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.

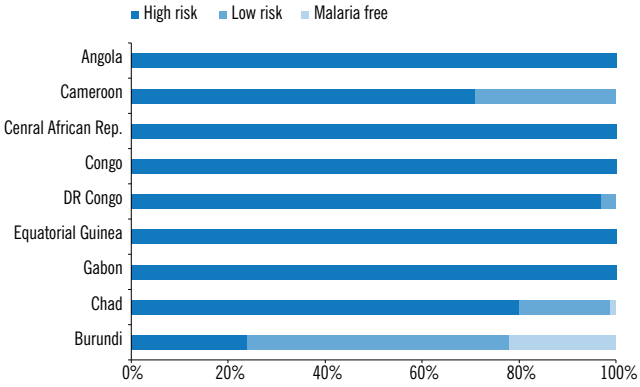
D–F. Trends in the numbers of reported cases: Figure D shows the percentage reductions in numbers of confirmed cases between 2000 and 2010 (fewer cases, upward bars; more cases, downward bars). For countries in the African Region (except Algeria, Cape Verde, Sao Tome and Principe, and five countries 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.

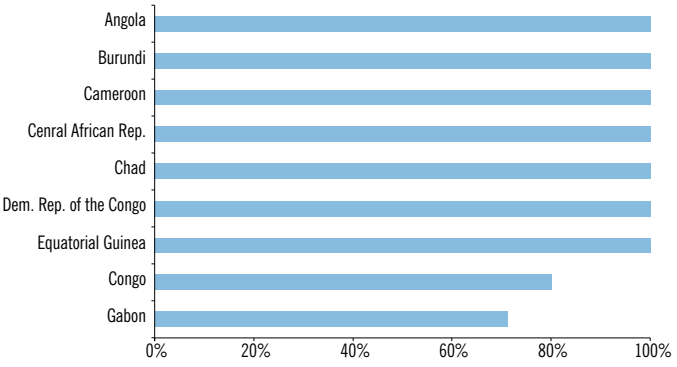
H. Cases potentially treated with antimalarial drugs. The number of treatment courses available is shown as a percentage of malaria cases reported (correcting for reporting completeness in the public sector). The bars for any antimalarial treatment indicate whether an adequate number of treatment courses 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

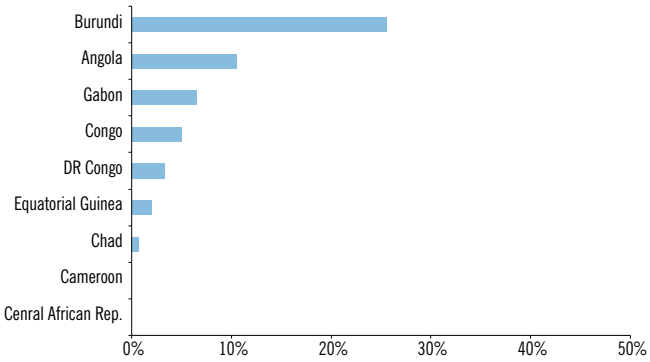
a) Population at risk, 2010



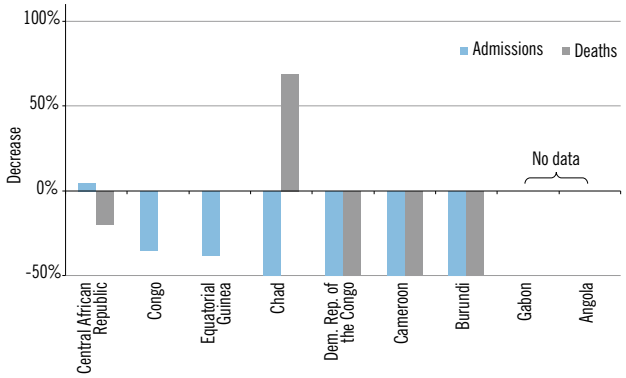
b) Percentage of cases due to P. falciparum, 2006-2010



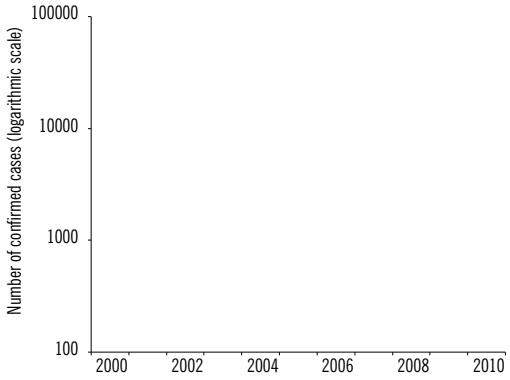
c) Annual blood examination rate, 2006–2010



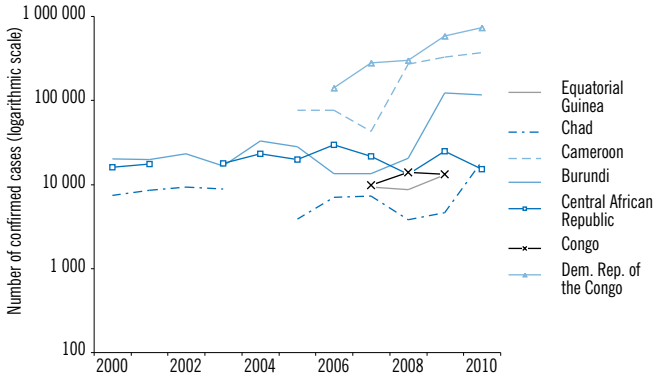
d) Percentage decrease in admissions and deaths, 2000–2010



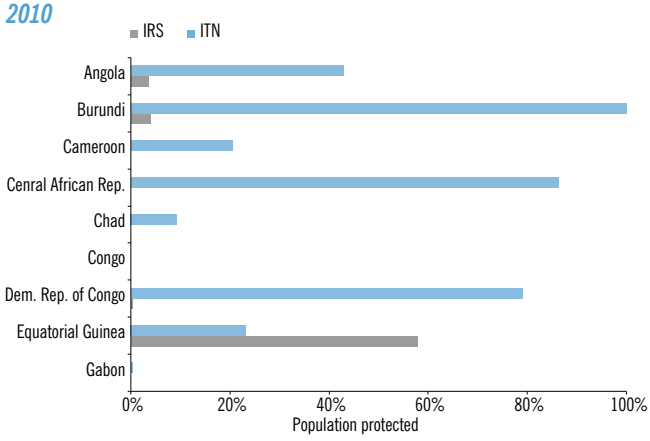
e) Countries with > 25% decrease in malaria admissions, 2000–2010



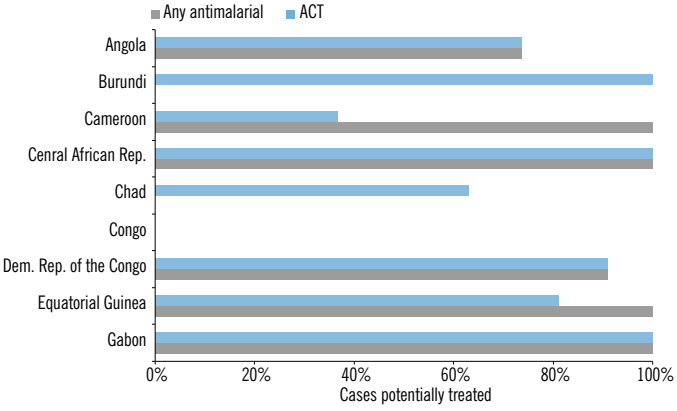
f) Countries with increase or < 25% decrease, 2000-2010



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



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



7.2.2 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 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.

