further increases in malaria funding within health sector financing may be unlikely.

9. There appears to be scope for domestic governments to invest more in malaria control. If just 1% of total domestic spending were made available for malaria control, 75 of the 99 countries with ongoing malaria transmission could raise enough to provide each person at risk with access to an ITN. Global economic growth has allowed many malaria-endemic countries to increase total domestic government spending; more than 42 countries increased per capita spending by US$ 1000 between 2000 and 2010.

10. Innovative financing mechanisms are in the early stages of development. Taxes on bonds and derivatives transactions may offer the greatest potential for revenue generation – estimated in excess of US$ 250 billion – but their suggested uses go beyond malaria control. Taxes on airline journeys currently raise more than US$ 200 million for health development and their extension to additional countries could generate significant additional funds. Other country-specific schemes, such as tourist taxes, may offer opportunities to raise funds for control programmes in malaria-endemic countries.

Progress in vector control

Coverage with ITNs and IRS has increased rapidly in some countries of sub-Saharan Africa, with household ITN ownership reaching 50% by mid-2011 and IRS protecting 11% of the population at risk. Resistance to pyrethroids has been detected in 27 countries in sub-Saharan Africa.

Insecticide-treated mosquito nets

11. In 2010, 27 countries in the African Region and 42 in other WHO Regions had adopted the WHO recommendation to provide ITNs for *all* persons at risk for malaria, not only pregnant women and children; this represents an increase of 4 countries since 2009. A total of 82 countries, of which 38 are in the African Region, distribute ITNs free of charge.

12. The number of ITNs delivered by manufacturers increased dramatically from 5.6 million in 2004 to 145 million in 2010 in sub-Saharan Africa. The numbers procured between 2008 and 2010 (294 million) were sufficient to cover 73% of the 800 million persons at risk, but this does not take into account delays in delivering ITNs in countries or loss of ITNs after delivery to households.

13. The number of ITNs supplied by manufacturers in 2011 appears to have decreased to approximately 100 million. This is partly because some countries have made substantial progress towards achieving universal access to ITNs in 2010 and are not yet scheduled to reorder ITNs, but also because some countries are still not expanding programmes to a sufficient scale.

14. Using a model that takes into account the number of ITNs supplied by manufacturers, the number of ITNs delivered by national malaria control programmes (NMCPs), and household survey data, the percentage of households owning at least one ITN in sub-Saharan Africa is estimated to have risen from 3% in 2000 to 50% in 2011. Considerably more work is required to ensure that ITNs reach all households where they are needed.

15. Analysis of recent household surveys indicates that approximately 96% of persons with access to an ITN within the household actually use it, suggesting that the main constraint to enabling persons at risk of malaria to sleep under an ITN remains the insufficient availability of nets.

16. The rapid scale-up of ITN distribution in Africa is an enormous public health achievement, but also presents a formidable

challenge for the future in ensuring that the levels of coverage are maintained. There is uncertainty over the extent to which ITN effectiveness decays over time, but the lifespan of a long-lasting insecticidal net (LLIN) is currently estimated to be 3 years. Nets delivered in 2007 and 2008 are therefore now due for replacement, soon to be followed by those delivered in 2009 and 2010.

Indoor residual spraying

17. IRS with WHO-approved chemicals (including DDT) remains one of the main interventions for reducing and interrupting malaria transmission through vector control in all epidemiological settings. In 2010, 73 countries, including 36 in the African Region, recommended IRS for malaria control and 13 countries reported using DDT for IRS.

18. A total of 185 million people were protected by IRS in 2010, representing 6% of the global population at risk. The number of people protected by IRS in the African Region increased from 10 million in 2005 to 78 million in 2010; including all countries in sub-Saharan Africa 81 million people were protected, which corresponds to protection for 11% of the population at risk. In other WHO Regions the number of people protected by IRS is generally stable.

Insecticide resistance

19. Monitoring of insecticide resistance is a necessary element of any medium-scale or large-scale deployment of an insecticidal intervention. In 2010, 78 countries reported that they were carrying out insecticide resistance monitoring.

20. Current methods of malaria control are highly dependent on a single class of insecticides, the pyrethroids, which is the only insecticide class used for ITNs and accounts for approximately 77% of IRS in terms of spray area covered. The widespread use of a single class of insecticide increases the risk that mosquitoes will develop resistance to it. This risk is of particular concern in sub-Saharan Africa, where insecticidal vector control is being deployed with unprecedented levels of coverage. Resistance to pyrethroids has been reported in 27 countries in sub-Saharan Africa; the point at which this reduces the effectiveness of vector control is still uncertain, and may depend on the locally identified resistance mechanism. As requested by the World Health Assembly, WHO is currently working with a wide variety of stakeholders to develop a Global Plan for Insecticide Resistance Management in malaria vectors, to be released in early 2012.

Progress on chemoprevention

The percentage of pregnant women who received two doses of IPTp during pregnancy in ranged from 4% to 68%.

21. Intermittent preventive treatment (IPT) is recommended for population groups in areas of high transmission who are particularly vulnerable to *Plasmodium* infection and its consequences, particularly pregnant women and infants. A total of 35 of 45 sub-Saharan African countries had adopted IPT for pregnant women (IPTp) as national policy by the end of 2010. Papua New Guinea, in the Western Pacific Region, also adopted this policy in 2009.

22. In the 21 high-burden countries in the African Region which have adopted IPTp as national policy, data reported by NMCPs indicate that the percentage of women attending antenatal clinics who received the second dose of IPTp in 2010 was 55% (inter-quartile range 47% – 61%).

23. In 13 countries in the African Region for which household survey data were available for 2008–2010, the percentage of women who received two doses of IPTp during pregnancy in ranged from 4% in Namibia to 68% in Zambia; the weighted average remained low, at 24%, primarily due to low coverage in Nigeria and the Democratic Republic of Congo.

24. All infants at risk of *P. falciparum* infection in countries in sub-Saharan Africa with moderate to high malaria transmission should receive 3 doses of sulfadoxine-pyramethamine (SP), to be provided through immunization services at defined intervals corresponding to routine vaccination schedules. No country has yet adopted a national policy of IPT for infants (IPTi) since its recommendation in 2009.

Progress in diagnostic testing and malaria treatment

The number of RDTs and ACTs procured is increasing, and the percentage of reported suspected cases receiving a parasitological test has also increased, from 67% globally in 2005 to 73% in 2009. Many cases still are treated presumptively without a parasitological diagnosis.

Diagnostic testing

25. Prompt parasitological confirmation by microscopy or RDT is recommended for all patients with suspected malaria, before treatment is started. In 2010, 37 of 43 malaria-endemic countries in the African Region and 53 of 63 endemic countries in other WHO Regions reported having adopted a policy of providing parasitological diagnosis for all age groups, an increase of 4 countries in the African Region since 2009, and 8 elsewhere.

26. The number of RDTs supplied by manufacturers increased from 45 million in 2008 to 88 million in 2010. Product testing has shown an improvement in test quality over time, and proportionally more high quality tests are being procured over time; nearly 90% of RDTs procured in 2011 had panel detection scores of more than 75%, compared with only 23% of RDTs procured in 2007.

27. The percentage of reported suspected malaria cases receiving a parasitological test has increased between 2005 and 2010, particularly in the African Region (from 26% to 45%), Eastern Mediterranean Region (60% to 91%) and South-East Asia Region excluding India (from 58% to 95%). Low rates persist

in the majority of African countries: in 21 out of 42 countries which reported on testing, the percentage of cases tested was less than 20%.

28. Data from a limited number of countries suggest that both microscopy and RDTs are less widely available in the private sector than in the public sector. A total of 48 countries report deployment of RDTs at the community level and 11 million patients were tested through such programmes in 2010.

Treatment

29. Confirmed cases of uncomplicated *P. falciparum* malaria should be treated with an ACT. In 2010, 84 countries and territories had adopted ACT for first-line treatment of *P. falciparum* malaria, representing an increase from 77 countries in 2010. *P. vivax* malaria should be treated with chloroquine where this drug is effective, or an appropriate ACT in areas where *P. vivax* is resistant to chloroquine. Treatment of *P. vivax* should be combined with a 14-day course of primaquine to prevent relapse.

30. The number of ACT treatment courses procured by the public sector increased greatly from 11.2 million in 2005 to 76 million in 2006, and reached 181 million in 2010. A total of 35 million treatments were estimated to have been procured by the private sector in 2010. Total ACT demand is projected to reach 287 million treatment courses in 2011, an increase of 32% over that in 2010. The main driver of this increase is the almost 10-fold increase in subsidized private sales through the AMFm.

31. A limited number of recent household surveys undertaken between 2008 and 2010 suggest that febrile patients attending public health facilities are more likely to receive an ACT than those attending private facilities, but this may change in 2011 for those countries participating in the AMFm pilot programme.

32. In the African Region in 2010, the number of ACTs distributed by NMCPs was more than twice the total number of tests (microscopy + RDTs) carried out in 2010, indicating that many patients continue to receive ACTs without confirmatory diagnostic testing.

Drug resistance

33. WHO recommends that oral artemisinin-based monotherapies be withdrawn from the market and replaced with ACTs. By November 2011, 25 countries were still allowing the marketing of these products (no change from 2010) and 28 pharmaceutical companies were marketing them (down from 39 in 2010). Most of the countries that still allow the marketing of monotherapies are in the African Region, while most of the manufacturers are in India.

34. Therapeutic efficacy studies remain the gold standard for guiding drug policy and should be undertaken at least every 3 years. Efficacy studies of first-line or second-line antimalarial treatments were completed in 31 of 75 countries where *P. falciparum* efficacy studies are possible (in 17 countries efficacy studies are impractical because of low malaria incidence, and 15 countries are endemic for *P. vivax* only). A further 12 had

planned to conduct studies in 2010 or 2011. Efficacy studies were last conducted more than three years ago in 32 countries.

35. Suspected resistance to artemisinins has now been identified in four countries in the Greater Mekong subregion: Cambodia, Myanmar, Thailand and Viet Nam. Containment efforts have shown that a reduction in malaria incidence, a key component of the overall containment plan to halt the spread of resistant parasites, can be achieved. Despite the observed changes in parasite sensitivity to artemisinins, the clinical and parasitological efficacy of ACTs remains high in most settings. However, high treatment failure rates to several ACTs, in particular to dihydroartemisinin-piperaquine which is one of the newest ACTs, has already been identified in Pailin province in Cambodia. This highlights the need for vigilance not only to protect the efficacy of artemisinins, but also the partner medicines in the drug combinations.

36. In 2011 WHO published the *Global Plan for Artemisinin Resistance Containment* (GPARC), which recommends five key activities for successful management of artemisinin resistance: stop the spread of resistant parasites; increase monitoring and surveillance to evaluate the threat of artemisinin resistance; improve access to diagnostics and rational treatment with ACTs; invest in research related to artemisinin resistance; and motivate action and mobilize resources.

Impact of malaria control

A growing number of countries have recorded decreases in the number of confirmed cases of malaria and/ or reported admissions and deaths since 2000. Global control efforts have resulted in a reduction in the incidence of malaria and malaria-specific mortality rates.

37. A total of 8 countries and one area in the WHO African Region showed > 50% reduction in either confirmed malaria cases or malaria admissions and deaths in recent years (Algeria, Botswana, Cape Verde, Namibia, Rwanda, Sao Tome and Principe, South Africa, Swaziland, and Zanzibar, United Republic of Tanzania). Eritrea, Ethiopia, Senegal and Zambia showed reductions of 25%–50%. In all countries, the decreases are associated with intense malaria control interventions.

38. The increases in malaria cases observed in Rwanda and in Sao Tome and Principe in 2009 (two countries that had previously reported reductions) were reversed after intensification of control measures. This highlights the need to build systems for effective surveillance of malaria and to rigorously maintain control programmes even when cases have been reduced substantially. According to available information, increases in cases and deaths observed in Zambia in 2009 have not yet been reversed.

39. While substantial decreases in the numbers of malaria cases are observed in countries with well developed surveillance systems, it is much more difficult to detect such changes in countries where surveillance systems are weaker, particularly in the more populous countries of Central and West Africa. In countries which are expanding the use of microscopy and RDTs the numbers of confirmed cases have risen, reflecting changes in diagnostic practice and concealing the underlying trends

in malaria incidence. More detailed investigation of trends in malaria cases and changes in diagnostic practice is needed to obtain a more accurate picture of the real changes in malaria incidence.

40. In other WHO Regions, the number of reported cases of confirmed malaria decreased by more than 50% in 35 of the 53 countries with ongoing transmission between 2000 and 2010 and downward trends of 25%–50% were seen in 4 other countries. In 2010, the European Region reported only 176 indigenous cases. The number of cases continued to fall least in countries with the highest incidence rates, indicating that greater attention should be given to countries which harbour most of the malaria burden outside Africa.

41. There were 8 countries in the pre-elimination stage of malaria control in 2011 and 9 countries are implementing elimination programmes nationwide (8 having entered the elimination phase in 2008). A further 8 countries (Bahamas, Egypt, Georgia, Iraq, Jamaica, Oman, Russian Federation, and Syrian Arab Republic) have interrupted transmission and are in the prevention of reintroduction phase. Armenia was certified as free of malaria by the WHO Director-General in 2011.

42. An estimated 3.3 billion people were at risk of malaria in 2010. Of this total, 2.1 billion were at low risk (< 1 reported case per 1000 population), 94% of whom were living in geographic regions other than the WHO African Region. The 1.2 billion at high risk (> 1 case per 1000 population) were living mostly in the WHO African (47%) and South-East Asia Regions (37%).

43. There were an estimated 216 million episodes of malaria in 2010, with a wide uncertainty interval (5th–95th centiles) from 149 million to 274 million cases. Approximately 81%, or 174 million (113–239 million) cases, were in the African Region, with the South-East Asian Region accounting for another 13%.

44. There were an estimated 655 000 (537 000–907 000) malaria deaths in 2010, of which 91% (596 000, range 468 000–837 000) were in the African Region. Approximately 86% of malaria deaths globally were of children under 5 years of age.

45. The estimated incidence of malaria has fallen by 17% globally between 2000 and 2010. Larger percentage reductions are seen in the European (99.5%),American (60%) and Western Pacific regions (38%). Malaria specific mortality rates have fallen by 25% between 2000 and 2010 with the largest percentage reductions seen in the European (99%), American (55%), Western Pacific (42%) and African Regions (33%).

46. Estimates of malaria incidence are based, in part, on the numbers of cases reported by NMCPs. These case reports are far from complete in most countries. A total of 24 million confirmed malaria cases was reported by NMCPs in 2010, or 11% of the estimated global case incidence.

Chapter 1

Introduction

This report summarizes the current status of malaria in the world. It reviews progress towards internationally agreed targets and goals, describes trends in funding, and documents the increasing coverage of interventions and their impact. Data from 106 malaria-endemic countries and territories are analysed up to 2010, the year established by the international community to attain universal coverage of preventive and case management interventions for all populations at risk of malaria, and reduce the global malaria burden by 50% from the levels in 2000. Additionally, it includes country-specific information in the form of 99 country profiles for countries and territories with ongoing malaria transmission, complemented by 6 annexes, which provide detailed information about progress in global malaria control and elimination.

Caused by five species of parasites of the genus *Plasmodium* that affect humans *(P. falciparum, P. vivax, P. ovale, P. malariae* and *P. knowlesi),* malaria due to *P. falciparum* is the most deadly, and it predominates in Africa. *P. vivax* is less dangerous but more widespread, and the other three species are found much less frequently. Malaria is transmitted to humans by the bite of infected female mosquitoes of more than 30 anopheline species. An estimated 3.3 billion people were at risk of malaria in 2010, although of all geographical regions, populations living in sub-Saharan Africa have the highest risk of acquiring malaria; in 2010 81 % of cases and 91 % of deaths are estimated to have occurred in the WHO African Region, with children under five years of age and pregnant women being most severely affected.

Malaria is an entirely preventable and treatable disease, provided that currently recommended interventions are properly implemented. These include (i) vector control through the use of insecticide-treated nets (ITNs), indoor residual spraying (IRS) and,

in some specific settings, larval control; (ii) chemoprevention for the most vulnerable populations, particularly pregnant women and infants; (iii) confirmation of malaria diagnosis through microscopy or rapid diagnostic tests (RDTs) for every suspected case, and (iv) timely treatment with appropriate antimalarial medicines (according to the parasite species and any documented drug resistance).

The World Malaria Report is a key publication of the WHO Global Malaria Programme (GMP), providing over the years a historical record of the global malaria situation and the progress made through national and international efforts to control the disease. GMP has four essential roles: (i) to set, communicate and promote the adoption of evidence-based norms, standards, policies and guidelines; (ii) to ensure ongoing independent assessment of global progress; (iii) to develop strategies for capacity building, systems strengthening and surveillance; and (iv) to identify threats to malaria control and elimination, and new opportunities for action.

The World Malaria Report sets out a critical analysis and interpretation of data provided by national malaria control programmes (NMCPs) in endemic countries. Standard reporting forms were sent in March 2011 to 99 countries and territories with ongoing malaria transmission (80 countries in the control phase, and 19 countries in the pre-elimination and elimination phases). Information was requested on (i) populations at risk (ii) vector species (iii) number of cases, admissions and deaths for each parasite species (iv) completeness of outpatient reporting (v) policy implementation (vi) commodities distributed and interventions undertaken (vii) results of household surveys, and (viii) malaria financing. **Table 1.1** summarizes the percentage of countries responding by month and by WHO Region.

TABLE 1.1
Percentage of reporting forms received by month and by WHO Region, 2011

WHO REGION	July	August	September	October	November	Total countries
African		84%	91%	91%	91%	43
Americas	48%	76%	81%	86%	90%	21
South-East Asia	33%	100%	100%	100%	100%	10
European	100%	100%	100%	100%	100%	6
Eastern Mediterranean	22%	89%	89%	89%	89%	9
Western Pacifc	80%	90%	100%	100%	100%	10
TOTAL	**30%**	**86%**	**91%**	**92%**	**93%**	**99**

Source: NMCP data.

Information from household surveys was used to complement data submitted by NMCPs, notably the Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and Malaria Indicator Surveys (MIS). These surveys provide information on the percentage of the population that sleeps under a mosquito net, and of children with fever who are treated and the medication they receive. Information was also received from ACT Watch on the proportion of treatment outlets that have diagnostic facilities and antimalarial medicines in stock, and on antimalarial prices and sales volumes. Information on malaria financing was obtained from the OECD database on foreign aid flows and directly from the Global Fund and the US President's Malaria Initiative (PMI).

Data were analysed and interpreted by WHO staff at headquarters and regional offices, in extensive consultation with WHO country offices and NMCPs regarding the interpretation of country information. Assistance in data analysis and interpretation was also provided by ACT Watch, the African Leaders Malaria Alliance (ALMA), the Clinton Health Access Initiative (CHAI), the Institute of Health Metrics and Evaluation (IHME), Johns Hopkins University, US Centers for Disease Control and Prevention (CDC), the Global Fund, MEASURE / DHS, Tulane University, and the United Nations Children's Fund (UNICEF).

The following chapters consider the policies and interventions recommended by WHO, the implementation of interventions, and the impact on malaria cases and deaths from a global and regional perspective. They also include country examples to illustrate more general assessments within each chapter.

Chapter 2 summarizes internationally agreed goals for global malaria control and the policies and strategies recommended by WHO to achieve them. It then discusses the indicators recommended by WHO, and other agencies, for monitoring progress towards targets.

Chapter 3 reviews the resource requirements for meeting global malaria control targets and recent trends in international and domestic financing. It considers the scope for potential cost savings and the prospects of mobilizing increased funding for malaria control.

Chapter 4 considers the policies that national programmes have adopted for vector control implementation and the progress made towards universal access to ITNs and IRS. It also addresses the increasingly important issue of insecticide resistance and the appropriate monitoring and management of resistance.

Chapter 5 reviews progress in implementation of chemoprevention, particularly the intermittent preventive treatment of malaria in pregnancy and in infants, and the introduction of seasonal chemoprevention in older children. It also reports on the current status of malaria vaccine development.

Chapter 6 reports the extent to which national programmes have adopted policies for universal diagnostic testing of suspected malaria cases and examines trends in the availability of parasitological testing. It reviews the adoption of policies and implementation of programmes for improving access to effective treatment for malaria. The latest trends in drug resistance and efforts to contain artemisinin resistance on the Cambodia-Thailand border are also considered, as well as the progress made in withdrawing oral artemisinin-based monotherapies from the market.

Chapter 7 summarizes the trends in numbers of malaria cases and assesses the evidence that malaria control activities have had an impact on malaria disease burden in each WHO Region. It also provides an update on malaria elimination and on imported malaria, and concludes by presenting estimates of the number of cases and deaths by WHO Region and worldwide for the period 2000–2010.

Profiles of 99 countries with ongoing malaria transmission are provided, followed by **Annexes** which give data by country for the malaria-related indicators.

During 2010 there were 99 countries and territories with ongoing malaria transmission and 7 countries in the prevention of reintroduction phase, making a total of 106 countries in which malaria is considered endemic. In July 2011, South Sudan became an independent state, increasing the number of countries and territories with ongoing transmission to 100 and total endemic countries and territories to 107. In October 2011, Armenia was certified free of malaria by WHO, reducing the number of malaria-endemic countries and territories to 106. As 2010 is the latest year for which most data are available, results for South Sudan and Sudan are reported as from a single country. However in the country profiles and annexes, data from high-transmission and low transmission areas are reported separately.

Chapter 2

Goals, targets, policies and strategies for malaria control and elimination

This chapter summarizes the internationally agreed goals for malaria control and the policies and strategies recommended by WHO to achieve them. It has four sections: (i) goals and targets; (ii) policies and strategies; (iii) malaria elimination; and (iv) indicators to track progress.

2.1 Goals and targets for malaria control and elimination

The year 2010 was an important milestone on the way to achievement of internationally agreed goals and targets for malaria control. It was the date set by the World Health Assembly in 2005 to ensure that at least 80% of those at risk of, or suffering from, malaria would benefit from major preventive and curative interventions, in order to reduce the malaria burden by at least 50% compared to the levels in 2000 (*1*). In 2008, the UN Secretary General set a more ambitious objective: to halt malaria deaths by ensuring universal coverage of malaria interventions by 2010. The aim was to make indoor residual spraying (IRS) and long-lasting insecticidal nets (LLINs) available to all people at risk of malaria, especially children and pregnant women in Africa, and for all public health facilities to be able to provide reliable diagnosis and effective treatment for malaria (*2*). Also in 2008, and aligned with these targets, the Global Malaria Action Plan (GMAP) was launched by the Roll Back Malaria Partnership (RBM) as a blueprint for the control, elimination and eventual eradication of malaria, setting as its objective the reduction of the number of preventable malaria deaths worldwide to near zero by 2015 (*3*).

In the light of progress made by 2010, RBM updated the GMAP targets in June 2011. Maintaining an overall vision of a "malaria-free world" (*4*), the targets are now to: (i) reduce global malaria deaths to near zero by end-2015[1], (ii) reduce global malaria cases by 75% from 2000 levels by end-2015, and (iii) eliminate malaria by end-2015 in 10 new countries since 2008, including in the WHO European Region (*5*) (**Table 2.1**). These targets will be met by: achieving and sustaining universal access to and utilization of preventive measures; achieving universal access to case management in the public and private sectors and in the

community (including appropriate referral); and accelerating the development of surveillance systems.

Achievement of these objectives and targets are based on a number of critical assumptions:

- Sufficient and timely domestic and international funding is available to accomplish and sustain scale-up of the interventions needed to meet the objectives, targets and milestones.

- Scale-up of preventive measures and greater access to diagnostic testing and treatment through the public and private sectors and community case management, along with referral when needed, are sufficient to allow effective treatment of all cases of confirmed malaria.

- Political commitment to sustain malaria control interventions and high-quality surveillance – including the elimination of malaria where that is technically, operationally, and financially feasible – continues even as malaria cases and deaths decline significantly.

- Access to vulnerable populations and the safety and security of health workers are maintained to ensure surveillance, outbreak response, and delivery of diagnostic, treatment, and preventive interventions to populations in fragile and conflict-affected states.

Acknowledging that 'business as usual' will not be enough for achieving the agreed goals, the World Health Assembly in May 2011 urged Member States, WHO, and international partners to undertake a series of actions to sustain the gains that have been made in decreasing the burden of malaria and reducing transmission – among others, to take immediate action to combat resistance to artemisinin-based medicines and resistance to insecticides (*6*).

The deadline for achieving the RBM objective coincides with that of the Millennium Development Goals (MDGs). Malaria control forms part of MDG 6 – to have halted and begun to reverse the incidence of malaria and other major diseases by 2015. Given that malaria accounted for 8% of deaths in children under 5 years of age globally in 2008 and 16% of deaths in children under 5 in Africa (*7*), it is also central to MDG 4 – achieving a two-thirds reduction in the mortality rate among children under 5 years of age between 1990 and 2015. Malaria control is additionally expected to contribute to achievement of MDG 1 (eradicate extreme poverty and hunger), MDG 2 (achieve universal primary education) MDG 3 (promote gender equality and empower women), MDG 5 (improve maternal health) and MDG 8 (develop a global partnership for development) (*8*).

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[1] In areas where public health facilities are able to provide a parasitological test for all suspected malaria cases, near zero malaria deaths is defined as no more than 1 confirmed malaria death per 100,000 population at risk.

TABLE 2.1
Goals and targets for malaria control

Targets for 2005	Targets for 2010	Targets for 2015
	Reduce global malaria deaths from 2000 levels by 50% *(3)*	Reduce global malaria deaths to near zero *(5)*
	Reduce global malaria cases from 2000 levels by 50% *(3)*	Reduce global malaria deaths from 2000 levels by 75% *(1)*
		Reduce global malaria cases from 2000 levels by 75% *(1,5)*
		MDG 6: Have halted and begun to reverse the incidence of malaria and other major diseases *(8)*
At least 60% of those at risk of malaria particularly pregnant women and children under five years of age, benefit from the most suitable combination of personal and community protective measures *(9)* 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 *(9)*	Achieve universal coverage for all populations at risk of malaria using locally appropriate interventions for prevention and case management *(3)* 80% of people at risk from malaria are protected, thanks to locally appropriate vector control methods such as insecticide-treated nets (ITNs), and, where appropriate, indoor residual spraying (IRS) and, in some settings, other environmental and biological measures *(1, 10)* At least 80% of pregnant women receive intermittent preventive treatment in areas where malaria transmission is stable *(1, 10)*	Achieve universal access to and utilization of prevention measures: By end 2013, in countries where universal access and utilization have not yet been achieved, achieve 100% access to and utilization of prevention measures for all populations at risk with locally appropriate interventions *(5)* Sustain universal access to and utilization of prevention measures: By 2015 and beyond, all countries sustain universal access to and utilization of an appropriate package of preventive interventions *(5)*
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 *(9)*	80% of malaria patients are diagnosed and treated with effective antimalarial medicines, e.g. artemisinin-based combination therapy (ACT) within one day of the onset of illness *(1, 10)*	Achieve universal access to case management in the public sector: By end 2013, 100% of suspected cases receive a malaria diagnostic test and 100% of confirmed cases receive treatment with appropriate and effective antimalarial drugs *(5)* Achieve universal access to case management, or appropriate referral, in the private sector: By end 2015, 100% of suspected cases receive a malaria diagnostic test and 100% of confirmed cases receive treatment with appropriate and effective antimalarial drugs *(5)* Achieve universal access to community case management (CCM) of malaria: By end 2015, in countries where CCM of malaria is an appropriate strategy, 100% of fever (suspected) cases receive a malaria diagnostic test and 100% of confirmed uncomplicated cases receive treatment with appropriate and effective antimalarial drugs, and 100% of suspected and confirmed severe cases receive appropriate referral *(5)*
		Accelerate development of surveillance systems: By end 2015, all districts are capable of reporting monthly numbers of suspected malaria cases, number of cases from all public health facilities, or a consistent sample of them *(5)*

2.2 Malaria control policies and strategies

The strategic approaches to malaria control come within two major domains: (i) prevention and (ii) case management. Together, these strategies work against the transmission of the parasite from mosquito vector to humans, and the development of illness and severe disease.

2.2.1 Malaria prevention through malaria vector control

The goals of malaria vector control are two-fold:

- to protect individual people against infective malaria mosquito bites, and

- to reduce the intensity of local malaria transmission at community level by reducing the longevity, density and human-vector contact of the local vector mosquito population.

The two most powerful and most broadly applied interventions are long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS). These interventions work by reducing human-vector contact and by reducing the lifespan of female mosquitoes (so that they do not survive long enough to transmit the parasite).

Insecticide-treated nets (ITNs), which include both LLINs and conventional nets that are later treated with an insecticide, work both by protecting the person sleeping under the net (individual level) and by extending the effect to an entire area (community level). Personal protection operates by preventing contact between the mosquito and the person under the net. The wider effect occurs when the insecticide in the net actually kills the mosquitoes that touch it, therefore affecting the vector population and lowering the overall intensity of transmission in the targeted area. However, the protective effect of ITNs for people sleeping outside the net within the same household is less than for those sleeping under the net *(11)*. Therefore, since 2007, WHO has recommended universal coverage with ITNs (preferably LLINs), rather than a pre-determined number per household.

IRS involves the application of residual insecticides to the inner surfaces of dwellings, where many vector species of anopheline mosquito tend to rest after taking a blood meal *(12)*. IRS is effective in rapidly controlling malaria transmission, hence in reducing the local burden of malaria morbidity and mortality, provided that most houses and animal shelters (e.g. > 80%) in targeted communities are treated *(13)*.

Achieving universal coverage with effective vector control requires a sustained programme of vector control delivery operations which are carried out correctly and on time. This in turn requires specialized personnel at national, provincial and district levels. As well as practical experience in the delivery of vector

control interventions, these teams must also have the capacity to monitor and investigate vector-related and operational factors that may compromise intervention effectiveness, for which specialized entomological knowledge and skills are essential.

WHO recommendations for vector control are the following:

Insecticide-treated nets

1. As high coverage rates are needed to realize the full potential of vector control, WHO recommends that in areas targeted for malaria prevention, ITNs should be made available to all people at risk, i.e. "universal access" (*14*). Because of the operational advantages of LLINs over ITNs, and the fact that the vast majority of nets being procured and distributed today are indeed LLINs, the remainder of this section will refer to LLINs rather than ITNs. In order to meet the target of universal access, it is currently proposed that one LLIN should be distributed for every two persons. At the household level, the distribution of one LLIN for every two members of the household will entail rounding up in households with an odd number of members (e.g. 3 LLINs for a household with 5 members, etc). Because

of this rounding up, the achievement of "one LLIN for every two people" at household level requires an overall ratio, for procurement purposes, of 1 LLIN for every 1.8 people in the target population (*13*).

2. LLINs should be provided either free of charge or be highly subsidized. Cost should not be a barrier to making them available to all people at risk of malaria, especially those at greatest risk such as young children and pregnant women (*14*).

3. Universal access to LLINs is best achieved and maintained by a combination of delivery systems. The basic concept is a combination of 'catch up' and 'keep up'. Catch up means mass distribution campaigns, which can rapidly achieve universal coverage of LLINs. However it is essential to complement such campaigns with continuous 'keep up' delivery systems, particularly routine delivery to pregnant women through antenatal services and to infants at immunization clinics. In malaria-risk areas, ensuring that these routine systems have the sustained LLINs stocks needed to provide an LLIN to all pregnant women receiving antenatal care, and to all infants receiving routine immunization, should be given as much priority as repeated campaigns (*14*).

4. In order to be protected, households must not only own LLINs but also use them. Behaviour change interventions including information, education, communication (IEC) campaigns and post-distribution "hang-up campaigns" are strongly recommended (*14*).

5. Only LLINs recommended by the WHO Pesticide Evaluation Scheme (WHOPES) should be procured by national malaria control programmes and partners for malaria control. At present there are 12 recommended products (*15*, *16*, *17*). Detailed guidance on good practice in the handling and use of pesticides, and on quality control in procurement, can be found on the WHOPES website (*18*). Independent quality control of products (including insecticides) should be undertaken before shipment, to ensure that sub-standard products are not delivered to countries. The supplier of pesticide should bear the cost of analysis, including for samples to be sent to an accredited or recognized laboratory for analysis for countries that do not have national quality control laboratories (*19*).

6. It is now recognized that the lifespan of LLINs is variable, among settings and among products. Therefore, all large-scale LLIN programmes (including those implemented by non-governmental organizations) should make efforts to monitor LLIN durability in the local setting, using standard methods published in 2011 (*20*). The collection of local data on the comparative durability of alternative LLIN products, using rigorous and auditable methods, is expected to enable procurement decisions to be made on the basis of "price per year of protection" rather than unit price per net; this in turn is expected to bring rapid and potentially substantial cost savings. This is important because LLINs represent a large proportion of the global malaria control budget (*21*).

Indoor residual spraying

7. IRS is applicable in many epidemiological settings, provided the operational and resource feasibility are considered in policy and programming decisions. IRS requires specialized spray equipment and techniques, and both the equipment and the quality of application must be scrupulously maintained.

8. Currently 12 insecticides belonging to 4 chemical classes are recommended by WHOPES for IRS (*22*). An insecticide for IRS is selected in a given area on the basis of data on resistance, the residual efficacy of the insecticide, costs, safety and the type of surface to be sprayed.

9. DDT has a comparatively long residual efficacy (≥ 6 months) as an insecticide for IRS. The use of DDT in agriculture is banned under the Stockholm Convention, but countries can use DDT for IRS for as long as necessary and in the quantities needed, provided that the WHO guidelines and recommendations are followed and until locally appropriate, cost-effective alternatives are available for a sustainable transition from DDT (*23*).

Larval control

10. In a few specific settings and circumstances, the core interventions of IRS and LLINs may be complemented by other methods, such as larval source control including environmental management. However, larval control is appropriate and advisable only in a minority of settings, where mosquito breeding sites are few, fixed, and easy to identify, map and treat. In other circumstances, it is very difficult to find a sufficiently high proportion of the breeding sites within the flight range of the vector (*13*). Currently 8 compounds and formulations for mosquito larval control are recommended by WHOPES for Larval Source Management (LSM). In Africa, larviciding interventions are most likely to be appropriate in urban settings, and are unlikely to be cost-effective in most rural settings (*24*).

2.2.2 Insecticide resistance

11. The spread of insecticide resistance, especially pyrethroid resistance in Africa, is a major threat for vector control programmes. Insecticide resistance management has to be considered as important as epidemiological cost-effectiveness in all programmatic decisions about vector control, including the selection of insecticides for IRS (*25*). In particular:

- Resistance management measures should be part of every vector control programme, and deployed pre-emptively, without waiting for signs of the presence of resistance or of control failure.

- A substantial intensification of resistance monitoring is needed, using both bioasssay (susceptibility) tests and genetic methods. Resistance monitoring should be seen as a necessary element of any medium- or large-scale deployment of an insecticidal intervention (including LLIN distribution by NGOs); it is the responsibility of the implementing agency to make sure that this testing is done properly. All data on vector resistance should be submitted (in confidence if necessary) to the national malaria control programme within three months of the test performance, even if the study is not yet complete. Donors financing insecticide procurement should ensure that the decision regarding the choice of insecticide is supported by adequate and up-to-date information on resistance among local anopheline vectors.

- Using the same insecticide for multiple successive IRS cycles is not recommended; it is preferable to use a system of rotation with a different insecticide class being used each year. In areas where IRS is the main vector control intervention, this rotation system may include the use of a pyrethroid.

- In areas with high LLIN coverage, pyrethroids should not be used for IRS.

12. Currently, there is heavy reliance on pyrethroids for malaria vector control especially in the form of LLINs. The preservation of pyrethroid susceptibility in target vector populations is therefore an overwhelming priority in the choice of vector control methods. The combination of non-pyrethroid IRS with LLINs involves significantly increased costs, but it has two expected advantages. First, there is evidence that the presence of a non-pyrethroid on the wall reduces the strength of selection for pyrethroid resistance that might occur as a result of an LLIN in the same room; this combination is therefore recommended as a means of insecticide resistance management (*25*). Second, there is observational evidence suggesting that the combination of IRS and LLINs is more effective than either intervention alone, especially if the combination helps to increase overall coverage with vector control (*26*). Such evidence, is limited and collection of data from a wide variety of settings is needed. It should be noted that in areas with high levels of LLIN coverage in which pyrethroid resistance is identified, focal IRS is recommended. Broad deployment of IRS and LLINs in combination, while potentially very effective, is currently financially unsustainable.

WHO is currently developing a *Global Plan for Insecticide Resistance Management in malaria vectors* (GPIRM) through extensive consultation with a wide variety of stakeholders; it will be released in early 2012.

2.2.3 Diagnosis and treatment of malaria

The main objectives of an antimalarial treatment policy are:

- to reduce morbidity and mortality by ensuring rapid, complete cure of *Plasmodium* infection, thus preventing the progression of uncomplicated malaria to severe and potentially fatal disease, as well as preventing chronic infection that leads to malaria-related anaemia;

- to reduce the frequency and duration of malaria infection during pregnancy and its negative impact on the fetus; and

- to curtail the transmission of malaria by reducing the human parasite reservoir.

The 2nd edition of the WHO *Guidelines for the treatment of malaria* was published in March 2010 (*27*). The current WHO recommendations for diagnosis and treatment are as follows:

1. Prompt parasitological confirmation by microscopy, or alternatively by rapid diagnostic tests (RDTs), is recommended in all patients with suspected malaria before treatment is started. Antimalarial treatment solely on the basis of clinical suspicion should only be considered when a parasitological diagnosis is not accessible.[1] Treatment based on diagnostic testing is good clinical practice and has the following advantages over presumptive treatment of all fever episodes:

- improved care of parasite-positive patients because of confirmation of infection;

- identification of parasite-negative patients, in whom another diagnosis must be sought and treated accordingly;

- avoidance of antimalarial medicine use in parasite-negative patients, thereby reducing side effects, drug interactions and selection pressure for drug resistance, and potentially resulting in financial savings;

- better public trust in the efficacy of artemisinin-based combination therapy (ACT) when it is used only to treat confirmed malaria cases; and

- better public trust in diagnosis and treatment of non-malaria causes of febrile illness.

2. Uncomplicated *P. falciparum* malaria should be treated with an ACT. In addition to an ACT, a single dose of primaquine is recommended for treatment of *P. falciparum* malaria as an anti-gametocyte medicine (particularly as a component of a pre-elimination or an elimination programme), subject to consideration of the risks of haemolysis in patients with glucose-6-dehydrogenase (G6PD) deficiency.

3. *P. vivax* malaria should be treated with chloroquine in areas where this drug is effective; an appropriate ACT (not artesunate plus sulfadoxine-pyrimethamine) should be used in areas where *P. vivax* resistance to chloroquine has been documented. Both chloroquine and ACTs should be combined with a 14-day course of primaquine for the treatment of *P.vivax* malaria in order to prevent relapses, subject to consideration of the risk of haemolysis in patients with G6PD deficiency.

4. The 5 ACTs currently recommended for use are artemether plus lumefantrine, artesunate plus amodiaquine, artesunate plus mefloquine, artesunate plus sulfadoxine-pyrimethamine, and dihydroartemisinin plus piperaquine. The choice of the ACT should be based on the efficacy of the combination in the country or area of intended use.

5. Artemisinin and its derivatives should not be used as oral monotherapies for the treatment of uncomplicated malaria as poor adherence to the required 7 days of treatment results in partial clearance of malaria parasites which will promote resistance to this critically important class of antimalarials.

6. Severe malaria should be treated with a parenteral artesunate and followed by a complete course of an effective ACT as soon as the patient can take oral medications. Where complete parenteral treatment of severe malaria is not possible, e.g. in peripheral health posts, patients should be given pre-referral treatment and referred immediately to an appropriate facility for further treatment. Options available for pre-referral treatment are: artesunate (rectal), quinine (IM), artesunate (IM) or artemether (IM).

7. In settings with limited health facility access, diagnosis and treatment should be provided at community level through a programme of community case management (formerly known as home-based management) of malaria. The introduction of parasitological testing of malaria allows the identification of non-malaria febrile illnesses, which also need appropriate care, notably pneumonia and other causes of childhood mortality. The successful implementation of community case management therefore requires diagnosis and treatment for other frequent causes of febrile disease. This new strategy is termed integrated community case management (iCCM) of childhood illness.

2.2.4 Intermittent preventive treatment

Intermittent preventive treatment is the administration of a full course of an effective antimalarial treatment at specified time points to a defined population at risk of malaria, regardless of whether the recipients are parasitaemic, with the objective of reducing the malaria burden in the target population.

1. *Intermittent preventive treatment in pregnancy (IPTp):* All pregnant women at risk of *P. falciparum* infection in countries in sub-Saharan Africa with stable malaria transmission, should receive at least 2 doses of sulfadoxine-pyrimethamine (SP), given at the first and second scheduled antenatal care visits (at least one month apart) after "quickening" (the first noted movement of the fetus). The doses of SP should be taken under direct observation during the antenatal visits (*28*).

2. *Intermittent preventive treatment in infants (IPTi)*: All infants at risk of *P. falciparum* infection in countries in sub-Saharan Africa with moderate to high malaria transmission should receive 3 doses of SP along with the DTP2, DTP3 and measles immunization through the routine immunization programme (*29, 30*).

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[1] Within a short time (less than 2 hours) of the patient's presentation at the point of care.

2.2.5 Resistance to antimalarial drugs

Antimalarial drug resistance is a major public health problem which hinders the control of malaria. Continuous monitoring of the efficacy of and resistance to antimalarial drugs is important to inform treatment policy and ensure early detection of changing patterns of resistance.

Therapeutic drug efficacy studies allow measurement of the clinical and parasitological efficacy of medicines and the detection of subtle changes in treatment outcome when monitored consistently over time. Therapeutic drug efficacy studies are considered the gold standard for determining antimalarial drug efficacy, and their results are the primary data used by national malaria control programmes to revise the national malaria treatment policies for first- and second-line drugs and ensure appropriate management of clinical cases. Therapeutic drug efficacy studies are also used to detect suspected artemisinin resistance, defined as an increase in parasite clearance time, as evidenced by ≥ 10% of cases with parasites detectable on day 3 after treatment with an ACT.

BOX 2.2
The *Global Plan for Artemisinin Resistance Containment* (GPARC)

The *Global Plan for Artemisinin Resistance Containment* (GPARC) was released in January 2011, in response to the emergence of artemisinin resistance in the Greater Mekong subregion. The goal of the GPARC is to protect ACTs as an effective treatment for *P. falciparum* malaria by defining priorities for the containment and prevention of artemisinin resistance. Five activities are recommended by the GPARC as important for successful management of artemisinin resistance:

1. **Stop the spread of resistant parasites**. In areas for which there is evidence of artemisinin resistance, an immediate comprehensive response using a combination of malaria control and elimination measures is needed to stop the survival and spread of resistant parasites.

2. **Increase monitoring and surveillance to evaluate the threat of artemisinin resistance.** Regular monitoring and surveillance are essential to rapidly identify new foci of resistant parasites and to provide information for containment and prevention activities. Countries endemic for malaria should undertake routine monitoring of antimalarial drugs at sentinel sites every 24 months in order to detect changes in their therapeutic efficacy (*31*).

3. **Improve access to diagnostics and rational treatment with ACTs.** Programmes should ensure: consistent, accurate diagnostic testing of suspected malaria cases; better access to ACTs for confirmed cases; compliance with ACT treatment; and removal from the market of oral artemisinin-based monotherapies as well as substandard and counterfeit antimalarial medicines.

4. **Invest in artemisinin resistance-related research.** Research is important to improve understanding of resistance and the ability to manage it. Priority should be given to research in five disciplines should be a priority: laboratory research, research and development, applied and field research operational research, and mathematical modeling.

5. **Motivate action and mobilize resources.** Successful implementation of the GPARC will depend on motivating many stakeholders at global, regional and national levels to support or conduct the recommended activities.

The GPARC defines three tiers based on the evidence of artemisinin resistance. Each endemic country should evaluate its level of risk and apply the GPARC recommendations accordingly.