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

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

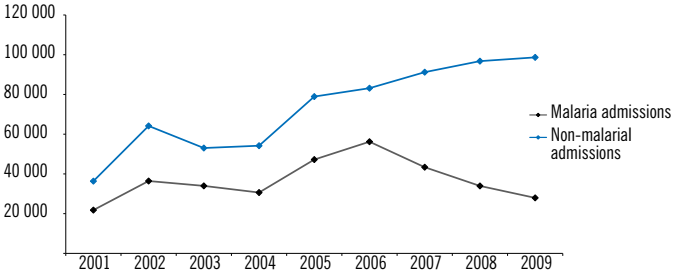
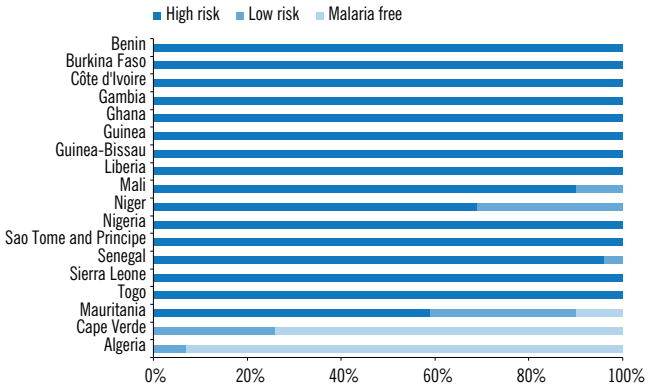
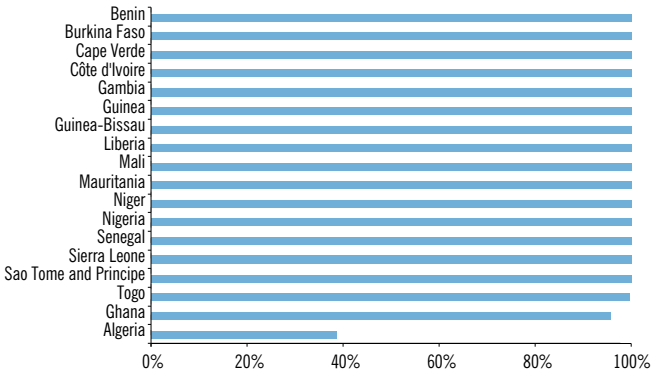


Figure 7.2 West Africa

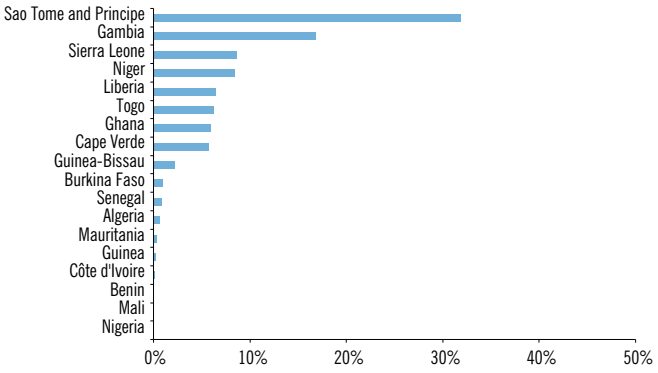
a) Population at risk, 2010



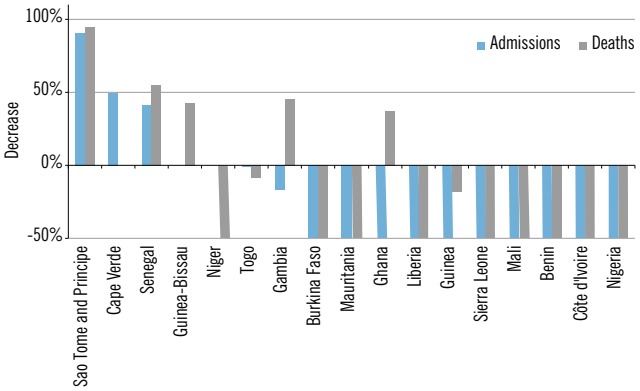
b) Percentage of cases due to P. falciparum, 2006-2010



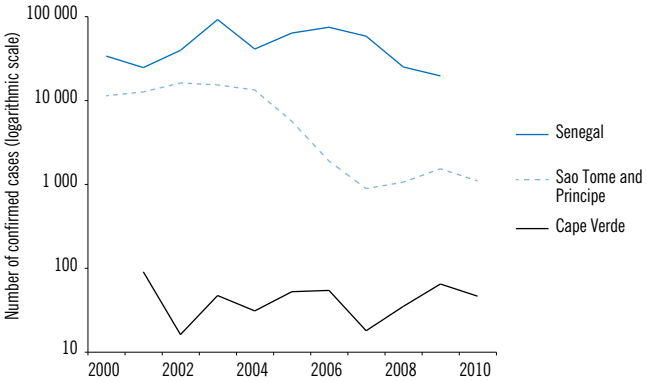
c) Annual blood examination rate, 2006–2010



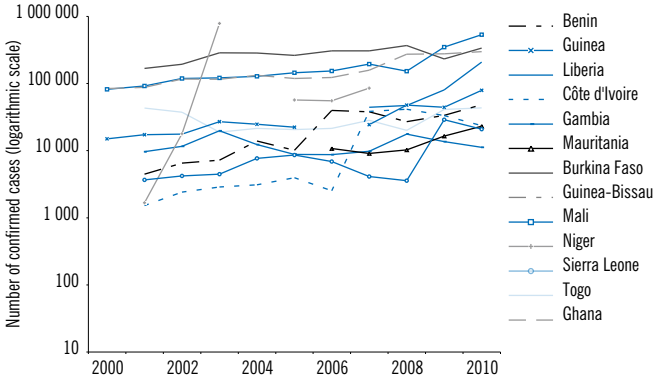
d) Percentage decrease in admissions and deaths, 2000–2010



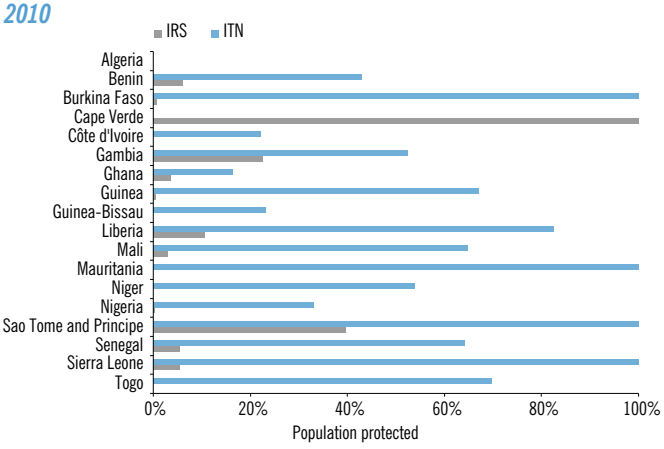
e) Countries with > 25% decrease in malaria admissions, 2000–2010



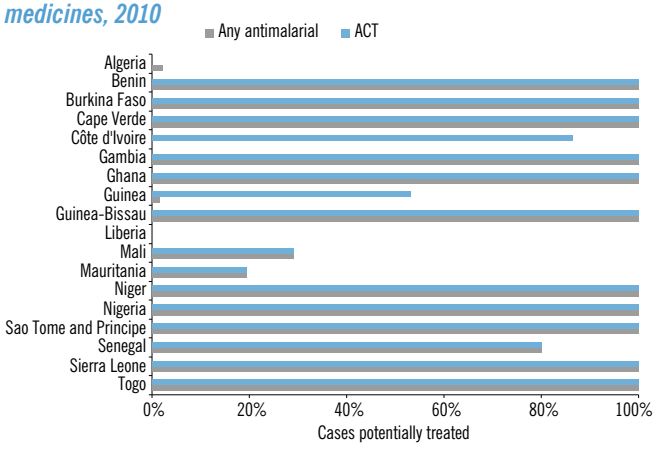
f) Countries with increase or < 25% decrease, 2000-2010



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

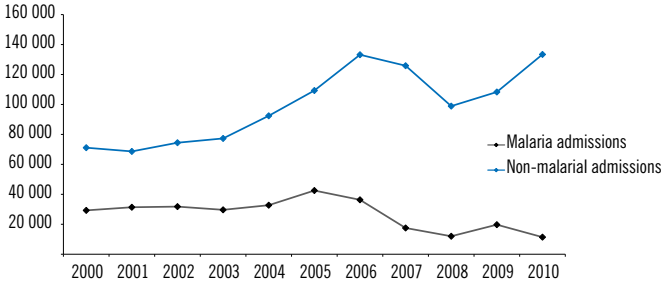
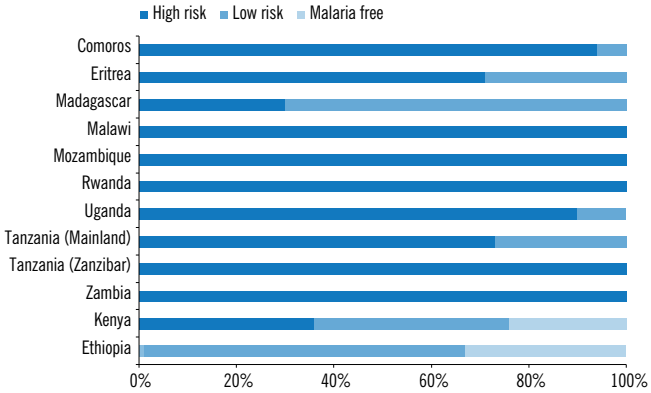
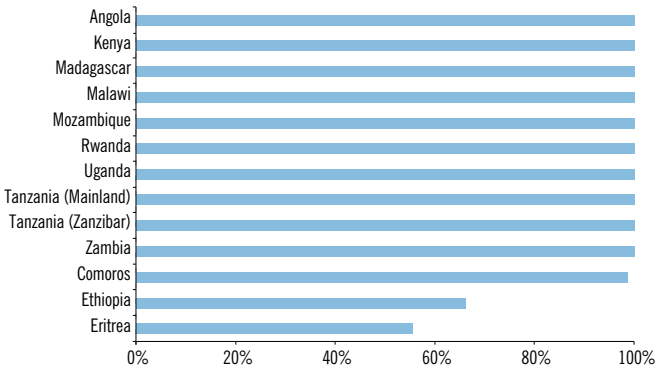


Figure 7.3 East Africa and high transmission areas in Southern Africa

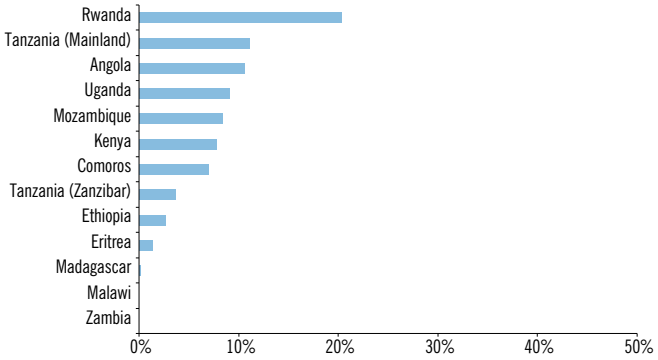
a) Population at risk, 2010



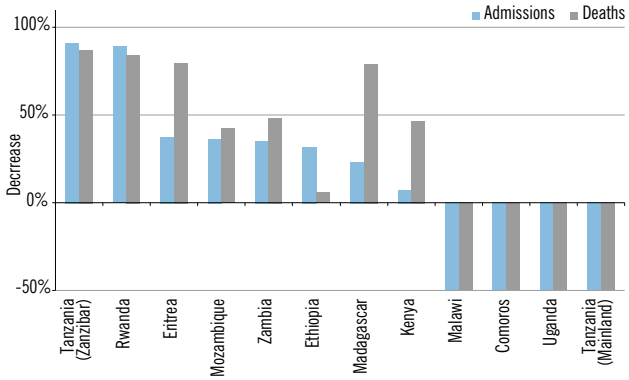
b) Percentage of cases due to P. falciparum, 2006-2010