Tier 1: Areas with credible evidence of artemisinin resistance. The recommended response for tier 1 areas is a combination of intensified malaria control and tools for elimination including: parasitological diagnosis for all patients with suspected malaria; a full course of quality-assured ACTs plus primaquine for confirmed cases; vector control to lower transmission and minimize the spread of resistant parasites; and launch of specific activities to contain or eliminate resistant parasites such as intensified monitoring of therapeutic efficacy near current foci to track the spread of artemisinin resistance; enforcement to eliminate use of oral artemisinin-based monotherapies and substandard and counterfeit antimalarial medicines; programmes to reach mobile and migrant populations with adequate prevention, diagnosis and treatment; and epidemiological or transmission-reduction tools.

Tier 2: Areas with significant inflow of mobile and migrant populations from tier 1 areas or shared borders with tier 1 areas. As in tier 1 areas, the recommendations largely mirror those for malaria control. The specific recommendations for tier 2 areas are: intensify and accelerate malaria control activities; implement specific measures to manage the potential spread of resistant parasites from tier 1 areas, including programmes to reach mobile and migrant populations; launch of activities specific for the prevention of resistance, in particular intensified monitoring of therapeutic efficacy to track the spread of artemisinin resistance; and education and enforcement to eliminate the use of oral artemisinin-based monotherapies and substandard and counterfeit antimalarial medicines.

Tier 3: *P. falciparum* endemic areas which have no evidence of artemisinin resistance and have limited contact with tier 1 areas. In tier 3, the main objective is to prevent the emergence of artemisinin resistance in implementation and scale-up of effective control measures, including: increasing access to parasitological diagnosis; improving access to quality-assured ACTs for confirmed cases; increasing coverage with vector control to limit malaria transmission; monitoring the therapeutic efficacy of first- and second-line treatments every 24 months; introducing or enforcing actions to eliminate the use of oral artemisinin-based monotherapies or poor-quality drugs.

For more details see
http://www.who.int/malaria/publications/atoz/artemisinin_resistance_containment_2011.pdf

To interpret and compare results within and between regions and to follow trends over time, therapeutic efficacy monitoring must be conducted with similar standardized procedures. WHO updated the protocol for assessing antimalarial drug efficacy in 2009 (*31*). WHO has also developed a guideline on genotyping malaria parasites to distinguish between reinfection and recrudescence, which is necessary as part of the therapeutic efficacy testing (*32*). The following recommendations are drawn from the 2009 edition of *Methods for surveillance of antimalarial drug efficacy* (*31*).

1. National malaria control programmes should establish sentinel sites (selected health facilities) for the surveillance of antimalarial drug efficacy. Experience suggests that 4–8 sites per country will achieve a balance between representativeness and practicality. The sentinel sites should represent all the epidemiological strata in the country but it is essential to select a 'manageable' number of sites to ensure proper monitoring and supervision.

2. Efficacy of first- and second-line medicines should be tested at least once every 24 months at all sites. For the purposes of comparability, assessments should always be conducted at the same time of year.

3. A follow-up of 28 days is recommended as the minimum duration for medicines with elimination half-lives of less than 7 days (amodiaquine, artemisinin derivatives, atovaquone–proguanil, chloroquine, lumefantrine, quinine, and sulfadoxine-pyrimethamine). For medicines with longer elimination half-lives (mefloquine, piperaquine), a longer follow-up period of 42 days is necessary.

4. The standard protocol to test the efficacy of medicines against *P. falciparum* needs adjustment for *P. vivax*. Since *P. vivax* infection has a dormant liver stage and therefore the potential to relapse, many countries recommend primaquine therapy for radical cure. Administration of primaquine concurrently or soon after administration of chloroquine may conceal resistance to chloroquine alone, resulting in underestimation of the risk of therapeutic failure or resistance to chloroquine. Therefore, in certain cases primaquine therapy should be postponed until after the 28-day follow-up. Nonetheless, if local health policy includes mandatory administration of primaquine with chloroquine, the failure rate should be considered to be that of the combination regimen.

5. Countries should consider changing the first-line treatment for malaria if the total failure (defined as the sum of the patients presenting with early treatment failure, late clinical failure or late parasitological failure) rate exceeds 10%; the selection of a new antimalarial treatment for use at public health level in the context of national treatment guidelines should be based on an average cure rate of ≥ 95% as assessed in clinical trials (*27*).

While therapeutic efficacy studies conducted according to a standard protocol provide an excellent indication of drug efficacy, additional studies are needed to confirm and characterize drug resistance. These additional studies include (i) in vitro studies to measure the intrinsic sensitivity of parasites to antimalarial drugs; (ii) molecular marker studies to identify genetic mutations and subsequently confirm the presence of mutations in blood parasites and (iii) pharmacokinetic studies to characterize drug absorption and drug action in the body. WHO has prepared a field manual on in vitro assays (*33*) and on methods for assessing exposure to antimalarial drugs (*34*).

Over the last decade, most countries endemic for *P. falciparum* have shifted their national treatment policies to ACTs, although therapeutic efficacy studies are still not routinely conducted in many of these countries (*35*). Resistance to artemisinins has been confirmed in the Greater Mekong subregion. Neither the mechanism of artemisinin resistance, nor a molecular marker to screen for it, has yet been identified. The current working definition of artemisinin resistance is:

- an increase in parasite clearance time, as evidenced by ≥ 10% of cases with parasites detectable on day 3 after treatment with an ACT (suspected resistance);

 or

- treatment failure after treatment with an oral artemisinin-based monotherapy with adequate antimalarial blood concentration, as evidenced by the persistence of parasites for 7 days, or the presence of parasites at day 3 and recrudescence within 28–42 days (confirmed resistance)[1].

Following the confirmation of artemisinin resistance, the *Global Plan for Artemisinin Resistance* (GPARC) was developed (*35*), outlining the necessary actions to contain and prevent resistance to artemisinins (see **Box 2.2**).

2.3 Malaria elimination

From a country perspective, interruption of local mosquito-borne malaria transmission, i.e. elimination of malaria, is the ultimate goal of malaria control. The WHO recommendations regarding malaria elimination are summarized below: (*36, 37*)

1. In areas of high, stable transmission, where a marked reduction in malaria transmission has been achieved (as may be indicated by slide positivity rates of less than 5%[2]), a 'consolidation period' should be introduced, in which (i) control interventions are sustained, even in the face of limited disease; (ii) health services adapt to the new clinical and epidemiological situation with a lower case load and reduced levels of immunity; and (iii) surveillance systems are strengthened to allow rapid response to new cases. This transformation phase precedes a decision to re-orient programmes towards elimination.

2. Countries with low, unstable transmission (as may be indicated by less than 1 case per 1000 population per year should be encouraged to proceed to malaria elimination, with falciparum elimination preceding vivax elimination where these species co-exist. Before making this decision, however, countries should take account of the overall feasibility, including entomologic situation, programmatic capacity, fiscal commitment, political commitment, and potential threats to success, including the malaria situation in neighbouring countries. Malaria elimination may require regional initiatives and support and will require strong political commitment.

3. Countries with an absence of locally acquired malaria cases for 3 consecutive years, and with sufficiently robust surveillance and reporting systems in place to demonstrate this achievement, are eligible to request WHO to initiate procedures to certify that they are malaria-free.

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1 This definition is prone to confounding factors (known and unknown) such as splenectomy, haemoglobin abnormalities and reduced immunity.
2 These milestones should be adjusted for each country and situation, keeping in mind the resources available for notification, investigation and follow-up of malaria cases.

4. Failure to sustain malaria control will result in a resurgence of malaria, as has happened in the past, and must be avoided. Therefore, public and government commitment to intensified malaria control and elimination needs to be sustained, even when the malaria burden has been greatly reduced.

5. Because malaria control today relies heavily on a limited number of tools, in particular artemisinin derivatives and pyrethroids, which could potentially become less effective because of resistance, the development of new tools is a necessary priority, particularly for vector control and other preventive measures, diagnostic testing, treatment and surveillance.

BOX 2.3
Definitions (37)

Malaria control: reducing the malaria disease burden to a level at which it is no longer a public health problem.

Malaria elimination: the interruption of local mosquito-borne malaria transmission; reduction to zero of the incidence of infection caused by human malaria parasites in a defined geographical area as a result of deliberate efforts. Continued measures to prevent re-establishment of transmission are required.

Certification of malaria elimination: the official recognition of malaria-free status granted by WHO after it has been proven beyond reasonable doubt that the chain of local human malaria transmission by *Anopheles* mosquitoes has been fully interrupted in an entire country for at least 3 consecutive years.

Malaria eradication: permanent reduction to zero of the worldwide incidence of infection caused by a particular malaria parasite species. Intervention measures are no longer needed once eradication has been achieved.

2.4 Indicators

The UN Inter-agency and Expert Group on MDG Indicators has established the following indicators for malaria (8):

6.6   Incidence and death rates associated with malaria

6.7   Proportion of children under 5 years sleeping under insecticide-treated bednets

6.8   Proportion of children under 5 years with fever who are treated with appropriate antimalarial medicines.

As policies and strategies for malaria control have evolved over the last decade, standard indicators have been adapted to reflect the latest recommendations. For example, indicator 6.7 has

been expanded to consider also the proportion of the population of all age groups that sleep under ITNs (38). Similarly, indicator 6.8 does not reflect current policy recommendations to provide a parasitological test for all fever cases.

Table 2.2 summarizes 28 indicators recommended by WHO for use by national malaria programmes to measure coverage with malaria control interventions (ITNs, IRS, IPTp, diagnosis and treatment) and their epidemiological impact. The selection of indicators draws upon: the Abuja Declaration in 2000 (9), the resolution of the World Health Assembly in 2005 (1), the RBM *Global Malaria Action Plan* (3), the work of the RBM Monitoring and Evaluation Reference Group (MERG) (39)[1],previous editions of the *World Malaria Report* (38, 40, 41) and guidelines on *Universal Access to Malaria Diagnostic Testing* (42). Of the 28 indicators, 17 are derived from routine information systems and would typically be available for monitoring on a monthly basis. Not all indicators are applicable to every epidemiological setting and individual programmes would use only a sub-set of the 17 routine indicators. The remaining 10 indicators are derived from household surveys and, while these would not normally be available every year for every country, they provide complementary information for programme assessment.

The *major changes* from the indicator list in the *World Malaria Report 2010* are: (i) the addition of an indicator on *the proportion of households with at least one ITN for every two people;* (ii) the case management indicator of the proportion of malaria cases receiving appropriate treatment is modified to focus solely on cases with a positive test result, so that the indicator is now *the proportion of confirmed malaria cases receiving first-line antimalarial treatment;* (iii) the addition of an indicator, *the proportion of all antimalarial medicines that are recommended as first-line therapies.*

2.5 Policy development

In 2011 the WHO Global Malaria Programme embarked on a review and re-design of its policy-setting process so that it is more responsive to a rapidly evolving malaria landscape. The result is the establishment of the Malaria Policy Advisory Committee (MPAC), which will provide independent advice to WHO regarding policy recommendations to control and eliminate malaria (43).

The MPAC will advise WHO specifically on: appropriate malaria policies and standards based on data from malaria programme implementation by member states and malaria control partners as well as reviews of the best available evidence; engagement of WHO in malaria-related initiatives; major issues and challenges for achieving global malaria goals; and the identification of priority activities to address identified challenges. The MPAC is scheduled to become operative during the first quarter of 2012.

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1   Updated guidelines on indicators from household surveys are being developed by RBM MERG and are due to be issued in 2012.

TABLE 2.2
Malaria indicators, targets and sources of data

Trends in malaria cases and deaths

Impact measure	Indicator	Numerator	Denominator	Break-down	Data source	Target
Malaria cases						
	1.1 Confirmed malaria cases (microscopy or RDT) per 1000 persons per year [a]	Confirmed malaria cases per year x1000	Population	All ages, < 5, male, female, PCD, ACD	Routine surveillance system or HMIS	Reduction of cases per 1000 of ≥ 50% by 2010, and ≥ 75% by 2015 in comparison with 2000
	1.2 Inpatient malaria cases per 1000 persons per year [b]	No. of inpatient malaria cases per year x 1000	Population	All ages, < 5, male, female	Routine surveillance system or HMIS	
	In low transmission / elimination settings:					
	1.3 Number of active foci reported per year	Number of active foci reported per year	None	None	Routine surveillance system	
	1.4 Number of cases by classification	Number of cases by classification	None	Local (introduced, indigenous, relapsing), imported, induced	Routine surveillance system	
Malaria transmission						
	1.5 Malaria test positivity rate	No. of laboratory-confirmed malaria cases	No of suspected malaria cases with parasite-based test	Microscopy, RDT, P.*f*, P.*v*, PCD, ACD	Routine surveillance system or HMIS	No target set. Indicates level of control [c]
	In high-transmission areas:					
	1.6 Proportion of children aged 6-59 months with evidence of malaria infection	*Number of children aged 6-59 months with malaria infection detected by microscopy or RDT*	*Total number of children aged 6-59 months tested for malaria parasites by microscopy or RDT*		*Household survey*	
Malaria deaths						
	1.7 Inpatient malaria deaths per 1000 persons per year	No. of inpatient malaria deaths per year (< 5 years or total) x 1000	Population	All ages, < 5, male, female, pregnant women	Routine surveillance system or HMIS	Reduction in deaths per 1000 of ≥ 50% by 2010, and ≥ 75% by 2015 in comparison with 2000 [d]
	1.8 Malaria-specific deaths per 1000 persons per year	*No. of malaria deaths per year x 1000*	*Population*	*All ages, < 5, male, female, pregnant women*	*Verbal autopsy (surveys), complete or sample vital registration systems*	*Reduction in deaths per 1000 of ≥ 50% by 2010, and ≥ 75% by 2015 in comparison with 2000 [d]*
	In high-transmission areas:					
	1.9 All-cause under 5 mortality rate (5q0)	*No. of deaths in children < 5 years from all causes x 1000*	*Number of live births*		*Household surveys, complete or sample vital registration systems*	*No specific malaria target set*

Coverage with interventions

Control strategy	Indicator	Numerator	Denominator	Break-down	Data source	Target
Vector control						
	2.1 Proportion of population at risk potentially covered by nets distributed [e]	No. of persons with ITN from no. of ITNs distributed [e]	No. of persons at risk of malaria		Routine data on commodities distributed	≥ 80%
	2.2 Proportion of targeted risk group receiving ITN	No. of ITNs distributed to risk groups	No. of persons in risk groups targeted for receiving ITN	Pregnant women attending antenatal clinics, children attending immunization clinics, migrant workers	Routine data on commodities distributed	≥ 80%
	2.3 Proportion of households with at least one ITN	Number of households surveyed with at least one ITN	Total number of households surveyed		Household survey	
	2.4 Proportion of households with at least one ITN for every two people	Number of households surveyed with at least one ITN for every two people	Total number of households surveyed		Household survey	
	2.5 Proportion of individuals with access to an ITN in a household [f]	Number of individuals with access to an ITN in a household [f]	Total number of individuals who slept in surveyed households the previous night		Household survey	
	2.6 Proportion of individuals who slept under an ITN the previous night	Number of individuals who slept under an ITN the previous night	Total number of individuals who slept in surveyed households the previous night	All ages, < 5, pregnant women	Household survey	≥ 80%
	2.7 Percentage of population at risk protected by IRS	No. of persons protected by IRS	No. of persons at risk for malaria		Routine data from national malaria control programme	No target set. Indicates contribution of IRS to overall malaria control
	2.8 Households sprayed with insecticide among those targeted	No. of households sprayed in 1 year according to national guidelines	No. of households targeted according to national guidelines		Routine data from national malaria control programme	100%
	2.9 Proportion of households with at least one ITN and/ or sprayed by IRS in the last 12 months.	*Number of households that have at least one ITN and/or have been sprayed by IRS in the last 12 months.*	*Total number of households surveyed*		*Household survey*	
Diagnosis and treatment						
	2.10 Percentage of all suspected malaria cases that receive parasitiological test [g]	No. of all suspected malaria cases that receive parasitological test [g]	No. of all suspected malaria cases		Routine surveillance system or HMIS	≥ 90%
	2.11 Proportion of children under 5 years old with fever in the last 2 weeks who had a finger or heel stick	*Number of children under 5 years old who had a fever in the previous 2 weeks who had a finger/heel stick*	*Total number of children under 5 years old who had a fever in the previous 2 weeks*		*Household survey*	
	2.11 Percentage of confirmed malaria cases receiving first-line antimalarial treatment according to national policy [h]	No. of confirmed malaria cases receiving first-line antimalarial treatment at health facility [h]	No. of confirmed malaria cases at health facility [h]	P.f, P.v.	Routine surveillance system, HMIS or special studies	100%
	2.12 Proportion of first-line treatments among children under five years old with fever in the last two weeks who received any antimalarial medicines[i]	*Number of children under five years old with fever in the last two weeks receiving recommended first-line treatment [i]*	*Number of children under five years old with fever in the last two weeks receiving antimalarial medicine [i]*	*P.f, P.v.*	*Household survey*	*100%*
	In high-transmission areas:					
	2.13 Pregnant women who received two doses of intermittent preventive therapy	No. of pregnant women who received two doses of intermittent preventive therapy	No. of pregnant women who made at least one antenatal care visit in 1 year		Routine data from HMIS	≥ 80%
	2.14 Proportion of women who received intermittent preventive treatment for malaria during ANC visits during their last pregnancy	*Number of women who received two or more doses of a recommended antimalarial drug treatment during ANC visits to prevent malaria during their last pregnancy that led to a live birth within the last 2 years*	*Total number of women surveyed who delivered a live baby within the last 2 years*		*Household survey*	≥ 80%

Management systems

System	Indicator	Numerator	Denominator	Break-down	Data source	Target
Supplies						
	3.1 Proportion of health facilities without stock-outs of key commodities by month	Number of health facilities without stock-outs of key commodities by month	No. of health facilities	ACTs, RDTs, ITNs	Routine reporting system or HMIS	100%
Reporting						
	3.2 Annual blood examination rate	No. of all suspected malaria cases that receive parasitological test	Population	ACD, PCD	Routine surveillance system or HMIS	
	3.3 Completeness of monthly health facility reports [j]	No. of health facility reports received each month [j]	No. of health facility reports expected each month	Commodities distributed, stock-outs, outpatient cases, inpatient cases	Routine surveillance system or HMIS	> 90%
	In low transmission / elimination settings:					
	3.4 Proportion of private facilities reporting to national malaria surveillance system [k]	Number of private facilities in areas at risk for malaria reporting to national malaria surveillance system [k]	Number of private facilities in areas at risk for malaria		Routine surveillance system	

From references *36-42*. Indicators derived from household surveys are in italics.

RDT, rapid diagnostic test; MDG, Millennium Development Goal; ITN, insecticide-treated net; IRS, indoor residual spraying; ACD active case detection; PCD passive case detection

a   Use only if > 90% of suspected cases have examination for parasites (microscopy or RDT).

b   Marker for severe malaria

c   Malaria test positivity rate < 5% during the malaria season is considered as an indicator of readiness for transition from control stage to pre-elimination stage.

d   An updated RBM target was adopted in 2011: "near zero malaria deaths" by 2015. This target is more ambitious than the target of 75% reduction in malaria deaths by 2015.

e   This indicator is estimated from the number of LLINs or ITNs distributed by ministries of health and partners. LLINs are assumed to protect for 3 years and conventional ITNs or retreated nets for 1 year. A single net is assumed to protect two persons. Hence the number of people potentially covered is the 2 * (number of LLINs delivered in last three years + number of conventional ITNs and retreatments delivered in last year). This indicator measures distribution and not hanging or use.

f   This indicator is estimated from the number of ITNs available in each household. Each net is assumed to protect two persons. Thus a household with 5 residents will require 3 ITNs.

g   Parasitological tests include microscopy and RDT.

h   Per WHO recommendations all suspected cases should be given a diagnostic test and only treated with an antimalarial if they test positive for *Plasmodium*.

i   Comments h apply to indicator 2.12 also. The intention is to treat all persons with an appropriate antimalarial medicine; however, children are at greatest risk, especially in areas of high transmission and many household surveys do not ask about antimalarial treatment over age 5 years. In areas of low transmission, it is recognized that this indicator may be less useful.

j   This indicator can vary depending on data collection forms and reporting channels. For example, the inpatient data channel may be separate from the outpatient data channel, or the commodities and disease surveillance data channels may be combined.

k   Facilities should report even if they have zero cases.

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Financing malaria control

This chapter reviews (i) recent trends in international and domestic financing in relation to global malaria control and elimination targets, (ii) how funds have been spent on the different interventions, (iii) the scope for cost savings, and (iv) prospects for mobilizing additional resources.

3.1 Resource requirements

Global resource requirements for malaria control were estimated in the 2008 Global Malaria Action Plan to exceed US$ 5 billion per year between 2010 and 2015 and US$ 4.75 billion between 2020 and 2025 (1)[1]. The reduced amounts in the later years are primarily due to a projected reduction in the need for diagnostic testing and treatment as malaria becomes better controlled, as has been observed in several low transmission countries over the past decade. However, it is possible that future needs for diagnostic testing will not be reduced substantially in the near term; in countries that currently have high rates of malaria transmission, fever cases may still require parasitological testing even if malaria has been well controlled, for as long as there is a continuing risk of malaria transmission.

3.2 International financing of malaria control

International disbursements to malaria-endemic countries have increased vastly over the past decade but appear to have peaked in 2011, at US$ 2 billion (**Fig.3.1**). The Global Fund remains the single largest source of funding for malaria control globally, with a peak in disbursements over 2009–2011, reflecting the larger Round 8 and Round 9 Global Fund grants approved in 2008 and 2009, respectively. DFID, PMI, the World Bank and other donors accounted for 49% of total disbursed funding in the year 2010. PMI contributions rose from US$ 385 million in 2009 to US$ 585 million in 2010.

With the exception of the Global Fund, information on disbursements is not available for years after 2010. To assess trends in the funds available for malaria control between 2011 and 2015, it is necessary to examine formal commitments made by funding agencies or, if data are not available, to examine

pledges or to make projections regarding the funds that could be available according to information on financing trends (see **Box 3.1** for a description of the difference between pledges, commitments, disbursements and expenditures).

For the Global Fund, actual disbursements are shown up to October 2011; disbursements expected in the following years are estimated from the remaining resources in existing grants, including approved Round 10 proposals, allocated to the remainder of 2011 and 2012 and future years according to the number of days remaining in grants. On 22 November 2011 the Global Fund announced that the Round 11 of grant applications would be cancelled owing to lower than expected revenues (3). The next opportunity for countries to apply for new grants will be for 2014 onwards, but the amounts available are not yet known. A transitional funding mechanism has been established to ensure continuity of services for grants that end before 2014. Savings from phase 2 renewals will also be sought. In particular, Group of 20 (G-20) upper middle income countries with less than an extreme disease burden will no longer be eligible for renewals of grants[2].

Figure 3.1   Past and projected international funding for malaria control
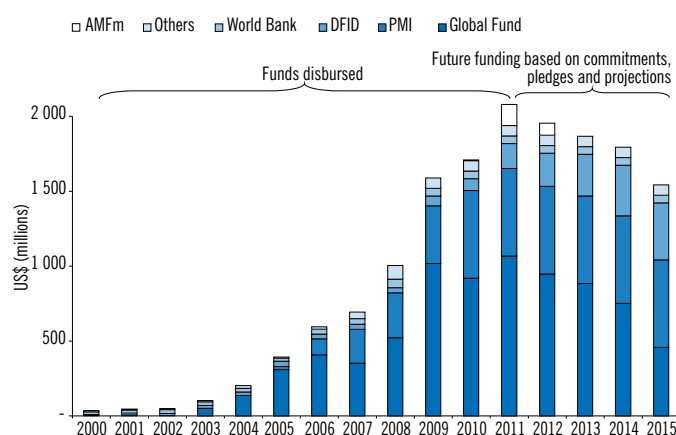
Source: Global Fund: Actual disbursements to October 2011, then resources remaining in existing grants, with 20% efficiency savings, allocated to the remainder of 2011 and future years according to the number of days remaining in grants. PMI: appropriation for 2012 onwards set to 2011 levels. DFID: Average of amounts in country operational plans (lower case scenario) and total of US$ 500,000 in 2015 excluding Global Fund and other contributions (upper case scenario). World Bank and others: funding beyond 2009 assumed to remain at 2009 levels. AMFm: Actual disbursements in 2011 up to September then remaining resources allocated to 2011 and 2012 according to the rate of spending to date. Note that the graph excludes funding of AMFm beyond 2012 and possible new round of Global Fund in 2014, owing to uncertainty over future resourcing of these mechanisms.

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1   Kiszewski et al (2) estimated that between US$ 3.5 billion and US$ 5.6 billion would be required per year between 2006 and 2015, but used a slightly different basis for calculation, e.g. not budgeting for the use of RDTs in children under five years of age in Africa.

2   Brazil had already announced at the 21st RBM board meeting that it would decline to accept funds for Phase 2 of its Round 8 malaria grant.

Future PMI funding is assumed to be held at 2011 levels of US$ 620 million. United Kingdom direct bilateral funding available to endemic countries for malaria control is projected to increase from US$ 66million in 2009 to US$ 260 million in 2015[1] (*4*). For the World Bank together with other agencies, future funding is assumed to remain at 2009 levels, the latest year for which data are available, at US$ 51 million. AMFm disbursements in 2011 up to September totalled US$ 105 million; the remainder of the initial AMFm budget of US$ 216 million has been allocated to 2011 and 2012 according to the rate of spending to date. Future AMFm funding is uncertain and has been excluded from the graph.

This analysis suggests that international funding for malaria control will reach its highest ever levels in 2011 at US$ 2 billion, of which the Global Fund accounts for approximately 50%. Funding will then remain relatively stable until 2013 largely as a result of increased financing from DFID. However, without further rounds from the Global Fund, it will decrease to US$1.5 billion in 2015. Such analysis is relatively optimistic, since in the absence of firm information, it does not project decreases in funding from PMI, World Bank or other sources. As well as reduced amounts of funding, the nature of malaria financing could change as the bilateral programmes of DFID and PMI dominate funding for malaria control in 2015. Such bilateral support is concentrated in the highest burden countries in Africa. Countries outside Africa may find it increasingly difficult to attract international funding for malaria control.

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[1] This excludes support to the Global Fund and UNITAID and indirect funding for malaria through direct budget and sector support and maternal, newborn and child health programme support.

3.3 Domestic financing of malaria control

WHO obtains information on domestic financing from data submitted by NMCPs for the *World Malaria Report.* Such reports are restricted to malaria-specific expenditures incurred by NMCPs for commodities, programme supervision and management, training and behavioural change interventions. They exclude general health systems spending, particularly for treatment of malaria, such as the cost of health workers, hospitals, clinics and other infrastructure which are typically provided by the national governments or supported by non-governmental organizations.

A total of 68 countries submitted data on domestic government and international malaria expenditures for 2010. **Figure 3.2** shows a breakdown of malaria expenditures per person at risk for countries in each WHO Region which submitted more complete data. While data are only shown for 18 of the countries, they illustrate that total spending per person at risk for malaria varies from just a few cents per person at risk to more than US$ 10. Total spending per person at risk is higher in countries approaching elimination, while contributions from domestic governments appear to be relatively small in countries with high malaria transmission, generally less than US$ 1 per person at risk. Only in countries with relatively low malaria transmission are domestic government malaria expenditures more than international expenditure. While it is not yet possible to ascertain total global domestic government malaria spending from the data available, it seems likely to be substantially less than that of international spending, which was less than US$ 2 billion in 2010 (**Fig. 3.1**). Consequently, total funds available for malaria control fall short of the US$ 5 billion identified in the Global Malaria Action Plan as being necessary for effective malaria control.

Figure 3.2 Malaria expenditure per person at risk by source of funding

Source: NMCP data

Figure 3.3 Use of funds from different sources

a) Government 2010

b) The Global Fund 2010

c) PMI Operational Plans 2011

Source: NMCP data, GF enhanced financial reporting system, PMI operational plans.
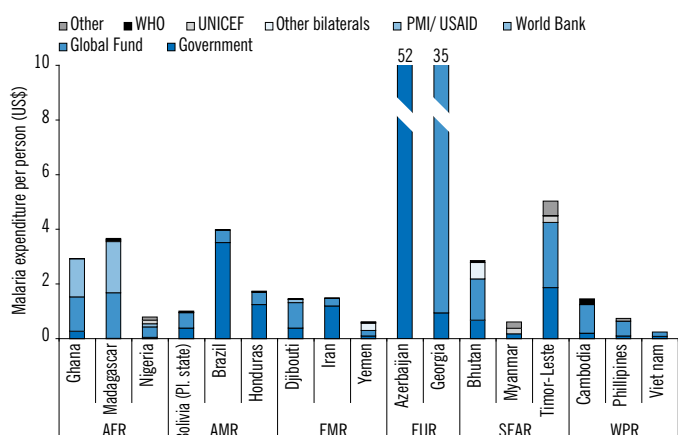
3.4 Categories of expenditure by source of funds

Figure 3.3 shows how funding from different sources is spent. The proportion of national government spending on different activities was calculated from the 42 reports with a breakdown of government expenditures for 2010 submitted by NMCPs to WHO, with each country weighted equally (rather than by total expenditures). Information on Global Fund expenditures was obtained from the fund's enhanced financial reporting system for 2010. Information on planned PMI expenditures was obtained from country operational plans for 2011.

National government expenditure for malaria is generally focused on human resources (36%), IRS (17%) and programme management (16%), although this varies by WHO Region, with proportionally more spent on human resources in the American and South-East Asian Regions (72% and 74% respectively) compared to 22% in the African Region. The majority of Global Fund resources are used for ITNs (43%), antimalarial treatment (21%), programme management (12%) and diagnostic testing (3%). PMI funds are allocated primarily for ITNs (35%), IRS (25%), treatment (20%) and diagnostic testing (7%).

3.5 Potential Savings

The fact that current funding for malaria programmes falls short of the amount required to achieve universal access to malaria interventions implies that funding needs to be increased from existing levels and/or that malaria control programmes should seek cost savings so that more can be done with existing funds. Larger cost savings are likely to be achieved by focusing on elements that account for the largest proportion of expenditures in malaria control programmes, i.e. ITNs, IRS, diagnosis and treatment. This section draws on findings of the Results for Development Institute's LLIN Market Dynamics Project and work by the Clinton Health Access Initiative (CHAI) on value for money in malaria programming(5).
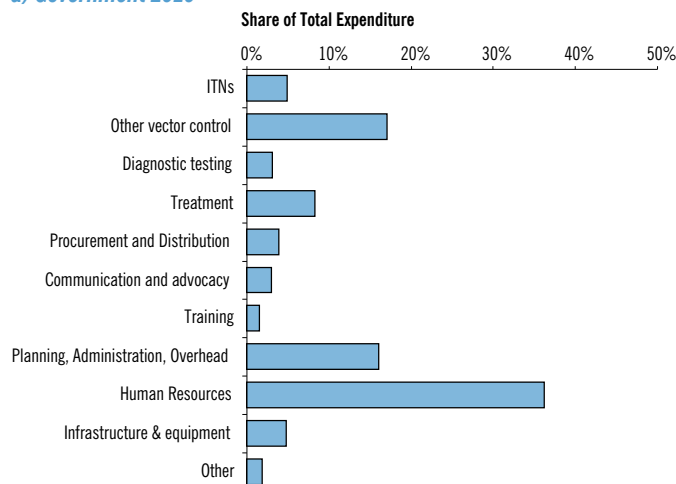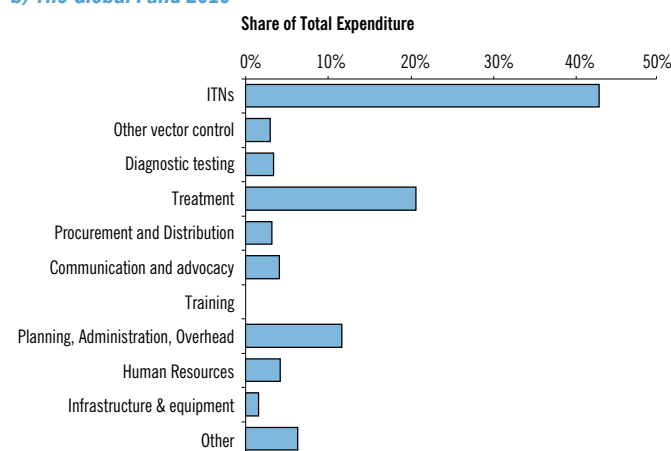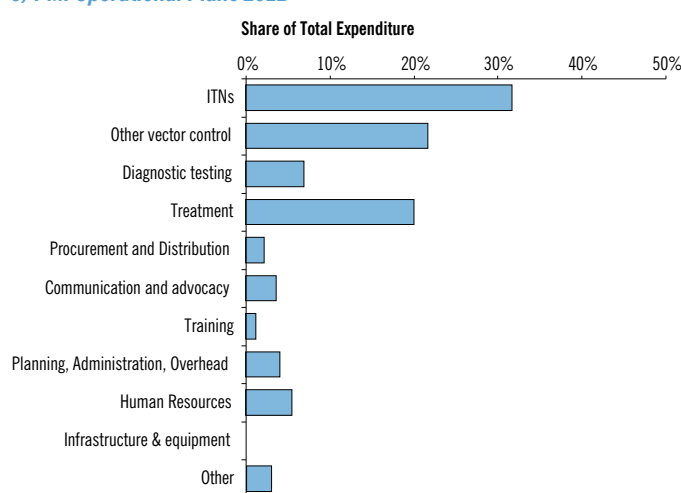
3.5.1 Vector control

ITN prices: ITNs, or more specifically LLINs, account for the largest share of most malaria programme expenditures. The median cost of delivering a LLIN in studies conducted since 2005 was US$ 7.66 (range US$ 6.61–US$ 10.84). Most of the cost (70%–85%) is accounted for by the cost of the LLIN, including shipping and insurance costs (**Fig.3.4**).

Figure 3.4   Breakdown of costs to deliver an LLIN
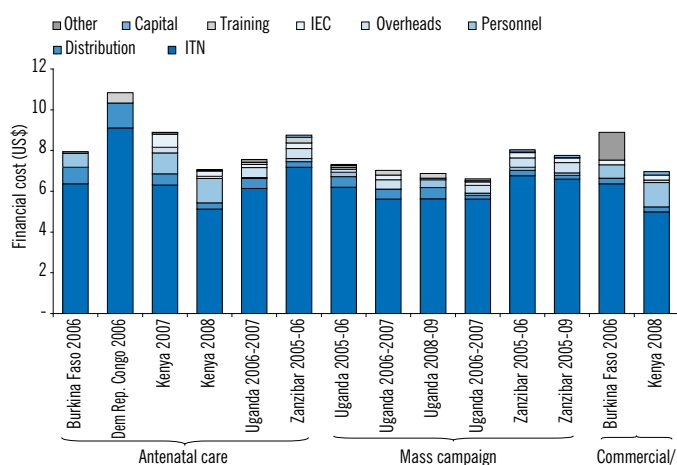
Source: Financial costs of delivering an LLIN derived from (6) Burkina Faso, (7) Democratic Republic of the Congo, (8) Kenya, (9, 10) Uganda and (11) Zanzibar, United Republic of Tanzania.

Historical LLIN pricing data from the Global Fund's Price and Quality Reporting[1] (PQR) database shows a downward pricing trend since 2007. The average price of the most widely procured 180x190x150cm net, which accounted for 47% of purchases in 2009–2010, fell by 22% between 2007 and 2010, and by an additional 9% in the first half of 2011(**Fig.3.5**).

This decreasing price trend is likely to be due to a combination of several factors: a dramatic increase in LLIN purchases, from 17 million in Africa in 2007 to 145 million in 2010; increased market competition, with the number of WHOPES-recommended suppliers increasing from three in 2007 to ten in 2011; and most recently, excess production capacity after the scale-up in 2010 to meet universal coverage targets. The most recent decreases may or may not be maintained if manufacturers cut manufacturing capacity.

Analysis conducted by CHAI suggests that the savings achievable by accessing lower prices in the market are modest, because large purchasers are already obtaining the lowest prices. If all countries were able to access the lowest price reported to the PQR database for the net types that they purchased, total expenditure would fall by only 11%. However, value for money depends not only on the cost of nets, and it may be more cost effective to pay more for a more durable net that is likely to last longer in the field, or for a type of net that may be more popular with the local population, and therefore increase net usage.

ITN delivery costs: Distribution costs, which include warehousing and transportation, typically comprise approximately 5%–10% of the total cost of delivery (**Fig.3.4**). A review has suggested that mass campaigns have the lowest median cost per net delivered,

with continuous distribution through routine health services slightly behind, and continuous retail and community-based strategies being 50%–100% more expensive (*12*). While the cost of delivering an ITN may be modest for the two most commonly used strategies (through mass campaigns or health services) the strategy chosen to identify recipients may offer an opportunity for savings. Some programmes deliver a fixed number of ITNs per household in a mass campaign, such as two nets per household, rather than providing them according to the number of people in the household. Such a strategy could not only fail to provide sufficient ITNs to all of the population at risk, but would provide more nets than needed for households of only one or two people and lead to significant wastage if the extra nets were not shared with neighbours who have insufficient nets (**Fig.3.6**). In a country the size of Nigeria the number of excess ITNs delivered to households with just one or two residents would be more than 10 million nets costing at least US$ 60 million.

ITN coverage begins to fall even in the first year after a campaign as a result of loss, damage, and population growth, so that regular top-ups are necessary (*12*). Mass campaigns to replace nets at regular intervals would be wasteful, as older but still effective nets would be replaced. ITNs can be delivered through antenatal and immunization clinics, but some households without a birth in a year would not be covered, while it is also possible that ITNs would be supplied to families which had already received an ITN through other channels (e.g. an ITN supplied at both antenatal and immunization clinics). Ideally, nets would be replaced continuously as they wear out, but a practical strategy for identifying the need for replacement nets at the household level has not been fully developed, and administrative costs may be high. There is an urgent need to devise ways of efficiently targeting households in need of nets.

Spatial targeting of ITNs: Malaria transmission is heterogeneous, particularly outside Africa, and cost savings might be achieved by focusing vector control only on areas above a specific threshold of transmission intensity[2]. However, evidence suggests that the levels of vector control coverage required to suppress malaria in low transmission areas are lower than in high transmission areas (*13*). While it is possible that some populations in areas of very low transmission may not derive substantial benefits from ITNs (*14*), precise knowledge of the levels of risk and the required levels of coverage for effective control in different epidemiological settings is lacking, and suspending vector control or aiming for partial coverage targets could put some populations at heightened risk of malaria. Hence, the scope for cost savings by better spatial targeting currently appears to be limited. More knowledge is needed on the extent to which universal coverage of vector control measures is required in areas of very low transmission, and where they could be replaced by intensified case detection and response.

Increasing the lifespan of ITNs: Although manufacturers state that nets may last for more than three years, in practice net lifespan varies widely (*15, 16*). With ITNs that last three years, approximately 1.25 billion ITNs will be required to ensure that all people at risk of malaria in Africa have access to an ITN between 2011 and 2020, whereas only 750 million ITNs would be required for ITNs that last five years. If the unit cost of delivering both types of ITNs were similar, at US$ 7.66 (as described above, **Fig.3.4**), US$ 3.8 billion could be saved from a total ITN financing requirement of US$ 9.6 billion. However, the savings would depend on the strategy for replacing nets. Moreover, the distribution of net life is as important as the average value, because net distribution mechanisms must replace nets that fail before the end of the average net lifespan and, ideally, avoid replacing nets that last longer than expected. Additionally, with

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1 http://www.theglobalfund.org/en/procurement/pqr/

2 At present there is little evidence that substantial vector control resources are spent on areas with no malaria risk.

increasing concerns about pyrethroid resistance, caution is needed regarding the implications of more durable nets. It will be important to consider whether a more durable net should also have resistance-breaking or resistance management insecticidal properties.

WHO has developed guidelines on measuring ITN durability, and has recommended that procurement decisions should be based on the cost per year of protection, not simply on the cost per net (*16, 17*). While retrospective data on existing nets is being gathered, the guidelines emphasize the importance of prospective data gathering on ITN durability in order to establish whether the LLIN product procured by a country for large-scale distribution is indeed the best for that particular local setting, and should be purchased again, or whether a different product would give better value for money in the next round of procurement. Prospective data gathering involves comparing up to six different products, including the one or more products that are already in large-scale use in that setting, together with some selected alternatives (e.g. some of those that were not selected in the last tender). The median lifespan of each product (i.e. the time at which 50% had been lost) could then be divided into the quoted offer price for each product in a tender, to produce an estimate of the cost-per-year of effective coverage. In this way, price can be considered in the tender process as 'per year of expected coverage' rather than 'per net', while the other tender criteria (such as delivery conditions) can retain their respective weightings relative to price.

Once protocols for measuring the life of nets are implemented in the field, and the results considered in tenders, manufacturers will have strong incentives to develop better, longer-lasting nets. Extension of the lifespan of nets would not only reduce commodity costs but also the frequency of redistribution campaigns and expenditures associated with ITN delivery.

IRS expenditure: Expenditure on IRS comprises a significant share of malaria control programme expenditures, particularly those of ministries of health and the PMI (**Fig.3.3**). Analysis of PMI programme costs indicated that the cost per person protected by IRS per year varies by programme size (*18*): those protecting 1 million people or more were less costly (median US$ 2.62 per person protected) than those that protect fewer than 1 million (median US$ 5.52 per person protected) (**Fig.3.7**). Costs in large programmes also decreased over time by about 25% as they matured. Evidently IRS may have to be undertaken on a considerable scale for the lowest costs to be achieved.

To reduce the risk of insecticide resistance emerging, IRS programmes should use several different insecticides, either in annual rotation or as a mosaic, and avoid using pyrethroids where LLIN coverage is high. Where pyrethroids were the predominant class of insecticide, insecticides comprised only 13%–18% of total costs in large IRS programmes, and 7%–10% in small programmes (*18*), the difference due to proportionally higher staff and other costs in small programmes. Given that carbamates cost roughly five times more than pyrethroids, these proportions suggest that spraying costs would increase by 50%–70% in large programmes and 30%–40% in small programmes if pyrethroids were replaced by carbamates in a cycle (or to US$ 4.0–4.5 per person protected in large programmes compared to US$ 7.0–7.7 in small programmes). While IRS is undoubtedly effective, and there is scope for reducing the cost per person protected by expanding programmes, the cost per person protected per year is greater than that for ITNs (which is approximately US$ 1.39[1] assuming ITNs are used at 96% of capacity (see section 4.1.3, **Fig.4.5**)).

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[1] The cost of delivering an LLIN which lasts three years and covers an average of 1.8 people is US$ 7.66.

Figure 3.5   Weighted average unit price for 190x180x150 LLINs (US$)
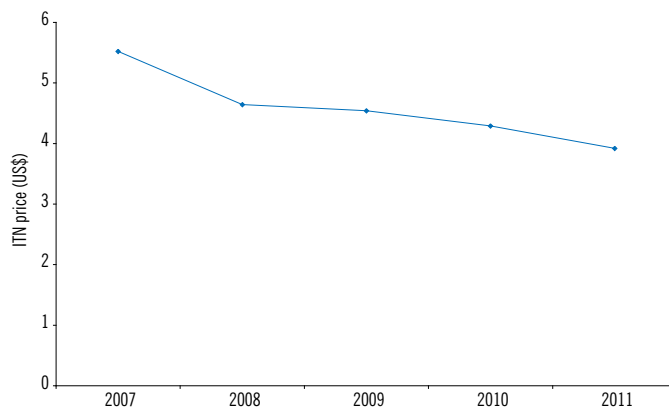
Source: Global Fund PQR database accessed Nov 2011. Includes only entries with 'Shipping reported separately'. Prices for 2011 are up to June.