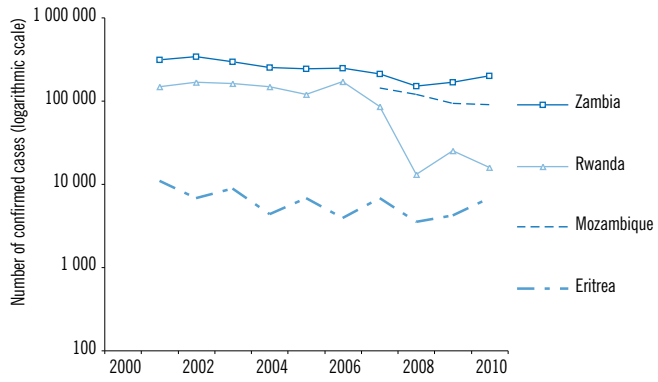
c) Annual blood examination rate, 2006–2010



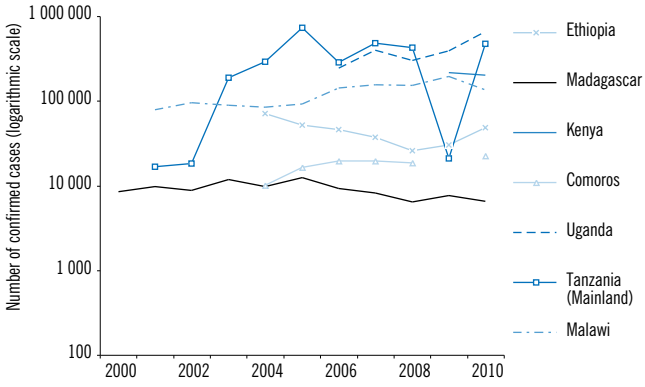
d) Percentage decrease in admissions and deaths, 2000–2010



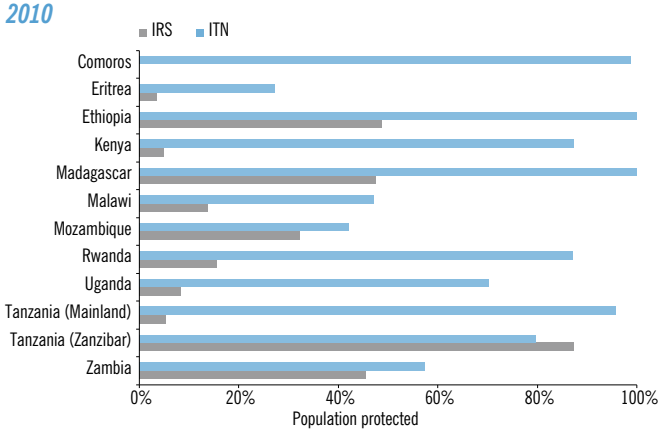
e) Countries with > 25% decrease in malaria admissions, 2000–2010



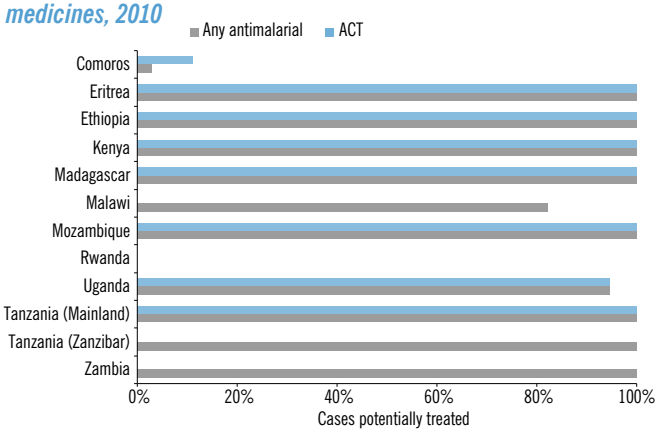
f) Countries with increase or < 25% decrease, 2000-2010



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

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 20% 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 675 000 confirmed cases were reported from 19 countries in 2010; ABERs were very heterogeneous across the Region. *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, 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 in 2010 followed the earthquake in January of the same year. 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).

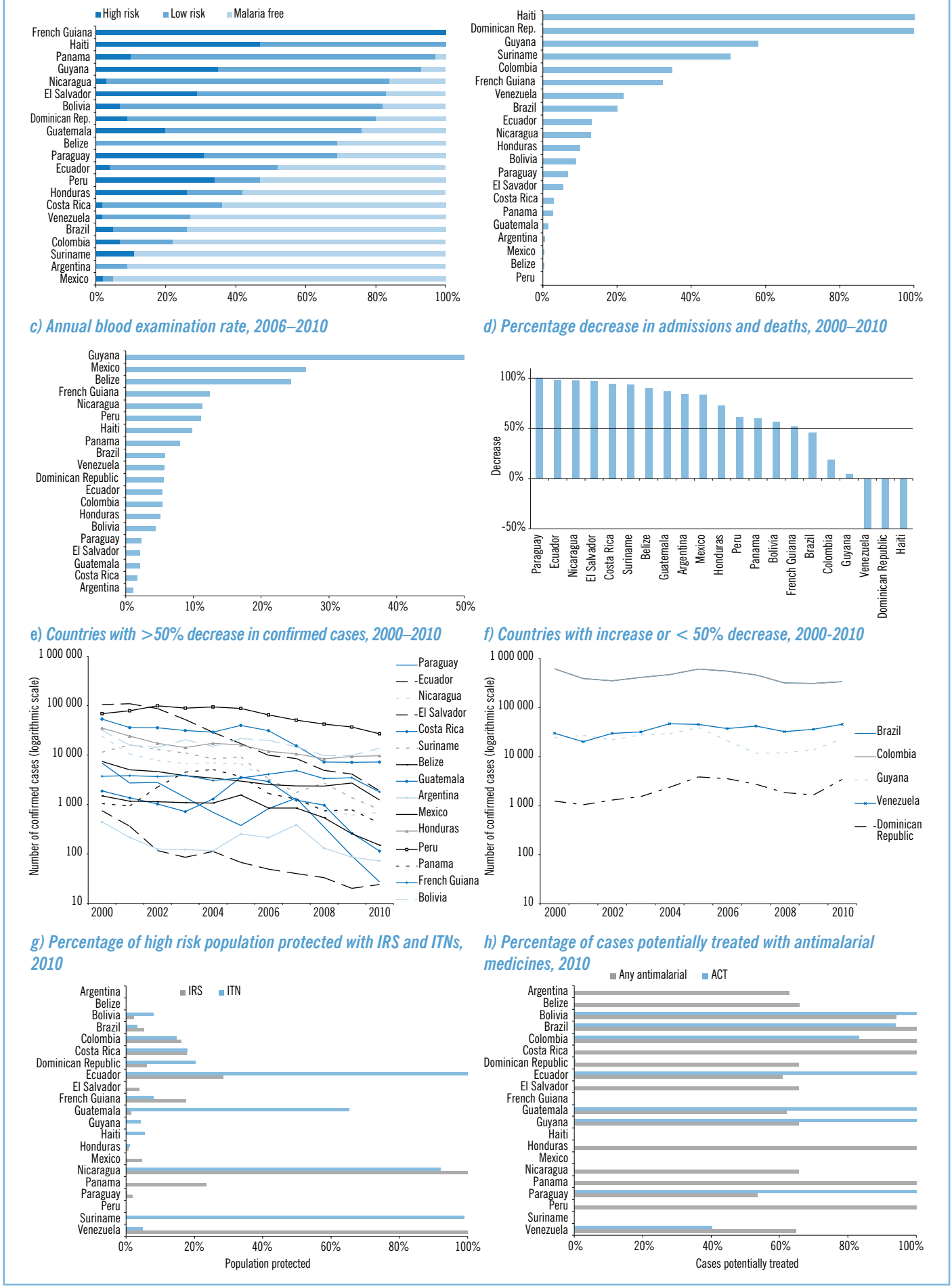
RAVREDA is a network of countries including the Plurinational State of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and the Bolivarian Republic of Venezuela, along with WHO/PAHO, established in 2001 to respond to the challenge of antimalarial drug resistance in the Amazon. RAVREDA has also 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, Research Triangle Institute (RTI) 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