Figure 3.6   Effect of delivering two ITNs per household in a mass campaign
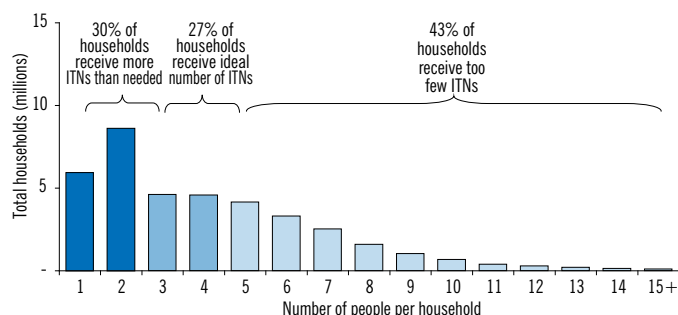
Source: Population distribution as documented in Nigeria DHS 2008.

Figure 3.7   Cost per person protected by IRS per year in relation to programme size
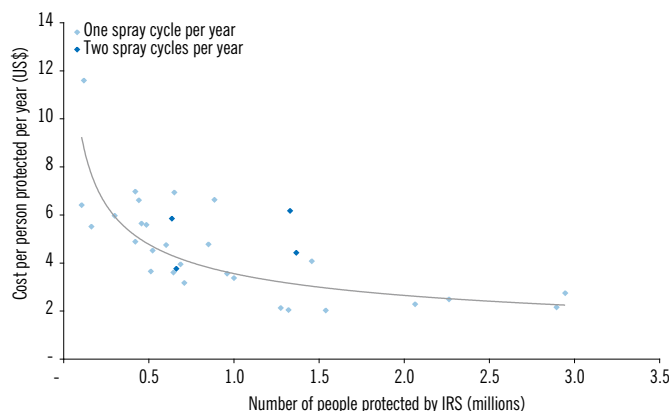
Source: An economic analysis of the costs of indoor residual spraying in 12 PMI countries, 2008–2010 (18).

3.5.2 Diagnostic testing and treatment

Diagnostic testing and treatment is the largest category of expenditure after vector control. In countries with high levels of transmission, suspected malaria cases can comprise up to 50% of outpatient visits and all should receive a diagnostic test; in the absence of availability of malaria diagnostic testing, such patients are generally treated presumptively with antimalarial medicines.

Rapid diagnostic tests: According to 2010 PQR data, the weighted average price for *P. falciparum*-specific RDTs was US$ 0.51 (range: US$ 0.42–0.88) and US$ 0.69 (US$ 0.58–1.05) for multi-species tests. The weighted average prices for both types of tests fell by 11%–15% annually from 2008 to 2010.

The scope for cost savings by improving procurement is limited. If all countries purchasing *P. falciparum* or multi-species tests had been able to access the lowest price recorded in the PQR in 2010, they would have collectively saved approximately 15%. However, because of differences between competitors' tests, there are costs involved in switching from one product to another (e.g. re-training, new job aids, increased supervision). Even if countries had continued to purchase the same products, but with access to the lowest prices for each (for instance, through effective pooled procurement), they could have saved only 11%.

Little is known about the cost structure of RDTs for malaria. With the exception of monoclonal antibodies for detecting malaria-specific antigens, all of the components are readily available commodities, suggesting that there may be limited scope for reducing costs. In round 3 of product quality testing, undertaken by WHO, FIND, CDC, and TDR in 2010, 23 suppliers submitted 50 products for test quality assessments (*19*) suggesting that the market is relatively competitive, although in practice five manufacturers dominate actual sales. As the drive towards universal diagnostic testing accelerates, expenditures on RDTs will increase and the potential for cost savings will need to be kept under continual review. Excessive focus on RDT prices could jeopardize product quality. However, RDTs that score highest in quality testing also appear to be among the least expensive, perhaps because their popularity enables the manufacturers to achieve economies of scale (see **Fig.5.3**).

Decreases in the cost of RDTs may require new technologies, but research expenditure on diagnostic testing lags far behind that of ACTs, representing only 4.5% of total malaria research and development funding, compared to 31% for drugs (amounting to US$ 12 million in 2009)(*20*). The impact of reducing RDT costs could be considerable: even if RDTs were used for only half of the fever cases attending public health facilities in the WHO African Region, reducing their cost from US$ 0.50 to US$ 0.25 would save over US$ 45 million annually. Cheaper diagnostics would also encourage their use in the private sector, and thereby promote more rational use of subsidized ACTs.

Artemisinin-based combination therapy: Two artemisinin combinations dominate the market today, artemether-lumefantrine (AL) and artesunate-amodiaquine (AS-AQ). The public sector accounts for the largest share of orders for prequalified ACTs, and in 2011 the price offers of adult treatment packs of AL ranged between US$ 1.30 and US$ 1.40, while for adult treatment courses of AS-AQ the price was US$ 0.78 for a co-blister pack and

US$ 0.94 for a fixed-dose combination. Despite its higher cost, AL accounted for two thirds of ACTs procured by the public sector in 2010 (**Fig.6.10 page 42**).

From 2007 to 2009 five additional ACT manufacturers met the WHO prequalification standards and the growing demand for ACTs in 2010 was met by increased production capacity. Higher sales volumes, increasing competition and lower artemisinin price have led to a progressive reduction of ACT prices. However, the tight supply of artemisinin in 2011 and its marked price increase this year is likely to have an impact on ACT prices in 2012: total sales were approximately 180 million treatment courses in 2010 but global ACT demand is forecast to reach 300 million treatment courses in 2012 (**Fig.6.12 page 44**). The demand for ACTs could potentially decrease in the future if diagnostic testing for malaria becomes more widely available.

Increasing parasitological testing: Expenditure on antimalarial treatment currently greatly exceeds that on diagnostic testing: the Global Fund spent US$ 630 million on treatment in 2010 compared to US$130 million on diagnostic testing.[1] In addition to regular Global Fund grant disbursements, US$ 216 million were committed to subsidize ACTs as part of AMFm Phase 1 implementation, which started in the second half of 2010.[2] The PMI allocated US$ 104 million for malaria treatment in 2011compared to US$ 37 million for diagnostics.[3]

Expenditures on malaria diagnostic tests are expected to increase and expenditures on malaria medicines to decrease as parasitological testing is extended to all suspected cases of malaria. RDTs are currently the most practical tool for expanding testing in health facilities that are unable to offer malaria microscopy. The extent to which cost savings on malaria commodities will be achieved by expanding parasitological diagnosis will depend on the relative cost of RDTs and ACTs and the endemicity of malaria as measured by the test positivity rate. With current prices of RDTs and ACTs (US$ 0.50 for RDT and US$ 1.40 for AL), and perfect compliance with test results, savings on commodities can be expected if test positivity rates are less than 64% (**Fig.3.8**). Test positivity rates lower than 60% are observed in the vast majority of African countries and in all countries elsewhere. It is estimated that approximately 183 million fever cases are seen annually at public health facilities in the WHO African Region;[4] this would give rise to a commodity cost of US$ 256 million if all cases were treated presumptively with AL, but only US$ 188 million if all cases had a parasitological diagnosis and were only treated with AL if positive, a saving of US$ 68 million. Further savings would be made if the cost of RDTs decreases relative to that of ACTs. However, savings will be less if health workers continue to provide antimalarial medicines to patients who have negative test results.

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1   Global Fund enhanced financial reporting system
2   The Global Fund To Fight AIDS, Tuberculosis and Malaria (2011). AMFm Frequently Asked Questions. Updated: July 2011.
3   PMI operational plans for fiscal year 2011. http://www.pmi.gov/countries/mops/index.html
4   Of the estimated 174 million malaria cases in WHO African Region (Section 7.11), 40% are estimated to attend public health facilities, according to the treatment-seeking behaviour for fever observed in household surveys. The number of fever cases is estimated from the test positivity rates observed in each country.

This type of analysis does not take into account increased staff costs (if the time required to perform tests implies that more staff will be hired or that staff time will be taken away from other activities), the costs of establishing a quality control system for testing, the cost of alternative therapies in the event of a negative test, as well as the start-up costs of training staff, revising protocols and supervision which will be important in ensuring that health workers comply with test results. If these costs are taken into account, the expansion of RDTs may not lead to overall cost savings. However, any additional costs need to be balanced against the improved quality of care provided to patients, the expected enhanced health outcomes, and the reduction in the risk of emergence and spread of antimalarial drug resistance.

The impact of improved malaria control: Improved malaria control should result in lower numbers of malaria cases. Randomized controlled trials indicate that high coverage with ITNs reduces the incidence of malaria by 50% in a variety of settings (*22*). Therefore, the number of malaria cases can be expected to decrease to 119 million per year in the African Region if universal coverage with either ITNs or IRS is achieved by 2015, compared to 197 million cases if current rates of coverage are maintained (or respectively 48 million and 79 million attending public sector facilities) (**Fig.3.9**).[1]

Potential cost savings on antimalarial medicines will not be fully realized as long as antimalarial drugs are given as presumptive treatment to all patients with fever. With a policy of universal parasitological testing, the reduction in cases due to universal vector control coverage would result in total commodity cost savings of US$ 110 million compared to zero ITN coverage, or US$ 59 million compared to current ITN coverage levels. With a policy of presumptive treatment of all fever cases in the public sector the corresponding savings accrued through improved vector control would be US$ 81 million and US$ 44 million (**Fig.3.10**). On this basis, the additional costs for enhanced vector control would be compensated in part by the reduced diagnostic testing and treatment commodity costs; the amounts saved would be sufficient to purchase and deliver 7.8 million additional ITNs, providing 42 million person-years of protection.

There may be economic benefits beyond commodity costs, and which may fully justify investments in malaria control. For example, in Rwanda it has been estimated that while it would cost US$ 265 million to sustain the malaria control programme over the next five years, the public health system could avert about US$ 267 million in the costs of diagnosing and treating malaria; and households could avert about US$ 547 million in direct and indirect costs, equivalent to about 7% of household income (*25*). Much of the health-care savings would not result in cash savings since they relate to health worker time and the cost of infrastructure and equipment, but these could be applied to other medical conditions.

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[1] The current number of cases would be expected to increase in line with population growth if intervention coverage remained unchanged. Non-malarial fevers would also increase in line with population growth irrespective of changes in intervention coverage.

Figure 3.8   Cost of commodities for treating suspected malaria patients: test and treat versus presumptive treatment
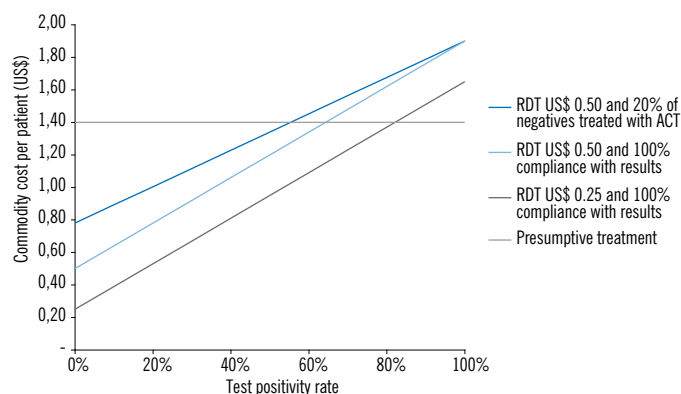
Source: WHO model

Figure 3.9   Estimated number of fever cases seen at public health facilities in Africa in 2015 according to different levels of ITN coverage
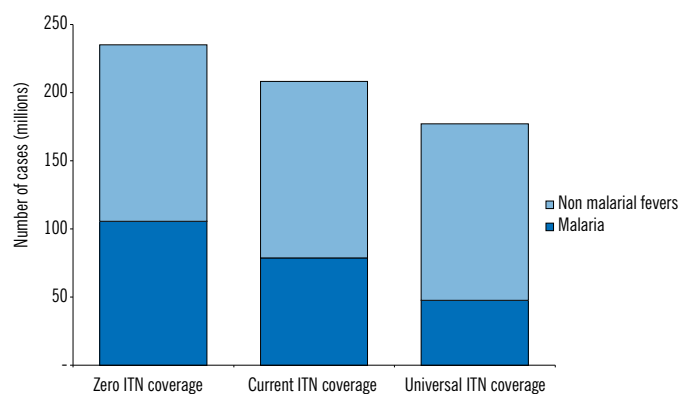
Source: WHO model for estimating number of malaria cases in sub-Saharan Africa (23, 24)

Figure 3.10   Commodity cost of treating cases presumptively, or with a policy of test and treat, with different levels of ITN coverage
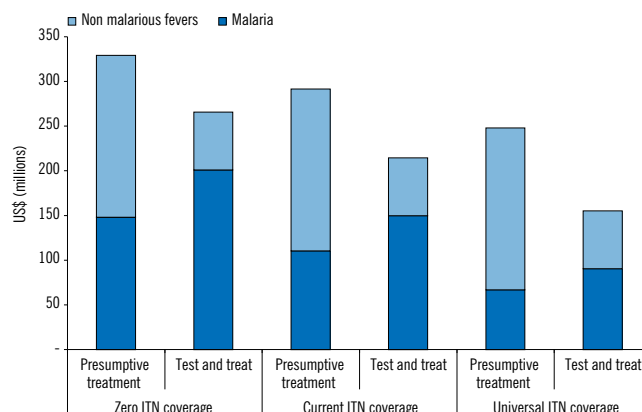
Source: WHO model for estimating number of malaria cases in sub-Saharan Africa (23, 24). The cost of treating malaria cases presumptively includes the cost of ACTs only, while the cost of treating malaria with a policy of universal parasitological testing includes the cost of ACTs and RDTs. The cost of treating non-malarial fevers presumptively includes only the cost of ACTs, and with a policy of universal parasitological testing only the cost of RDTs.

3.6   Potential for increased funds for malaria control

International financing: Malaria programmes accounted for approximately 8% of Official Development Assistance (ODA) for health and population in 2009, increasing from 3% in 2005 (**Fig 3.11**). Overall financing for health and population remained stable between 2008 and 2009; while data for 2010 and 2011 are not yet available, there is little indication that the total funding amount will have increased. Given that malaria programmes account for such a significant proportion of health and population financing, and that total funding will probably remain stable, further increases in malaria funding may be unlikely unless a robust case can be made for investment in malaria control relative to other spending priorities.

It is not yet clear how the economic benefits of malaria control compare with other investments in the health and other sectors. However, malaria control may have wide economic benefits which would warrant its consideration alongside investment projects in other sectors and provide access to a broader range of funding. While total ODA disbursements across all sectors have not increased substantially since 2008, they amounted to US$ 147 billion in 2010.[1] Approximately US$ 49.3 billion has been pledged for the 16th International Development Association (IDA[2]) replenishment for the period July 2011–June 2014. IDA funds are traditionally used for infrastructure projects – if just 1% of these funds were made available for malaria control, approximately US$ 160 million could be raised over and above the World Bank's commitments to the Malaria Booster Program.

Domestic financing: Global economic growth since 2000 has led to increased domestic government revenues and spending in malaria-endemic countries (**Fig 3.12**). Total domestic government spending exceeded US$ 1000 per capita in 43 malaria-endemic countries in 2010, compared to 24 in 2000.[3]

While there are many demands on domestic government financing, if a modest proportion of 1%[4] of domestic spending were dedicated to malaria, this could raise more than US$ 1.39 per capita in 75 of the 99 countries with ongoing malaria transmission, the amount required to provide one person each year with access to an ITN.

Several countries have experienced particularly rapid growth in recent years, yet still benefit from international financial support for malaria control. A total of 28 malaria-endemic countries increased spending per capita by more than US$ 1000 between 2000 and 2010, and 5 more will have done so by 2015. These countries also tend to have relatively low malaria endemicity. If countries with a per capita domestic spending of more than US$ 1500 were to relinquish international assistance from the Global Fund for malaria control, a further US$ 80 million could be released for use in lower-income countries. At the 21st RBM board meeting in November 2011, Brazil announced that it would not accept funds

for Phase 2 of the Round 8 malaria grant, even though it has successfully completed Phase 1.

Innovative financing mechanisms: A number of innovative financing schemes have been proposed, most of which are in the early stages of development. One option that has already been implemented is to impose taxes on selected financial transactions: the amounts are small enough to have a negligible effect on transaction frequency but generate sufficient funds for malaria control or other health projects for their collection to be worthwhile. For example, under UNITAID, a levy of between US$ 1.20 and US$ 6 is charged on each economy international flight (and more for business and first class). As of September 2011, nine countries were implementing the airline tax: Cameroon, Chile, Republic of Congo, France, Madagascar, Mali, Mauritius, Niger, and Republic of Korea.[5] In 2010 the tax generated approximately US$ 210 million (*26*). The amount generated in countries without well developed tourist industries is modest (e.g. Mali raised US$ 402,000) suggesting that such a tax, if extended to all malaria-endemic countries, would not generally provide sufficient funds for significant malaria programme expansion, but could nevertheless provide an important source of revenue domestically for programme maintenance. Extension of the tax to markets in which airline traffic is prominent and growing could potentially raise significant additional funds – for example, the top three airlines alone carried more than 150 million passengers in China in 2010.[6]

Other specific taxes may also generate significant revenues locally. Such schemes include a tourist tax, perhaps levied on international arrivals. In Zanzibar, the United Republic of Tanzania, it has been estimated that a tourist tax of US$ 5–10 levied on international arrivals may finance 10%–20% of the annual operating costs of the malaria control programme (*25*). Senegal is considering creating a solidarity fund which will support the purchase of a range of public health commodities, raising revenue from taxes on products potentially harmful to health (e.g. cigarettes), community health insurance schemes and private sector contributions. In addition, ways to involve the private sector to support malaria control efforts are being considered, either through tax breaks or direct support to the programmes in districts or areas where companies operate.

A tax on bonds and derivatives transactions could also raise significant resources for health development. At low rates, ranging from 0.0001% to 0.2% per transaction, such a tax could generate 12 billion euros annually in a country such as France, and 265 billion across all G20 countries (*27*). Such a financial transaction tax would be unlikely to have a significant impact on the domestic financial markets of the countries which implement it. However, various uses of such tax revenues have been proposed apart from malaria control or other health and development initiatives, not least to insure against defaults in loan repayments.

Different types of malaria bond have been proposed in order to encourage greater involvement of private sector investors. One such bond would aim to raise money for malaria control from private investors and provide them with a return according to the degree of success of a malaria control programme.[7] Ultimately the bond would be repaid by an international donor or domestic government. The advantage of involving the private sector in making an up-front investment is that the risk of programme failure is shared by the

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1 Data on disbursements across all sectors are available up to 2010 but a breakdown by sector only to 2009.
2 World Bank financing for malaria is usually provided as a credit from IDA, which is an interest-free loan, with repayments starting after 10 years and maturing at 35 or 40 years. An annual service charge of 0.75% applies.
3 International Monetary Fund World Economic Outlook Database , September 2011, http://www.imf.org/external/pubs/ft/weo/2011/02/weodata/WEOSep2011all.xls
4 This could happen if 10% if domestic government spending were spent on health programmes, and 10% of that amount spent on malaria.

5 Norway allocates part of its tax on CO2 emissions from aviation fuel to UNITAID
6 http://www.iata.org/ps/publications/Pages/wats-passenger-carried.aspx
7 Private investors typically expect a return on investments that is proportional to the risk but may be willing to forgo some of the return if investments were linked to a social cause.

private investor and international donor or domestic government, and payments can be linked to improved efficiencies in programme delivery, the aim being that these efficiencies would be sufficient to offset the cost of paying premiums to investors. Other types of bond that have been considered aim to encourage local private sector consortia to take on the role of international donors and domestic governments in bearing the cost of bonds, since they stand to benefit if malaria control is successful.

In another approach, diaspora bonds would target nationals living abroad who may be prepared to lend to their national governments at favorable rates, although such a bond would only apply to a limited number of countries.

Private sector markets might also be used to bridge short term funding gaps in a similar way to the "Vaccine Bonds" issued to finance GAVI. To date US$ 1.8 billion have been disbursed by GAVI to immunization programmes as a result of funds raised in the capital markets since 2006, and repaid over 20 years by Australia, France, Italy, The Netherlands, Norway, the United Kingdom, South Africa, Spain and Sweden (28).

Improved accountability is being increasingly emphasized in malaria programme financing. The Global Fund has always operated on a principle of results-based disbursement. A restructuring of its grant architecture will emphasize achievement of outcomes and impact, as well as requiring domestic government financial contributions. The mechanisms by which development funds are delivered could have a significant influence on the efficiency of programmes. If programmes are rewarded for reducing costs while maintaining coverage, total programme costs could be reduced and the savings used to further increase coverage. More research is needed to assess what mechanisms are likely to maximize programme outcomes from the same levels of investment.

Figure 3.11   Official development assistance for malaria and other health and population activities
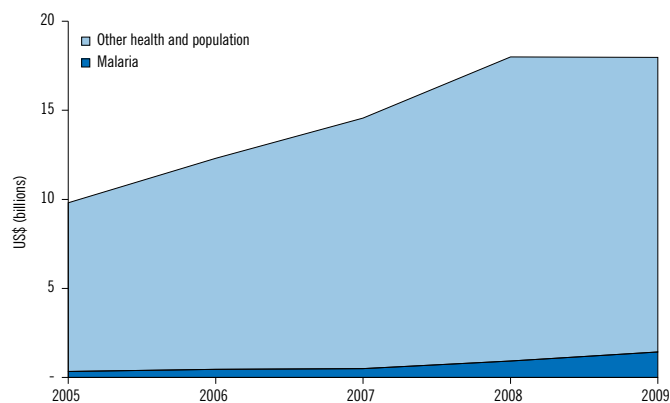
Source: OECD database on foreign aid flows http://stats.oecd.org/qwids/

Figure 3.12   Median total domestic government spending in malaria-endemic countries by WHO Region
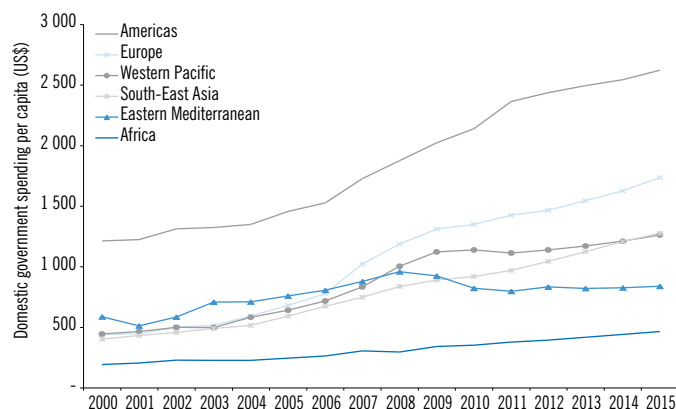
Source: International Monetary Fund World Economic Outlook Database, September 2011

3.7   Conclusions

International funding for malaria control is expected to peak at US$ 2 billion in 2011. From 2012 to 2013 it is projected to remain relatively stable, but then decrease to US$ 1.5 billion in 2015. This analysis is relatively optimistic as it assumes consistency in funding over time for agencies where firm information on future funding trends is not available, although it excludes a possible future round of funding from the Global Fund in 2014.

Domestic government funding of malaria programmes is generally less than US$ 1 per person at risk in the most highly endemic countries. Domestic government expenditures are also generally substantially less than international malaria expenditures except in countries with relatively low malaria transmission. Thus, while it is currently not possible to ascertain total domestic government spending on malaria, it is likely to be less than the US$ 2 billion from international sources, and the total funds available for malaria control fall short of the US$ 5 billion identified in the *Global Malaria Action Plan* as being necessary for fully effective malaria control.

ITN and other vector control interventions account for the majority of malaria programme spending. The cost of delivering a LLIN is approximately US$ 7.50. While IRS is effective, and there is scope for reducing the cost per person protected by expanding programmes, the cost per person protected per year is US$ 2.62 in large programmes, which is higher than that for ITNs (approximately US$ 1.39).

The price of an ITN represents the largest component of the cost of supplying an ITN. Prices of the most widely procured ITNs decreased by 22% between 2007 and 2010, and by an additional 9% in the first half of 2011. Large purchasers usually obtain the lowest prices, and in general, most countries now achieve prices quite close to the minimum, leaving little room for further efficiencies through procurement prices alone. However, even relatively small savings may be important to particular countries.

Distribution costs typically comprise approximately 5%–10% of the total cost of delivery. The costs of the two main strategies for delivering ITNs, through mass campaigns and or health services, are similar. Existing channels may need to be refined to ensure that ITNs are delivered to all of those, and only those, who need them. As country programmes mature, the cost of delivery may increase as programmes consider how to replace ITNs, where only a proportion of a population may require a new ITN at any one time, compared to rapidly expanding coverage where ITNs are delivered to the entire population at risk.

Potentially large savings could be made by developing and deploying longer lasting ITNs. Approximately 1.2 billion ITNs are required to ensure that all people at risk of malaria in Africa have access to an ITN between 2011 and 2020 if ITNs last for 3 years. If ITNs lasted for 5 years, only 750 million ITNs would be required. If the unit cost of delivering both types of ITNs were similar, at US$ 7.66, a total of US$ 3.8 billion could be saved from a financing requirement of US$ 9.6 billion.

Expansion of diagnostic testing offers modest potential for cost savings on commodities. Diagnostic testing and treatment constitute the second largest category of malaria programme spending after vector control. Expenditure on treatment currently greatly exceeds that on diagnostic testing but is expected to decrease as parasitological testing is expanded to all suspected cases of malaria. With current prices of RDTs and ACTs (US$ 0.50 and US$ 1.40 for AL respectively), perfect compliance with test results, and test positivity rates less than 60%, savings on commodities could amount to US$ 68 million in the public sector in Africa. The price of RDTs has fallen by11%–15% annually from 2008 to 2010. The impact of further cost reductions could be considerable: even if RDTs were used for only 50% of fever cases in the WHO Africa Region, reducing their cost from the current US$ 0.50 to US$ 0.25 would save a further US$ 45 million a year.

Improved malaria control will itself lead to some cost savings. With a policy of universal parasitological testing, the reduction in cases accruing from universal coverage of vector control would result in total commodity cost savings of US$ 110 million compared to zero coverage or US$ 59 million compared to current coverage levels. There may be additional significant economic benefits beyond commodity costs, which may further justify investment in malaria control.

There is limited scope for malaria control to attract additional international financing. Malaria programmes accounted for approximately 8% of Official Development Assistance (ODA) for health and population in 2009, increasing from 3% in 2005. Overall financing for health and population remained stable between 2008 and 2009, and is likely to do so thereafter. Given stable total funding, and that malaria programmes already receive a significant proportion of health and population financing, further increases in malaria funding within health sector financing may be unlikely. A clearer demonstration of the economic benefits of malaria control may help malaria programmes to access a broader range of development funding.

There is scope for domestic governments to invest more in malaria control. If just 1% of total domestic government spending were made available for malaria control in 2010, 75 of the 99 countries with ongoing malaria transmission could raise enough funds to provide each person at risk with access to an ITN. Global economic growth has allowed many malaria-endemic countries to increase total domestic government spending: more than 28 countries increased per capita spending by ≥US$ 1000 between 2000 and 2010.

Innovative financing mechanisms are in the early stages of development. Several schemes have been proposed. Taxes on bonds and derivatives transactions may offer the greatest potential for revenue generation – estimated in excess of US$ 250 billions – but their suggested uses go beyond malaria control. Taxes on airline journeys currently raise more than US$ 200 for health development and their extension to additional countries could generate significant additional funds. Other country-specific schemes, such as tourist taxes, may offer opportunities to raise funds for control programmes in malaria-endemic countries.

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Chapter 4

Vector Control

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This chapter reviews (i) adoption of national policies for malaria vector control (ii) coverage and progress towards the goal of universal access and utilization, and (iii) the monitoring and management of insecticide resistance.

4.1 ITN policy and implementation

4.1.1 Policy adoption

Adoption and implementation of policies for ITN/LLIN programmes by WHO Regions is shown in **Table 4.1** and adoption of policies by country is shown in **Annex 4A**.

ITNs are distributed free of charge in 82 countries, mainly in Africa and South-East Asia. In some of these countries, programmes are targeted to specific age groups but in a majority – 67 of the 82 countries – ITNs are distributed free of charge to all age groups. In 28 countries, mainly in Africa, they are sold at subsidized prices through social marketing or routine delivery with vouchers, usually in parallel with free distribution campaigns.

The most common strategy for distribution of ITNs is through mass campaigns, which are used in 57 countries, followed by distribution through antenatal clinics in 56 countries. Antenatal clinics are the most widely used channel in the African Region, although greater quantities of ITNs are distributed through mass campaigns.

The Alliance for Malaria Prevention (AMP) collates information on the number of LLINs delivered by seven manufacturers which are believed to supply almost all ITNs for public sector distribution in Africa. While almost all ITNs distributed in Africa are long-lasting insecticidal nets (LLINs), this chapter refers to all treated nets as ITNs.

The number of nets delivered by manufacturers increased from 5.6 million in 2004 to 145 million in 2010 in sub-Saharan Africa (**Figure 4.1**), with a further 75 million ITNs supplied in 2011 to the end of September. While the number of ITNs supplied increased annually through 2010, the rate of supply from January to September 2011 suggests that the total number supplied in 2011 will be lower.

Figure 4.1   Number of LLINs delivered by manufacturers to countries in sub-Saharan Africa, 2004–2011
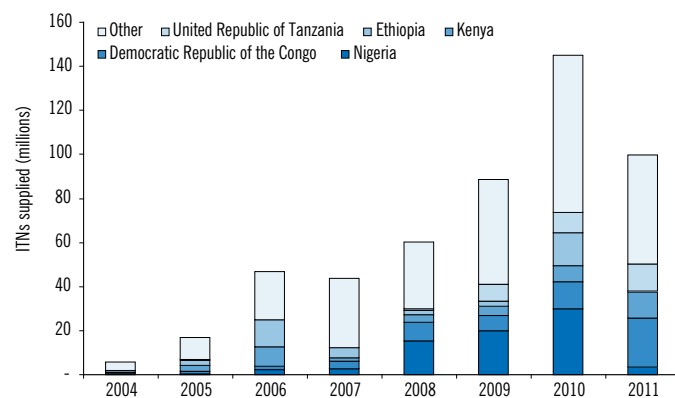
Source: Alliance for Malaria Prevention. Data for the first three quarters of 2011 have been multiplied by 4/3 to provide an annual estimate.

TABLE 4.1
Adoption of Policies for ITN Programmes by WHO Region, 2010

Policy	Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific	Grand Total
ITNs/ LLINs are distributed for free	38	13	8	3	10	10	82
ITNs/ LLINs are sold at subsidized prices	21	2	1		1	3	28
ITNs/ LLINs are distributed to all age groups	27	12	7	2	10	9	67
ITNs/ LLINs distributed through mass campaigns to all age groups	27	12	4		6	8	57
ITNs/ LLINs distributed through mass campaigns to under 5 only	9	4	1		2	1	17
ITNs/ LLINs are distributed through antenatal clinics	38	5	3		4	5	56
ITNs/ LLINs are distributed through EPI clinics	29	1	2		1	1	32
Number of endemic countries/areas	**45**	**23**	**12**	**8**	**10**	**10**	**106**
Number of P. falciparum *endemic countries/areas*	**43**	**18**	**8**		**9**	**9**	**87**

Source: NMCP reports.

Between 2008 and 2010 a cumulative total of 294 million ITNs were supplied by manufacturers to countries in sub-Saharan Africa. Assuming all ITNs last three years, this would be enough to cover 73% of the 800 million persons at risk in 2011 (assuming an average of 1.8 people sleeping under each ITN). Such an estimate does not take into account delays in delivering ITNs within countries or loss of ITNs after delivery to households (due to wear and tear) and therefore produces an optimistic estimate of the availability of ITNs.

Outside Africa, available records show that 60 million ITNs were supplied between 2008 and September 2011, with six countries accounting for 66% of deliveries (India 13.7 million, Indonesia 7.9 million, Afghanistan 6.3 million, Pakistan 3.3 million, Papua New Guinea 2.8 million, Philippines 2.8 million).

During the last three years mass campaigns have been the main channel used by NMCPs to deliver ITNs, accounting for 71% of ITNs delivered (**Figure 4.2**), followed by antenatal care clinics (15%), immunization clinics (7%) and other channels (7%). The proportions vary by WHO Region.

4.1.2 Trend in ITN coverage

Household surveys are the preferred means of assessing whether or not sufficient ITNs have been delivered to cover populations at risk of malaria, although surveys are not conducted frequently enough to provide up-to-date estimates for most countries. In the absence of a recent household survey, it is possible to estimate the ITN coverage by combining data from manufacturers' reports on ITNs delivered to countries, NMCP reports on ITNs distributed within countries, and previous household surveys as described in the *World Malaria Report 2009* and by Flaxman *et al* (*1*). The advantage of such an approach is that it uses all available data to estimate ITN coverage for years in which no survey was carried out.

From this analysis it is estimated that the proportion of households owning at least one ITN in sub-Saharan Africa has risen from 3% in 2000 to 50% in 2011 (**Figure 4.3**). Estimates are for 30 June of each year; the estimate for 2011 assumes that all nets delivered by manufacturers by December 2010 were distributed by NMCPs. Some countries appear to have made considerable advances towards achieving universal access to ITNs (e.g. Burundi, Madagascar, Namibia, Niger, Rwanda, Sierra Leone, United Republic of Tanzania) while others have yet to expand programmes to the scale required (**Figure 4.4**).

The estimate is lower than that obtained by simply considering the numbers of ITNs supplied by manufacturers in relation to the population at risk (73%). This may be partly because the ITN coverage model reflects lags in the delivery of ITNs by NMCPs after they have been procured from manufacturers, and takes into account the loss of ITNs occurring at household level after delivery. It may also be due in part to the fact that household surveys for several countries are more than three years old, and while the model summarizes the relationship between the numbers of ITNs delivered and household survey results over the entire period 2000–2010, it may not adequately reflect the rapid increases in coverage that are possible when mass campaigns are undertaken. There is a need for more up-to-date information on the availability and use of ITNs at household level, particularly after mass campaigns.

Figure 4.2   Channels used by NMCPs to deliver ITNs by WHO Region, 2008–2010
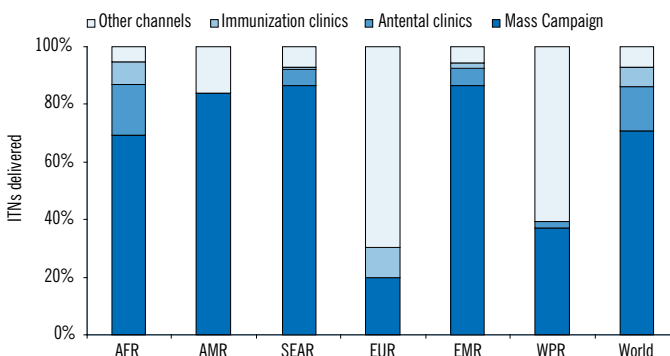
Source: NMCP reports.

Figure 4.3   Trend in estimated proportion of households with at least one ITN in sub-Saharan Africa, 2000–2011
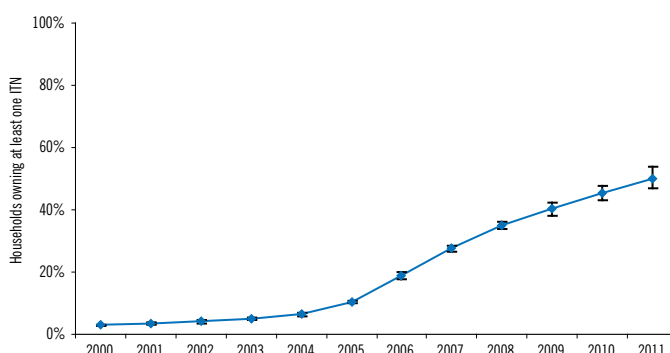
Source: ITN coverage model taking into account ITNs supplied by manufacturers, ITNs delivered by NMCPs and household survey results (1). Includes Djibouti, Somalia and Sudan which are in the WHO Eastern Mediterranean Region.

Figure 4.4   Estimated proportion of households with at least one ITN in sub-Saharan Africa, June 2011
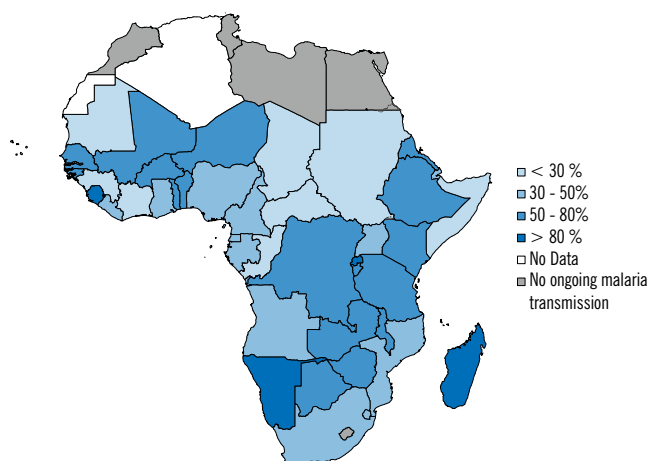
Source: ITN coverage model taking into account ITNs supplied by manufacturers, ITNs delivered by NMCPs and household survey results (1)

4.1.3 Coverage and use at population level

With the gains in malaria control over the past decade, and in line with recommendations by WHO in 2007 for universal coverage of all populations at risk (2), programmes have advanced from providing ITNs only to the population groups at greatest risk (children < 5 years of age and pregnant women) to seeking coverage for all people at risk in the population. To meet this target several intermediate steps need to be accomplished to ensure that: (i) ITN programmes have sufficient geographical reach to provide ITNs to all households; (ii) sufficient nets are provided to households to cover all people living in them; and (iii) people within households use the available nets.

In reviewing 15 household surveys with data on ITN coverage for the period 2008–2010, it was evident that modest proportions of households own at least one ITN (median 56%, lower quartile 39%, upper quartile 59%) (**Figure 4.5**). In almost all these countries less than half of households that had received ITNs had enough for all occupants (median 15%, lower quartile 11%, upper quartile 19%). It is possible that household surveys conducted from 2008 to 2010 do not yet adequately reflect the change in policy to provide ITNs to all persons living in households rather than focusing on pregnant women and children under 5 years of age.

In all surveys, a high proportion of available ITNs within households appear to be used; the median proportion of persons with access to an ITN who use it is 96% (lower quartile 93%, upper quartile 99%) assuming that one net can cover two people (**Figure 4.6**). Some countries have lower rates of use than others. These results are consistent with previous analyses which suggest that the main constraint to enabling persons at risk of malaria to sleep under an ITN is lack of availability of nets (3).

While many countries have adopted policies to achieve universal access to ITNs, and there has been considerable progress in increasing the supply of ITNs to endemic countries, evidence suggests that there is long way to go before the goal of universal access to ITNs will be reached. Where ITNs are available however, there appears to be a high rate of use.

Figure 4.5   Household ownership of ITNs
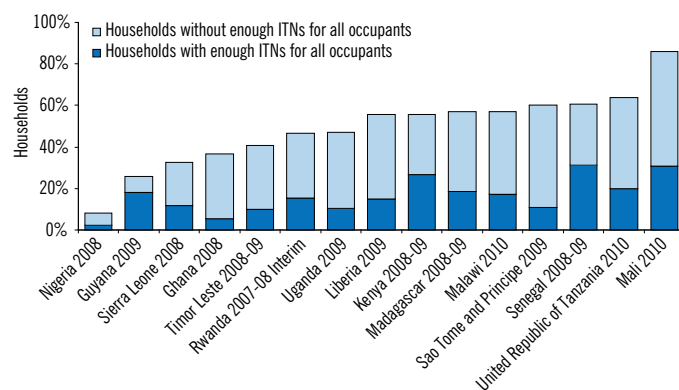
Source: Demographic and Health Surveys (Timor Leste, Ghana, Guyana, Kenya, Madagascar, Malawi, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, United Republic of Tanzania); Malaria Indicator Surveys (Uganda, Liberia); and a Special Survey (Mali).

Figure 4.6   Use of ITNs available in households
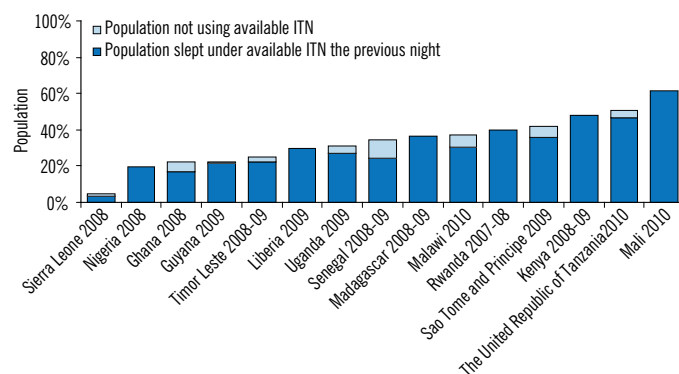
Source: Demographic and Health Surveys (Timor Leste, Ghana, Guyana, Kenya, Madagascar, Malawi, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, United Republic of Tanzania); Malaria Indicator Surveys (Uganda, Liberia); and a Special Survey (Mali).

TABLE 4.2

Adoption of policies for IRS programmes by WHO Region, 2010

Policy	Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific	Grand Total
IRS is recommended by malaria control programme	36	15	5	6	6	5	73
IRS is used for the prevention and control of epidemics	21	9	4	6	4	7	51
IRS and ITNs used together for malaria control in at least some areas	31	11	3	6	5	6	62
DDT is used for IRS	12				1		13
Insecticide resistance monitoring is undertaken	35	12	6	6	10	9	78
Number of endemic countries/areas	**43**	**23**	**12**	**8**	**10**	**10**	**106**
Number of P. falciparum *endemic countries/areas*	**43**	**18**	**8**		**9**	**9**	**87**

Source: NMCP data

4.2 IRS policy and implementation

4.2.1 IRS policy adoption

Adoption and implementation of policies for IRS programmes by WHO Region are shown in **Table 4.2**. Adoption of policies by country is shown in **Annex 4A**.

IRS is recommended for the control of malaria by 73 countries, 36 of which are in Africa. IRS is sometimes used for control of epidemics in 51 countries and in combination with ITNs in 62countries, including 31 in Africa. DDT is reported to be used for IRS in 13 countries, of which 12 are in Africa. Approximately three quarters of endemic countries report that they are carrying out insecticide resistance monitoring.

4.2.2 IRS coverage achieved

National malaria control programmes in malaria-endemic countries reported that a total of 185 million people were protected by IRS in 2010, representing 6% of the global population at risk. The use of IRS for vector control has continued to increase since 2006, particularly in the African Region where 78 million people, or 11 % of the population at risk, were protected in 2010 (**Figure 4.7**). Including the African countries in the Eastern Mediterranean Region, 81 million people were protected by IRS, representing 11% of the at risk population in sub-Saharan Africa. The rate of increase in IRS coverage in Africa appears to have slowed over the past two years, after rapid scale up of IRS operations during 2006 to 2008. IRS coverage in the Western Pacific Region has increased in 2010, largely due to an increased number of people covered by IRS in China, and is equivalent to the proportion of the population covered by IRS in the Regions of the Americas and South-East Asia.

The proportion of the population at risk covered by IRS varies by country in the African Region (**Figure 4.8**). South Africa employed IRS to protect more than 80% of the population at risk, while Ethiopia, Madagascar, Zambia, and Zimbabwe protected at least 40%, and several countries used IRS in a more limited fashion. In other WHO Regions, Bhutan (26%) and Solomon Islands (36%) cover a substantial proportion of their population at risk of malaria through IRS.

In 2009, pyrethroids were estimated to account for approximately 77% of IRS coverage in terms of spray area covered.[1] DDT was the second most widely used insecticide for IRS, accounting for approximately 20% of sprayed areas in covered households. Carbamates and organophosphates represented a very small proportion of global usage for vector control (*4*). There has been a move away from using pyrethroids since 2009, largely because of increases in ITN coverage and concerns about potential development of insecticide resistance. For example, PMI supported the use of pyrethroids for IRS in 13 of 15 countries in 2009, but in only 12 of 16 countries in 2010; spraying with non-pyrethroid insecticides is being implemented in approximately half of the countries supported by PMI in 2011 (*5*) .

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1 Pyrethroids account for a lower proportion of insecticide used when measured by tonnes of active ingredient, but a high proportion by area sprayed, as a unit of active ingredient of pyrethroids by weight covers approximately 60 times the area of other insecticide classes.

Figure 4.7 Proportion of population at malaria risk protected by IRS by WHO Region, 2002–2010
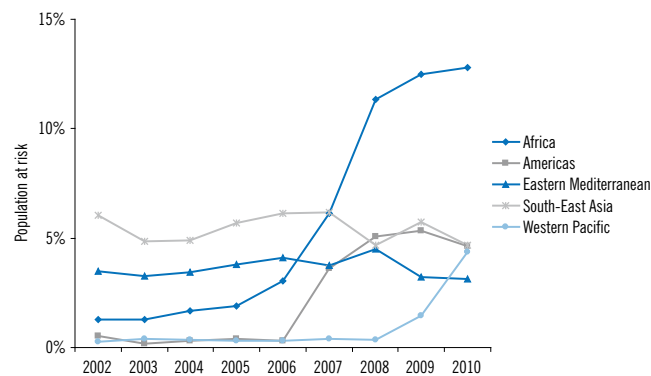
Source: NMCP reports.

Figure 4.8 Proportion of population at malaria risk protected by IRS in sub-Saharan Africa, 2010
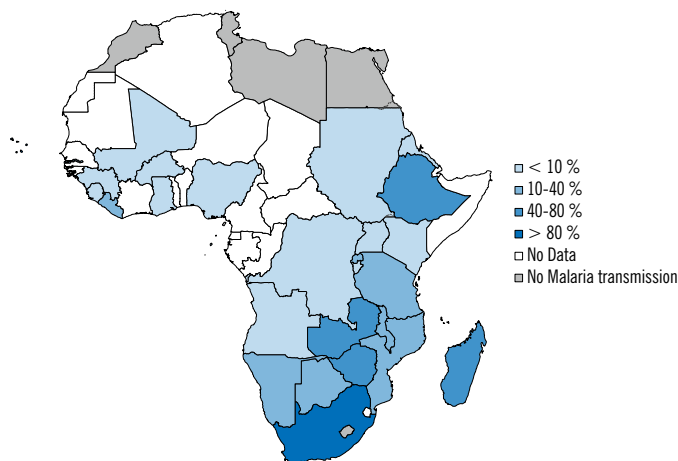
Source: NMCP reports.

4.3 Malaria vector insecticide resistance

4.3.1 Insecticide resistance

Current malaria vector control uses insecticides from four chemical classes: pyrethroids, organochlorines (including DDT), organophosphates (OPs), and carbamates. The use of one class, the pyrethroids, far exceeds that of the other three due to its rapid and durable effect and its low toxicity and cost (**Box 4.1**). IRS can be conducted with any of the four classes of insecticides, whereas pyrethroids are the only insecticide class used for ITNs. Vector control can be rendered less effective by anopheline mosquitoes developing resistance to insecticides used in IRS and ITNs. Given the importance of vector control in combating malaria, retaining the susceptibility of malaria vectors to pyrethroids, and the other classes of currently available insecticides, is of critical importance.

Two main mechanisms of insecticide resistance have been identified: target site resistance and metabolic resistance. Target site resistance occurs when the site of action of an insecticide (typically within the nervous system of the anopheline mosquito) is

modified in resistant mosquito populations so that the insecticide no longer binds effectively and the insect is therefore unaffected, or less affected, by the insecticide. Resistant mutations can affect acetylcholinesterase, which is the molecular target of OPs and carbamates, or voltage-gated sodium channels (for pyrethroids and DDT), which is known as *knock-down resistance (kdr)*. Metabolic resistance occurs when increased levels or modified activities of a detoxifying enzyme system prevent the insecticide from reaching its intended site of action.

Both metabolic and target site resistance can be found in the same vector populations and sometimes within the same vector.

Metabolic and target site resistance mechanisms appear to have differing capacity to reduce the effectiveness of insecticide-based vector control interventions. Metabolic resistance is the stronger resistance mechanism, and is of greater concern.

Insecticide resistance can be measured at the molecular level, by the presence of known resistance gene (such as *kdr*) in a mosquito population, and through a bioassay susceptibility test, which measures mosquito mortality to a standard dose of insecticide. In public health, resistance is more commonly presented through reports of bioassay susceptibility results.

BOX 4.1
Insecticides used for malaria vector control

Key attributes of the chemicals used for vector control insecticides are summarized below:

Pyrethroids. Pyrethroids are the only insecticides that are used for both IRS and LLINs, in the form of alphacypermethrin, bifenthrin , cyfluthrin, deltamethrin, lambdacyhalothrin and etofenprox. It has been the chemical class of choice in agriculture and public health applications over the last several decades because of its relatively low toxicity to humans, rapid knock-down effect, relative longevity (duration of 3–6 months when used as IRS), and low cost. It is also the only insecticide class used currently in recommended LLINs.

Pyrethroids have multiple modes of action on the mosquito vector. They open sodium channels, which leads to continuous nerve excitation, paralysis and death of the vector. They also have an irritant effect, resulting in hyperactivity, rapid knock-down, feeding inhibition, shorter landing times and undirected flight, all of which reduce vector biting ability.

Organochlorines. Organochlorines are used for IRS vector control in the form of DDT, which was the primary insecticide used in the eradication campaigns in the 1950s. At the Stockholm Convention in 2001, usage of DDT was banned for all applications except for disease control, due to concerns over its long-term toxicity. Because of limited options of equally effective and efficient alternative insecticides, continued use of DDT was permitted in public health until "locally safe, effective, and affordable alternatives are available for a sustainable transition from DDT". The 2006 WHO position statement reasserted the public health value of DDT when used for IRS.

As for pyrethroids, DDT has been popular because of its rapid ability to "knock down" mosquitoes, relative longevity (duration of 6–12 months when used for IRS), and low cost. DDT is not used on ITNs or LLINs.

Despite chemical structural differences, DDT and pyrethroids have similar modes of action, and therefore cross-resistance to these two classes of insecticide may occur.

Organophosphates. Organophosphates comprise a vast range of chemicals, but are used for IRS vector control in the form of fenitrothion, malathion and pirimiphos-methyl. This insecticide class is highly effective, but has relatively short

residual activity (duration of 2–3 months when used for IRS) compared to pyrethroids and DDT. At current price levels, it is also significantly more expensive. Because of the risk of accidental human overexposure to organophosphates and subsequent toxicity, toxicological monitoring is recommended. Those handling organophosphates during spray operations have the highest risk of exposure, and toxicity can be monitored through measurement of blood acetylcholinesterase enzyme levels.

The mode of action on the mosquito vector differs from that of pyrethroids and organochlorines. Organophosphates inhibit cholinesterase, thereby preventing neurotransmitter acetylcholine breakdown, resulting in neuromuscular over-stimulation and subsequent death of the vector.

Carbamates. Carbamates are used for IRS vector control, in the form of bendiocarb and propoxur. Carbamates have a similar mode of action to organophosphates, and as with organophosphates, they are highly effective. However, they have short residual activity (duration of 2–6 months when used for IRS) and are more expensive than pyrethroids and DDT.

TABLE BOX 4.1
Characteristics of insecticide classes used in malaria vector control

	Insecticide cost : Estimated approximate cost range per household sprayed [1]	Current ITN products	Current IRS products	Molecules recommended for use in IRS	Toxicity	Duration of effect per spay [4]
Pyrethroid	▬	✔	✔	6	Class II / III / U [2]	3-6 months
Organo-chlorine (DDT)	▬	✘	✔	1	Class II	6-12 months
Organo-phosphate	▬	✘	✔	3	Class II / III [3]	2-3 months
Carbamate	▬	✘	✔	2	Class II	2-6 months

0   5   10   15 ($)

1. Analysis calculated for a household of 5 people (150 sqm sprayed) and based on WHOPES spraying guidelines and PMI cost data

2. Lambdacyhalothrin is WHO class III; Etofenprox is WHO class U 3. Malathion, pirimiphos-methyl are class III

Note: Toxicity ratings: Class II: Moderately hazardous; Class III: Slightly hazardous; Class U: Unlikely to present acute hazard in normal use 4. Duration as based on typical formulation for use in malaria control

Source: WHO , "WHO Recommended Classification of Pesticides by Hazard" (2009); WHOPES, "WHOPES guidelines for insecticide use in IRS" (2009); PMI, "PMI Insecticide resistance guidelines, 2010" (2010)

### 4.3.2 Current situation and operational impact on malaria control

In 2011, WHO regional entomologists collected available data on insecticide resistance from malaria endemic countries which are conducting resistance monitoring. Among 87 countries for which information was available, 45 countries reported that resistance had been detected to at least one insecticide used for malaria vector control in at least one malaria vector in at least one monitoring site. The vast majority (39) of these reported resistance to pyrethroids, 27 of which are in sub-Saharan Africa (**Figure 4.9**). DDT resistance is also prevalent worldwide (14 countries), and there are some instances of resistance to organophosphates (5 countries) and carbamates (8 countries).

These data may underestimate the extent of insecticide resistance globally as regional entomologists may not have access to all information on all monitoring activities within any given country. Also, these resistance reports encompass a range of monitoring approaches by different investigators. However, other sources of information on insecticide resistance reveal a similar pattern. A review of recently published literature on the distribution of pyrethroid resistance in Africa reflecting data from 23 countries found evidence of resistance in 17 of them (6). Widespread reports of pyrethroid resistance in sub-Saharan Africa are of particular concern since this region has the highest high malaria burden, and a reduction in vector control effectiveness could have serious consequences. In the South-East Asia Region the resistance situation in India is of greatest concern as there is widespread DDT resistance and patches of pyrethroid and OP (malathion) resistance (7).

In some cases, the increasing reports of resistance are partly a reflection of increased monitoring of insecticide resistance, but there are also many reports of resistance in places where it is known to have been absent before. However, the presence of resistance is of concern whether or not it developed recently. Building entomological capacity in all malaria endemic countries (both human and physical infrastructures) - including the capacity to conduct routine monitoring of insecticide resistance, analyse and use the data to take appropriate decisions on management of resistance in a multisectoral approach - will be crucial for the success of global insecticide resistance management (**Box 4.2**). Systematic, comprehensive tracking of resistance among insecticides used for malaria control, nationally and globally, has long been a priority activity for WHO, malaria endemic countries, and other global malaria control partners. A global plan for insecticide resistance management will address limitations of previous resistance monitoring systems and build on regional efforts such as the African Network on Vector Resistance to insecticides.[1]

The level of insecticide resistance at which the effectiveness of malaria vector control is compromised remains uncertain. Resistance is not a factor that can be randomly allocated to communities and withheld from others in field trials, so it is difficult to isolate the effect of resistance from that of other factors such as variations over time and space in background transmission intensity, and in vector control intervention coverage (IRS and LLINs). With at least one form of resistance, LLIN use can still have a valuable effect on malaria despite high frequencies of the resistance gene in local vector populations (8). On the other hand, in some situations, resistance has led to failure of IRS and a serious resurgence in malaria (9).

Figure 4.9 Malaria-endemic countries in Africa reporting resistance to pyrethroids in at least one malaria vector in at least one monitoring site, 2011.
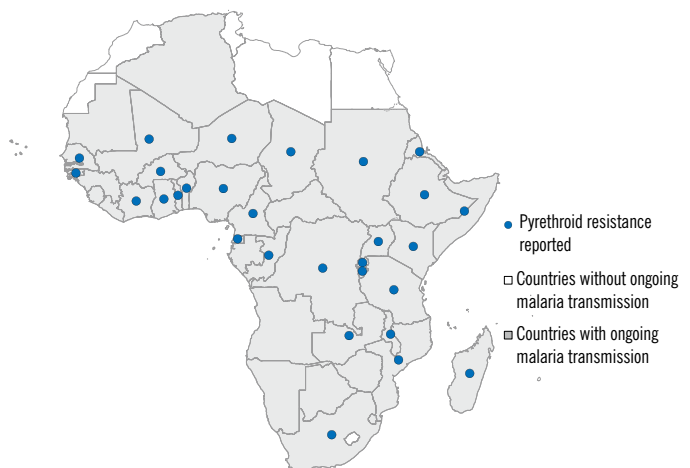
Source: Reports from WHO regional entomologists in AFRO and EMRO. A dot indicates that resistance to pyrethroids has been reported in at least one malaria vector in at least one monitoring site. Note that map provides no indication of how widespread resistance is within a country. Countries with no insecticide resistance reported may have no resistance, or no susceptibility testing may be performed or results of susceptibility test may be unavailable.

It is important to note that IRS and LLINs are the two primary interventions not only because they are powerful, but also because they are durable (with a long period of effectiveness) and robust (effective despite imperfect conditions and coverage). It is therefore possible that as resistance evolves, vector control interventions will retain a degree of effectiveness, but with reduced durability (a shorter effective life) and with reduced robustness (less tolerance to gaps in coverage and sub-optimal circumstances). With funding from the Bill & Melinda Gates Foundation, WHO is coordinating studies in India, Sudan, Cameroon, Benin and Kenya to examine the association between resistance and malaria control failure.

4.3.3 Current recommendations and the Global Plan for Insecticide Resistance Management in malaria vectors (GPIRM)

WHO current guidance on measures to prevent the development and manage the spread of insecticide resistance is summarized in *The technical basis for coordinated action against insecticide resistance: preserving the effectiveness of modern malaria vector control* (*10*). Such measures include avoiding the use of pyrethroids for IRS when LLIN coverage is high, and the use of different classes of insecticides in rotation for IRS. The use of combination interventions (e.g. LLIN plus non-pyrethroid focal IRS) is also encouraged, as is the use of mixtures of different classes of insecticides when these become available. A key recommendation is that all vector control programmes should have a resistance management strategy, to be implemented pre-emptively without waiting for the appearance of resistance or for evidence of control failure. Insecticide resistance monitoring should be intensified and carried out as a routine activity by all vector control implementation agencies, including vector control programmes that rely solely on LLINs.

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1 https://apps.who-int/tdr/topics/mol_entomology/files/anvr_1.pdf

BOX 4.2
Insecticide resistance monitoring in Sudan

Sudan established sentinel sites for insecticide resistance monitoring in 2006. There are a total of 64 sentinel sites in 12 of 15 states (provinces) (the remaining 3 states are either desert or inaccessible for security reasons). As part of a Regional initiative a total of 74 entomologists have received postgraduate training. Consequently, all the endemic states have at least 2 qualified entomologists whose responsibility is to carry out insecticide resistance monitoring. The field staff is supported by a core of 14 entomologists at the central level to guide decisions on vector control based on collected data. A multisectoral steering committee, including representatives from relevant ministries, academic and research institutions, and WHO, was set up to guide the vector control programme.

At each site, insecticide resistance monitoring was carried out every one to two years according to the availability of funds. Anopheline mosquito larvae were collected by dipping from a range of breeding sites and larvae were reared to adults in the field laboratories, under standard conditions (25 +/– 2 °C and 64%–80% relative humidity (RH). Insecticide susceptibility tests were performed using the WHO standard procedures and test kits for adult mosquitoes under optimum conditions (temperature 26–29 °C and 70%–80% RH).

This investment in capacity building and data systems began to yield benefits soon after the programme was established. Resistance to organochlorines and organophosphates was already widespread, especially in irrigated agricultural areas, prior to 2006. In 2006 resistance to pyrethroids was detected in 13 of 17 sites in Gezira and Sennar state, at levels of kdr allele frequency of 0.47 to 0.68. The multisectoral steering committee was called upon to propose recommendations for the IRS programme in 2006. The input of international experts was sought in making this decision. In 2007 a rotation plan for IRS, replacing pyrethroids with a more expensive alternative (carbamate), was recommended by the committee and subsequently implemented in Gezira state through the state's governmental budgeting and support. In 2008, following decentralization of some governmental operations, vector control activities were devolved to states. Due to the high cost of carbamate, IRS was stopped in Gezira state after the first round. With comprehensive political advocacy to raise awareness of the threat to malaria control posed by cessation of IRS, state financial support was obtained and spraying resumed with carbamates in 2011.

TABLE BOX 4.2
Republic of Sudan, Federal Ministry of Health, National Malaria Control Programme:
Sites for monitoring of insecticides resistance 2010–2011

State	No. of sites	Sites Investigated
Khartoum	13	Kafori, Al Faki Hasim, Shambat, El Giraif Sharg, Soba east, Soba West, Jabra, Arkaweet, Al Salama Al Jadida, Al Shigailab, Al Ameir
Gezira	9	El Masalamia, Tabat, El Hoosh, Haj Abdellah, Medani,Mobi,Rofaa,Wad Rawa,El Managil
Sennar	2	Sennar Sugar area, El Soki
Blue Nile	1	Damazin
White Nile	4	Kosti, Kennan sugar area, Assalaya sugar area, El Duwaim, Rebak
N. Kordofan	7	Bara, elnuhood, elobied, el rahad,abuzabadel khowai, umrwaba
Gedarif	2	Gedarif, Galabat East
Kassala	3	Kassala, El Gerba, New Halfa
River Nile	4	Abu Hamad, Attbara, El Damar, Shendi
Northern	6	Meowe,Kareema,Al Daba,Dongola,Burgage, Dalgo
West Darfu	5	Genaina,Fur Baranga,Zalengi,Garsilla,Um Dokhon
S. Dar Fur	9	Nyala, Eid Elfiran, Rehad elberdi, Kas, Tulus, sharia, Eldaien, Adella and Elburam

The 2011 World Health Assembly resolution on malaria[1] included the provision that WHO should "provide support to Member States in identifying new opportunities for malaria control, as well as combating major threats, notably plasmodial resistance to antimalarial agents and mosquito resistance to insecticides, through the development and implementation of the Global Plan for Artemisinin Resistance Containment and a global plan for the prevention and management of insecticide resistance".

Consequently, the WHO Global Malaria Programme is currently developing the *Global Plan for Insecticide Resistance Management* (GPIRM) in consultation with almost 150 stakeholders. The plan will: (i) define what is known, what is assumed and what remains unknown with regard to insecticide resistance among malaria vectors, its spread and operational impact, and options for managing the problem; (ii) estimate the potential impact of insecticide resistance on malaria burden, and the financial cost of monitoring and managing insecticide resistance; and (iii) based on these elements, define the plan for managing insecticide resistance and the way forward, including a short-term action plan with clear responsibilities, and ongoing research and development requirements. The GPIRM is expected to be released in the first quarter of 2012.

[1] http://apps.who.int/gb/ebwha/pdf_files/WHA64/A64_R17-en.pdf

4.4   Conclusions

Progress in increasing access to ITNs: The number of ITNs delivered by manufacturers increased dramatically from 5.6 million in 2004 to 145 million in 2010 in sub-Saharan Africa. However, the number of ITNs supplied in 2011 appears to have reduced, partly because some countries have made substantial progress towards achieving universal access to ITNs in 2010 and are not scheduled to reorder ITNs, but also because some countries are still not expanding programmes to a sufficient scale. Using a model that takes into account the number of ITNs supplied by manufacturers, the number of ITNs delivered by NMCPs, and household survey data, the percentage of households owning at least one ITN in sub-Saharan Africa is estimated to have risen from 3% in 2000 to 50% in 2011, reflecting considerable progress but also signifying there is much more work to be done.

A high proportion of available ITNs within households appear to be used; approximately 96% of persons with access to an ITN within the household use it, suggesting that the main constraint to enabling people at risk of malaria to sleep under an ITN remains lack of available nets. There is a need for more up-to-date information on the availability and use of ITNs at household level, as the timing of existing household surveys may not adequately capture the progress made after mass campaigns.

Sustainability of ITN implementation: While the rapid scale up of ITN distribution in Africa is an enormous public health achievement, it also represents a formidable challenge for the future in ensuring that the high levels of coverage are maintained. During the last three years mass campaigns have been the main channel used by NMCPs to deliver ITNs, accounting for 71% of ITNs delivered, followed by antenatal care clinics (15%). Measures need to be in place to ensure that those not benefiting from the campaigns also have access to nets. Moreover, strategies will be needed to deal with replacement of the large number of ITNs that have recently been delivered, while continuing to scale up programmes in countries that have not achieved universal access. There is uncertainty over the extent to which ITN effectiveness decays over time, but the lifespan of an LLIN is currently estimated to be 3 years. Nets delivered in 2007 and 2008 are therefore due for replacement, soon to be followed by those delivered between 2009 and 2010. Failure to replace these nets will increase the risk of a resurgence of malaria cases and deaths.

Progress in implementation of IRS: IRS programmes have also expanded considerably in recent years, with the number of people protected in the African Region increasing from 10 million in 2005 to 78 million in 2010, and to 81 million among all countries in sub-Saharan Africa, a quantity which corresponds to protection for 11% of the population at risk. In other WHO Regions IRS implementation has not been expanding as rapidly, and is generally relatively stable. With the exception of India, the proportion of the population protected by IRS tends to be smaller than in the African countries which use IRS. The less extensive use of IRS vector control may reflect the more focal nature of malaria outside Africa, where smaller proportions of the population at risk would benefit from large-scale spray programmes.

Potential for insecticide resistance: Current methods of malaria control are highly dependent on a single class of insecticides, the pyrethroids, which are the most commonly used compounds for IRS and the only insecticide class used for ITNs. Pyrethroids are exceptionally safe for people and the environment, and effective compared to other classes of insecticide used in public health. However, the widespread use of a single class of insecticide increases the risk of mosquitoes developing resistance, and this could rapidly lead to a major public health problem. The risk is of particular concern in sub-Saharan Africa, where insecticide resistance has been reported in 27 countries and where insecticidal vector control is being deployed with unprecedented levels of coverage. Interim guidance on insecticide management is available and a *Global Action Plan for Insecticide Resistance Management* will be released in 2012. Prudent management of insecticide use, including monitoring for resistance and adopting practices which minimize selective pressure for insecticide resistance, are required to preserve the effectiveness of this important malaria control tool.

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Chapter 5

Preventive therapies for malaria

This chapter reviews (i) the adoption of policies and implementation of programmes to expand access to and utilization of intermittent preventive treatment of malaria in pregnancy and in infants and (ii) progress in the development of two new therapeutic tools for malaria prevention: seasonal malaria chemoprevention and malaria vaccine.

5.1 Intermittent preventive treatment

5.1.1 Intermittent preventive treatment of pregnant women

The countries which had adopted intermittent preventive treatment for pregnant women (IPTp) with sulfadoxine-pyramethamine (SP) as national policy by the end of 2010 include 35 high-burden countries in sub-Saharan Africa spanning two WHO Regions, and also Papua New Guinea (**Table 5.1**).

For 21 of the 36 high-burden countries which have adopted IPTp as national policy, consistent data for 2010 were available from NMCPs on both the second dose of IPTp (numerator) and the number of women who had attended antenatal care at least once (denominator). Approximately half of women attending antenatal clinics (52%, inter-quartile range 47%–61%) received a second dose of IPTp in countries which responded (**Figure 5.1**).

Information on the proportion of all pregnant women receiving the second dose of IPTp can be derived from household surveys. Data on IPTp for pregnant women from surveys in 2009–2011 were available for 12 countries in Africa, representing a combined population of 409 million. Although some low IPTp coverage rates for two doses may be attributable to the fact that some pregnant women do not attend ANC or only make a single ANC visit, a substantial proportion of all pregnant women nonetheless did not receive a second dose of IPTp. In 2009–2011, the percentage of women who received two doses of IPTp during pregnancy ranged

from 5% in Namibia to 69% in Zambia (**Figure 5.2**); the weighted average remained low, at 23%, primarily due to low coverage rates in Nigeria and the Democratic Republic of the Congo.

Figure 5.1 Proportion of women attending antenatal care receiving the second dose of IPTp, 2010
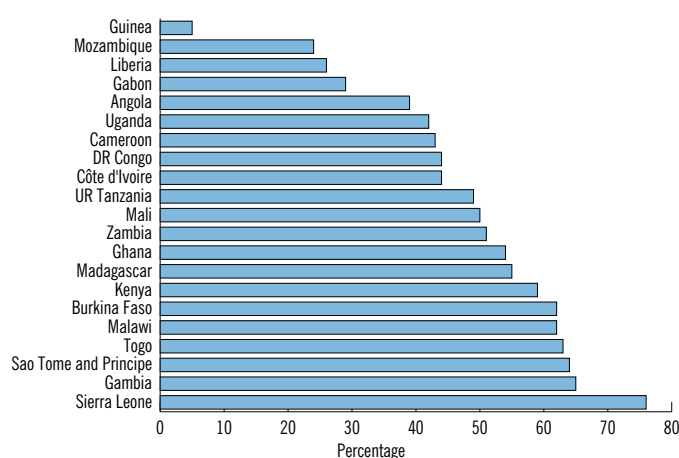
Source: NMCP reports

Figure 5.2 Proportion of all pregnant women receiving the second dose of IPTp, 2009-2011
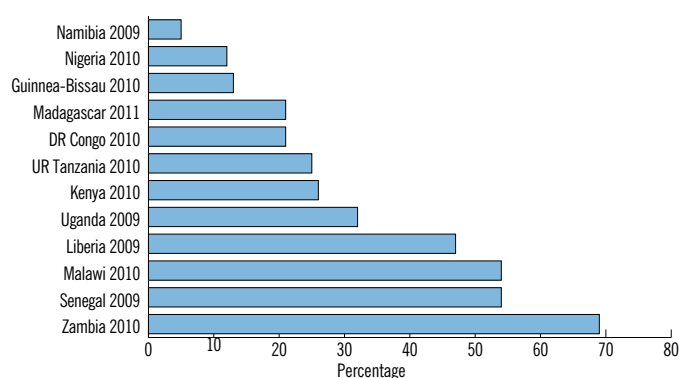
Source: Household survey data

TABLE 5.1

Adoption of Policies for Intermittent Preventive Treatment for Pregnant Women (IPTp)

Policy	Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific	Grand Total
IPTp used to prevent malaria during pregnancy	33		2			1	36
Number of endemic countries/areas	43	23	12	8	10	10	106
Number of P. falciparum *endemic countries/areas*	43	18	8		9	9	87

5.1.2 Intermittent preventive treatment of infants

Intermittent preventive treatment in infancy (IPTi) with SP is the administration of a full therapeutic course of SP delivered through immunization services at defined intervals corresponding to routine vaccination schedules – usually at 10 weeks, 14 weeks, and approximately 9 months of age – to infants at risk of malaria. WHO recommends IPTi in countries with moderate to high malaria transmission, where levels of parasite resistance to SP are low. So far no country has adopted IPTi as national policy since its recommendation in 2009; however, the IPTi implementation guidelines were released only in September 2011, and eight countries recently met to discuss possible implementation.

5.2 New therapeutic tools for malaria prevention

The scale-up of currently available tools for malaria prevention and treatment has resulted in substantial progress in malaria control in many countries. However, new tools are needed, especially in countries where there is high malaria transmission potential. Two new therapeutic tools currently in development for malaria prevention are seasonal malaria chemoprevention and malaria vaccines.

5.2.1 Seasonal malaria chemoprevention

Seasonal malaria chemoprevention (SMC), previously termed intermittent preventive treatment in children, is defined as the intermittent administration of full treatment courses of an effective antimalarial medicine during the malaria season to prevent malarial illness. The objective of SMC is to maintain therapeutic antimalarial drug concentrations in the blood throughout the period of greatest malarial risk.

SMC has been studied most frequently in areas with seasonal malaria transmission where the main burden of malaria is in older children, rather than in infants, and the main risk of clinical malaria is restricted to a few months each year. WHO is presently assessing the potential role of SMC for use as an additional malaria measure strategy in different malaria epidemiological settings.

As a first step in the policy development process, the Technical Expert Group (TEG) on Preventive Chemotherapy was convened in May 2011 to review the current evidence on the efficacy, safety and feasibility of large-scale implementation of SMC, and to assess the risks and potential benefits. The report of this consultation will be presented to the newly established Malaria Policy Advisory Committee (MPAC) in early 2012. The MPAC will review the recommendations of the TEG together with additional analysis carried out since the consultation, and advise WHO on the potential role of SMC in the control of malaria. In accordance with this advice, a WHO policy recommendation will be formulated in the first quarter of 2012.

5.2.2 Malaria vaccine development

An effective vaccine against malaria has long been envisaged as a valuable addition to the available tools for malaria control. There are as yet no licensed malaria vaccines. A single candidate vaccine is currently being assessed in phase 3 clinical trials, and approximately 20 other projects are in phase 1 or phase 2 clinical trials.

Vaccine candidate RTS,S/AS01: The RTS,S/AS01 vaccine targets *P. falciparum.* It comprises a fusion protein of a malaria antigen with hepatitis B surface antigen, and includes a new potent adjuvant. Now in phase 3 clinical trials, the vaccine is being developed in a partnership between GlaxoSmithKline and PATH Malaria Vaccine Initiative (MVI), with funds provided by the Bill & Melinda Gates Foundation to MVI. The vaccine manufacturer's target group for this vaccine is African infants resident in malaria-endemic countries, with vaccination administered at 6–14 weeks of age, together with other vaccines administered routinely to infants.

The first of three sets of results from the phase 3 trial were published in October 2011 and were consistent with results from the phase 2 trials (*1*). Conducted at 11 trial sites in seven countries across sub-Saharan Africa, the preliminary results from the phase 3 trial showed that the vaccine reduced the incidence of clinical malaria by 55% when evaluated over 12 months following the third dose; this conclusion was based on data from the first 6000 children, aged 5–17 months.

A preliminary analysis for efficacy against severe malaria was made when 250 cases accrued in both the 5–17 month and 6–14 week age groups in the trial. This analysis found an efficacy of 35% with variable follow-up from zero to 22 months after the third dose. The full trial results will become available to WHO in late 2014 and will include 30 months' safety and efficacy data from the target group aged 6–14 weeks, together with data on an 18-month booster dose and site-specific efficacy data.

The Joint Technical Expert Group on Malaria Vaccines, set up by the WHO Global Malaria Programme and Department of Immunization, Vaccines & Biologicals in April 2009, has advised that, in the light of the published results to date, a policy recommendation could be made once the full trial results become available. The timelines of the phase 3 trial may allow a policy recommendation in 2015, subject to vaccine performance. This vaccine will then be considered for potential addition to the current WHO recommended malaria preventive measures.

Other malaria vaccine candidates in development: Several other scientifically promising vaccine candidates are currently being explored, but their development is at least 5–10 years behind that of RTS,S/AOS1. Details are provided in the rainbow tables[1], WHO's comprehensive annually updated spreadsheets of global malaria vaccine project activity.

In the longer term WHO is committed to working with malaria vaccine stakeholders towards the 2025 goal set out in the malaria vaccine technology roadmap – a vaccine with at least 80% efficacy against clinical malaria. WHO also participated in the

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1 Malaria Vaccine Project Spreadsheets (known as 'the rainbow tables'): www.who.int/vaccine_research/links/Rainbow/en/index.html

malaria eradication R&D agenda (malERA)[1] consultative process which supported the concept of a vaccine that can interrupt malaria transmission. The long-term goals for malaria vaccines will therefore include not only protection against clinical malaria, but also impact against malaria transmission as a core feature of vaccine performance (2).

5.3   Conclusions

Scale-up of intermittent preventive treatment of pregnant women: There has been substantial progress in scaling up IPTp in several countries, but implementation has been slow in many others. Overall progress in achieving coverage targets across high burden malaria-endemic countries has lagged behind the scale-up of other malaria control measures. This limited progress is unlikely to be related solely to low ANC attendance, as ANC attendance is fairly high in Africa, and even among women attending the clinics, IPTp coverage is only moderate. Simplified IPTp messages and health worker training have been shown to improve IPTp coverage (3). To facilitate scale-up, malaria control programmes should encourage ANC attendance and identify barriers to implementation. As the effectiveness of IPTp with SP is sensitive to changes in malaria burden and the level of resistance to SP, a decreasing malaria burden or increasing resistance to SP may render IPTp with SP a less attractive intervention in some areas. In such situations, programmes may need to reorient their malaria prevention efforts in pregnancy towards other approaches.

Implementation of intermittent preventive treatment of infants: The recent WHO policy recommendation for IPTi is based on results from seven studies on IPTi with SP in areas of moderate to high transmission of malaria, with varied levels of other malaria control measures in place. These studies showed that IPTi delivered through EPI services provides protection in the first year of life against clinical malaria and anaemia, as well as reductions in hospital admissions for patients with malaria parasitaemia and admissions for all causes. Introduction of this new intervention builds on established collaboration between malaria and other maternal and child health programmes in the distribution of ITNs through EPI services and delivery of IPTp in antenatal clinics. These established relationships should facilitate implementation in countries wishing to add IPTi to their malaria control efforts. The efficacy of IPTi is dependent upon resistance levels to SP, and, as for IPTp, new regimens are under investigation. These new regimins may prove useful where SP resistance prohibits IPTi implementation.

Development of policy on new tools for malaria control: An assessment of seasonal malaria chemoprevention will be one of the first tasks taken up by WHO's newly established Malaria Policy Advisory Committee. While much progress has been made in scaling up existing interventions, further efforts will be required to introduce and widen the application of new tools. The MPAC will have an important role in policy development on new tools for malaria control, an essential step towards making the tools available in the communities that will benefit from them.

1   The Malaria Eradication Research Agenda (malERA) initiative was a consultative initiative aimed at identifying current knowledge gaps and new tools needed for malaria eradication; it concluded its activities in 2011.

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Chapter 6

Diagnostic testing and treatment of malaria

This chapter reviews (i) the extent to which national programmes have adopted policies for universal diagnostic testing of suspected malaria cases and trends in the availability and utilization of parasitological testing, (ii) the adoption of policies and implementation of programmes to expand access to, and utilization of, effective treatment for malaria, (iii) the progress made in withdrawing oral artemisinin-based monotherapies from the market, (iv) the current status of drug efficacy monitoring and the latest trends in antimalarial drug resistance, and (v) efforts to contain artemisinin resistance on the Cambodia-Thailand border.

## 6.1 Diagnostic testing for malaria

6.1.1 Policy adoption

WHO recommends that all persons of all ages in all epidemiological settings with suspected malaria should receive a parasitological confirmation of diagnosis by either rapid diagnostic test (RDT) or microscopy (*1*). National adoption and implementation of policies for diagnosis of malaria by WHO Region are shown in **Table 6.1** and by country in Annex 4A. In 2010, 37 of 43 malaria-endemic countries in the WHO African Region and 53 of 63 endemic countries in other Regions reported having adopted a policy of providing parasitological diagnosis for all age groups, an increase of 4 countries in the African Region and

8 elsewhere. A total of 20 African countries are now deploying RDTs at the community level, as are 28 countries in other Regions, 10 more countries than in 2009.

6.1.2 RDTs procured and distributed

RDTs procured: In 2011, manufacturers participating in the WHO Malaria RDT Product Testing Programme supplied data on RDT sales to public and private sectors in malaria endemic regions (**Figure 6.1**). Sales have increased dramatically over the last 3 years, for both *P. falciparum*-specific tests and combination tests that can detect more than one species.

Figure 6.1   RDT sales to public and private sectors 2008–2010
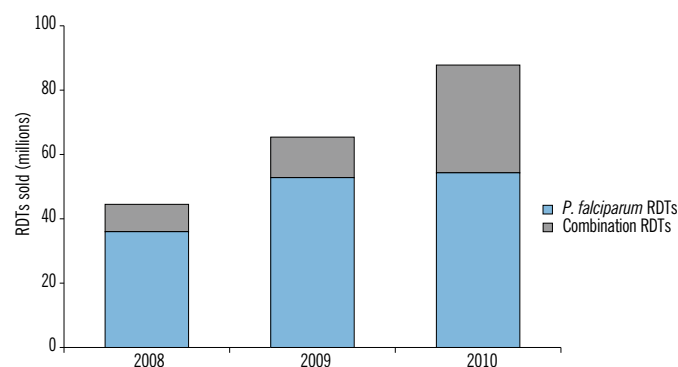
Source: data provided by 31 manufacturers participating in the WHO Malaria RDT Product Testing Programme

Results of product quality testing undertaken by WHO, Foundation for Innovative New Diagnostics (FIND), Special Programme for Research and Training in Tropical Diseases, and the US Centers for Disease Control and Prevention (CDC) show an

TABLE 6.1
Adoption of policies for malaria diagnosis's by WHO Region

Policy	Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific	Grand Total
Patients of all ages should get diagnostic test	37	19	8	7	9	10	90
Only patients >5 years get diagnostic test	4						4
RDTs used at community level	20	8	6		8	6	48
Malaria diagnosis is free of charge in the public sector	28	18	8	8	10	9	81
Number of endemic countries/areas	43	23	12	8	10	10	106
Number of P. falciparum *endemic countries/areas*	43	18	8		9	9	87

improvement in test quality over time (*2*), and, as a consequence, proportionally more high quality tests are being procured over time (**Figure 6.2**). The panel detection score (PDS) measures the performance of RDTs against samples of known parasite presence; WHO recommends procurement of RDTs with PDS greater than 50% against low parasite densities of *P. falciparum* in areas of high transmission, and PDS greater than 75% for areas of low to moderate transmission. According to data supplied to FIND by 17 manufacturers, nearly 90% of RDTs procured in 2011 had panel detection scores of more than 75%, compared with only 23% of RDTs procured in 2007, before the Product Testing Programme began.

RDTs distributed: The reported number of RDTs delivered by NMCPs has increased rapidly, from less than 200 000 in 2005 to more than 50 million in 2010 (**Figure 6.3**). Most of the RDTs delivered (65%) were used in the African Region followed by the South-East Asia Region (30%) and Eastern Mediterranean Region (5%). Although these totals underestimate the total quantity of RDTs distributed (only 32 of the 44 endemic countries in Africa reported these data in 2010), the same upward trend is seen as in RDT sales, with most growth occurring in the African Region.

6.1.3 Microscopic examinations undertaken

The number of patients tested by microscopic examination increased to a peak of 165 million in 2010 (**Figure 6.4**). The global total is dominated by India, which accounted for over 100 million slide examinations in 2010. Decreases in the number of patients examined by microscopy were reported in the Americas, Eastern Mediterranean, and European Regions which may be due to a reduction in numbers of cases, particularly in the American and European Regions, and to increased use of RDTs. The number of patients examined by microscopy remains relatively low in the African Region, although it has increased over the last four years.

6.1.4 Place of care for patients with fever

With the adoption of a new diagnostic testing policy for suspected malaria, delivery of care by trained health-care providers is increasingly important. The providers considered to be appropriate may vary by country context. Household survey data from 42 countries from 1990 to 2010, with each country weighted equally, show that more children received care from public health facilities than private in the African and American Regions, while relatively few received care from community health workers (**Figure 6.5**). A more recent subset of surveys indicates that the proportion seeking care from different providers differs greatly by country (**Figure 6.6**), which suggests that the strategy for expanding access to treatment may also need to vary by country.

6.1.5 Parasitological testing in the public sector

The proportion of reported suspected cases receiving a parasitological test is highest in the American and European Regions followed by South-East Asia (**Figure 6.7**), with the value for the South-East Asia Region heavily influenced by India. The

testing rate in the Eastern Mediterranean Region rose to 80% in 2010 while in the African Region it has risen from 20% in 2005 to 45% in 2010. Much of the increase in testing in the African Region is from an increase in use of RDTs, which accounted for nearly one third of confirmed cases diagnosed in 2010. The reported testing rate may overestimate the true extent of diagnostic testing in the public sector since countries with higher testing rates may have a greater propensity to report, and therefore countries with lower testing rates are underrepresented in the overall rate.

As diagnostic testing is scaled up, the need for quality assurance monitoring becomes even more important. In 2011, WHO and global malaria partners released an operational manual on improving access to malaria diagnostic testing (*3*), which included guidance on quality management of malaria diagnostic testing programmes. Some malaria programmes have made special efforts to improve the quality of diagnostic testing (**Box 6.1**).

BOX 6.1
Quality assurance for malaria microscopy in the Philippines

The quality assurance (QA) system for malaria microscopy in the Philippines, which was first piloted in five provinces in Mindanao in 2005, has now been expanded to 31 provinces. The Philippines Department of Health coordinates and monitors the implementation of the system with stakeholders at the national, provincial and/or regional level. The Research Institute for Tropical Medicine (RITM) is the national reference centre for QA and provides a core group of trainers who conduct training at all levels of the system. Other partners include ACTMalaria and WHO, which provide experts for conducting external competency assessments and training materials, the Global Fund and the Centers for Health Development (CHD).

Microscopists are assessed at three levels: Level 1 – entry level for microscopists who undergo the basic malaria microscopy training; Level 2 – 82 qualified validators who are assessed by RITM every 2 years; and Level 3 – the national core group of 26 trainers who are certified through the WHO regional accreditation system every two to three years.

The Level 3 core group has attained performance benchmarks of >90% score in the detection of parasitemia, >90% score in species identification, and >50% on blood film readings that fall within ±20% of the true parasite count. The Level 2 validators adopt the appropriate slide sampling scheme based on the number of slides that each microscopist had read the previous year. Following the expansion of the QA system, the 457 Level 1 trained microscopists who have achieved an average of 80%–90% proficiency are currently providing quality diagnostic services.