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%).

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.

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

BOX 7.6
Progress towards malaria elimination in Saudi Arabia

Saudi Arabia took the decision in 2004 to eliminate malaria nationwide. Principal components of the elimination strategy are: laboratory confirmation of all cases and strengthened case management; vector control, mainly by IRS, ITNs, larviciding of breeding sites mapped by a geographical information system, and space spraying; improved surveillance, with the introduction of active case detection, epidemiological investigation of all cases, plus mapping of malaria foci; and cross-border initiatives including the establishment of surveillance units with Yemen, which provide free diagnosis and treatment, mostly for Yemeni people living (legally or illegally) in the border villages.

The border malaria units are supported by the mobile teams for active case detection. The joint Saudi –Yemeni vector control teams are responsible for spraying a 10 kilometre-wide border area inside Yemen. Enabling factors for the cross-border initiative include strong political commitment and mechanisms for intersectoral cooperation.

The malaria control programme distributed approximately 581 000 LLINs during 2008–2010, targeting populations at risk in focal areas. In addition, focal IRS protected approximately 2.5 million people at risk in 2010. ACTs and other antimalarial treatments are available through public health services, free of charge for all who need them. The government is the principal source of funding for the malaria programme, providing an average US$ 27 million annually between 2005 and 2010.

The impact of these interventions is clear. The number of autochthonous malaria cases in Saudi Arabia dropped from 36 139 in 1998 to just 29 in 2010, with 4657 and 1912 imported cases in 1998 and 2010 respectively. In 2010, all locally-acquired infections were due to *P. falciparum*. Most of the imported malaria cases in Saudi Arabia are detected by the border malaria units.

Considering the higher burden of malaria in neighbouring countries, the Gulf Cooperation Council, with Saudi Arabia taking the lead and technical support from WHO/EMRO, initiated the Malaria Free Arabian Peninsula Initiative in 2006. Six countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) have agreed to support intensification of malaria control, aiming for elimination of malaria in Yemen. Implementation began in 2010.

Figure Box 7.6 Locally acquired and imported malaria cases in Saudi Arabia 1990-2010

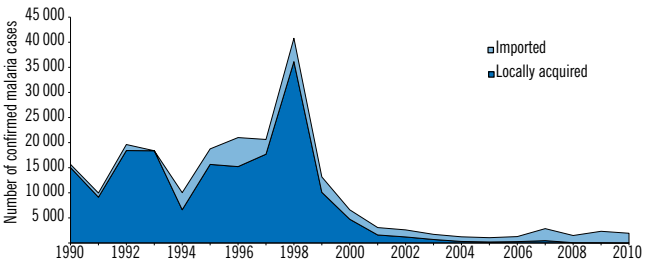
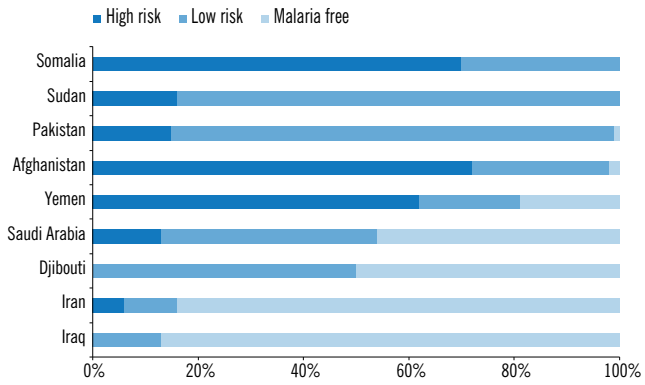
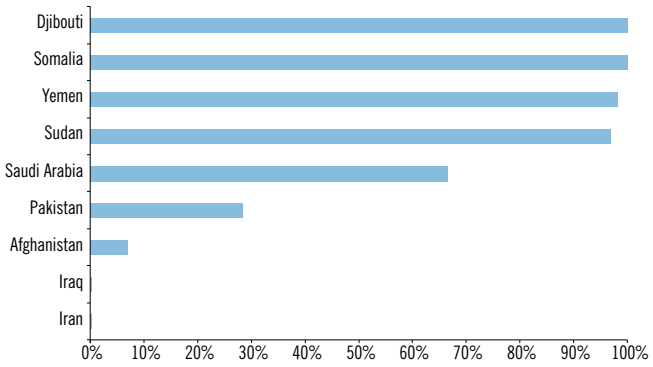


Figure 7.6 Eastern Mediterranean Region

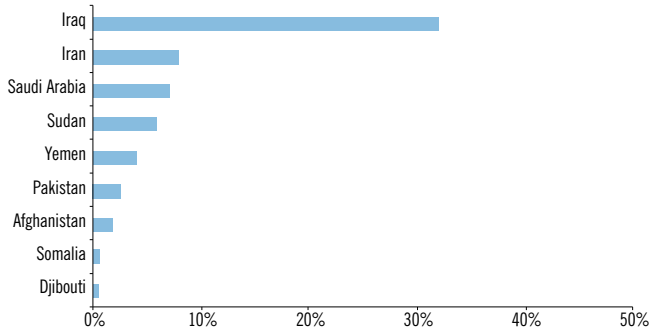
a) Population at risk, 2010



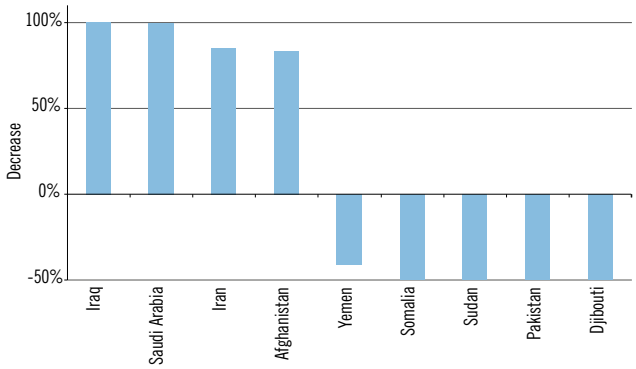
b) Percentage of cases due to P. falciparum, 2006-2010