6.1.6 Utilization of parasitological tests in the private sector

Data reported by ministries of health on the number of RDTs distributed and patients examined by microscopy or RDTs generally cover the public sector only. However, approximately 40% of malaria patients worldwide seek treatment in the private sector,

Figure 6.2   RDTs sales by panel detection score (PDS)
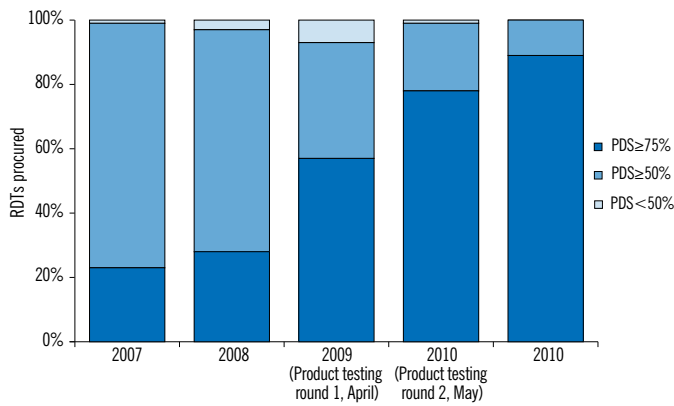
Source: Data provided to FIND by 17 manufacturers eligible for the WHO Malaria RDT Product Testing Programme

Figure 6.3   RDTs distributed by NMCPs, by WHO Region
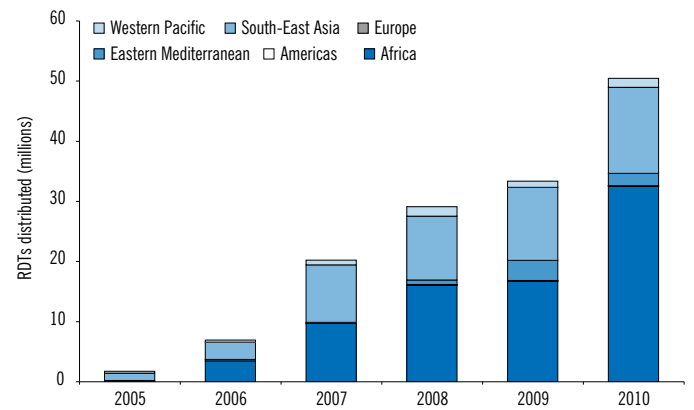
Source: NMCP reports

Figure 6.4   Number of patients examined by microscopy, by WHO Region
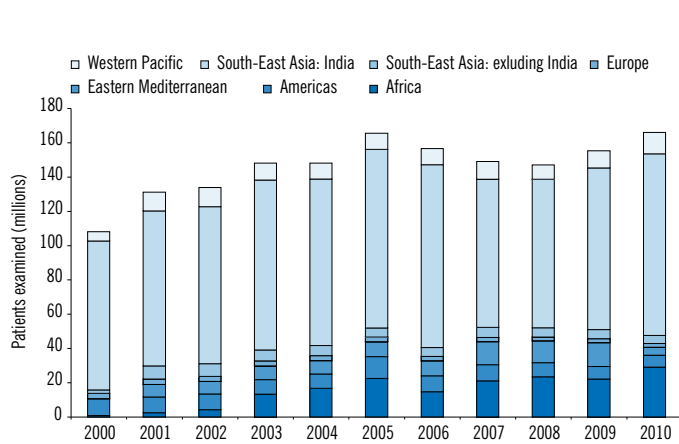
Source: NMCP reports

Figure 6.5   Proportion of febrile children seeking treatment from different sources, by WHO Region
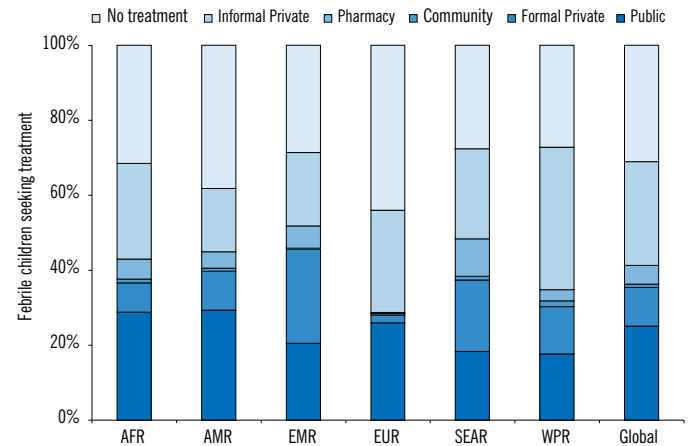
Source: Household survey data

Figure 6.6   Proportion of febrile children seeking treatment from different sources, 2008–2010
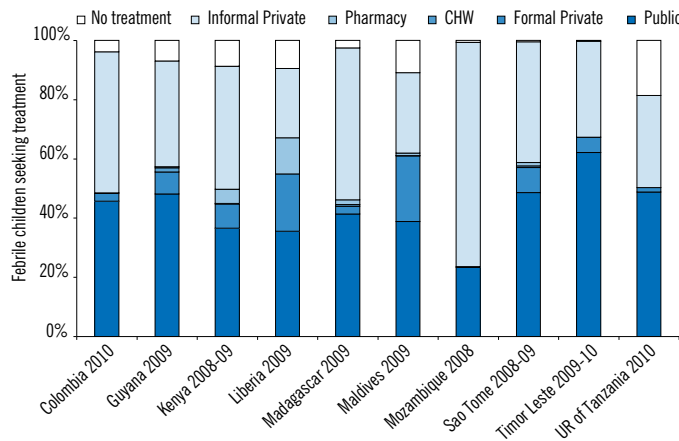
Source: Household survey data

Figure 6.7   Proportion of suspected malaria cases attending public health facilities that receive a diagnostic test
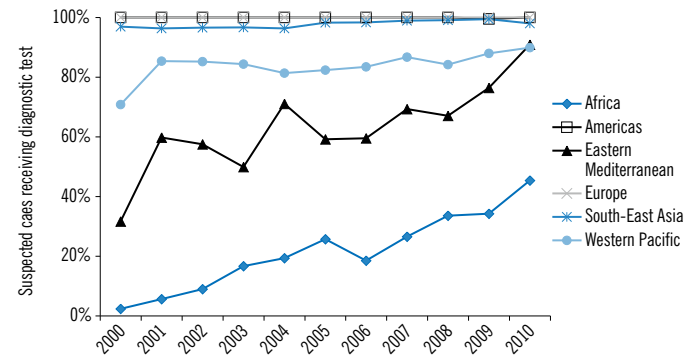
Source: NMCP reports

which includes regulated health facilities, pharmacies and other retail outlets *(4)*. Information on the extent of parasitological testing in the private sector is limited. Country-specific data collected by ACT Watch[1] in 2009–2010 suggest that with few exceptions, both microscopy and RDTs are more widely available in the public sector. Consequently, among selected countries in Africa, the proportion of children under 5 who received a blood test for suspected malaria was higher in public than in private facilities (**Figure 6.8**).

6.1.7 Malaria diagnostics in the community

A total of 42 countries report deployment of RDTs at the community level and 11 million patients were tested in 2010, including 10 million patients tested with RDTs in India. However, patients tested using RDTs in the community represent a relatively small proportion (5%) of the total number of patients receiving a parasitologic test. For 10 countries, information on RDT positivity rates was available from NMCP reports for the community and at public health facilities (**Figure 6.9**). Although community diagnosed cases accounted for a low proportion of all cases, in most of the countries, test positivity rates for these cases were similar to or higher than those reported for outpatient cases. A reporting bias cannot be excluded, however, this suggests that further expansion of diagnostic testing to the community level could potentially identify many additional confirmed malaria cases.

6.1.8 Scaling up diagnostics

Despite recent expansion of malaria diagnostic testing, many patients still do not receive a parasitological test. In the African Region in 2010, the number of ACTs distributed by NMCPs was more than twice the total number of tests (microscopy + RDTs) carried out in 2010, indicating that many patients receive ACTs without confirmatory diagnosis. Shortfalls in the availability of diagnostic testing can be attributed at least in part to the relatively recent policy change and the expected lag time in securing financing and subsequent procurement of RDTs.

The use of RDTs provides the most feasible means of rapidly expanding diagnostic testing, especially in peripheral health facilities and at community level in remote rural areas. The introduction of RDTs can significantly reduce expenditures on antimalarial drugs,

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[1]   www.actwatch.info

Figure 6.8   **Proportion of children under 5 with fever receiving a blood test for malaria**
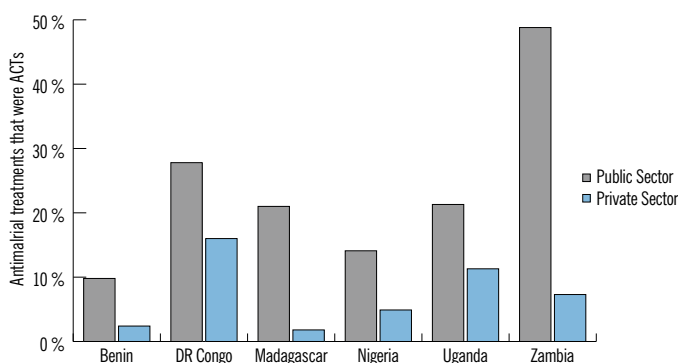
Source: adapted from Littrell, M., et al. Monitoring fever treatment behavior and equitable access to effective medicines in the context of initiatives to improve ACT access: baseline results and implications for programming in six African countries. Malaria Journal, 2011, 10:327.

Figure 6.9   **RDT positivity rate among patients tested in outpatient facilities and in the community for 10 countries, 2010**
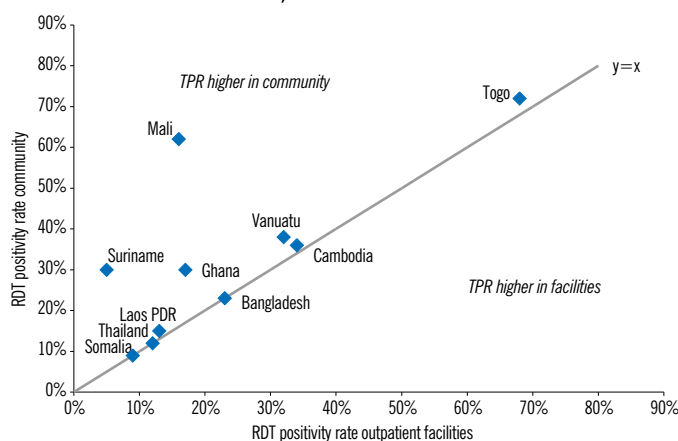
Source: NMCP reports

Figure 6.10   **ACT sales to the public sector, 2005–2010**
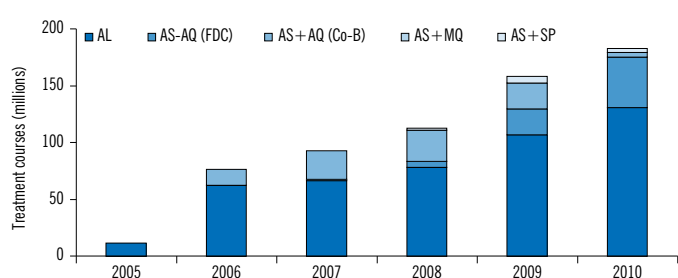
Source: data provided by 8 companies eligible for procurement by WHO/UNICEF

TABLE 6.2

Adoption of Policies for Malaria Treatment by WHO Region

Policy	Africa	Americas	Eastern Mediterranean	Europe	South-East Asia	Western Pacific	Grand Total
ACT is used for treatment of of *P. falciparum*	42	10	12		9	9	84
ACT is free of charge for all age groups in public sector	28	10	7		8	7	60
ACT is free of charge only for under 5 years old in the public sector	5					1	6
ACT is delivered at community level	24	6	2		2	4	38
Pre-referral treatment with quinine/artemether IM/artesunate suppositories	34	4	6		7	7	58
Therapeutic efficacy monitoring is undertaken	27	10	5		7	6	55
Number of endemic countries/areas	**43**	**23**	**12**	**8**	**10**	**10**	**106**
Number of P. falciparum *endemic countries/areas*	**43**	**18**	**9**		**9**	**9**	**87**

Reductions in ACT use after RDT introduction in Zambia

Malaria remains a public health problem in Zambia, despite recent progress in its control. ACTs were introduced in 2004 and RDTs at the village level in 2007. Diagnostic testing before starting antimalarial treatment is compulsory, where capacity exists, for patients above five years of age and recommended where possible for patients under five years of age. RDTs are made available primarily at health centres and health posts, with priority given to facilities without microscopy.

The results of a scale up in diagnostic testing can be seen in data for the period January 2004 to August 2009 from Kazungula, Mumbwa and Mwense districts in southern, central and northern Zambia respectively. After RDTs were introduced, testing rates have gradually increased over time with a corresponding reduction in the number of reported cases of malaria (which were previously diagnosed symptomatically and included non-malaria fevers) and consumption of antimalarial drugs.

There were differences between districts, with the two lower prevalence districts, Kazungula and Mumbwa, showing large reductions in both the proportion of patients reported as having malaria and those given antimalarial treatment, while in Mwense district no clear trends were discernable. It is possible that testing excluded fewer patients from malaria diagnosis and treatment in Mwense owing to the higher incidence of malaria in that district.

The data from Mumbwa and Kaznungula districts show that reductions in ACT consumption did not occur until 6–18 months after the introduction of RDTs. This delay could be due in part to improved acceptance of test results over time, as clinicians gradually gained confidence in the new tests. Across the three districts, RDTs led to an approximate 9% reduction in prescriptions of antimalarial drugs which led to an overall reduction in commodity costs of approximately US$ 500 per facility per year, at current RDT and ACT prices.

Figure Box 6.2 **Proportion of patients recorded as malaria, tested and treated, and introduction of RDTs in three districts, Zambia, 2004–2009**
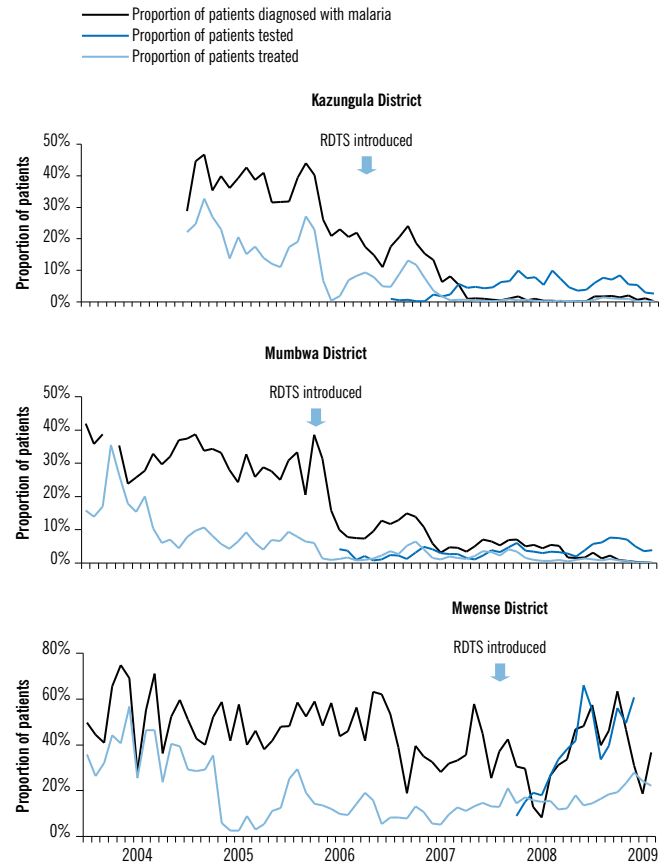
but usually this cost saving does not fully compensate for the cost of the tests. (5) Moreover, as diagnostic testing is expanded, the decrease in antimalarial use is likely to be gradual and programmes will experience a transition period in which the needs for treatment may equal those for diagnostic testing (**Box 6.2**). While any overall cost-savings will depend on the intensity of malaria transmission and other factors, RDTs appear to be cost-effective compared to presumptive treatment, largely due to improved patient outcomes for non-malarial febrile illness (6).

6.2　Treatment of malaria

6.2.1　Policy adoption

By the end of 2010, ACTs had been adopted as national policy for first-line treatment in 84 countries. In some cases *P. falciparum* cases will be exclusively imported. Chloroquine is still used in some countries in the Region of the Americas where it still remains efficacious. By mid-2010, 70 countries were deploying these medicines within their general health services, with varying levels of coverage.[1] The adoption of policies for the treatment of malaria is summarized by WHO Region in **Table 6.2** and by country in Annex 4A and 4B.

6.2.2　Quantity of ACTs procured and distributed

ACTs procured: The number of ACT treatment courses procured by the public sector increased greatly from 11 million in 2005 to 76 million in 2006, and reached 181 million in 2010 (**Figure**

1　Information on adoption of the WHO policy on ACTs and their deployment (i) country adoption of ACTs: the WHO/GMP Antimalarial Drug Policies Database (http://www.who.int/malaria/am_drug_policies_by_region_afro/en/index.html); and (ii) country deployment of ACTs to general health services: compiled by the GMP Supply Chain Management Unit on the basis of reports from WHO regional and country offices.

6.10). Artemether-lumefantrine (AL) accounted for the largest volume of ACTs procured by the public sector (70%) in 2010. The second ACT in terms of volumes procured was artesunate + amodiaquine, which increased from fewer than 1 million treatment courses in 2007 to 41 million in 2010.[1] The proportion of fixed-dose combination ACTs (with the two medicines combined in the same tablet), which are preferred because of improved patient adherence to the recommended regimen, has been increasing and in 2010 accounted for 97% of all ACT sales.

Between 2006 and 2008, most AL was procured for young children weighing less than 15 kg, and the smallest proportion was supplied for patients with a body weight of 25–34 kg. Compared with previous years, in 2010 an increased amount of AL was procured for patients with a body weight over 35 kg, while supplies procured for young children weighing less than 15 kg[2] were unchanged (**Figure 6.11**). Whether this represents a response to changing epidemiology and age distribution of cases in endemic countries, or to other market forces, is unclear.

Figure 6.11   Artemether-lumefantrine sales to the public sector by weight-based treatment course
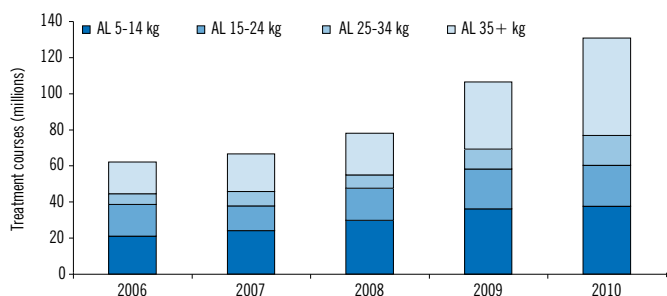
Source: data provided by 4 companies prequalified by WHO.

Forecasting future demand for ACTs is crucial for planning by manufacturers, funding agencies, and malaria control programme managers. In forecasts of global ACT demand (**Figure 6.12**), the proportion of ACT sales in the public sector compared to the private sector is changing, largely as a consequence of the implementation of the Affordable Medicines Facility-malaria (AMFm) initiative (**Box 6.3**). Overall ACT demand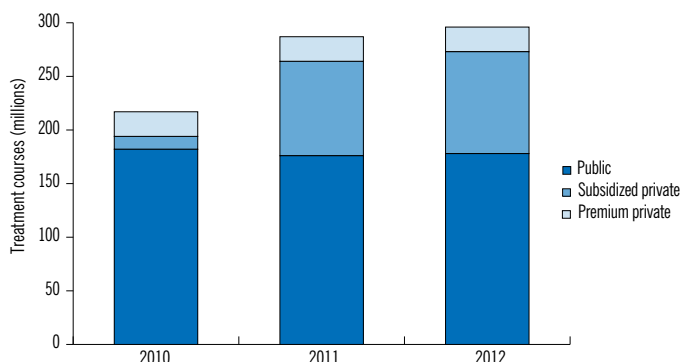 is estimated to reach 287 million treatments in 2011, an increase of 32% over that in 2010. The driver of this increase is the almost 10-fold increase in subsidized private sales through the AMFm while estimated premium (non-subsidized) private sales remain unchanged..

ACTs distributed by ministries of health: The number of ACTs distributed by NMCPs appears to have increased between 2007 and 2010 but reporting by countries is incomplete, and the totals do not match those delivered by manufacturers. The majority of ACTs distributed by NMCPs are in Africa, which accounted for 110 of 117 million treatments worldwide in 2010. Country reports indicate that by the end of 2010, 19 African countries had distributed sufficient

courses of ACTs to cover more than 50% of patients treated in the public sector and 17 of these countries were providing ACTs for nearly 100% of public sector malaria cases seen.

Figure 6.12   Projected global ACT demand 2010–2012

Source: ACT Forecasting Consortium. presentation at WHO-RBM Round Table on ACT Supply, September 8, 2011 (http://www.rollbackmalaria.org/partnership/wg/wg_procurementsupply/docs/RBM-WHO-Round-Table-on-ACT-Supply.pdf).

6.2.3 Utilization of appropriate antimalarial medicines to treat febrile children

It has been difficult to track the extent to which malaria cases confirmed by RDT or microscopy receive antimalarial medicines because information on diagnostic testing has not generally been included in household surveys, and diagnostic test results are usually not linked to the treatment given to patients. Similarly, while routine information systems generally include data on diagnostic confirmation, they rarely track treatments given to patients diagnosed with malaria. The development of routine systems that track febrile patients, testing, results, and treatments given, would enable better tracking of antimalarial utilization. However, such systems seldom exist, especially in Africa, and comprehensive information on the relationship between diagnostic test results and treatments given is therefore lacking.

On the basis of the available data it is possible to examine the proportion of current antimalarial treatments that use an ACT. ACTWatch conducted household surveys in selected countries during 2009–2010 and collected information on antimalarial medicines received by patients in different health sectors (**Figure 6.13**). Among those surveyed in six countries, a higher proportion of patients attending a public facility received an antimalarial (of any type) than those attending private facilities, and among those who received an antimalarial, patients attending public facilities were more likely to receive an ACT. These results are consistent with those reported by WHO from an analysis of antimalarial treatments in 37 nationally representative household surveys (7) and suggest that ensuring access to ACTs remains a challenge in both public and private health care sectors.

Expanding malaria diagnostic testing and treatment to the community level would further improve access to appropriate antimalarial therapy. Programmes implementing community case management of malaria have been evolving (**Box 6.4**) and many now appropriately favour an integrated approach that includes other major childhood illnesses, namely pneumonia and diarrhoea.

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1 WHO monitors the global supply of and demand for the artemether–lumefantrine fixed-dose combination as part of the requirements of the Memorandum of Understanding signed with the manufacturer Novartis in 2001, in order to make Coartem® available at cost price for distribution in the public sector of malaria-endemic developing countries.

2 Information on past AL sales for public sector use was obtained from manufacturers of ACTs which have been prequalified by in 2010.

BOX 6.3
Forecasting global ACT demand

The ACT Forecasting Consortium was created to develop regular forecasts of the global demand for ACTs and artemisinin requirements; it is sponsored by UNITAID, managed by Boston Consulting Group (BCG) and involves forecasting experts from BCG, Clinton Health Access Initiative (CHAI), and the International Logistics Programme at MIT-Zaragoza. The Consortium produces quarterly updates of a 2-year global forecast of ACT demand and artemisinin supply, providing important information to the main funding agencies and the pharmaceutical companies which supply ACTs.

Forecasting the ACT market is difficult because market data are incomplete, and there is often only limited access to country data on past consumption, current procurement, and projected demand. In addition, the lead time for the market to react to changes in demand is lengthy, primarily due to the long production time for artemisinin, which is currently derived exclusively from plants. The forecast combines available market data from all major funding and procurement agencies placing orders of prequalified ACTs, with corrective factors based on disbursement levels and procurement lead times, as well as modeled inputs on expected consumer demand in both public and private sectors. The combination of these multiple factors introduces significant uncertainties around the estimates.

Based on the best information available, the Consortium presented the latest forecasts at the recent RBM-WHO Round Table on ACT Supply in September, 2011 (**Figure 6.12**). Global WHO Pre-Qualified ACT consumer demand for 2011 is estimated at 287 million treatments, a 32% increase over 2010. The forecast for 2012 is for 295 million treatments. While the demand via the public sector seems to have reached a plateau after several years of annual increases, the main driver of this recent increase is the significant growth of demand for ACTs in the procurement for the Affordable Medicine Facility for malaria (AMFm). The AMFm was launched in 2010, hosted by the Global Fund, and is currently in Phase I, offering subsidies for purchase of ACTs by public and private First Line Buyers (FLBs) in 7 African countries. In addition to the demand for the private sector via AMFm, the premium private ACT market (i.e. for non-subsidized ACTs) requires an estimated additional 23 million treatments worldwide and has remained relatively constant.

BOX 6.4
From Community Case Management of Malaria (CCM) to integrated Community Case Management (iCCM)

Community Case Management of Malaria (previously known as Home Management of Malaria) has been evolving beyond malaria over the last several years into a more comprehensive strategy that addresses the three main killer diseases of children: malaria, pneumonia and diarrhoea. This new approach is termed integrated Community Case Management, iCCM.

While the former strategy was based on the presumption that most fever cases in malaria endemic countries were due to malaria (and consequently the recommendation was to administer antimalarial medicines to all febrile children indiscriminately), iCCM incorporates the updated malaria treatment guidelines recommendation to confirm malaria infection in all patients prior to treatment. The availability of high-quality RDTs for malaria has made testing for malaria at the community level possible. This places a higher demand for high quality integrated treatment, so that when febrile children are found not to have malaria, there are other treatment options. The significant overlap in the clinical manifestation of pneumonia and malaria, often simultaneous with diarrhoeal disease and malnutrition, further justifies an integrated diagnostic and therapeutic approach.

As part of the iCCM approach, front-line workers at the community level are trained, supplied and supervised to treat children for malaria *and* pneumonia *and* diarrhoea, using ACT, oral antibiotics, and oral rehydration salts and zinc. All patients are screened for the three diseases and treatment is administered based on the results of diagnostic tests that include malaria RDTs, disease history, and respiratory rate.

The first experiences with iCCM are encouraging. In Ghana, nearly all carers of sick children (92%) sought treatment from community-based agents trained to manage pneumonia and malaria (8). Indeed, most (77%) sought care for their children with fever within 24 hours of onset. In Zambia, an iCCM study for pneumonia and malaria found that 68% of children with pneumonia received early and appropriate treatment from community health workers, and overtreatment of malaria significantly declined (9). In Ethiopia, iCCM workers deployed in remote communities delivered 2.5 times as many treatments for the three diseases than all the district's facility-based providers combined (10). The evidence for impact on mortality is still being collected, but programmatic experience suggests that the iCCM strategy can be effective in achieving high treatment coverage and delivering high quality care for sick children in the community.

An inter-agency iCCM task force has recently been established with the participation of international partners including WHO, UNICEF and USAID, NGOs (Save the Children, BASICS International Rescue Committee) and research institutions (Karolinksa Institute, Boston University, University of Dakar, and the Special Programme for Research and Training in Tropical Diseases, TDR). More information on iCCM and programme support tools can be found at the task force web site: www.ccmcentral.com

Figure 6.13 Proportion of ACTs among antimalarial treatments given to febrile children, by sector
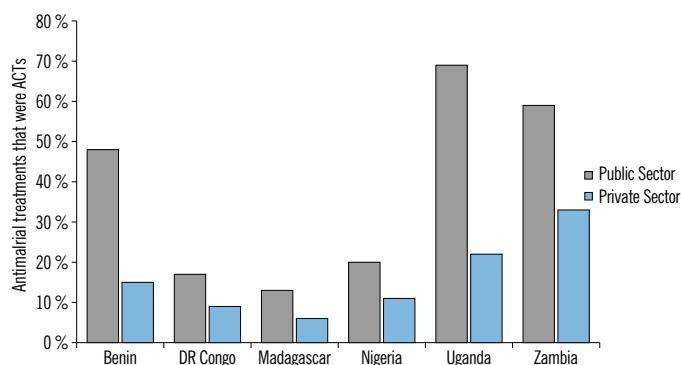
Source: adapted from Littrell, M., et al. Monitoring fever treatment behavior and equitable access to effective medicines in the context of initiatives to improve ACT access: baseline results and implications for programming in six African countries. Malaria Journal, 2011, 10:327.
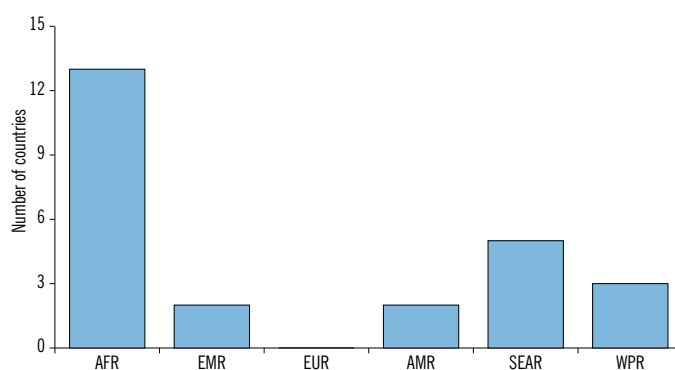
6.3 Antimalarial drug resistance

6.3.1 Policy adoption: withdrawal of oral artemisinin-based monotherapy medicines

The use of oral artemisinin-based monotherapies threatens the long-term usefulness of ACTs by fostering the emergence and/or spread of resistance to artemisinin. To contain this risk and to ensure high cure rates for *P. falciparum* malaria, WHO recommends the withdrawal of oral artemisinin-based monotherapies from the market and their replacement by ACTs, as indicated by the World Health Assembly in 2007. WHO also calls upon manufacturers to cease the marketing of oral artemisinin-based monotherapies. (For the full text of the WHA resolution, see *http://apps.who.int/gb/ebwha/pdf_files/WHA60/A60_R18-en.pdf.)*

WHO compiles data on the marketing of oral artemisinin-based monotherapies by manufacturers and on the regulatory action taken by malaria-endemic countries; these data are posted on the Internet.[1] By November 2011, 25 countries were still allowing the marketing of these products and 28 pharmaceutical companies were manufacturing these products, down from 39 one year ago. Most of the countries that still allow the marketing of monotherapies are located in the African Region (**Fig. 6.14**), while most of the manufacturers are located in India. One of the main reasons for the limited success in phasing out oral artemisinin-based monotherapy is the weak regulation of pharmaceutical markets in many malaria-endemic countries. Greater collaboration and involvement of national regulatory authorities is required to ensure complete withdrawal of oral artemisinin-based monotherapies from all countries.

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1 Information is available on the internet via the following links:
Manufacturing companies: http://www.who.int/malaria/monotherapy_manufacturers.pdf
National Regulatory Authorities: http://www.who.int/malaria/monotherapy_NDRAs.pdf

Figure 6.14 Number of countries allowing marketing of oral artemisinin-based monotherapies, by WHO Region

Source: http://www.who.int/malaria/monotherapy_NDRAs.pdf

6.3.2 Drug efficacy monitoring

Status of drug efficacy monitoring: Therapeutic efficacy studies remain the gold standard for guiding drug policy; the standard WHO protocol was updated in 2009 (11). WHO compiles the results of efficacy tests conducted by national malaria programmes and research institutes in the WHO Global Database on Antimalarial Drug Efficacy. The database currently contains over 4000 studies carried out between 1996 and 2011 and it formed the basis of the *Global report on antimalarial drug efficacy and drug resistance: 2000–2010* (12). Experience with previous antimalarial treatments shows that significant levels of resistance can develop within a short time, and therefore WHO recommends that the efficacy of first- and second-line antimalarial treatments be monitored at least once every two years.

In 2008–2009 studies of first- or second-line antimalarial treatments were completed in 31 of 75 countries where *P. falciparum* efficacy studies are possible (**Figure 6.15**) In 17 countries, efficacy studies are impractical because of low malaria incidence, and 15 countries are endemic for *P. vivax* only. In 32 countries in which therapeutic efficacy studies are feasible, studies were last conducted more than three years ago, longer than recommended by WHO.

Figure 6.15 Status of therapeutic efficacy monitoring in 106 countries endemic for malaria

Source: WHO Global Malaria Program database on antimalarial therapeutic efficacy monitoring by country

Treatment of P. falciparum malaria: major findings related to the development of drug resistance concerning the treatment of *P. falciparum* globally are as follows:

- Artemether-lumefantrine is first- or second-line treatment in 56 countries worldwide and remains highly effective in most parts of the world, with the exception of Cambodia. However, more studies are needed to monitor the efficacy of artemether-lumefantrine, especially in Africa where the treatment is widely used.

- Among the 21 African countries which have adopted artesunate-amodiaquine, six countries have reported at least one study showing a high level of treatment failure (>10%). A high treatment failure rate for this combination was also observed in four Indonesian studies.

- The efficacy of artesunate-mefloquine is lowest in areas where mefloquine resistance is prevalent in Thailand and Cambodia. In Africa and the Americas, the combination remains highly effective.

BOX 6.5
Containment of artemisinin resistance

The Global Plan for Artemisinin Resistance Containment (GPARC) recommends that in areas with evidence of artemisinin resistance, an immediate, multifaceted response should be launched with the aim of containing and, if feasible, eliminating the resistant parasites.

Suspected resistance to artemisinins has been identified in four countries in the Greater Mekong subregion. Containment activities were first started in eastern Thailand and western Cambodia, following the evidence of resistance to artemisinins on the Cambodia–Thailand border that was found in therapeutic efficacy studies in 2006. The project started in 2009 and received funding from the Bill & Melinda Gates Foundation for the first two years of activities. The project covered 380 000 people on both sides of the border, in tier 1 areas, where artemisinin resistance had already been detected (Zone 1) and more than 4.1 million people in tier 2 buffer areas, where there was no evidence of resistance but the risk was deemed high (Zone 2). More than half a million LLINs were distributed to achieve universal coverage, allowing every person to sleep under a net each night. In addition, all villages in Zone 1 and all high-risk villages in Zone 2 had access to early diagnosis and treatment provided free of charge by trained village malaria workers. As a result of the project, there has been a drop in the malaria incidence in many of these areas since 2008, notably in *P. falciparum* cases diagnosed at health facilities in Pailin province. Cases declined there after interventions were implemented in 2009 (**Figure Box 6.5**).

Therapeutic efficacy studies in 2009 and 2010 in western Thailand, south-eastern Myanmar and in one province in Viet Nam found >10% of patients with parasitaemia on day 3 after treatment. Consequently, containment projects have been initiated in these areas drawing on the experience gained from the project on the Cambodia–Thailand border. Project components include increased coverage with LLINs, better access to quality assured diagnosis and treatment among local and migrant populations, and directly observed treatment and follow-up of all confirmed falciparum malaria patients, as well as strengthened monitoring and surveillance. Thailand's containment project, which includes both eastern and western provinces, has already been approved for funding from Global Fund Round 10. All the suspected foci of artemisinin resistance are in areas close to the border where there are large numbers of migrants. A regional framework for containment in the Greater Mekong subregion is being developed to strengthen the cross-border collaboration.

In Myanmar, the Ministry of Health, and partners including funding agencies, endorsed a plan for containment of artemisinin resistance in April 2011, and containment activities have started with support from the funding consortium Three Diseases Fund and Bill & Melinda Gates Foundation. In Viet Nam, a containment project has been initiated, similar to that carried out on the Cambodia–Thailand border, and additional funding is being sought.

Figure Box 6.5 *P. falciparum* cases diagnosed by microscopy and RDT at health facilities in Pailin province, by month 2008–2011

Source: National Malaria Center Cambodia

- Artesunate-sulfadoxine-pyrimethamine remains effective in the countries using this combination as a first-line treatment (this includes countries in the Middle East, South and Central Asia and the Horn of Africa). Failure rates remain high in regions where resistance to sulfadoxine-pyrimethamine is high.

- Data on the therapeutic efficacy of dihydroartemisinin-piperaquine are limited and come mainly from studies carried out in parts or Africa and in the Greater Mekong subregion. More studies are needed before drawing conclusions about its overall efficacy in endemic countries.

The crucial role of monitoring drug efficacy has been demonstrated in the Cambodia–Thailand border area, where studies in 2002–2005 by the Cambodia and Thailand national malaria programmes demonstrated prolonged parasite clearance times following treatment with ACTs. In 2006–2007, two cases of artemisinin resistance were detected in Tasanh, Cambodia, by the Armed Forces Research Institute of Medical Sciences, providing the first evidence of artemisinin resistance. Since 2008, WHO has been coordinating containment activities in this area.

In 2009 and 2010, therapeutic drug efficacy studies also detected suspected artemisinin resistance in western Thailand and south-eastern Myanmar, and in one province in Viet Nam, as evidenced by ≥ 10% of cases with parasites detectable on day 3 after treatment with an ACT. Day 3 parasite detection is one of earliest signs of potential artemisinin drug resistance. Containment activities have begun in Thailand along the Myanmar border, in south-eastern Myanmar and in Viet Nam (**Box 6.5**).

Although the observations suggest that there are changes in parasite sensitivity to artemisinins, ACTs remain clinically and parasitologically effective, except in Pailin province, Cambodia. In Pailin, resistance to both components, artesunate and mefloquine, of a commonly used ACT have been confirmed, and resistance to piperaquine is under investigation after a study in 2010 found 27% treatment failure with dihydroarteminin-piperaquine. Many aspects of artemisinin resistance are still not well understood and more research is needed, e.g. the importance of non-artemisinin component drugs in ACTs needs further clarification. The partner drugs usually have a longer half-life than the artemisinin component, and therefore complement and extend the therapeutic efficacy of the combination. Indiscriminate use of ACTs in patients who do not have malaria risks not only the development of artemisinin resistance but potential failure of the partner drug as well.

Treatment of P. vivax malaria: Chloroquine remains the drug of choice in areas where chloroquine is still effective. Treatment failure on or before day 28 and/or prophylactic failures have been observed in Afghanistan, Brazil, Cambodia, Colombia, Guyana, Ethiopia, India, Indonesia, Madagascar, Malaysia, Myanmar, Pakistan, Papua New Guinea, Peru, the Republic of Korea, Solomon Islands, Thailand, Turkey, Sri Lanka, Vanuatu and Viet Nam. However, confirmation of true chloroquine resistance requires additional drug concentration studies and for this reason it is not entirely clear to what extent chloroquine-resistant *P. vivax* has spread. At least one case of chloroquine-resistant vivax malaria has been confirmed in Brazil, Ethiopia, Indonesia, Malaysia, Myanmar, Solomon Islands, Thailand, Papua New Guinea, and Peru. ACTs are now recommended for the treatment of chloroquine-resistant *P. vivax*, particularly where ACTs have been adopted as the first-line treatment for *P. falciparum*.

6.4   Conclusions

Utilization of parasitological testing: There have been significant increases in the availability and use of parasitological testing in the last few years, particularly in the WHO African Region where the percentage of reported suspected cases receiving a parasitological test increased from 20% in 2005 to 45% in 2010. Further funding and technical support are required to assist countries to achieve universal diagnostic testing of suspected malaria in the public sector. Given that a substantial proportion of children currently receive care in private facilities where the frequency of diagnostic testing for malaria is generally lower, further efforts are also needed both to increase the utilization of malaria diagnostic testing in the private sector and to encourage patients to seek care from providers who can provide the full range of diagnostic services and appropriate treatment.

Community-based diagnosis and treatment: For the many communities with limited access to public sector or private sector facility-based health-care providers, parasitological diagnosis and treatment of malaria will need to be provided by community-based programmes. The limited available data on testing carried out at the community level indicate that test positivity rates are in line with those among patients seen at public facilities; this implies that expanding access to testing and treatment to the community should have a positive effect on fever management in the periphery. There is progress in integrating community-based malaria programmes with those for other childhood illnesses (iCCM), and early experience in implementation of these programmes is encouraging.

Cost implications of improved diagnosis: Expanded use of diagnostic testing can significantly reduce expenditures on antimalarial drugs, but this saving generally does not fully compensate for the cost of the tests themselves. ACT needs may not decrease immediately after implementation of universal diagnostic testing due to delays in the uptake of testing, inconsistent use of test results in some settings (especially among medical personnel in facilities where microscopy already exists) and the collection and utilization of those data for estimating ACT procurement needs. Countries will need to take this lag time into account when planning diagnostic scale up, and have realistic expectations about the overall cost savings and the time frame. While the likelihood of cost-savings will depend on several factors, particularly the intensity of malaria transmission, RDTs appear to be cost effective compared to presumptive treatment, largely due to the improved patient outcomes for non-malarial febrile illness (*6*).

Access to treatment: Information from manufacturers indicates that the number of ACTs procured has increased in every year since 2005. It is difficult to track the extent to which malaria cases confirmed by RDT or microscopy receive antimalarial medicines because diagnostic test results are not usually linked to the treatment given to patients, in either household surveys or routine information systems. A limited number of recent household surveys suggest that febrile patients attending public health facilities are more likely to receive an ACT than those attending private facilities. The development of routine systems that track febrile patients, testing, results, and treatments given would enable better tracking of antimalarial utilization.

Combating drug resistance: The spread of resistance to antimalarial drugs over the past few decades has led to an intensification of efficacy monitoring to allow early detection of resistance in order to revise national malaria treatment policies and ensure proper management of clinical cases. Containment efforts in the Mekong subregion have

shown that malaria incidence can be decreased, a key component of the overall containment plan to halt the spread of resistant parasites. Despite the observed changes in parasite sensitivity to artemisinins, the clinical and parasitological efficacy of ACTs has not yet been compromised, except in Pailin province, Cambodia, where resistance to both ACT components has been found. In other areas in this region, the efficacy of both components of the combination is put at risk. Using an ACT containing a partner drug to which there is already resistance (and is therefore not effective) can increase the risk of development or spread of artemisinin resistance. The indiscriminate use of ACTs without diagnostic testing, especially in areas with higher malaria transmission, may also hasten the development of resistance to the partner drugs in ACTs. Similarly, if the efficacy of the artemisinin component is lost, the efficacy of the partner drug could be jeopardized. It is noted that 25 countries still allow the marketing of oral artemisinin-based monotherapies which threatens the continued efficacy of artemisinin.

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Chapter 7

Impact of malaria control

This chapter reviews trends in malaria cases and deaths and assesses the evidence that malaria control activities have had an impact on malaria disease burden in each WHO Region. Sections 7.1 to 7.7 present national data on malaria cases and deaths, the distribution of *P. falciparum* as compared with other *Plasmodium* species, level of diagnostic testing (as measured by the annual blood examination rate), malaria test positivity rate, and the potential for a plausible link between coverage of interventions for prevention (vector control) and treatment (antimalarial medicines) and trends in malaria burden over time. The comparison of interventions and trends leads to a discussion, and a cautious assessment, of the impact of malaria control across the Regions. Sections 7.8 and 7.9 give updates on malaria elimination and on imported malaria, respectively. The routine case reports presented in Sections 7.2 to 7.7 are part of the database used to estimate malaria incidence and mortality in Section 7.10. Finally, section 7.11 draws together the main conclusions on malaria burden and trends over the decade 2001–2010.

7.1   Assessing trends in the incidence of disease

The reported numbers of malaria cases and deaths are used as core indicators for tracking the progress of malaria control programmes (the working definition of a case of malaria is considered to be "fever with parasites" (*1*)). The main sources of information on these indicators are the disease surveillance systems operated by ministries of health. Data from such systems have three strengths: case reports are recorded continuously over time and can thus reflect changes in the implementation of interventions or other factors; routine case and death reports are often available for all geographical units of a country; and they reflect the burden that malaria places on the health system. Changes in the numbers of cases and deaths reported by countries do not, however, necessarily reflect changes in the incidence of disease in the general population, because: (i) not all health facilities report each month, and so variations in case numbers may reflect fluctuations in the number of health facilities reporting rather than a change in underlying disease incidence; (ii) routine reporting systems often do not include patients attending private clinics or treated at home, so disease trends in health facilities may not reflect trends in the entire community; and (iii) not all malaria cases reported are confirmed by microscopy or RDT, so that some of the cases reported as malaria may be other febrile illnesses (*2*). When reviewing data supplied by ministries of health in malaria-endemic countries, the following strategy was used to minimize the influence of these sources of error and bias:

- Focusing on confirmed cases (by microscopy or RDT) to ensure that malaria, and not other febrile illnesses, are tracked. For high-burden countries in the WHO African Region, where little case confirmation is done, the numbers of malaria admissions (inpatient cases) and deaths are reviewed because the predictive value of diagnosis undertaken for an admitted patient is considered to be higher than outpatient diagnosis based only on clinical signs and symptoms. In such countries, the analysis may be heavily influenced by trends in severe malaria rather than trends in all cases.

- Monitoring the number of laboratory tests carried out. It is useful to measure the annual blood examination rate (ABER), which is the number of parasitological tests (by microscopy or RDT) undertaken per 100 people at risk per year, to ensure that potential differences in diagnostic effort or completeness of reporting are taken into account. When reviewing the number of malaria admissions and deaths, the health facility reporting rate (the proportion of health facilities that report) should remain constant and should be high, i.e. > 80%.

- Monitoring trends in the malaria (slide or RDT) positivity rate. Since trends in the number of confirmed cases can be distorted by variations in case detection effort (as measured by ABER) it is often informative to examine trends in slide or test positivity rate, which is less affected by variation in ABER. For high-burden African countries, when the number of malaria admissions or deaths is being reviewed, it is also informative to examine the percentage of admissions or deaths due to malaria, as this proportion is less sensitive to variation in reporting rates than the number of malaria admissions or deaths.

- Examining the consistency of trends. Unusual variation in the number of cases or deaths that cannot be explained by changes in intervention coverage, climate or other factors, or inconsistency between trends in cases and in deaths, can suggest deficiencies in reporting systems.

Further description of the procedures used is provided in the *World Malaria Report 2010*. The aim is to exclude data-related factors, such as incomplete reporting or changes in diagnostic

practice, as explanations for a change in the reported incidence of disease. Even so, trends in health facility data may not reflect changes in the entire community. The conclusion that trends inferred from health facility data reflect changes in the community has more weight if (i) the changes in disease incidence are large (ii) coverage with public health services is high and (iii) interventions that promote a reduction in cases, such as use of ITNs, are delivered throughout the community and not restricted to health facilities.

7.2   African Region

Because of the diversity of malaria epidemiological settings and control activities among African countries, and the importance of malaria in the African Region as a whole, this report divides the Region's 43 countries which have malaria transmission into four groups: (i) Central Africa; (ii) West Africa; (ii) East Africa and high transmission countries in southern Africa; and (iv) low transmission southern African countries.

7.2.1 Central Africa

Ïn all of the nine countries of this subregion all inhabitants live in areas with a high risk of *P. falciparum* malaria (**Figs A, B**).

The data used to assess trends are the numbers of admissions to hospitals and health centres with inpatient services. Angola and Gabon did not provide data on malaria admissions. In all

other countries, malaria admissions were more or less stable (e.g. Central African Republic) or rising (e.g. Republic of the Congo and the Democratic Republic of the Congo) (**Figs D, F**). The sharp increases reported from some countries since 2007 may be due to improved reporting and/or better access to health services.