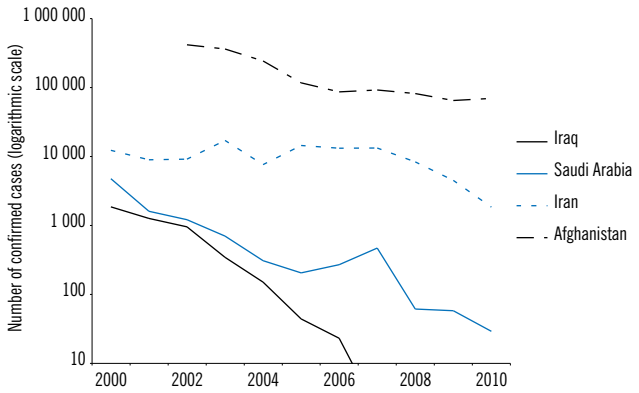
c) Annual blood examination rate, 2006–2010



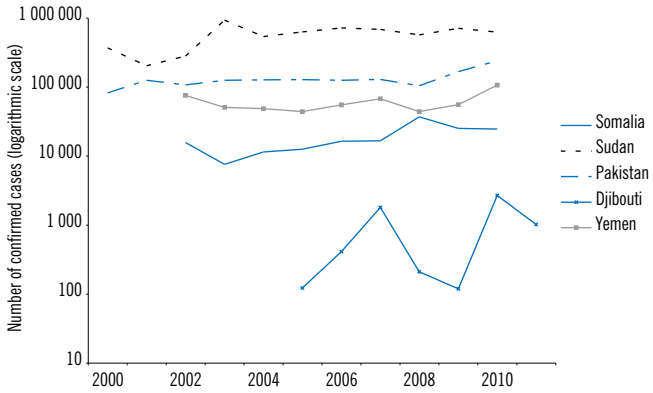
d) Percentage decrease in admissions and deaths, 2000–2010



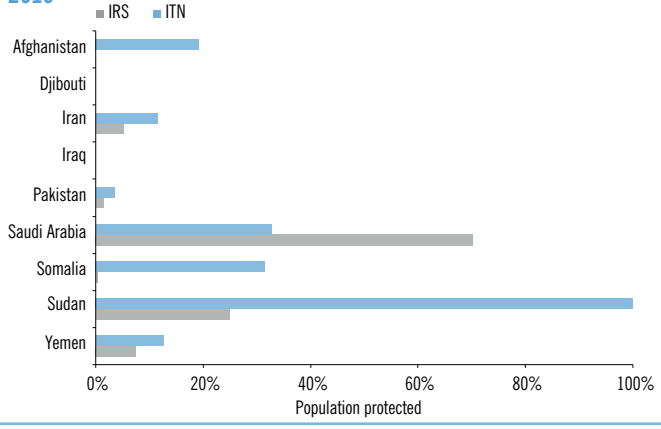
e) Countries with >50% decrease in confirmed cases, 2000–2010



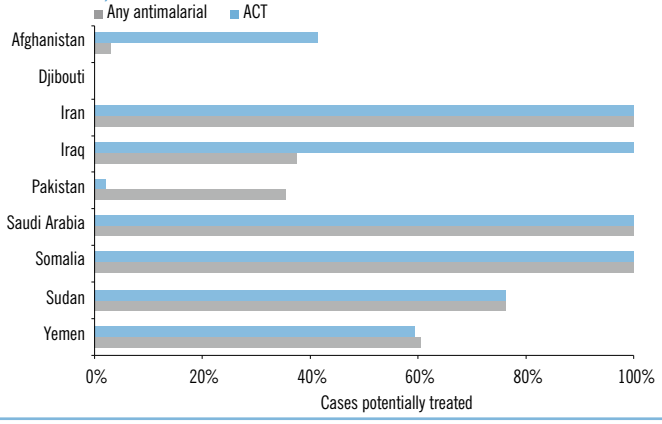
f) Countries with increase or < 50% decrease, 2000-2010



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. maculipennis* 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

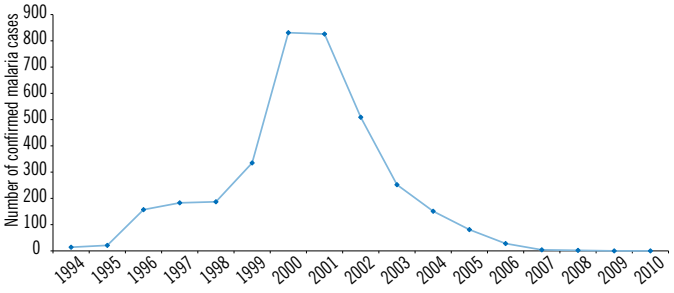
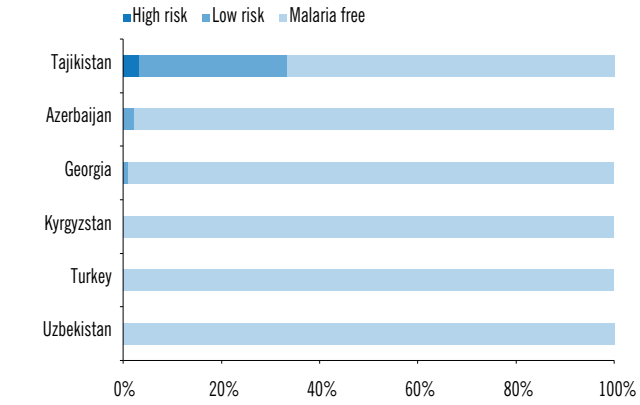
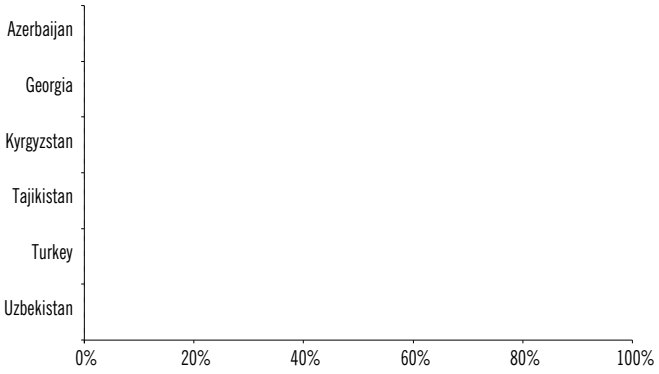


Figure 7.7 European Region

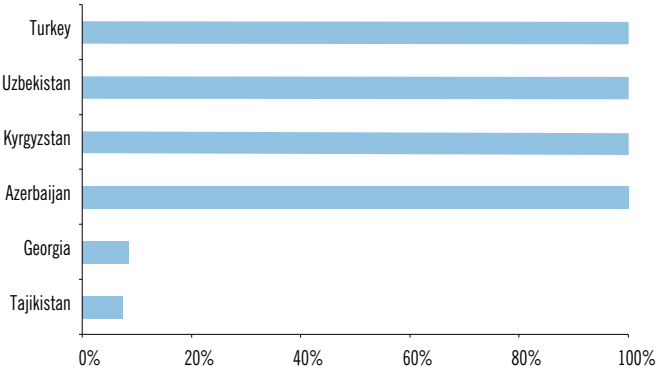
a) Population at risk, 2010



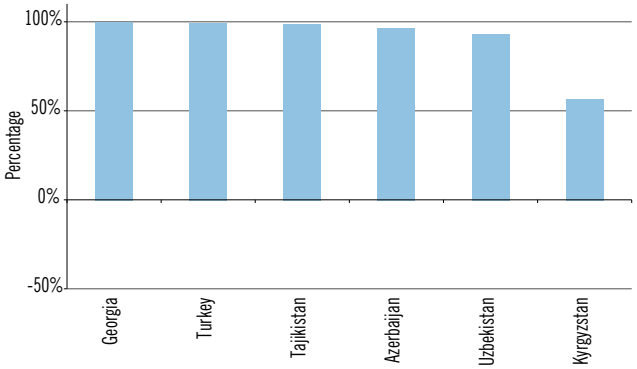
b) Percentage of cases due to P. falciparum, 2006-2010



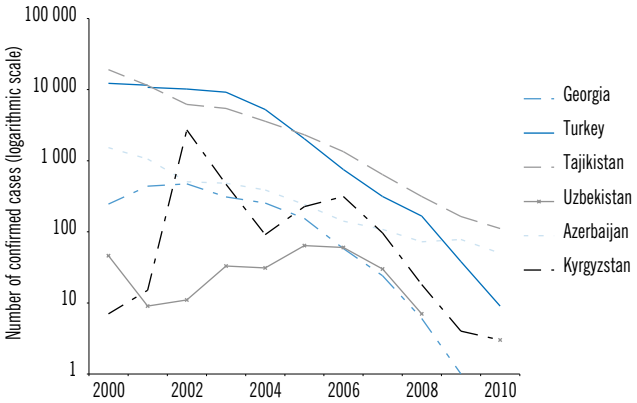
c) Annual blood examination rate, 2006–2010



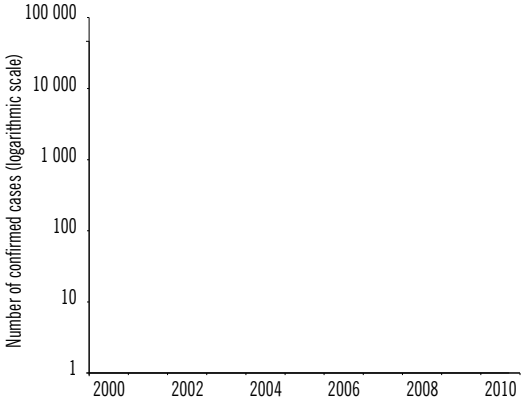
d) Percentage decrease in admissions and deaths, 2000–2010



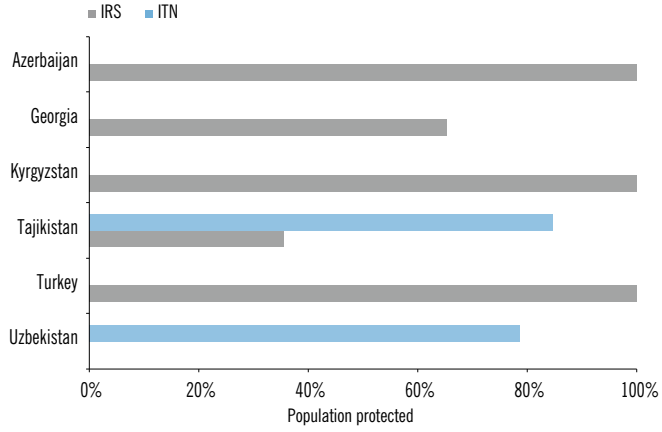
e) Countries with > 50% decrease in confirmed cases, 2000–2010



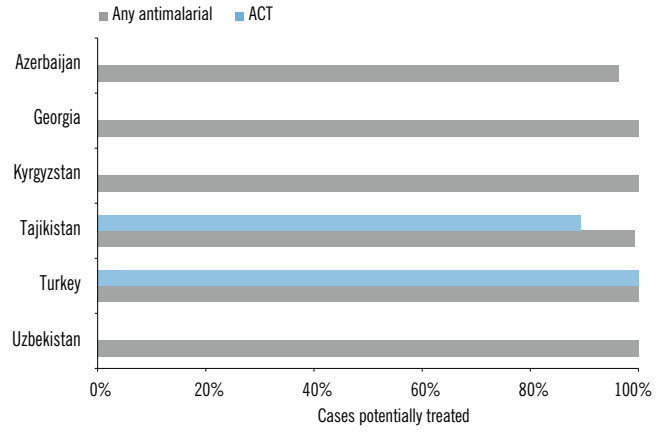
f) Countries with increase or < 50% decrease, 2000-2010