While there was no evidence of any decrease in malaria cases or deaths in nationally reported data from Equatorial Guinea, the prevalence of childhood infection on the Island of Bioko dropped from 40% in 2004 to 22% in 2005 after the combined implementation of ITNs (44% of children slept under an ITN) and IRS (78% of houses sprayed) (*3*). In Gabon, a study carried out in the general hospital of Libreville found that the slide positivity rate decreased from 45% in 2000 to 15% in 2008. It was also reported that introduction of IPTp in Gabon was associated with a reduction of 84% in maternal *P. falciparum* infection between 2004 and 2006 (*4*). Such selective studies, however, do not allow general conclusions to be drawn about trends in malaria throughout the subregion.

The percentage of the population potentially covered by ITNs delivered was high (>70%) in 2010 in Burundi, Central African Republic, the Democratic Republic of Congo and Equatorial Guinea (**Fig.G**). Of these countries, all except the Democratic Republic of Congo have at least moderately good access to ACTs (**Fig.H**). Although progress appears to have been made in delivering interventions within the subregion it has not been possible to evaluate the impact of these efforts because the quality of routinely collected data is generally poor, the parasitological confirmation rate is low, and there are few alternative sources of information such as population-based surveys or specific studies of the impact of interventions. Following substantial investments in malaria control in this subregion, greater emphasis needs to be placed on monitoring and evaluation.

BOX 7.1
Explanation of graphs A to H

A. Population at risk: Populations at high risk for malaria are those living in areas where the number of reported cases is ≥1 per 1000 per year, and those at low risk are living in areas with < 1 case of malaria per 1000 per year (defined at the lowest administrative level for which data are provided). Other parts of the country are free of malaria transmission.

B. Cases due to P. falciparum**:** Average percentage of confirmed cases in which *P. falciparum* was detected singly or in a mixed infection, 2006–2010.

C. Annual Blood Examination Rate (ABER): Number of slide examinations or rapid diagnostic tests carried out each year per person at any level of risk for malaria, expressed as the average percentage 2006–2010.

D–F. Trends in the numbers of reported cases: Figure D shows the percentage reductions in numbers of confirmed cases between 2000 and 2010 (fewer cases, upward bars; more cases, downward bars). For countries in the African Region (except Algeria, Cape Verde, Sao Tome and Principe, and five countries in low transmission South-East Africa, where confirmed cases are used) percentage reductions are in numbers of hospital admissions. For all other countries reductions are in confirmed cases reported by routine surveillance from all health facilities. Figures E and F present
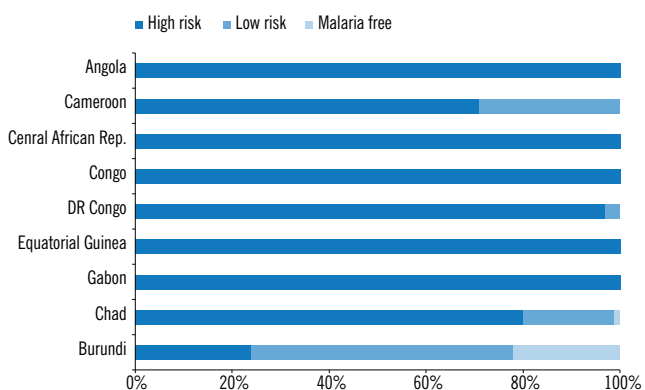
trends for each country between 2000 and 2010, dividing countries between those that show ≥50% (E) or <50% (F) reductions. Increases in numbers of cases are presented in the same graph as reductions of < 50% (F). The vertical axes in Figures E and F are on a logarithmic scale.

G. IRS and ITNs delivered: The vertical scale shows the percentage of the population at risk for malaria which is potentially covered by IRS and ITNs. It is assumed that each net delivered protects two people, that conventional nets are re-treated regularly, that each net lasts 3 years. For countries outside Africa, the denominator is the population living at high risk for malaria, as the number of malaria cases in areas of low risk is small. The scale of preventive efforts in any year can be calculated as 100 × (number of ITNs delivered in past 3 years + number of people protected by IRS in current year)/population at high risk, assuming that interventions are applied only to populations at high risk and that ITNs and IRS are used in different areas.
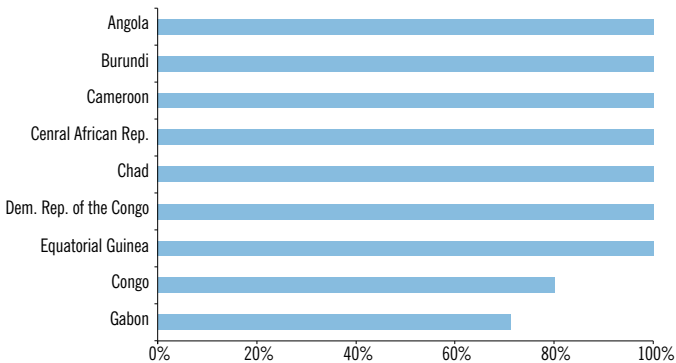
H. Cases potentially treated with antimalarial drugs. The number of treatment courses available is shown as a percentage of malaria cases reported (correcting for reporting completeness in the public sector). The bars for any antimalarial treatment indicate whether an adequate number of treatment courses have been supplied in relation to all malaria cases, including *P. falciparum*. The bars for ACT indicate whether an adequate number of treatment courses were made available for confirmed *P. falciparum* cases in the public sector.
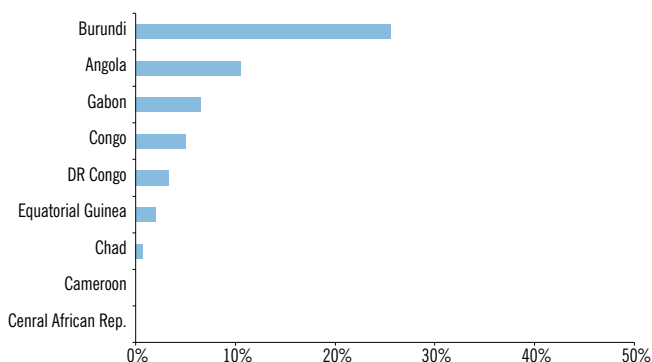
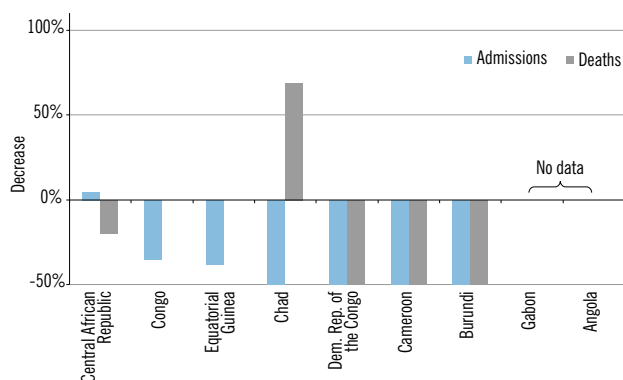---

Figure 7.1   Central Africa

a) Population at risk, 2010

Legend: High risk, Low risk, Malaria free

Countries (top to bottom): Angola, Cameroon, Central African Rep., Congo, DR Congo, Equatorial Guinea, Gabon, Chad, Burundi

X-axis: 0% – 100%

b) Percentage of cases due to P. falciparum, 2006-2010

Countries (top to bottom): Angola, Burundi, Cameroon, Central African Rep., Chad, Dem. Rep. of the Congo, Equatorial Guinea, Congo, Gabon

X-axis: 0% – 100%

c) Annual blood examination rate, 2006–2010

Countries (top to bottom): Burundi, Angola, Gabon, Congo, DR Congo, Equatorial Guinea, Chad, Cameroon, Central African Rep.

X-axis: 0% – 50%

d) Percentage decrease in admissions and deaths, 2000–2010

Legend: Admissions, Deaths

Y-axis: Decrease, -50% to 100%

Countries (left to right): Central African Republic, Congo, Equatorial Guinea, Chad, Dem. Rep. of the Congo, Cameroon, Burundi, Gabon, Angola

No data (Gabon, Angola)

e) Countries with > 25% decrease in malaria admissions, 2000–2010

Y-axis: Number of confirmed cases (logarithmic scale), 100 – 100000

X-axis: 2000 – 2010

f) Countries with increase or < 25% decrease, 2000-2010

Y-axis: Number of confirmed cases (logarithmic scale), 100 – 1 000 000

X-axis: 2000 – 2010

Legend: Equatorial Guinea, Chad, Cameroon, Burundi, Central African Republic, Congo, Dem. Rep. of the Congo

g) Percentage of high risk population protected with IRS and ITNs, 2010

Legend: IRS, ITN

Countries (top to bottom): Angola, Burundi, Cameroon, Central African Rep., Chad, Congo, Dem. Rep. of Congo, Equatorial Guinea, Gabon

X-axis: 0% – 100%, Population protected

h) Percentage of cases potentially treated with antimalarial medicines, 2010

Legend: Any antimalarial, ACT

Countries (top to bottom): Angola, Burundi, Cameroon, Central African Rep., Chad, Congo, Dem. Rep. of the Congo, Equatorial Guinea, Gabon

X-axis: 0% – 100%, Cases potentially treated

7.2.2 West Africa

In three of the 18 countries in this subregion intense malaria control has markedly reduced the number of cases over the past decade: Algeria, Cape Verde, and Sao Tome and Principe (**Figs. D, E**)[1]. In the remaining 15 countries, malaria transmission rates are among the highest in the Africa Region with infections almost exclusively due to *P. falciparum* (**Figs. A, B**).

Between 2000 and 2010, the number of confirmed malaria cases in Algeria[2] and Sao Tome and Principe, reported through their national surveillance systems, decreased by more than half (**Figs. D, E**). For all other countries in this subregion, attempts to evaluate malaria trends are based on time series of hospital admissions and deaths (**Figs D, E, F**) because there are few data on parasitologically confirmed malaria cases in health facilities. Cape Verde and Senegal (**Box 7.1C**) have reported reductions in hospital admissions (**Figs. D, E**), and Guinea Bissau in hospital deaths, but in all other countries the numbers of admitted cases have been rising (**Figs. D, F**). These striking upward trends are almost certainly due to improved reporting or access to health services, and as a result, cross-country comparisons of routinely collected data do not show a link between the coverage and the impact of interventions. In 2010, the number of ITNs delivered could potentially have protected more than half of the populations

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1   Algeria does not provide hospital data and is therefore not shown with other countries on trend graphs.

at high risk in Burkina Faso, Gambia, Guinea, Liberia, Mali, Mauritania, Sierra Leone, Senegal and Togo, and yet there is no evidence of reductions in malaria burden as reported through the routine health information system (**Fig.G**).

Apart from Senegal (**Box 7.2**), the strongest associations between interventions and impact are seen in data from two small island countries, Cape Verde and Sao Tome and Principe (**Fig.E**). The diagnostic testing effort in Sao Tome and Principe is high: the ABER exceeds 30% on average, far greater than in other countries in this subregion (**Fig.C**). Cape Verde and Sao Tome and Principe both use IRS at high coverage, and in Sao Tome and Principe IRS is used together with ITNs. In addition, a more detailed evaluation in Sao Tome of malaria cases, admissions and deaths, and of malaria infection rates, has linked malaria decline to the intense use of IRS, ITNs and ACTs (*5, 6*).

Two other special studies in Burkina Faso and Gambia have pointed to some additional successes in malaria control. In Gambia, a retrospective study carried out at four sites found reductions in the slide positivity rate, and in the proportions of hospital admissions and deaths due to malaria over the period 2003–2007 (*7*). And a malaria survey in a rural area of north-western Burkina Faso reported a 27% decline in rates of parasitaemia in 2009 compared to 1999 following an increase in ITN coverage from 22% to 73% (*8*). Many more special studies of this kind are needed to gain a full understanding of the effects of malaria control in this and other African subregions. Continued strengthening of routine health information systems is also necessary.

BOX 7.2
Malaria control in Senegal

The implementation of the Malaria control strategic plan during 2000–2005 was supported by JICA, USAID and WHO. From 2006, significant additional support from the Global Fund, complemented by funding from PMI, the Islamic Development Bank, UNICEF, the World Bank, with NGOs and local institutions, allowed the expansion of antimalarial interventions: universal coverage with LLINs, IRS in selected areas, IPTp, improved diagnostic testing, and more effective treatment.

In a malaria indicator survey (MIS) in 2006, 36% of households had at least one ITN and 21% of children < 5 years of age slept under an ITN the previous night. During 2006–2008, 2.3 million LLINs were delivered to pregnant women and children under 5, and during 2009–2010 about 3 million LLINs were distributed in a campaign that aimed to reach all people of all ages (one LLIN per sleeping space) in all 16 districts of the high transmission regions Kédougou, Tambacounda, Kolda and Sédhiou. Other regions were covered during 2010–2011. IRS has been used in six districts since 2007 (Richard Toll, Nioro, Vélingara, Guinguinéo, Koumpentoun, Malem Hodar), protecting almost a million people by 2010. Artesunate+amodiaquine was selected as first-line treatment for *P. falciparum* in March 2006. Universal diagnostic testing, primarily with RDTs, began in October 2007 and reached full coverage in 2008, with the exception of community case management.

Following the LLIN distribution campaign, a MIS in 2009 found that 82% of households had at least one ITN, 45% of children under 5 slept under an ITN the previous night, and 52% of pregnant women received at least two doses of SP during antenatal consultations.

The intensification of malaria control appears to have had an impact on the number of cases and deaths. In 14 of the 22 regional hospitals and in 52 of the 75 districts with complete data for 2001–2009, malaria hospital admissions (mostly confirmed by microscopy) decreased from 33 219 on average during 2001–2005 to 27 945 in 2009 (16% decrease). At the same time, non-malaria hospitalisations increased from 57 343 to 98 667 (72% increase). Similarly, malaria deaths decreased from an average of 1239 during 2001–2005 to 352 in 2009 (72% decrease), while other reported deaths increased from 3034 on average to 7194 (137% increase).

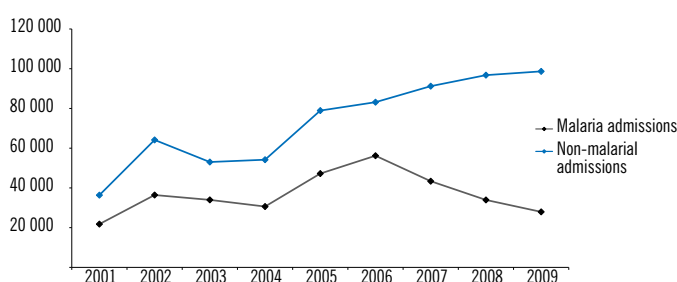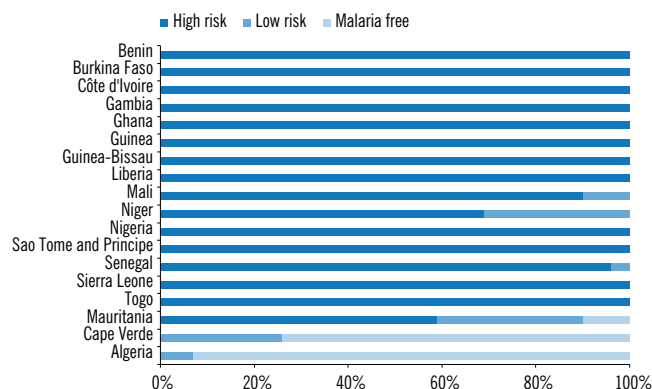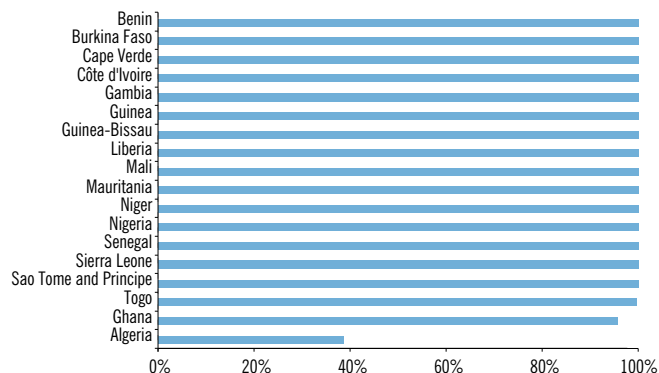**Figure Box 7.2   Trends in malaria and non-malarial admissions Senegal, 2001-2009**
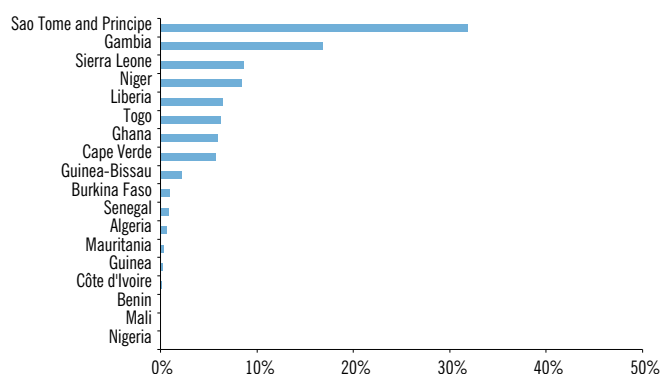
Figure 7.2   West Africa

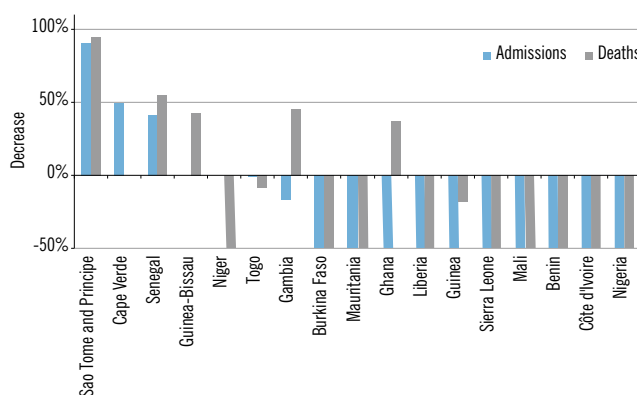### a) Population at risk, 2010

b) Percentage of cases due to P. falciparum, 2006-2010
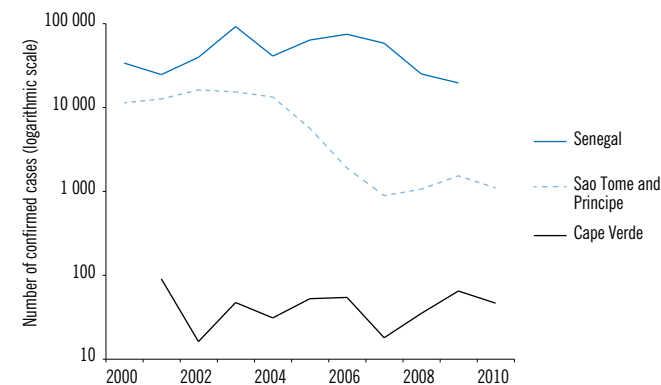

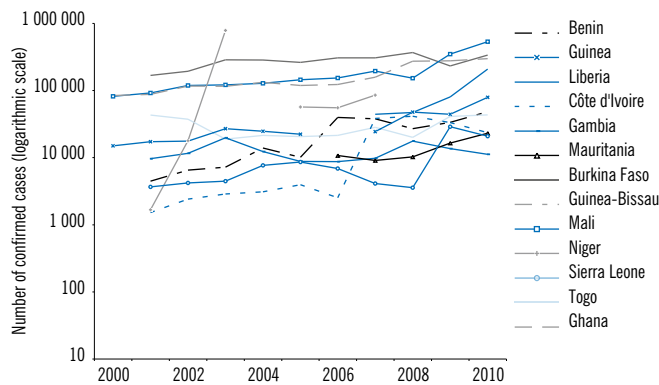### c) Annual blood examination rate, 2006–2010

d) Percentage decrease in admissions and deaths, 2000–2010
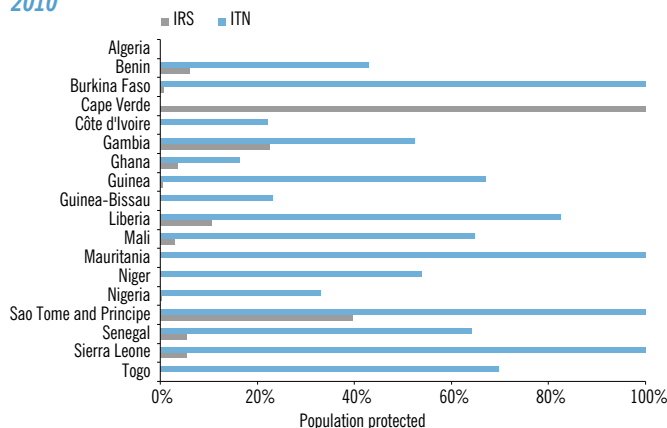

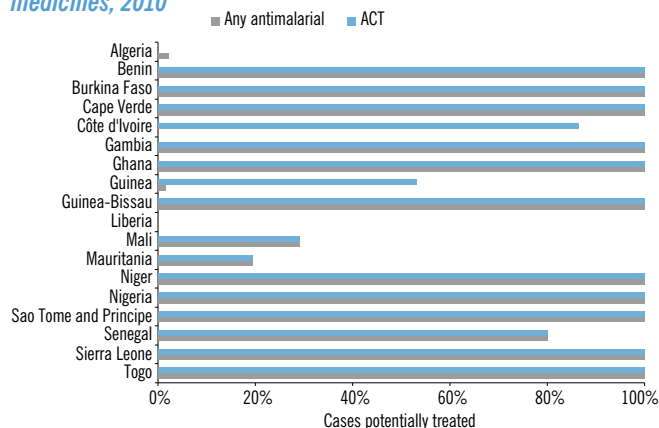### e) Countries with > 25% decrease in malaria admissions, 2000–2010

f) Countries with increase or < 25% decrease, 2000-2010

g) Percentage of high risk population protected with IRS and ITNs, 2010

h) Percentage of cases potentially treated with antimalarial medicines, 2010

7.2.3 East Africa and high transmission southern African countries

The majority of people in the 11 countries in this subregion are exposed to a high risk of malaria (**Fig. A**), although more than 20% of the population of Ethiopia and Kenya live in malaria-free areas. Cases of malaria are predominantly due to *P. falciparum* (**Fig. B**). The exceptions are Eritrea and Ethiopia where *P. vivax* causes a larger proportion of infections.

Between 2000 and 2010, malaria admissions to hospitals and health centres with inpatient services declined by more than half in Rwanda, United Republic of Tanzania (Zanzibar) and Zambia, but by smaller proportions in Eritrea, Ethiopia, Kenya, Madagascar and Mozambique (**Figs. D, E**). The four remaining countries/ areas (the Comoros, Malawi, Uganda, United Republic of Tanzania (mainland) reported increases in malaria admissions (**Figs. D, F**). As could be expected, the trends in hospital deaths were similar to the trends in hospitalized cases (**Fig. D**).

The declines in malaria admissions and deaths seen in nationally aggregated hospital data are consistent with published studies of data from health facilities in Eritrea, Ethiopia, Rwanda, and United Republic of Tanzania (Zanzibar) (*9,10,11*). In coastal areas of Kenya (Kilifi, Msambweni), district hospitals have reported that malaria cases declined among all paediatric admissions by 28%–63% between 1999 and 2007 (*12*). The observed increase in malaria admissions in Uganda agrees with an independent study, which found that hospitalizations increased by 47%–350% between 1999 and 2009 in four of five health facilities studied (*13*). An evaluation of malaria programmes in United Republic of Tanzania (mainland) from 1999 to 2010 found a 45% decline in the under-five mortality rate, and a 50% decline in severe anaemia prevalence in children 6–59 months of age following a 36-fold increase in ITN use among children <5 years (*14*). During this period, climatic conditions favourable for malaria transmission persisted, and there were no additional sustained increase in other child survival interventions, suggesting that the improvements in child health indicators observed could be plausibly linked, at least in part, to the scale-up of malaria control activities.

ITNs are the principal method of vector control in this subregion. A relatively high coverage of ITNs in Madagascar, Rwanda, and United Republic of Tanzania (mainland and Zanzibar, **Fig.G**) might explain why cases declined substantially between 2000 and 2010 (**Box 7.3**). But this association has not been observed in the Comoros (**Figs. F, G**). Mozambique had the lowest reported coverage of ITNs and IRS, and yet malaria admissions were falling between 2007 and 2010. Deeper investigations are needed to understand these inconsistencies. Most countries had full access to ACTs, but Uganda, United Republic of Tanzania (mainland) and Zambia did not report on ACT consumption (**Fig. H**).

BOX 7.3
Malaria control in Rwanda

With full government commitment, the country was supported by WHO to develop a malaria comprehensive strategic plan for the period 2005-2010. With the support from the Global Fund, PMI, and other development partners, the national malaria control programme has made ITNs and ACTs widely available since 2005 (Fig. 7.1C). Malaria control is part of the country's Comprehensive Poverty Reduction Strategy. A health insurance scheme (Mutuelle de Santé), implemented nationwide since 2004, has made malaria diagnosis and treatment accessible to everyone affected by malaria.

During 2006–2007, more than 3 million ITNs were distributed, targeting pregnant women and children under 5. Owing to inadequate funding, the replacement of LLINs was delayed until 2009–2011 when a further 6.1 million LLINs were distributed, which is enough to cover 81% of the entire population (with the objective of providing 1 net for every 2 people). Since 2006, ACTs have been available without interruption in all health facilities. And from 2007, case management has been carried out nationwide by trained community health workers who test febrile cases using RDTs and treat the confirmed cases. In 2007, with support from PMI, IRS was carried out in 36 sectors of 5 districts (Nyagatare, Bugesera, Nyanza, Gisagara and Kirehe). The possibility of using IRS nationwide is being evaluated, taking into account financial and operational feasibility.

A WHO rapid impact assessment was carried out at 30 of the 40 hospitals in Rwanda. The number of confirmed malaria cases among outpatients of all ages decreased from an average of 32 420 annually during 2000–2005 to 8528 cases in 2010 (74% reduction), reflecting the trend in national surveillance data (Figure 7.1C). The slide positivity rate fell from an average of 35% to 9% over the same period. Inpatient malaria cases among all age groups decreased from an average of 32 892 during 2000–2005 to 11 411 in 2010 (65% decrease), and malaria deaths fell from an average of 1220 during 2000–2005 to 546 in 2010 (55% decrease). Among children under 5 years of age, the reductions were greater.

There appears to have been a brief resurgence of malaria between 2008 and 2009: confirmed malaria cases in the 30 hospitals increased from 4190 to 9287, malaria admissions increased from 12 000 to 19 728, malaria deaths from 488 to 671, and the slide positivity rate from 7% to 11%. The resurgence was contained in 2010, just as 4 million new LLINs were distributed to replace those provided in 2006–2007. This situation is a reminder for countries with high malaria receptivity of the need for effective surveillance systems and to maintain the coverage of interventions for prevention and treatment.

Figure Box 7.4   Trends in malaria and non-malarial admissions Rwanda, 2000-2010
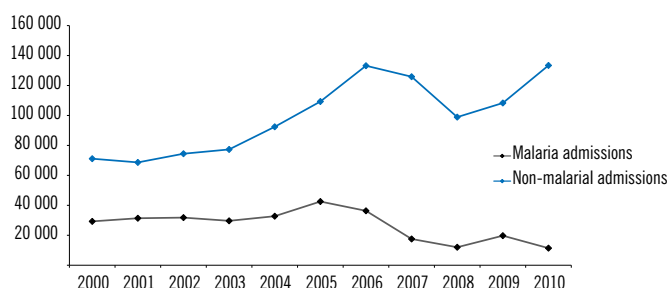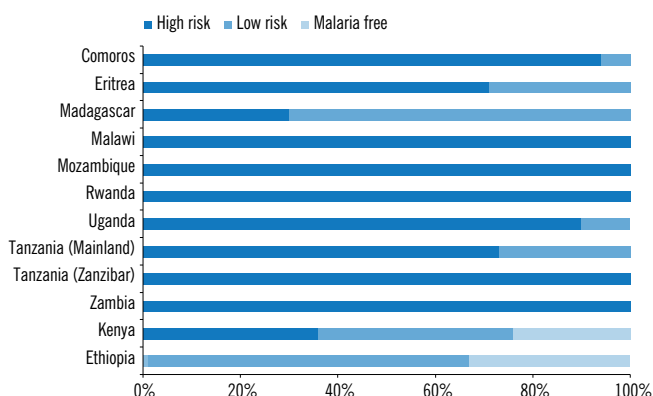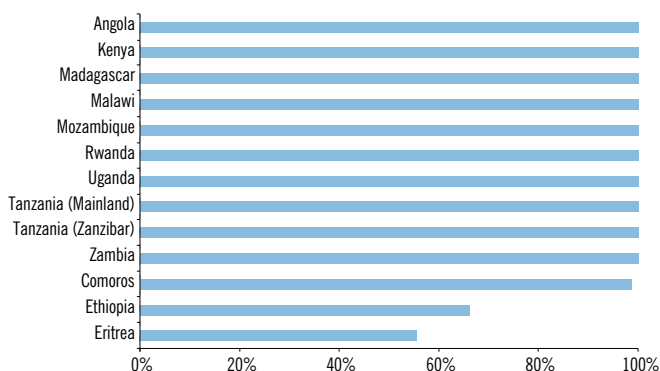
Figure 7.3   East Africa and high transmission areas in Southern Africa
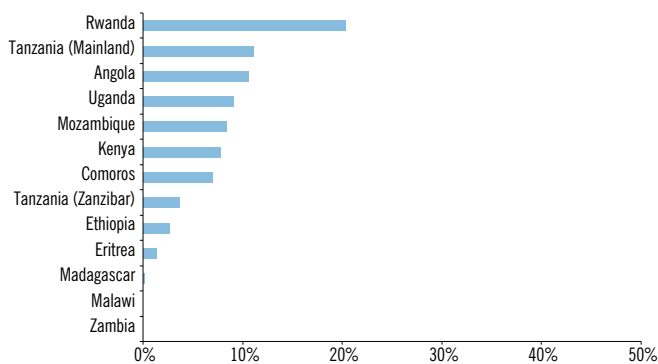
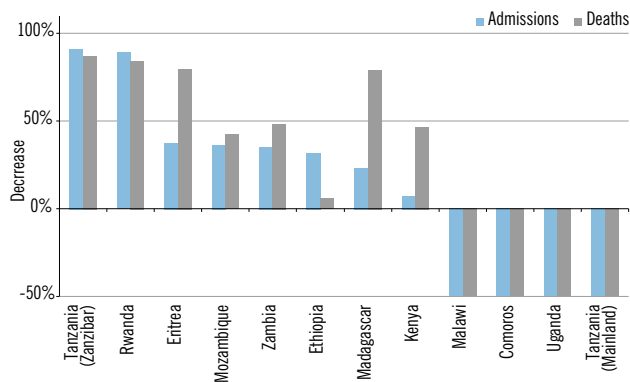a) Population at risk, 2010

b) Percentage of cases due to P. falciparum, 2006-2010

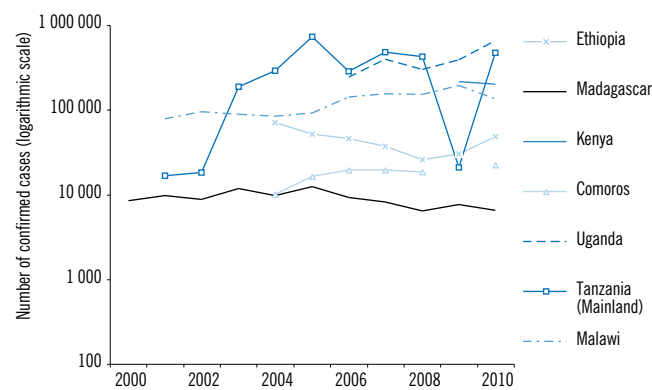c) Annual blood examination rate, 2006–2010

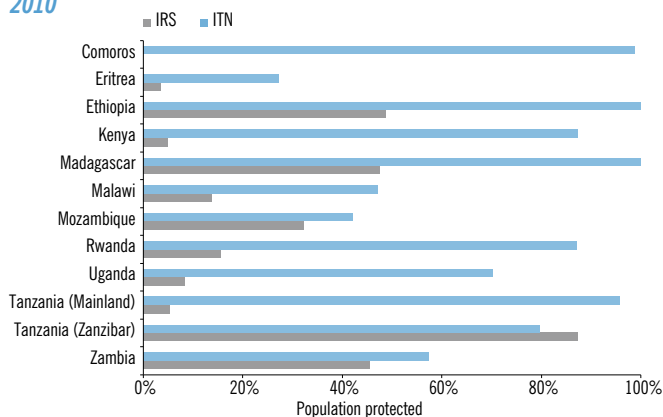d) Percentage decrease in admissions and deaths, 2000–2010

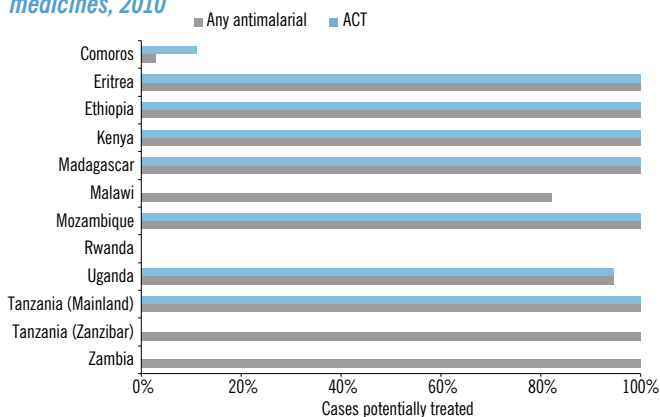e) Countries with > 25% decrease in malaria admissions, 2000–2010

f) Countries with increase or < 25% decrease, 2000-2010

g) Percentage of high risk population protected with IRS and ITNs, 2010

h) Percentage of cases potentially treated with antimalarial medicines, 2010

7.2.4 Low transmission southern African countries

The majority of the population in this subregion lives in areas that are free of malaria. Botswana, Namibia, South Africa, Swaziland and Zimbabwe are in the control phase and malaria is highly seasonal. During the transmission season, parts of the population of all these countries, with the exception of Swaziland, are temporarily at high risk (Lesotho is entirely free of malaria transmission) (**Fig. A**). Almost all malaria cases in the five countries are caused by *P. falciparum* (**Fig. B**).

The coverage of parasitological diagnosis in the subregion is relatively low (**Fig. C**). Against the background of seasonal variations in malaria burden, Botswana, Namibia, South Africa and Swaziland reported significant declines in malaria cases over the decade 2000–2010, albeit with some fluctuations from year to year (**Fig. E**). Case reports from Zimbabwe have been inconsistent over the past decade, varying between a minimum of 34 000 and a maximum of 250 000 cases (**Fig. F**). The increases since 2008 might be explained by improvements in diagnosis (both microscopy and RDTs). Whatever the explanation, it appears that malaria is not declining in Zimbabwe.

The population coverage of preventive and curative measures in the five countries is at least moderate and mostly high. South Africa has carried out intensive malaria control activities over many decades and has succeeded in halting transmission in most of the country, but malaria remains endemic in north-eastern border regions adjacent to Mozambique and Swaziland. IRS is the primary vector control measure in South Africa and Swaziland, whereas ITNs predominate in Botswana (**Fig. G**). All countries reported at least 60% coverage of populations at high risk with either ITNs or IRS, and all except Zimbabwe had adequate access to ACTs (**Fig. H**).

Building on recent successes, all the countries in this subregion are signatories to a southern Africa initiative known as the Malaria Elimination 8 (E8), launched in March 2009. The initiative centres on the southernmost countries that are most likely to achieve elimination by 2020, namely Botswana, Namibia, South Africa and Swaziland, but also includes Angola, Mozambique, Zambia and Zimbabwe as the immediate northern neighbours. A major issue for the E8 initiative is the carriage of malaria infection across borders, and particularly the importation of malaria into the four countries with low malaria burden. Malaria control in these countries requires interventions targeted at known foci, strong surveillance systems, cross-border communication, and screening of migrant workers.

BOX 7.4
Malaria control in Swaziland

The malaria control programme of Swaziland was established in the 1940s. With sustained support and resources for IRS, active surveillance, as well as increased control in neighbouring countries, Swaziland managed to maintain low incidence throughout the 1950s and 1960s. The country almost eliminated malaria in 1969 when only 46 cases were reported, 36 of which were imported. However, funding cutbacks led to malaria epidemics in the 1970s and 1980s. By the mid-1990s, malaria had re-emerged as a serious public health threat in Swaziland, with incidence returning to its highest level since 1947 due to a combination of above-average rainfall, parasitic resistance to treatment options such as chloroquine and sulfadoxine-pyrimethamine, and instability in the health system exacerbated by the emerging HIV epidemic. In 1995–1996, 9700 confirmed cases and over 38 000 clinical cases were recorded in outpatient departments across the country.

Recently, Swaziland has achieved success in reducing malaria transmission, reporting a 90% decrease in confirmed malaria cases from 2001 to 2010 (Fig E). A malaria indicator survey, developed as a baseline measurement for the elimination campaign, estimated parasite prevalence to be 0.2% and 53% of households being protected by either IRS or by ITNs in 2010.

An elimination strategy was launched in 2008, emphasizing confirmed diagnosis by RDT or microscopy, prompt treatment with ACTs for patients with positive tests, and universal coverage of IRS and LLINs in the at-risk region. In October 2009 Swaziland launched an active surveillance programme, with support from the Global Fund. Cases detected at health facilities are reported through a toll-free telephone number and recorded in a central database, which in turn alerts the malaria control team of the new case by SMS message and triggers a case investigation. Between four to seven days after the case presents, an NMCP surveillance agent visits the household to carry out the case investigation; the agent collects coordinates of the household using a GPS, administers a paper-based questionnaire to determine the origin of the case, and collects a blood slide to confirm treatment success. If local transmission is suspected or uncertain, the surveillance agent conducts a mass screening with RDTs of all residents living within one kilometre of the index case in order to detect and treat additional cases and interrupt onward transmission. Between October 2009 and June 2011, 464 cases have been investigated, of which 241 cases were determined to have been locally transmitted.

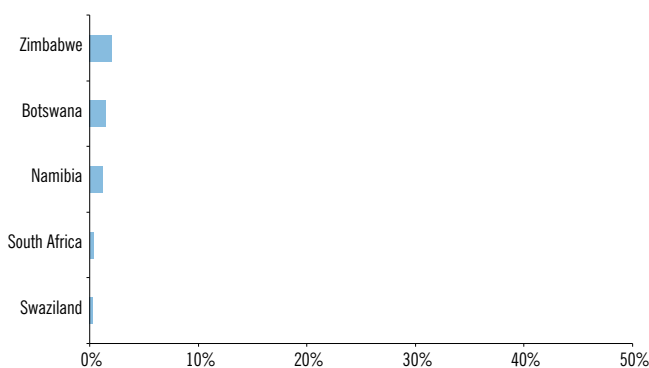## Figure 7.4   Low Transmission Southern African Countries
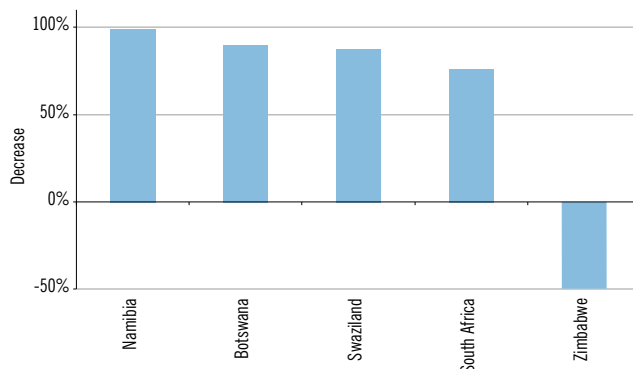

a) Population at risk, 2010
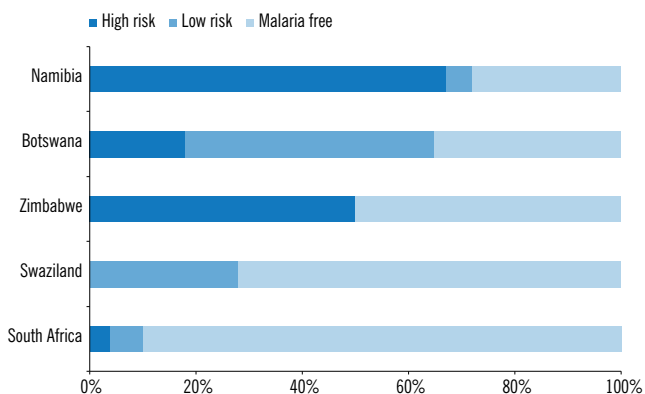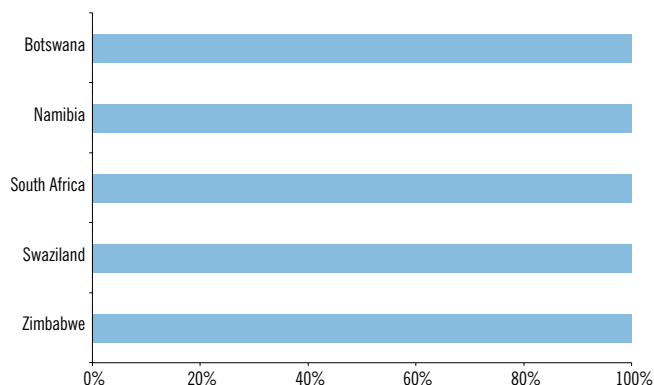
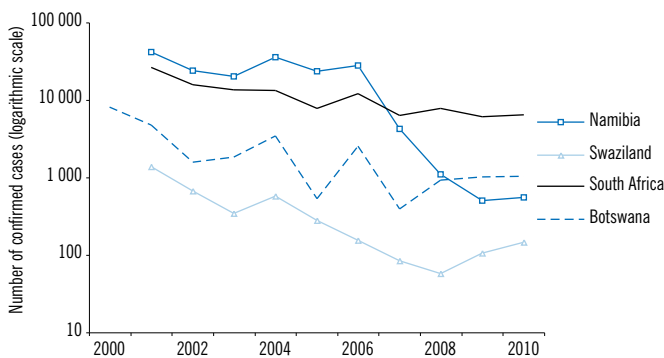b) Percentage of cases due to P. falciparum, 2006-2010

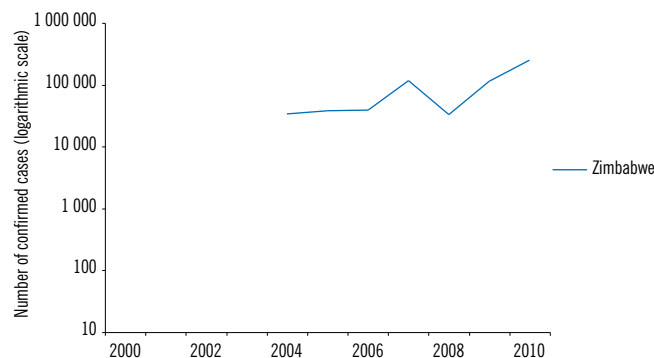c) Annual blood examination rate, 2006–2010

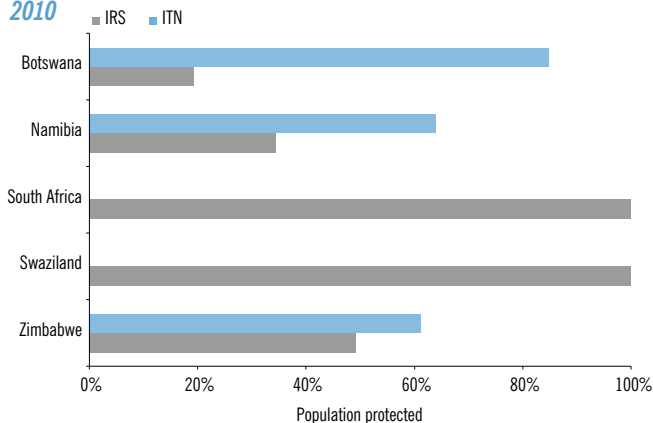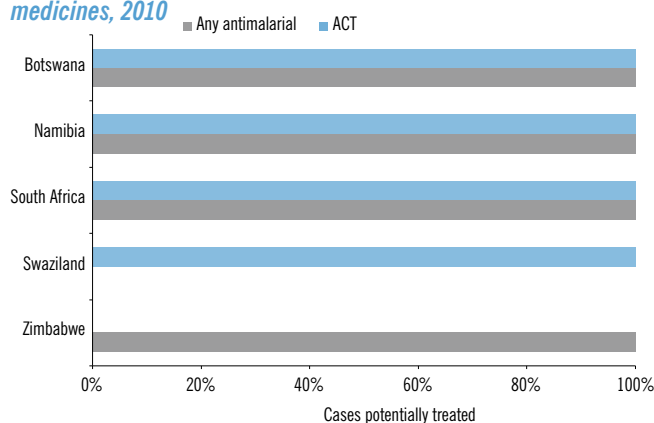d) Percentage decrease in admissions and deaths, 2000–2010

e) Countries with > 50% decrease in confirmed cases, 2000–2010

f) Countries with increase or < 50% decrease, 2000-2010

g) Percentage of high risk population protected with IRS and ITNs, 2010

h) Percentage of cases potentially treated with antimalarial medicines, 2010

7.3   Region of the Americas

The main characteristic of the Region of the Americas is that malaria is in decline in the majority of countries (**Fig. E**).

In 2010, malaria transmission occurred in 21 countries in the Region with about 30% of the total population at some degree of risk (**Fig. A**). Of these countries, 17 are in the control stage and four (Argentina, El Salvador, Mexico, and Paraguay) are in the pre-elimination stage. In addition two countries, the Bahamas and Jamaica, no longer have indigenous malaria, and are in the prevention of reintroduction stage.

Through routine surveillance, (**Fig. C**), approximately 673 000 confirmed cases were reported from 16 countries in 2010; ABERs were very heterogeneous across the Region. No country reports were received from Haiti, Peru or the Bolivarian Republic of Venezuela in 2010. *P. vivax* malaria accounted for 70% of reported cases in the Region, but cases in the Dominican Republic and Haiti are almost exclusively due to *P. falciparum* (**Fig. B**). In Suriname, the proportion of cases due to *P. falciparum* fell from 84% in 2000 to 38% in 2010, possibly linked to malaria control activities.

Between 2000 and 2009, the total number of confirmed cases reported by all countries dropped by 43%, with the majority of cases reported by Brazil and Colombia (typically 50%–60% in Brazil alone). Reductions of more than 50% between 2000 and 2010 were recorded in 15 countries, and smaller reductions in three countries (**Figs. D, E**). Three countries reported increases in case numbers between 2000 and 2010 – the Dominican Republic, Haiti, and the Bolivarian Republic of Venezuela (**Figs. D, F**). The increase in the Bolivarian Republic of Venezuela has been associated with an increased ABER and may reflect greater diagnostic effort rather than increased malaria incidence. The increase in Haiti followed the earthquake in January 2010. Given limitations in the surveillance system, it is unclear whether this reflects a real rise in incidence or disease prevalence, or is a consequence of increased availability of resources for case detection during the emergency

response. Data from the Dominican Republic suggest a higher incidence of malaria in 2005 and 2010 compared to other years.

Although country trends can be classified by comparing the beginning and the end of the decade, there have been important fluctuations within this time period. Panama experienced a five-fold increase in confirmed cases between 2001 and 2004, but nevertheless reported an overall reduction of more than half during the decade. The Plurinational State of Bolivia, Colombia and Guyana reported upturns in the number of cases between 2009 and 2010. In Guyana the upturn is associated with an increase in ABER and may not reflect a real change in malaria incidence.

The coverage of high risk populations with IRS or ITNs between 2006 and 2010 was highly variable among countries (**Fig. G**). IRS coverage exceeded 50% only in Ecuador and Nicaragua, and ITN coverage exceeded 50% only in Ecuador, Guatemala, Nicaragua and Suriname. The availability of antimalarial drugs was sufficient to cover more than half of the cases attending public sector health facilities in almost all countries that reported data (**Fig. H**). No distribution of ACTs was reported in the Dominican Republic, Haiti or Suriname, countries where *P. falciparum* malaria is prevalent.

Four countries with IRS or ITN coverage of more than 50% in high-risk populations (Ecuador, Guatemala, Nicaragua, and Suriname) also reported that malaria cases declined by more than half between 2000 and 2010 (**Figs D, E, F**), and these countries were comparatively well supplied with antimalarial medicines (Ecuador, Guatemala, Nicaragua and Suriname). Case numbers did not decline in the Bolivarian Republic of Venezuela, however, despite a high proportion of households reported as being protected by IRS.

The Dominican Republic and Haiti, reported increasing numbers of cases, and had inadequate coverage of IRS or ITNs. However, Costa Rica, Mexico and Paraguay reported low IRS or ITN coverage and yet showed significant reductions in malaria cases, possibly because of intensified surveillance of cases. The association between prevention (IRS, ITN) or treatment (antimalarial drugs) and malaria trends across the countries in the Region of the Americas is therefore inconsistent.

BOX 7.5

Ten years of effective partnership for malaria prevention and control in the Region of the Americas

Malaria control in the Americas has progressed over the past decade through strong regional partnerships. Two of the important networks and institutions are the Amazon Network for the Surveillance of Antimalarial Drug Resistance (RAVREDA) and the Amazon Malaria Initiative (AMI).

RAVREDA is a network of countries including the Plurinational State of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and the Bolivarian Republic of Venezuela, along with WHO/PAHO, established in 2001 to respond to the challenge of antimalarial drug resistance in the Amazon. RAVREDA has also partnered with international institutions and local organizations, and has recently expanded to include components of the Regional Strategic Plan for Malaria in the Americas 2006–2010. French Guiana is currently associated with the network as an observer, while efforts are also being made to link with Mexico and the Central American countries.

AMI was launched in 2001 by USAID/LAC (Office for Infectious Diseases in Latin America and the Caribbean) and focuses its financial and technical resources in support of the Roll Back Malaria Partnership in Latin America. It involves USAID, AMRO/PAHO, CDC, the MSH/RPM Plus

program, the United States Pharmacopeia's Drug Quality and Information (USP/DQI) program, and Linksmedia. AMI's thematic areas include surveillance of antimalarial resistance, drug policy implementation, access and quality of diagnosis and treatment, evidence-based vector control, epidemiological stratification, and advocacy and communication.

The AMI/RAVREDA network has helped countries in the Region to develop drug efficacy protocols based on current epidemiological situations and to conduct studies of therapeutic efficacy. As a result, eight countries were able to adopt ACTs as first-line treatment of *P. falciparum* malaria (the Plurinational State of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and the Bolivarian Republic of Venezuela). The network has also carried out more than 17 studies on chloroquine-resistant *P. vivax* in the Plurinational State of Bolivia, Brazil, Colombia, Peru, and the Bolivarian Republic of Venezuela. In 2009 and 2010, AMI/RAVREDA helped to standardize the methodology for ELISA-based tests used in monitoring temporal and spatial variations in drug susceptibility, to enable early detection of resistance to the new drugs used in the Region.

Finally, a key function of AMI/RAVREDA is to play a catalytic role in partnerships, filling regional gaps, supporting regional and subregional coordination, assisting in the preparation of Global Fund applications, and laying the foundations for malaria elimination in areas where this is deemed feasible.

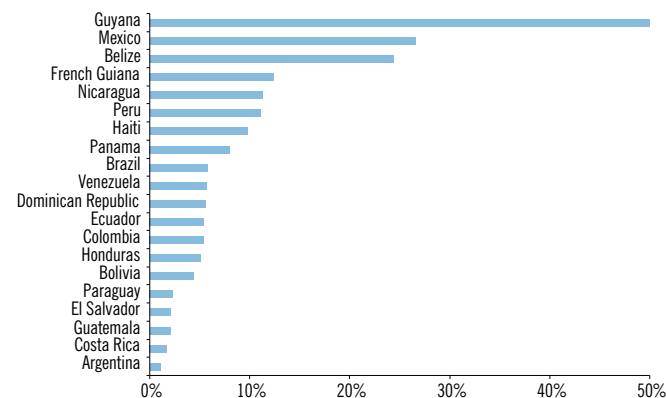**Figure 7.5   Region of the Americas**

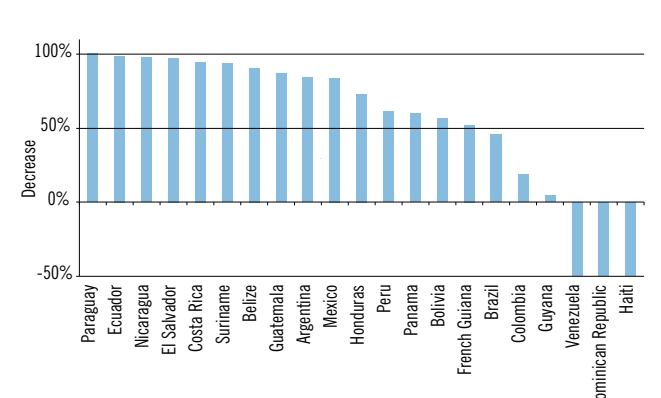a) Population at risk, 2010
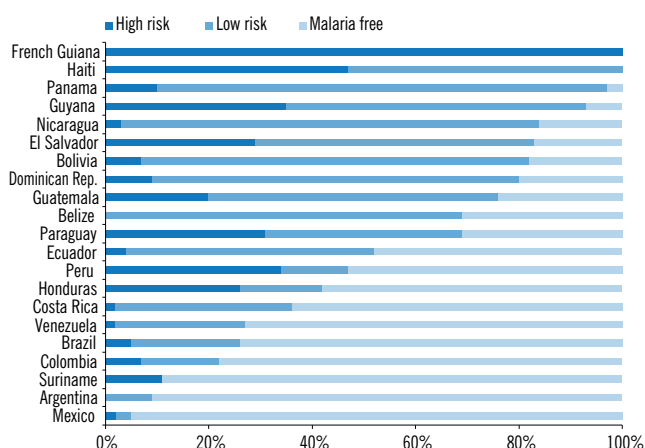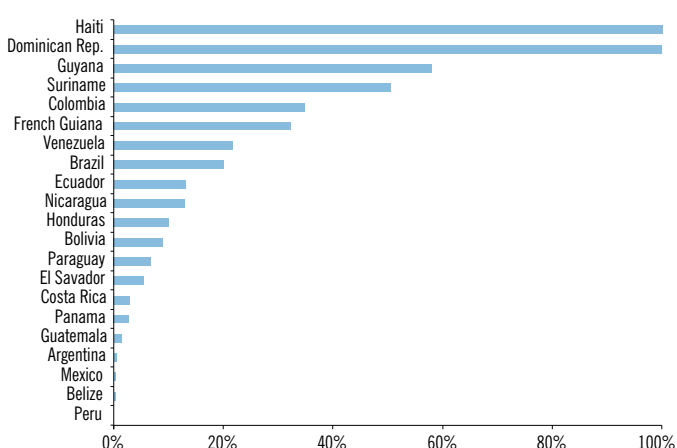
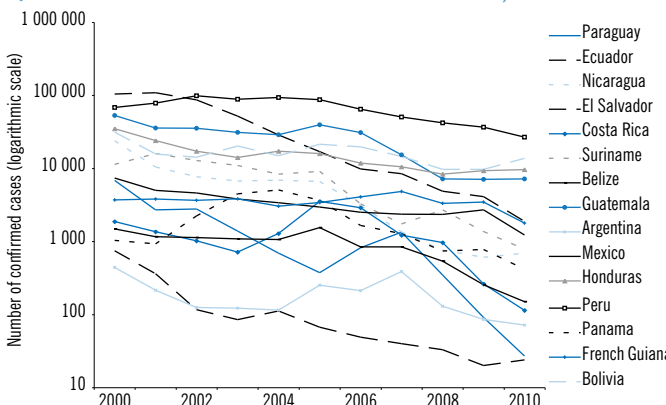b) Percentage of cases due to P. falciparum, 2006-2010

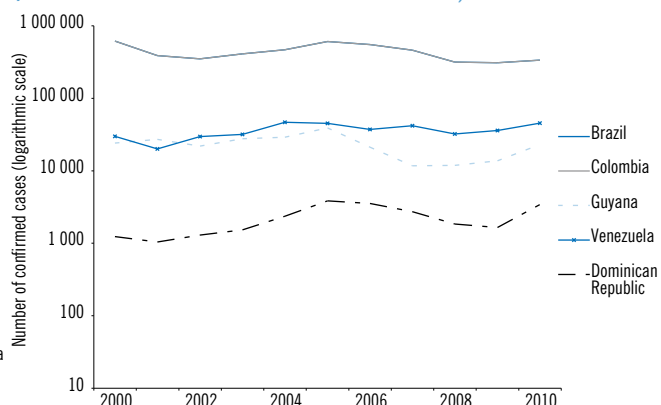c) Annual blood examination rate, 2006–2010

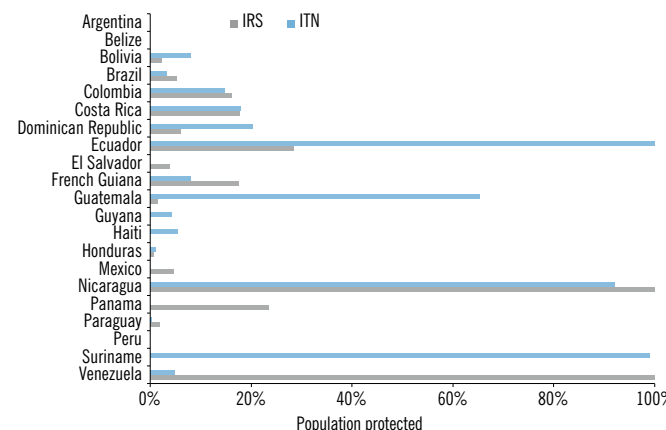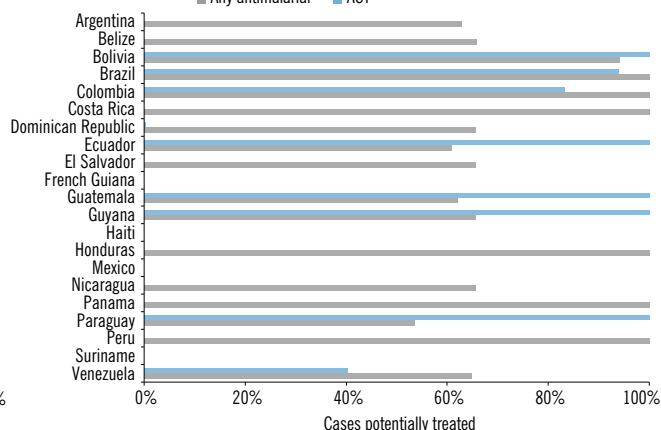d) Percentage decrease in admissions and deaths, 2000–2010

e) Countries with >50% decrease in confirmed cases, 2000–2010

f) Countries with increase or < 50% decrease, 2000-2010

g) Percentage of high risk population protected with IRS and ITNs, 2010

h) Percentage of cases potentially treated with antimalarial medicines, 2010

7.4   Eastern Mediterranean Region

Malaria endemicity varies enormously across the Eastern Mediterranean Region: some countries are already free of malaria, a few have made substantial progress in control over the past decade, and some have a persistently high disease burden.

In September 2011, South Sudan[1] became a new WHO member state, increasing the number of member states in the Eastern Mediterranean Region to 23. These countries are in various stages of malaria control: seven still have areas of high malaria transmission and are in the *control stage* (Afghanistan, Djibouti, Pakistan, Somalia, Sudan, South Sudan, and Yemen; **Fig. A**); two countries with geographically limited malaria transmission are in the *elimination* stage (the Islamic Republic of Iran, and Saudi Arabia). Egypt, Oman and the Syrian Arab Republic are in the *prevention of reintroduction* stage. The remaining countries are *malaria-free*.

P. falciparum is the dominant species of parasite in the Afrotropical countries (Djibouti, Saudi Arabia, Somalia, Sudan and Yemen) while the majority of cases in Afghanistan, Iran, and Pakistan are due to *P. vivax* (**Fig. B**). In 2010, the Region reported a total of 7.3 million malaria cases from nine countries, of which 1.2 million (15%) were confirmed parasitologically. Four countries accounted for 97% of the confirmed cases: Sudan (58%), Pakistan (22%), Yemen (10%) and Afghanistan (6%).

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1   Data reported to 2010 are compiled as from a single member state.

Afghanistan, Iran, Iraq, and Saudi Arabia reported that malaria cases fell by more than half between 2000 and 2010 (**Figs. D, E**). The decline in case numbers in Saudi Arabia has been aided by the high coverage of IRS, by the use of ITNs (**Fig. G**) and by the consistent availability of antimalarial drugs (**Fig. H; Box 7.3**).

Following the steep decline in case numbers, Iraq was able to report zero locally-acquired cases for the first time in 2009, and all seven cases in 2010 were imported. In 2010, Saudi Arabia reported 29 locally-acquired cases and 1912 imported cases (see **Box 7.6**); Iran recorded 1847 locally-acquired cases and 1184 imported cases.

Malaria remains problematic in five countries in which large numbers of cases were reported between 2000 and 2010 and no discernible downward trends occurred (**Fig. F**), perhaps because there are no underlying trends in incidence, or because any trends are masked by inconsistent diagnostic testing and reporting. For example, Sudan has reported large fluctuations in case numbers (**Fig. F**), even with an apparently high coverage of ITNs (**Fig. G**), and the link between control efforts and malaria epidemiology remains unclear.

Further investigations in these five countries will be difficult to carry out, but a more detailed appraisal of malaria epidemiology is nevertheless needed, including evaluations of the coverage and impact of control measures.

Figure 7.6   Eastern Mediterranean Region

a) Population at risk, 2010
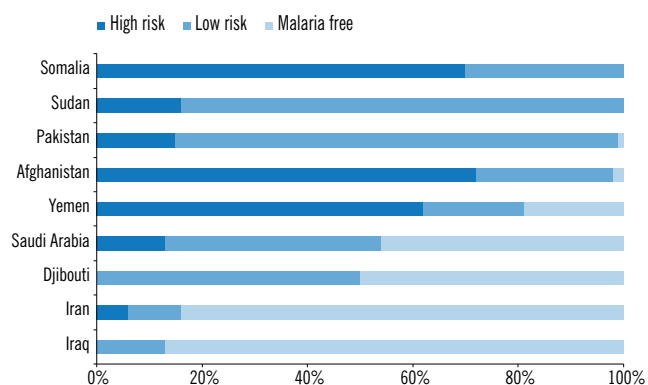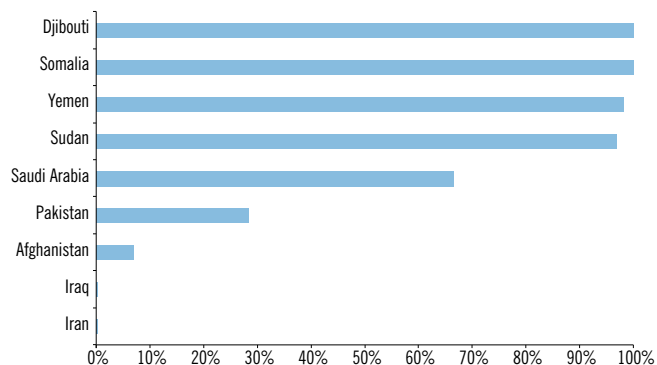
b) Percentage of cases due to P. falciparum, 2006-2010

c) Annual blood examination rate, 2006–2010
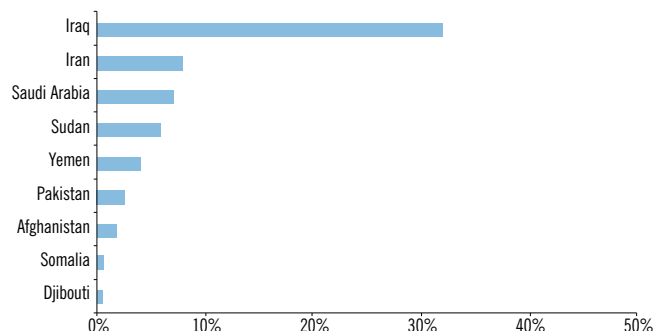
d) Percentage decrease in admissions and deaths, 2000–2010
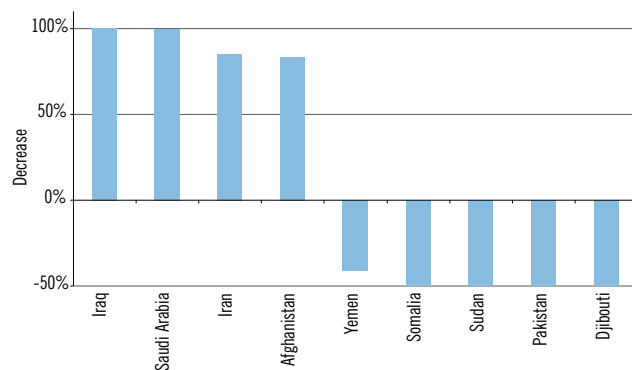
e) Countries with >50% decrease in confirmed cases, 2000–2010
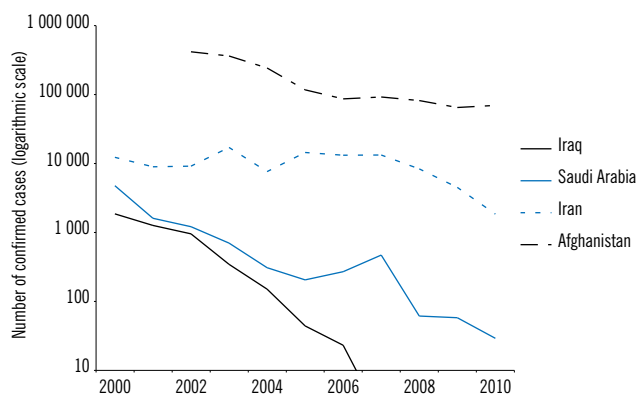
f) Countries with increase or < 50% decrease, 2000-2010
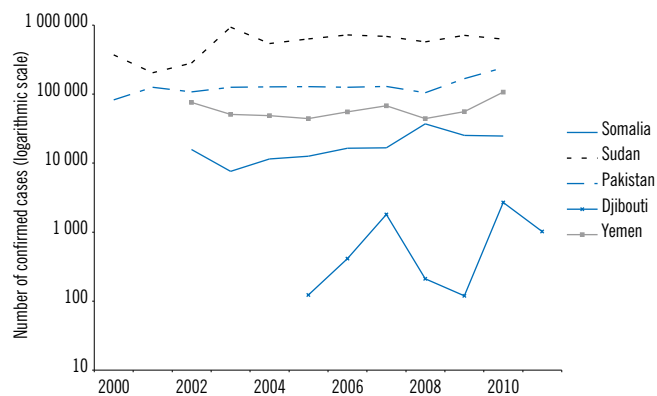
g) Percentage of high risk population protected with IRS and ITNs, 2010
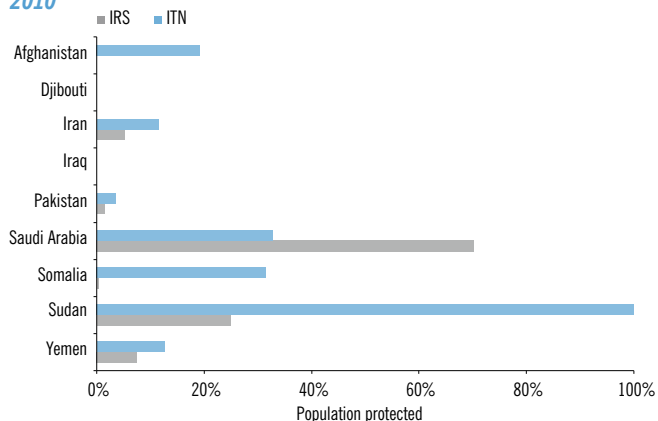
h) Percentage of cases potentially treated with antimalarial medicines, 2010
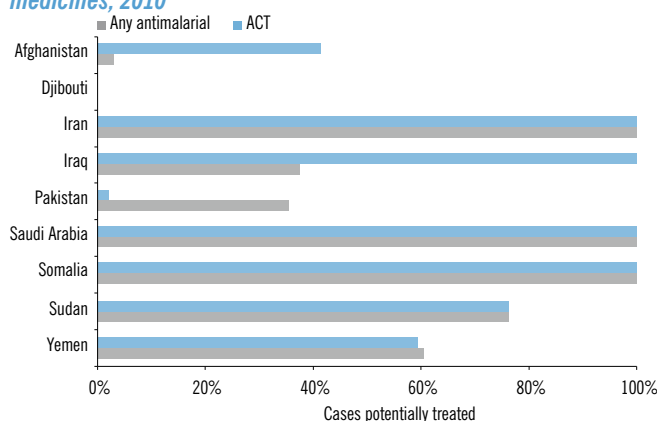
7.5   European Region

The European Region has a real possibility of becoming the first to achieve the complete elimination of malaria within the next few years, and aims to do so by 2015.

The 2005 Tashkent Declaration, "The Move from Malaria Control to Elimination in the WHO European Region", was endorsed by 10 malaria-affected countries, including the Russian Federation. In addition, the goal of the new WHO regional strategy for Europe developed in 2006 is to interrupt transmission and eliminate malaria by 2015. Since 2008, all endemic countries have had active elimination programmes. In support of the move towards elimination, the Global Fund has provided financial assistance to some countries, to strengthen national capacities for malaria control.

The total number of reported indigenous malaria cases in the European Region decreased from 32 394 in 2000 to only 176 in 2010. Locally-acquired *P. vivax* cases are now only reported from five countries in the Region: Azerbaijan, Kyrgyzstan, Tajikistan, Turkey and Uzbekistan. No locally-acquired *P. falciparum* cases have been reported since 2008. **Figs. D** and **E** show how incidence has fallen in the seven principally affected countries. There are now no countries where malaria is increasing (**Fig. F**). Between 2001 and 2005, Turkey reported around half of all cases in the European Region, but had only nine cases in 2010 (**Fig. E**). Kyrgyzstan suffered a large outbreak in 2002 but, like Turkey, reported very few (three) cases in 2010 (**Fig. E**).

In 2009, Uzbekistan reported zero cases from indigenous transmission for the first time, but three local *P. vivax* cases arose from residual foci of infection in 2010. In 2010, Georgia reported zero locally-acquired cases for the first time. The transmission of *P. falciparum* malaria was interrupted in 2009 in Tajikistan, the last remaining falciparum malaria-endemic country in the Region. All other *P. falciparum* malaria cases found in the Region in 2010 were imported (**Fig. B**, see also **Section 7.8**). Turkmenistan was certified malaria-free in October 2010. With support from WHO, Armenia was certified malaria-free in 2011 (see **Section 7.7**).

IRS is the primary vector control measure in countries in the Region, where each country aims for complete coverage (>80% of population at high risk) of all remaining and any new foci of malaria (**Fig. G**). ITNs are used as a supplementary intervention to IRS, particularly in Azerbaijan, Kyrgyzstan, Tajikistan and Uzbekistan (**Fig. H**).

Intense diagnostic efforts in Armenia, Azerbaijan, Kyrgyzstan and Turkey are reflected in high ABERs (**Fig. C**). All suspected cases in the Region are examined microscopically, and all cases are traced to determine whether infection is due to local transmission or has been imported. Antimalarial medicines are maintained to ensure radical treatment of all confirmed cases (**Fig. H**). Countries in the elimination phase pay particular attention to the risk of malaria spreading among countries in the Region, and between the European and East Mediterranean Regions.

BOX 7.7

Elimination of *P. falciparum* malaria in Tajikistan

Tajikistan is landlocked and mountainous, and only 10% of the land is cultivable. It is the smallest country in the south-eastern part of Central Asia, bordered by Afghanistan, China, Kyrgyzstan and Uzbekistan.

Early in the 20th century, the lower valleys were endemic for *P. falciparum* and *P. vivax*. Malaria control measures began in the 1930s, when more than 100 000 cases were reported each year (176 125 cases in 1932). By the 1960s, malaria had almost been eliminated following intensified vector control during the Global Malaria Eradication Programme, and by 1966 only 11 locally-acquired cases were reported in the south of the country.

During the 1990s the malaria situation deteriorated due to political instability and economic hardship, leading to the disruption of health services and of vector control activities. During the armed conflict in 1992, more than 500 000 people were displaced, many to malaria-endemic areas of Afghanistan. The return home of nearly 30 000 Tajik refugees from these endemic areas, together with changes in agricultural practices (increased rice cultivation), led to the reintroduction and spread of *P. falciparum* and *P. vivax* across the country.

In 1997, the new malaria epidemic peaked at nearly 30 000 officially reported cases, although the true number may have been much greater. Since then, the total number of cases has fallen, despite notable increases in *P. falciparum* cases from 183 in 1997 to 831 in 2000. *An. superpictus*, *An. pulcherimus*, *An. macullipennis* and *An. hyrcanus* are the principal and secondary malaria vectors in the country.

The epidemic of the 1990s prompted intensified malaria control measures supported by the Government, WHO, USAID, UNICEF, WFP, ECHO, international NGOs and others. A five-

year plan (2006–2010), developed in close cooperation with WHO and supported by the Global Fund, aimed to interrupt transmission of *P. falciparum* malaria by 2010.

Interventions included: case management and prevention through well-equipped public health services, adding malaria centres at national, district and regional level; deployment of 3600 trained health staff at all levels; vector control through intensified IRS covering around 120 000 households annually, complemented by the distribution of more than 35 000 LLINs in affected areas; plus the extensive use of larvivorous *Gambusia* fish in rice fields. Malaria diagnosis is based entirely on microscopy. ACTs (AS +SP) were adopted as first-line treatment for chloroquine-resistant *P. falciparum* in 2004, switching to artemether-lumefantrine in 2007.

As a result of all these activities, elimination of *P. falciparum* was achieved in 2009, one year ahead of schedule. At present only *P. vivax* is reported in the country. Malaria elimination measures now focus on improving capacity for early diagnosis and radical treatment of *P. vivax*, effective prevention through vector control, strengthening surveillance systems, and operational research for timely detection and response in the event of *P. falciparum* reintroduction.

Figure Box 7.7   Locally acquired *P. falciparum* cases in Tajikistan 1994-2010

**Figure 7.7   European Region**

a) Population at risk, 2010

Legend: High risk ■ Low risk ■ Malaria free ■

Countries (top to bottom): Tajikistan, Azerbaijan, Georgia, Kyrgyzstan, Turkey, Uzbekistan

X-axis: 0%, 20%, 40%, 60%, 80%, 100%

b) Percentage of cases due to P. falciparum, *2006-2010*

Countries (top to bottom): Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkey, Uzbekistan

X-axis: 0%, 20%, 40%, 60%, 80%, 100%

c) Annual blood examination rate, 2006–2010

Countries (top to bottom): Turkey, Uzbekistan, Kyrgyzstan, Azerbaijan, Georgia, Tajikistan

X-axis: 0%, 20%, 40%, 60%, 80%, 100%

d) Percentage decrease in admissions and deaths, 2000–2010

Y-axis: Percentage: -50%, 0%, 50%, 100%

Countries (left to right): Georgia, Turkey, Tajikistan, Azerbaijan, Uzbekistan, Kyrgyzstan

e) Countries with > 50% decrease in confirmed cases, 2000–2010

Y-axis: Number of confirmed cases (logarithmic scale): 1, 10, 100, 1 000, 10 000, 100 000

X-axis: 2000, 2002, 2004, 2006, 2008, 2010

Legend:
Georgia
Turkey
Tajikistan
Uzbekistan
Azerbaijan
Kyrgyzstan

f) Countries with increase or < 50% decrease, 2000-2010

Y-axis: Number of confirmed cases (logarithmic scale): 1, 10, 100, 1 000, 10 000, 100 000

X-axis: 2000, 2002, 2004, 2006, 2008, 2010

g) Percentage of high risk population protected with IRS and ITNs, 2010

Legend: IRS ■ ITN ■

Countries (top to bottom): Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkey, Uzbekistan

X-axis: 0%, 20%, 40%, 60%, 80%, 100%
Population protected

h) Percentage of cases potentially treated with antimalarial medicines, 2010

Legend: Any antimalarial ■ ACT ■

Countries (top to bottom): Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkey, Uzbekistan

X-axis: 0%, 20%, 40%, 60%, 80%, 100%
Cases potentially treated

7.6   South-East Asia Region

Malaria is clearly declining in the smaller countries of the South-East Asia Region, but is more stable in the major endemic centres – Bangladesh, India, Indonesia, and Myanmar.

Today, 10 of the 11 countries in the Region remain malaria-endemic. Bangladesh, Bhutan, the Democratic Republic of Timor-Leste, India, Indonesia, Myanmar, Nepal and Thailand are in the control phase. Two low-incidence countries are in the pre-elimination stage – the Democratic People's Republic of Korea and Sri Lanka. Only the Maldives is free of indigenous malaria transmission, as the country has been since 1984 (**Box 7.8**). Approximately 70% of the population of 1.8 billion people in the Region is at some risk for malaria, with 25% at high risk: 458 million people inhabit areas with a reported incidence of >1 case per 1000 population per year (**Fig. A**).

The majority of confirmed cases in the Region are due to *P. falciparum*, although the proportion varies greatly among countries (**Fig. B**). Malaria is due almost entirely to *P. falciparum* in Bangladesh, Myanmar and Timor Leste, mostly to *P. vivax* in Nepal and Sri Lanka, and exclusively due to *P. vivax* in the Democratic People's Republic of Korea. In Sri Lanka, the percentage of cases due *P. falciparum* has fallen from 29% in 2000 to only 2% in 2010.

In 2010, 4.3 million malaria cases were reported, of which 2.4 million were parasitologically confirmed. Three countries accounted for 94% of confirmed cases: India (66%), Myanmar (18%) and Indonesia (10%). A total of 2426 malaria deaths were reported from eight countries, the great majority (93%) in India,

Indonesia and Myanmar. Both cases and deaths are substantially underreported (see **Section 7.9**), but these proportions are indicative of the geographical distribution of malaria in the Region.

Bhutan, the Democratic People's Republic of Korea, Nepal, Sri Lanka and Thailand reported marked downward trends in confirmed cases, which probably reflect real declines in malaria incidence. In these countries the number of cases reported annually fell by more than half between 2000 and 2010 (**Figs. D, E**). India has reported a slow but steady decline in case numbers over the past decade, falling by 28% between 2000 and 2010 (**Figs. D, F**), while continuing to examine more than 100 million blood slides each year (**Fig. C**). The remaining countries reported either little change (Indonesia) or increasing case numbers. Between 2000 and 2010, the increases were 70% in Bangladesh, 250% in Myanmar and 216% in Timor-Leste; in all three countries the change is associated with a large increase in the extent of diagnostic testing, making it difficult to discern the underlying trend in malaria incidence.

The five countries in which cases fell by more than half over the past decade (**Fig. E**) all distributed adequate supplies of antimalarial medicines (**Fig. H**). Bhutan, the Democratic People's Republic of Korea and Thailand all reported combined totals of IRS and ITN coverage of more than 50%. However, the scale of preventive interventions appears to be limited in Nepal. Two countries in the pre-elimination stage (the Democratic People's Republic of Korea and Sri Lanka) actively follow up all suspected cases and this is reflected in a high ABER for Sri Lanka. As in other Regions, deeper analyses are needed of the determinants of malaria trends in the South-East Asia Region, specifically the potential association with scale up of vector control and treatment of confirmed malaria with antimalarial medicines.

BOX 7.8

Maldives: an example of prevention of reintroduction in the South-East Asia Region

Malaria eradication in the Maldives was achieved through the elimination of anopheline mosquito vectors. Malaria in the Maldives was transmitted, perhaps uniquely, by two casual vectors, *An. tessellatus* and *An. subpictus,* in a fragile and unstable ecosystem lacking higher mammals, and thus totally dependent on human blood. Mosquitoes not killed by DDT were confined to forests. Their displacement away from human habitation effectively removed blood sources. Other inadvertent mosquito control measures were the withdrawal of waters from wells and the harvesting of forests near swamps, disturbing or removing larval breeding sites. All of these changes together led to the extinction of the two mosquito vector species from the islands. The last specimen of *An. subpictus* was reported in Maavaidhoo (Haa-Dhaal Atoll) in 1984 and *An. tessellatus* was last detected at Maamigili (Alif Atoll) in 1991. Since 2001, fewer than 10 imported malaria cases have been reported each year, mostly from neighbouring Bangladesh, India and Sri Lanka.

The Maldives has successfully prevented reintroduction, and thus maintained its malaria-free status since 1984,

for three main reasons: (i) full political commitment by the government and continuous support by WHO, (ii) entomological surveillance since 1991, and (iii) parasitological and clinical surveillance.

Entomological surveillance has been carried out regularly at points of entry, notably Male' International airport, Seenu Regional airport, the sea port at Male' and three other ports on Lhaviyani, Gaafu, Alifu and Seenu atolls. Regular larval surveys have covered more than 50% of all domestic wells, rainwater holding containers and cisterns, solid waste containers that hold rainwater, soakage pits, natural ponds, tree holes and swamps.

For parasitological and clinical surveillance, passengers arriving at an international airport from malarious areas, with or without malaria symptoms, have been asked to provide blood samples that are examined within 1–2 days. Confirmed malaria cases are given radical treatment and followed up. Prophylactic treatment is given to Maldivians who travel to malaria endemic countries, and public health campaigns on the islands maintain a high level of awareness of the threat of malaria.

Figure 7.8   South-East Asia Region

a) Population at risk, 2010

Legend: High risk, Low risk, Malaria free

Countries (top to bottom): Timor-Leste, India, Nepal, Bhutan, Myanmar, Thailand, DPR Korea, Indonesia, Bangladesh, Sri Lanka

b) Percentage of cases due to P. falciparum, 2006-2010

Countries (top to bottom): Bangladesh, Timor-Leste, Myanmar, Indonesia, Bhutan, India, Thailand, Nepal, Sri Lanka, DPR Korea

c) Annual blood examination rate, 2006–2010

Countries (top to bottom): Sri Lanka, Bhutan, India, Timor-Leste, Thailand, Indonesia, Myanmar, Bangladesh, Nepal, DPR Korea

d) Percentage decrease in admissions and deaths, 2000–2010

Y-axis: Decrease. Countries (left to right): Sri Lanka, Bhutan, DPR Korea, Thailand, Nepal, India, Indonesia, Bangladesh, Timor-Leste, Myanmar

e) Countries with > 50% decrease in confirmed cases, 2000–2010

Y-axis: Number of confirmed cases (logarithmic scale). Legend: Sri Lanka, Bhutan, DPR Korea, Thailand, Nepal

f) Countries with increase or < 50% decrease, 2000-2010

Y-axis: Number of confirmed cases (logarithmic scale). Legend: India, Indonesia, Bangladesh, Timor-Leste, Myanmar

g) Percentage of high risk population protected with IRS and ITNs, 2010

Legend: IRS, ITN. Countries (top to bottom): Bangladesh, Bhutan, DPR Korea, Timor-Leste, India, Indonesia, Myanmar, Nepal, Sri Lanka, Thailand. X-axis: Population protected

h) Percentage of cases potentially treated with antimalarial medicines, 2010

Legend: Any antimalarial, ACT. Countries (top to bottom): Bangladesh, Bhutan, DPR Korea, Timor-Leste, India, Indonesia, Myanmar, Nepal, Sri Lanka, Thailand. X-axis: Cases potentially treated

7.7 Western Pacific Region

Nine of the ten principal malaria-endemic countries in the Western Pacific Region report downward trends in malaria but in some high-burden countries, notably Papua New Guinea, the rate of decline is still slow.

Malaria transmission in the Region is highly heterogeneous. It is intense through most of Papua New Guinea, Solomon Islands and Vanuatu. It is highly focal in the countries and areas of the Greater Mekong subregion, including Cambodia, Yunnan province (China), Lao People's Democratic Republic and Viet Nam, where transmission is most intense in remote forested areas and where the disease disproportionately affects ethnic minorities and migrants. Malaria is also restricted in distribution in Malaysia, the Philippines and the Republic of Korea. Of the Region's principal malaria-endemic countries, only the Republic of Korea has no high-risk areas of significant size.

Most countries have transmission cycles of both *P. falciparum* and *P. vivax,* but transmission is entirely due to *P. vivax* in the Republic of Korea and in central areas of China (**Fig. B**).

Approximately 262 000 confirmed malaria cases were reported from the Region in 2010. Three countries accounted for 70% of these cases: Papua New Guinea (36%), Cambodia, (19%) and Solomon Islands (15%).

In China, Philippines, Republic of Korea, and Viet Nam, the reported trends in confirmed cases were predominantly downwards, and the numbers of cases more than halved between 2000 and 2010, although numbers for the Republic of Korea showed wide fluctuations (**Figs. D, E**). In the remaining six countries, case numbers were falling more slowly (Cambodia, Lao People's Democratic Republic, Malaysia, Solomon Islands, Vanuatu), or were approximately stable (Papua New Guinea) (**Figs. D, F**). Increased use of RDTs by village health workers in Lao People's Democratic Republic, and increased reporting by private sector health facilities, probably contributed to the slower reported rates of decline.

Malaria interventions are implemented widely in the Western Pacific Region, both vector control and enhanced case management. However, the intensity of control varies among countries and the links between interventions and malaria trends in routinely collected data are imprecise. Two of the countries with large declines in malaria (China and Philippines) also reported a high coverage of either ITNs or IRS in 2010, but Viet Nam did not (**Fig. G**). Bednets have been widely used in Viet Nam, but most are not impregnated with insecticide and so ITN coverage is low (<10%); a household survey in Viet Nam (MICS 2006), found that only 19% of people sleep under an ITN. The proportion of people protected by ITNs is also low in Cambodia (5% in DHS 2005). The Republic of Korea reported almost no vector control activity in 2010.

Malaysia, Solomon Islands and Vanuatu have high diagnostic examination rates (ABER) (**Fig. C**), whereas ABER in the other countries is much lower. Antimalarial medicines were widely available in all ten countries (**Fig. H**). However, over the period 2006–2010 there were inadequate supplies of ACTs in two important *P. falciparum*-endemic countries, Papua New Guinea and Malaysia.

BOX 7.9
Increasing public health awareness of *Plasmodium knowlesi*

P. knowlesi is a malaria parasite of monkeys; it can also infect humans and is capable of producing severe illness with a high case fatality rate. *P. knowlesi* has been known as a human pathogen since early 1930s when thousands of people were deliberately infected with the parasite during the treatment of tertiary syphilis.

The first reported case of natural human infection with P. knowlesi was acquired in peninsular Malaysia in 1965, and since then other countries in South-East Asia have reported cases. Its importance as a public health problem is increasing although it is limited to population groups who live, work in, or visit forested areas. At highest risk are farmers, hunters, logging camp workers, army personnel and travellers.

The principal mosquito vectors are species of the *Anopheles leucosphyrus* group, found throughout the South-East Asian Region. The natural reservoir hosts and source of human infections in Sarawak (Malaysia) are the long-tailed macaque (Macaca fascicularis) and pig-tailed macaque (M. nemestrina). In peninsular Malaysia the banded leaf monkey (Presbytis melalophus) has been identified as a natural host.

Definite diagnosis of *P. knowlesi* by microscopy is difficult because it can be confused with P. malariae. PCR is currently the only definitive, validated diagnostic method. Genetic characterization of human blood samples taken in 1996 in an endemic area of Thailand revealed that P. knowlesi accounted for 0.67% of all malaria cases. Two cases of P. knowlesi infection in humans were identified in Cambodia by molecular detection assays and sequencing, and the first three cases in Viet Nam were detected by a survey in Ninh Thuan province during 2004. In 2008, five cases of P. knowlesi in humans were reported from Palawan, Philippines. In a study carried out in 12 hospitals in Sarawak, Malaysia during 2001–2006, *P. knowlesi* was identified by PCR in 266/960 (28%) of blood samples from malaria patients. Similarly, a hospital-based study in Kota Kinabalu, Sabah, Malaysia, found that *P. knowlesi* accounted for 24% (78/324) of all cases, with a case fatality rate of 11% of all cases and 28% of all severe cases.

In view of the public health importance of *P. knowlesi*, the WHO Regional Office for the Western Pacific presented a new set of recommendations for control in 2011 (15), summarized as follows:- (i) Provide personal protection measures (ITNs, protective clothing, repellents) and/or chemoprophylaxis together with health promotion for populations at risk. (ii) Countries which are close to elimination should be vigilant for P. knowlesi and develop strategies for prevention and control. (iii) Surveillance should be continued to investigate possible transmission of P. knowlesi from human to human without an intermediate host (iv) A new generation of rapid diagnostic tests is needed for P. knowlesi. (v) Funds should be mobilized to carry out further research in settings where human cases of P. knowlesi have been reported.
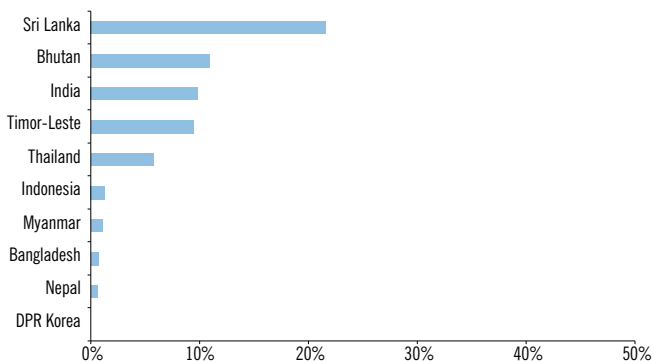
Figure 7.9   Western Pacific Region
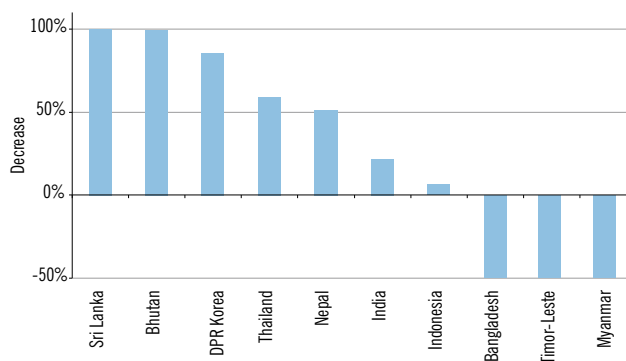

a) Population at risk, 2010
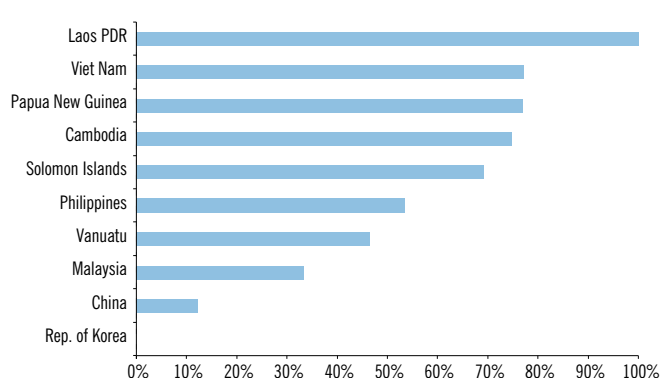
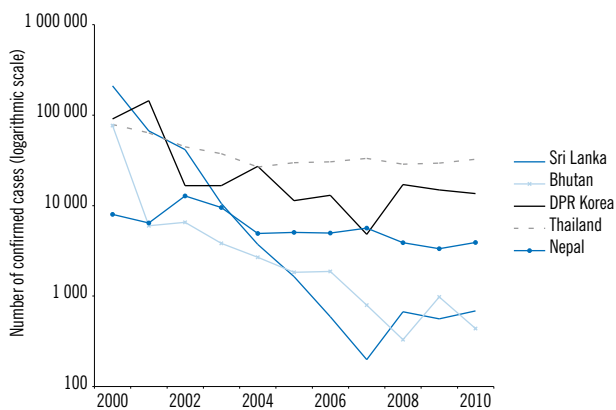b) Percentage of cases due to P. falciparum, 2006-2010

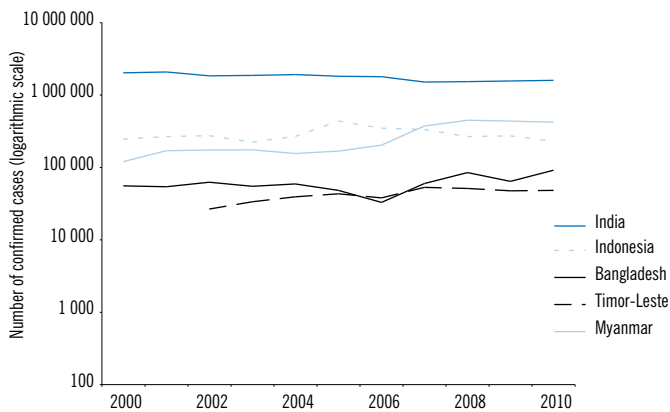c) Annual blood examination rate, 2006–2010
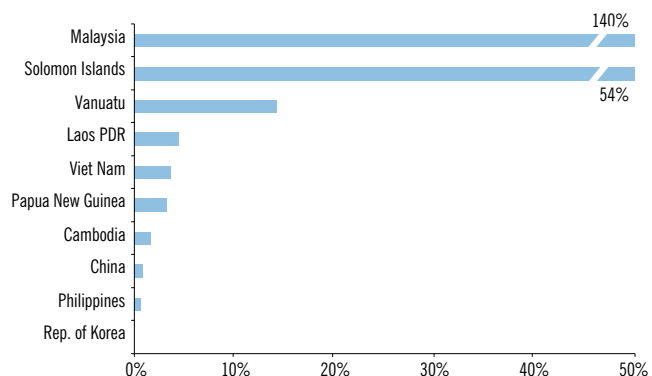
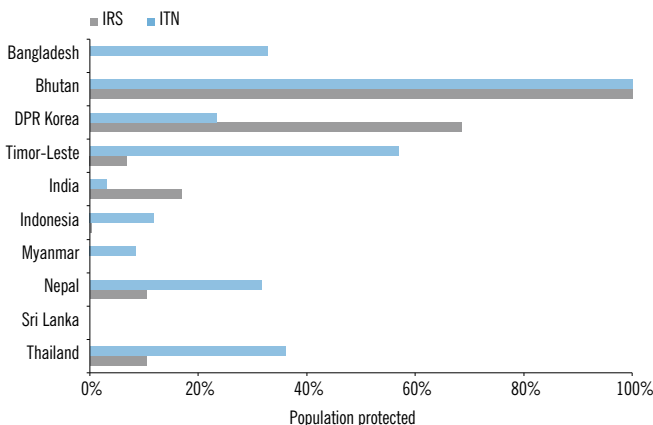d) Percentage decrease in admissions and deaths, 2000–2010
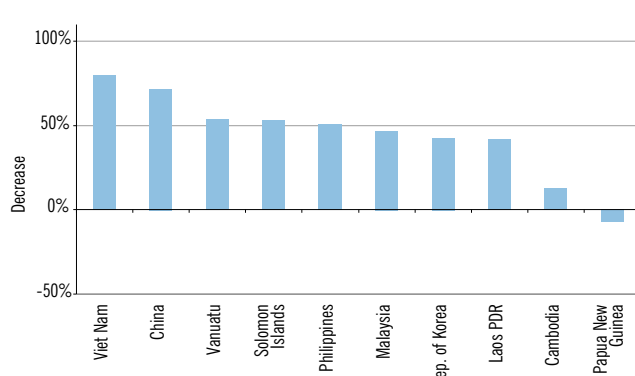
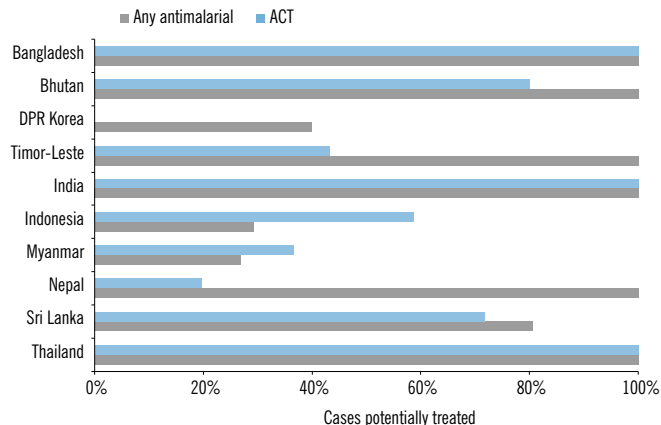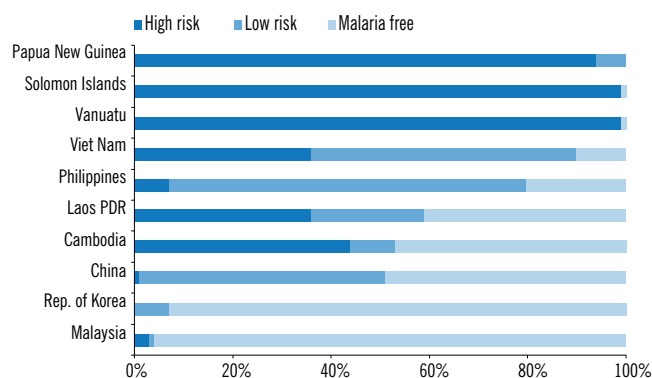e) Countries with > 50% decrease in confirmed cases, 2000–2010

f) Countries with increase or < 50% decrease, 2000-2010
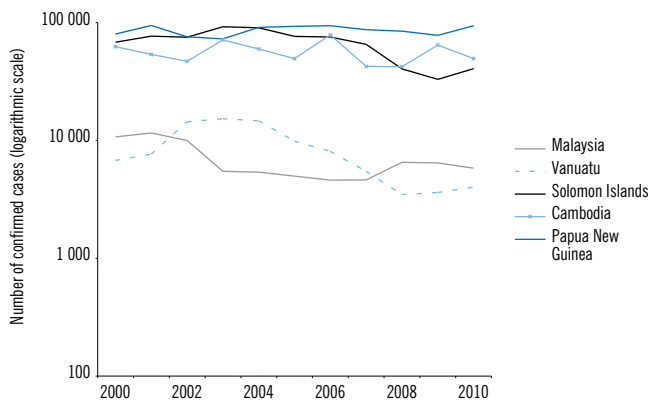
g) Percentage of high risk population protected with IRS and ITNs, 2010
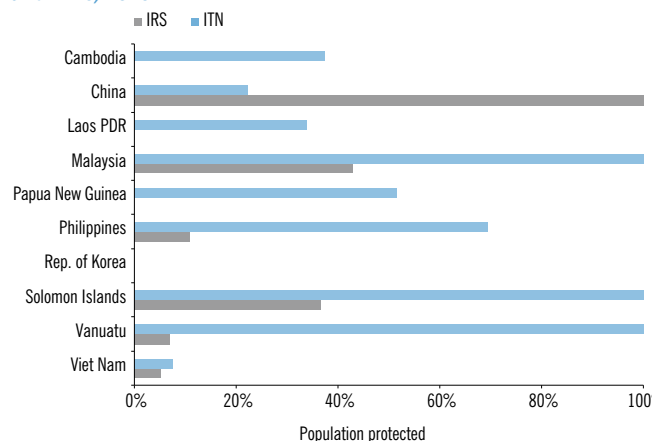
h) Percentage of cases potentially treated with antimalarial medicines, 2010
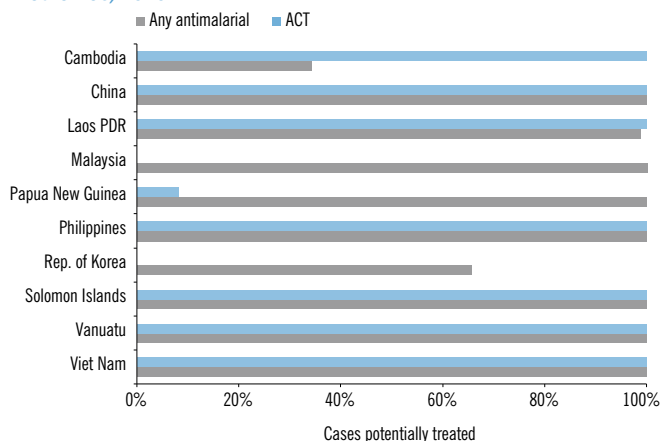
7.8. Malaria elimination

Table 7.1 shows the countries in the pre-elimination, elimination and prevention of reintroduction stages as of 1 December 2011. Several countries are preparing to move between categories, entering **Table 7.1** from the left, and moving to the right. The ultimate goal of all malaria affected countries is to be certified malaria-free, which requires that no local mosquito-borne transmission has taken place for at least three consecutive years. To achieve certification, the distinction must be made between imported cases (see **Section 7.8**) and those that arise from local transmission.

Table 7.1 contains just two representatives from the African Region: Algeria which is in the elimination stage and Cape Verde which entered the pre-elimination stage in 2010, and secured a grant from the Global Fund to aid programme transition.

In the Region of the Americas, falciparum malaria outbreaks in the Bahamas and Jamaica that began in 2006 were under control by 2010. Bahamas reported zero locally-acquired cases in 2009 and 2010, as did Jamaica in 2010. Both countries are well prepared for the prevention and management of possible future outbreaks. Argentina, El Salvador, Mexico and Paraguay, in the pre-elimination stage, have reported few malaria cases (mostly *P. vivax*) in recent years.

The European Region is aiming for complete elimination of malaria by 2015. *P. falciparum* transmission has already been eliminated from the Region, with the last cases reported in Tajikistan in 2008. Georgia reported zero locally-acquired cases in 2010, and has moved to the prevention of reintroduction stage. Only Azerbaijan (50 cases in 2010), Tajikistan (111 cases) and Turkey (9 cases) still report local *P. vivax* malaria transmission. Elsewhere, sporadic cases were reported from Kyrgyzstan (3 cases), the Russian Federation (1 case) and Uzbekistan (3 cases). The latter two countries reported no local transmission in 2009 or 2010. The Russian Federation reported one case arising from local transmission in 2010. In Uzbekistan, transmission persists in a few remaining foci.

Among countries in the Eastern Mediterranean Region, Egypt (malaria-free) reported its last malaria cases (*P. falciparum* and *P. vivax*) in 1997 in the El Faiyûm agricultural area. Iraq reported no cases arising from local transmission in 2009 and 2010, and has moved to prevention of reintroduction. Iran moved to the elimination stage in 2010, and adopted a nation-wide elimination strategy in that year.

Many hundreds of malaria cases were imported into Oman in 2009 (898 reported), and outbreaks of both *P. falciparum* and *P. vivax* were reported in the North Sharqiya region of the country in 2010. Saudi Arabia (elimination stage) also records many imported cases of malaria (1912 in 2010, including *P. falciparum*) with local outbreaks, though the number of cases is falling each year.

In the South-East Asia Region, the Democratic People's Republic of Korea and Sri Lanka are in the pre-elimination stage while Bhutan and Nepal were finalizing pre-elimination strategies in 2010, and will shortly begin transition from the control stage.

In the Western Pacific Region, Malaysia is moving towards the elimination stage. The Republic of Korea, currently in the elimination stage, reported 1745 locally-acquired *P. vivax* malaria infections in 2010 with 27 imported cases.

Morocco and Turkmenistan were certified as Malaria-free in 2010. Armenia reported its last indigenous case in 2005 and achieved certification in 2011. These countries, with United Arab Emirates, give a total of four countries that have been certified malaria-free since 2007.

7.9   Imported malaria, 2001–2010

Imported malaria refers to infections acquired outside and brought into a national territory. The character of imported malaria and the problems it poses for countries in the prevention of reintroduction and malaria-free stages has changed over the period 2001–2010. Factors influencing the change include the reduction of malaria incidence in tourist destinations, an increase in the number of countries recently classified as malaria-free, and new patterns of travel and international migration.

Prior to year 2000, the importation of malaria into non-endemic countries as "traveller's malaria" was primarily a matter for foreign tourists returning home after visiting endemic areas. Since 2000, the problem has grown and changed in at least four ways: (i) in non-endemic countries with large and relatively affluent immigrant populations (e.g. countries in North America and Western Europe), immigrants returning home to endemic areas to visit friends and relatives have become a high-risk group among travellers; (ii) non-endemic countries take refugees from malaria-endemic areas; (iii) malaria cases are imported with returning members of national armed forces and UN peacekeeping forces; and (iv) malaria infections are often brought into countries by temporary migrant workers.

Imported malaria was reported by 91 countries between 2001 and 2010; the largest total numbers of cases were in the United States of America (12 701) in the Region of the Americas, the United Arab Emirates (20 452) in the Eastern Mediterranean Region, France (48 580) and the United Kingdom (17 063) in the European Region, and Australia (3355) in the Western Pacific Region. Between 2001 and 2010, 45 countries in the European Region reported a striking and consistent decline in imported malaria cases and deaths, for reasons that have not yet been investigated (**Annex Tables 8A** and **8B, Figure 7.10**).

Critical for malaria control is whether imported cases lead to local outbreaks of malaria, transmitted by indigenous anopheline mosquitoes. The risk can be high, for example when temporary agricultural workers infected with malaria are recruited for harvesting during the malaria transmission season. However, while malaria outbreaks are commonly documented, they are less frequently investigated to understand the precise circumstances of the outbreak and to identify the local vectors.

In the European Region, local transmission from imported cases has been reported in France (2006, 2008–2010), Greece (2009–2010), Italy (2007), the Republic of Moldova (2003), Spain (2010) and Ukraine (2003). In all these instances, local outbreaks were limited to fewer than 10 cases.

In the Region of the Americas, the United States of America reported an outbreak of eight cases of *P. vivax* in Palm Beach County, Florida, in 2003, probably originating from a single infected person. Immigration was the cause of a large outbreak of *P. falciparum* malaria that occurred in Jamaica between September 2006 and December 2009, in which there were 406

TABLE 7.1

Classification of countries in the Pre-elimination, Elimination, Prevention of Reintroduction and Malaria-free stages, as of 1 December 2011

WHO Region	Pre-elimination	Elimination	Prevention of reintroduction	Certified malaria-free within last 5 years, or no local transmission reported for over a decade
Africa	Cape Verde	Algeria		
Americas	Argentina		Bahamas[1]	
	El Salvador		Jamaica[1]	
	Mexico			
	Paraguay			
Eastern Mediterranean	→	Iran	→ Egypt	Morocco
		Saudi Arabia	Iraq[2]	Turkmenistan
			Oman[1]	United Arab Emirates
			Syrian Arab Republic	
Europe		Azerbaijan	→ Georgia[2]	→ Armenia
		Kyrgyzstan	Russian Federation[1]	
		Tajikistan		
		Turkey		
		Uzbekistan		
South East Asia	DPR Korea			
	Sri Lanka			
Western Pacifc	Malaysia	Republic of Korea		
Typical additional programme activities and considerations in different phases of elimination (Footnote)				
Malaria situation	SPR < 5%[3] among suspected malaria patients throughout the year; a "manageable number" of cases	1 per 1000 population at risk[3]	Zero (or only very sporadic cases of) local transmission in recent years	
Programme goal	Programme reorientation from control towards elimination approach	Halt local transmission nation-wide	Prevent re-establishment of local transmission	
Case management	All malaria cases are microscopically confirmed, covering public and private sector Microscopy quality-assurance systems are put in place	Radical treatment of *P. vivax*; ACT plus gametocytocidal treatment for *P.falciparum* Routine QA/QC expert microscopic diagnosis	Case management of imported malaria	
Vector control and malaria prevention	Total IRS coverage in foci; IVM and LLIN as complementary measures in specific situations	Vector control to reduce receptivity in recent foci	Cluster response; and prevention in travelers	
Surveillance, monitoring and evaluation	All malaria cases are immediately notified GIS-based database for cases, vectors and foci Elimination database initiated	Active case detection cases and foci investigation and classification Collect documentation for eventual certification	Vigilance by the general health services Case investigation of imported cases; and response to introduced cases Certification process	
Health systems and financing	Mobilization of domestic resources	Largely reliant on domestic resources	Integration of malaria programme into other health and vector control programmes; maintance of a central nucleus of malaria expertise	

Arrows indicate movement of countries between categories in the interval 2010 to 2011. For further details of categores please refer to WHO 2007 Elimination Field manual.
1 Recently achieved zero locally acquired cases
2 Recent outbreaks after imported cases
3 These thresholds are indicative: in practice they will depend on the number of malaria cases that a programme can manage (including case notification, case investigations, etc.)

Transmission of malaria in Mauritius was interrupted in 1969 and the country certified by WHO as malaria-free in 1973. However, in 1975 an outbreak of 41 *P. vivax* cases was reported in a community of migrant workers. The outbreak resulted in a further 627 cases and continued sporadic local malaria transmission for the next 23 years. Many factors may have contributed to this resurgence. Of particular note is a four-fold increase in the number of new arrivals in Mauritius between 1968 and 1975, mainly from malaria-endemic areas of sub-Saharan Africa and India, as well as a relaxation of case detection activities.

A second effort to eliminate malaria succeeded in 1998 through the use of IRS focally, widespread larviciding, surveillance of passengers arriving in Mauritius, and a thorough case response system. Mauritius remains susceptible to outbreaks as there is continual importation of parasites and an efficient vector, *An. arabiensi*s. For this reason, the country invests significant resources to prevent the reintroduction of malaria, including larviciding in areas receptive for malaria transmission and IRS at ports of entry. It also maintains a passenger screening programme which was initiated in the 1960s. Health surveillance

officers take blood slides from all febrile passengers on entry and passengers that have a recent history of being in a malaria-endemic country are followed through home visits or telephone calls for up to six weeks. Each year, an average of 175 000 passengers are followed up; approximately 79% of passengers are contacted at least once and 38% followed for the full 42-day surveillance period. About 21% of passengers leave the country prior to contact or are not traceable.

From 2005 to 2008, on average 36 imported cases were reported annually. Of these cases, 47% were identified through passive case detection in public and private clinics, 27% from further investigation of cases detected by health services, and 26% from the passenger screening programme.

The prevention of malaria reintroduction currently costs an average of US$ 2.06 per capita per year; of these costs, 35% are dedicated to the passenger screening programme. The government of Mauritius is the primary source of funds for these activities.

From: Tatarsky A, et al. Preventing the Reintroduction of Malaria in Mauritius: A Programmatic and Financial Assessment. 2011, *PLoS ONE* 6(9): e23832.

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confirmed cases. In the Bahamas, 19 *P. falciparum* cases were identified on the island of Great Exuma between May and June 2006, apparently brought to the island by Haitian immigrants. These outbreaks in the Americas were contained by a swift reaction from public health authorities.

Figure 7.10 Reported number of imported malaria cases to malaria free countries
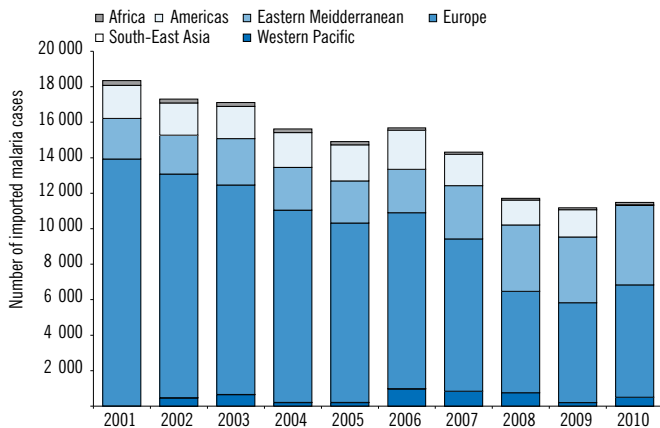
Source: WHO regional offices

In other parts of the world: three cases arising from local *P. falciparum* transmission were reported in Singapore in 2003; Oman, which interrupted transmission in 2004, has experienced several subsequent outbreaks of *P. vivax and P. falciparum* brought in by migrant workers from the Indian subcontinent; and Morocco, certified malaria-free in 2007, recorded two cases of "airport malaria" in 2009.

Other countries which eliminated malaria many years ago, including the Maldives, Mauritius and Tunisia, continue to invest effort in preventing the reintroduction of malaria. For the growing

number of countries progressing to the prevention of reintroduction and malaria-free stages, the nature of malaria control will change, moving towards outbreak preparedness, surveillance and rapid response, and studies of malaria risk and receptivity.

7.10 Global estimates of malaria cases and deaths 2000-2009

Methods

The number of malaria cases in 2010 was estimated by the following methods:

(i) Countries outside the WHO African Region and low transmission countries in Africa.[1] Estimates of the number of cases were made by adjusting the number of reported malaria cases for completeness of reporting, the likelihood that cases are parasite-positive, and the extent of health service use. The procedure, which is described in the *World Malaria Report 2008 (16, 17),* combines data reported by NMCPs (reported cases, reporting completeness, likelihood that cases are parasite-positive) with those obtained from nationally representative household surveys on health service use. If data from more than one household survey was available for a country, estimates of health service use for intervening years were imputed by linear regression. If only one household survey was available, health service use was assumed to remain constant over time; analysis summarized in the *World Malaria Report 2008* indicated that in countries with multiple surveys the percentage of fever cases treated in public sector facilities varies little over time. This procedure results in an estimate with wide uncertainty intervals around the point estimate.

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[1] Botswana, Cape Verde, Eritrea, Madagascar, Namibia, Swaziland, South Africa, and Zimbabwe

(ii) Other countries in the WHO African Region. For some African countries the quality of surveillance data did not allow a convincing estimate to be made from the number of reported cases. For these countries, an estimate of the number of malaria cases was derived from an estimate of the number of people living at high, low or no risk of malaria. Malaria incidence rates for these populations are inferred from longitudinal studies of malaria incidence recorded in the published literature. Incidence rates are adjusted downward for populations living in urban settings and the expected impact of ITN and IRS programmes. The procedure was initially developed by the RBM Monitoring and Evaluation Reference Group in 2004 *(18)* and also described in *World Malaria Report 2008 (16, 17).*

The number of malaria deaths was estimated as follows:

(i) Countries outside the WHO African Region and low transmission countries in Africa[1]. The number of deaths was estimated by multiplying the estimated number of *P. falciparum* malaria cases by a fixed case fatality rate for each country as described in the *World Malaria Report 2008 (16).* This method is used for all countries outside the African Region and for countries within the African Region where estimates of case incidence were derived from routine reporting systems and where malaria causes less than 5% of all deaths in children under 5 as described in the Global Burden of Disease 2004 update *(19).* A case fatality rate (CFR) of 0·45% is applied to the estimated number of *P. falciparum* cases for countries in the African Region and a CFR of 0·3% for *P. falciparum* cases in other Regions. In situations where the fraction of all deaths due to malaria is small, the use of a CFR in conjunction with estimates of case incidence was considered to provide a better guide to the levels of malaria mortality than attempts to estimate the fraction of deaths due to malaria.

(ii) Other countries in the WHO African Region, and Somalia and Sudan in the Eastern Mediterranean Region. Child malaria deaths were estimated using a verbal autopsy multi-cause model (VAMCM) developed by the WHO Child Health Epidemiology Reference Group (CHERG) to estimate causes of death for children aged 1–59 months in countries with less than 80% of vital registration coverage. The VAMCM is a revised model based on work described elsewhere *(20, 21).* The VAMCM derives mortality estimates for malaria, as well as 7 other causes (pneumonia, diarrhea, congenital malformation, other neonatal causes, injury, meningitis, and other causes) using multinomial logistic regression methods to ensure that all 9 causes are estimated simultaneously with the total cause fraction summing to 1. The regression model is first constructed using the study-level data and then populated with year 2000–2010 country-level input data to provide time-series estimates of causes of death in children aged 1–59 months. Deaths were retrospectively adjusted for coverage of ITNs and use of *Haemophilus influenzae* type b vaccine. The bootstrap method was employed to estimate uncertainty intervals by re-sampling from the study-level data to estimate the distribution of the predicted percent of deaths due to each cause.

Disease burden and trends

Cases: In 2010 there were an estimated 216 million cases of malaria (5th–95th centiles, 149–274 million) worldwide (see Table 7.2), of which 91% were due to *P.falciparum*. The vast majority of cases (81%) were in the African Region followed by the South-East Asia (13%) and Eastern Mediterranean Regions (5%). The number of confirmed cases reported by NMCPs was only 11% of the estimated number of cases. The gap between

case reports and estimated incidence was largest in the South-East Asia Region, and smallest in the American and European Regions.

The estimated number of malaria cases per 1000 persons at risk of malaria, which takes into account population growth over time, shows a reduction in case incidence of 17% globally between 2000 and 2010. Declines in cases incidence are seen in every Region but are greatest in the European (100%), American (60%) and Western Pacific Regions (38%).

Deaths: There were an estimated 655 000 malaria deaths worldwide in 2010. It is estimated that 91% of deaths in 2010 were in the African Region, followed by the South-East Asia (6%) and Eastern Mediterranean Regions (3%). About 86% of deaths globally were in children under 5 years of age.

Figure 7.11   Estimated trends in malaria case per 1 000 persons at risk by WHO Region, 2000–2010
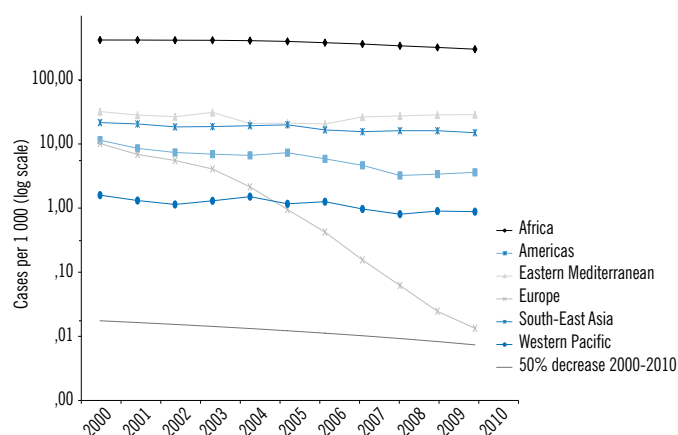
Source: WHO. Rates are plotted on a logarithmic scale. A line representing the slope required to achieve a 50% reduction between 2000 and 2010 is shown to aid interpretation.

Figure 7.12   Estimated trends in malaria deaths per 100 000 persons at risk by WHO Region, 2000–2010
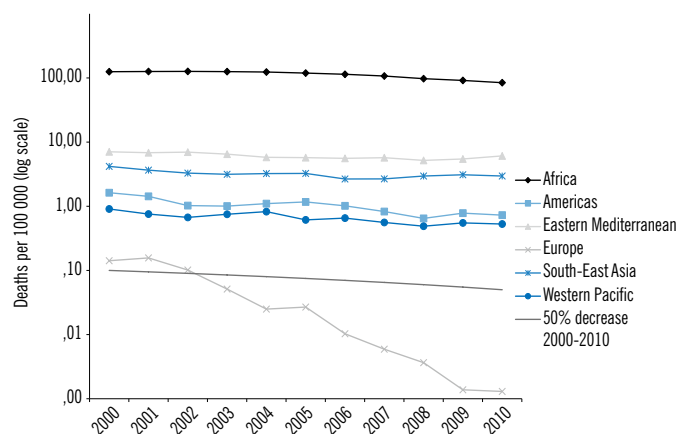
Source: WHO. Rates are plotted on a logarithmic scale. A line representing the slope required to achieve a 50% reduction between 2000 and 2010 is shown to aid interpretation.

The total number of deaths is substantially lower than that presented in the *World Malaria Report 2010*, 781 000 deaths, partly because of a downward revision to estimates of the total number of child deaths occurring globally made by the UN Inter-agency Group for Child Mortality Estimation *(22).* This revision reduced the estimates of malaria deaths in the WHO African Region by approximately 11%. Thus, of the difference (113 000)

TABLE 7.2.

Estimates of malaria cases and deaths by WHO Region, 2010

Region	Estimated cases ('000s)			% *P. falciparum*	Confirmed cases reported	Reported/estimated
	Estimate	Lower	Upper			
Africa	174 000	113 000	239 000	98%	20 000	11%
Americas	1 000	1 000	1 000	34%	1 000	59%
Eastern Mediterranean	10 000	8 000	14 000	82%	1 000	10%
Europe	0.2	0.2	0.2	5%	0.2	85%
South-East Asia	28 000	23 000	35 000	54%	2 000	9%
Western Pacific	2 000	2 000	2 000	77%	257	13%
World	216 000	149 000	274 000	91%	24 000	11%

Region	Estimated deaths			% <5
	Estimate	Lower	Upper	
Africa	596 000	468 000	837 000	91%
Americas	1 000	1 000	2 000	29%
Eastern Mediterranean	15 000	1 000	38 000	60%
Europe	0	0	0	4%
South-East Asia	38 000	28 000	50 000	31%
Western Pacific	5 000	3 000	6 000	41%
World	655 000	537 000	907 000	86%

between the total number of deaths estimated for the African Region in 2010 (709 000), and the estimated deaths in 2011 for 2010 (596 000), approximately 78 000 of the decrease is due to methodological changes while approximately 35 000 is due to a real decrease in the number of malaria deaths. This decrease can be attributed, at least in part, to improved malaria control.

The estimated number of malaria deaths per 100 000 persons at risk of malaria shows a reduction in malaria mortality rates of 26% globally between 2000 and 2010 (**Fig. 7.y**). The largest percentage decreases in malaria mortality rates were seen in the European (99%), American (55%), Western Pacific Regions (42%) and African Regions (33%).

7.11 Conclusions

7.11.1 Malaria in the African Region

The majority of the world's malaria cases and deaths occur in the African Region, but malaria burden and trends, and the success of control measures, appear to vary greatly across the continent (**Table 7.3**).

The 'E8 initiative', launched by eight southern African countries, has set the ambitious goal of eliminating malaria by 2020. Between 2000 and 2008 there were steep declines in malaria cases in Botswana, Namibia, South Africa and Swaziland, indicating progress in this direction. Beyond the southern tip of Africa, the biggest reductions in malaria cases and deaths since 2000 have been on islands and in small countries with intensive control programmes. The islands are Sao Tome and Principe, Bouaké (Equatorial Guinea), Cape Verde and Zanzibar (United Republic of Tanzania). The best-performing small countries are Eritrea, Rwanda and Senegal. Malaria also appears to be in decline in Ethiopia and Zambia which have greatly increased ITN and IRS coverage and expanded programmes for diagnostic testing and treatment of

malaria. In each of these countries, the number of cases reported annually fell by at least a quarter and, in some instances, by more than a half, between 2000 and 2010 (**Table 7.1**).

While substantial decreases in the numbers of malaria cases are observed in countries that have well developed surveillance systems, it is much more difficult to detect see such changes in countries where surveillance systems are weaker, particularly in the more populous countries of central and west Africa. The reasons are twofold:- (i) Most fever episodes have, until recently, been treated presumptively as malaria without diagnostic confirmation. With the expanding use of microscopy and RDTs, including in Burkina Faso, Democratic Republic of Congo and Nigeria, the numbers of confirmed cases has risen steadily, reflecting changes in diagnostic practice and concealing the underlying trends in malaria incidence. (ii) Because consistent information on confirmed cases may not be available, malaria trends have to be assessed from data on hospital admissions. While the predictive value of a malaria diagnosis for an admitted patient is considered to be higher than for an outpatient diagnosis based only on clinical signs and symptoms, many admissions may not be confirmed parasitologically and there may be uncertainty over whether malaria is being reported accurately; non-malarial admissions are not likely to respond to malaria therapy.

The implications for monitoring and evaluation in the African Region are clear: a better understanding of malaria trends and their causes requires improvements in routine national surveillance, with close monitoring of confirmed cases, medical certification of causes of death, and the documentation of intervention type and coverage on small spatial and temporal scales.

7.11.2 Malaria in other WHO Regions

Malaria outside Africa is caused by a variable mix of *P. falciparum*, *P. vivax* and other *Plasmodium* species, transmitted by a diversity of *Anopheles* vectors. The approach to vector control

TABLE 7.3

Decrease in cases, >50%	Decrease in cases, 25-50%	Change in cases, <25%	Increase in cases, >25%	Insufficient data
AFRICAN REGION				
Algeria Botswana Cape Verde Namibia Rwanda Sao Tome and Principe South Africa Swaziland	Ethiopia Senegal Eritrea Zambia	Gambia* Madagascar		Angola Benin Burkina Faso+ Burundi+ Cameroon Central African Republic Chad Congo Côte d'Ivoire Dem. Rep. of the Congo+ Equatorial Guinea* Gabon Ghana Guinea Guinea-Bissau Kenya* Liberia+ Malawi Mali Mauritania Mozambique Niger Nigeria Sierra Leone+ Togo+ Uganda+ United Republic of Tanzania* Zimbabwe+
REGION OF THE AMERICAS				
Argentina Belize Bolivia (Plurinational State) Costa Rica Ecuador El Salvador French Guiana Guatemala Honduras Mexico Nicaragua Panama Paraguay Peru Suriname	Brazil	Colombia Guyana	Dominican Republic Venezuela (Bolivarian Republic)	Haiti+
EASTERN MEDITERRANEAN REGION				
Afghanistan Iran (Islamic Republic) Iraq Saudi Arabia				Djibouti Pakistan* Somalia Sudan* Yemen*
EUROPEAN REGION				
Azerbaijan Georgia Kyrgyzstan Tajikistan Turkey Uzbekistan				
SOUTH-EAST ASIA REGION				
Bhutan Democratic People's Republic of Korea Nepal Sri Lanka Thailand		India		Bangladesh+ Timor-Leste Indonesia Myanmar+
WESTERN PACIFIC REGION				
China Philippines Republic of Korea Solomon Islands Viet Nam	Lao People's Democratic Republic Malaysia Vanuatu	Cambodia* Papua New Guinea		

Source: NMCP data.
* Progress in reducing cases by >50% has been reported sub-nationally where intervetniosn have been intensified
+ Country has recently expanded diagnostic testing, so assessment of trends is made difficult

and case management, and the predicted impact of control, are determined in each setting by the local combination of parasites and vectors.

Routine surveillance outside Africa does not capture all malaria cases, but the consistency of annual reporting means that time trends in confirmed cases probably reflect, to a good approximation, underlying trends in malaria incidence in most countries. As in the African Region, these trends are determined by multiple factors.

And, as in Africa, the challenge is to disentangle the effects of specific interventions from those of other determinants.

Against that biological background, all five Regions other than Africa offer striking examples of malaria in decline (**Table 7.3, Figure 7.12**). But in some Regions, and in some individual countries, the downward trends are more conspicuous than in others.

In the South-East Asia Region, malaria is clearly declining in the smaller countries but the burden appears persistently high in the

Figure 7.12   Total confirmed cases reported in five WHO Regions, and one subregion of southern Africa, 2000–2010
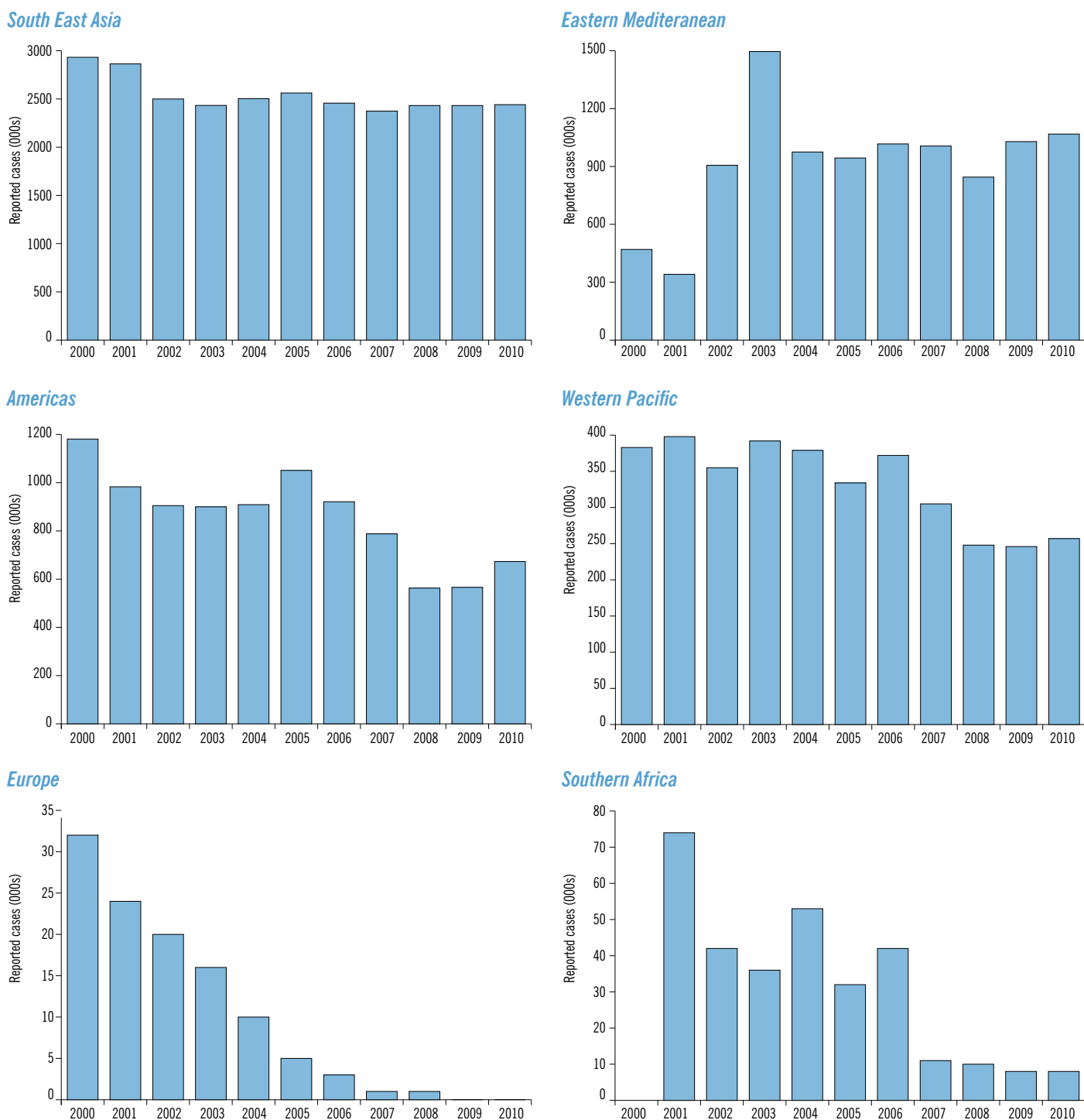
Source: NMCP data. The southern Africa group includes Botswana, Namibia, South Africa and Swaziland. South-East Asia reported the largest number of cases, and the slowest rate of decline. The Region of the Americas and Western Pacific Region have fewer cases with faster rates of decline, but malaria is in steepest decline in the European Region and the four southern African countries.

major endemic centres, which are Bangladesh, India, Indonesia and Myanmar. These large countries dominate the regional trend.

The Eastern Mediterranean Region is characterised by enormous heterogeneity in malaria burden and trends, and inconsistent reporting from the largest countries. The North African countries and United Arab Emirates are already free of malaria. Afghanistan, Islamic Republic of Iran, Iraq and Saudi Arabia have reported sharp declines in malaria over the past decade. But Pakistan, Somalia, Sudan and Yemen have persistently high burdens of disease.

Malaria is declining in most parts of the Region of the Americas, but comparatively slowly, if at all, in the high-burden countries Brazil and Colombia. The most impressive rates of decline have been reported in Costa Rica, Ecuador, El Salvador, Nicaragua, Paraguay and Suriname, while malaria incidence appears to be increasing in the Dominican Republic and possibly in Haiti.

Nine of the ten principal malaria-endemic countries in the Western Pacific Region have reported downward trends in malaria but in some high-burden countries, especially Cambodia and Papua New Guinea, the rate of decline is still very slow.

The European Region could be the first to eliminate malaria in the next few years. Almost all remaining malaria cases in 2010 were reported from just two countries, Azerbaijan and Tajikistan and case numbers are continuing to fall in both countries.

Cross-country comparisons of routine surveillance data are a weak instrument for assessing the effects of malaria control, but specific studies in selected countries have provided some good examples of the link between intervention and impact. These examples include Nicaragua in the Americas, Saudi Arabia in the Eastern Mediterranean Region, and Tajikistan in the European Region. It is very likely that the downward trends in other countries can be explained, at least in part, by recent improvements in vector control and case management. Further detailed studies, retrospective and prospective, are needed to document exactly where and by how much these measures are having an impact.

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