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



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



7.6 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

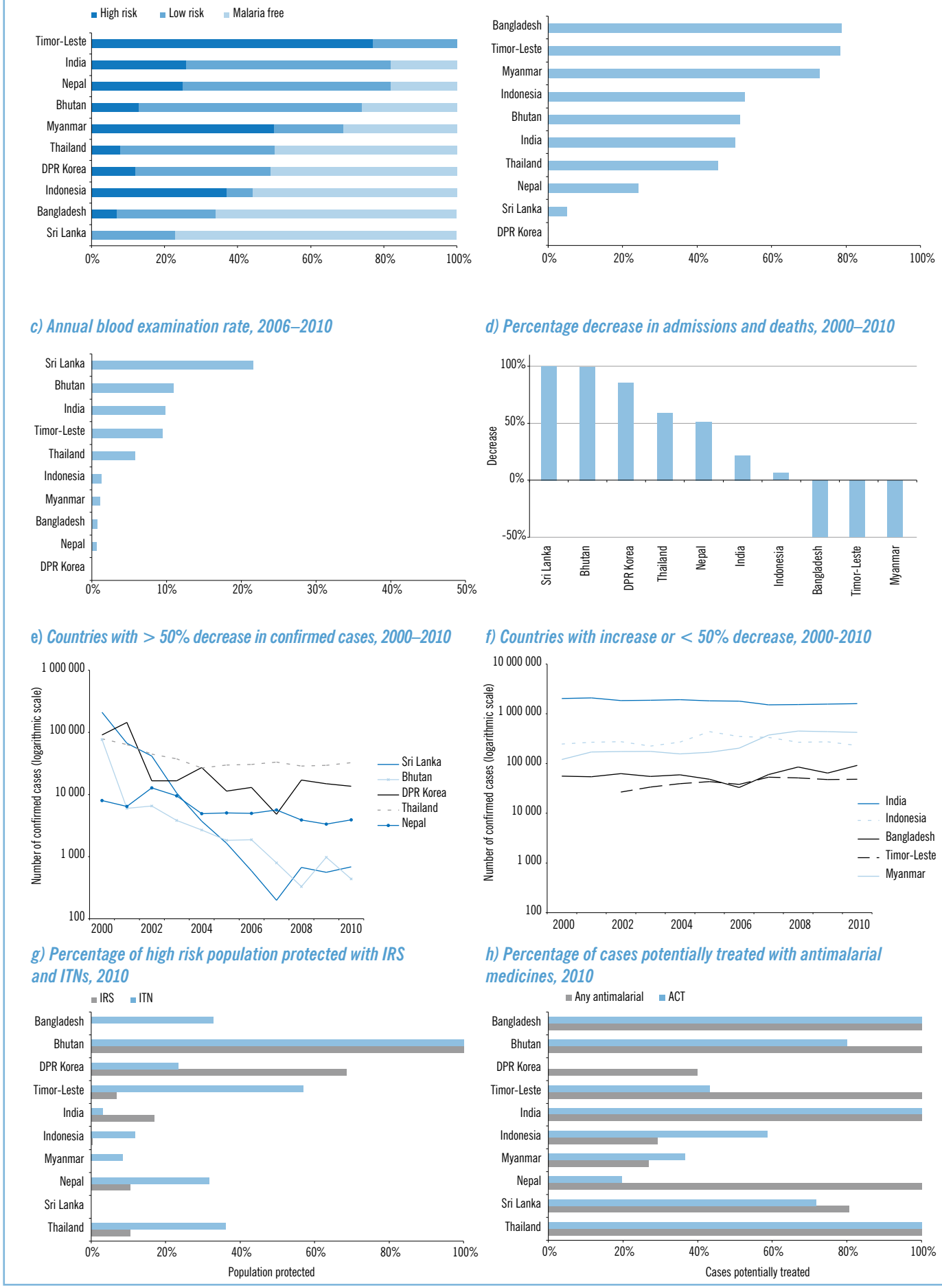
Malaria eradication in the Maldives was achieved through the elimination of anopheline mosquito vectors. Malaria in the Maldives was transmitted, perhaps uniquely, by two casual vectors, *An. tessellatus* and *An. subpictus,* in a fragile and unstable ecosystem lacking higher mammals, and thus totally 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



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.

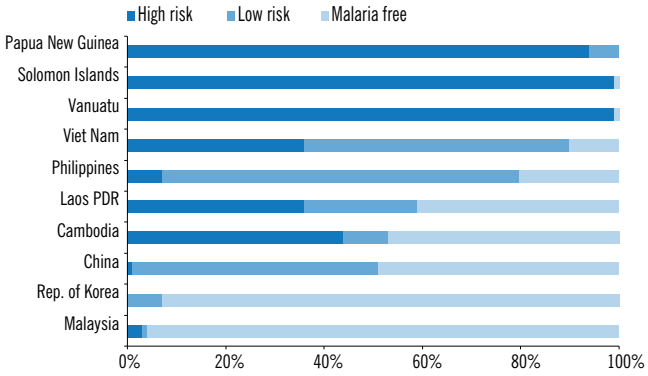
The principal mosquito vectors are species of the *Anopheles leucosphyrus* group, found throughout the South-East Asian Region. The natural reservoir hosts and source of human infections in Sarawak (Malaysia) are the long-tailed macaque (Macaca fascicularis) and pig-tailed macaque (M. nemestrina). In 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.

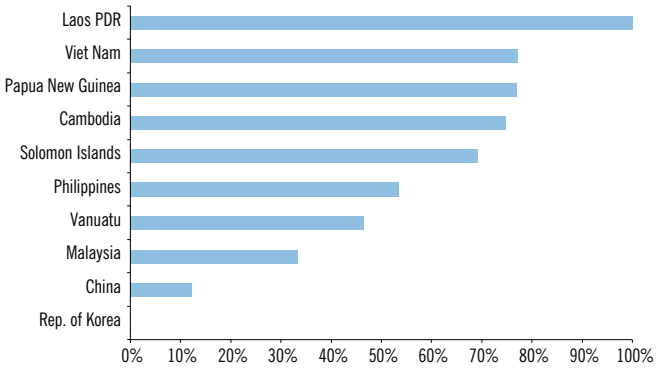
In view of the public health importance of *P. knowlesi*, the WHO Regional Office for the Western Pacific presented a new set of recommendations for control in 2011 (15), summarized as follows:- (i) Provide personal protection measures (ITNs, protective clothing, repellents) and/or chemoprophylaxis together 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

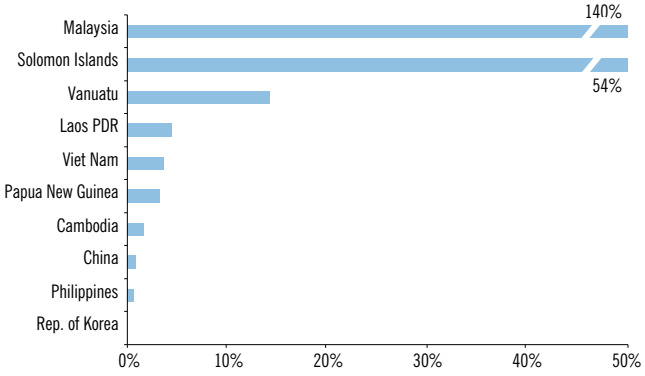
a) Population at risk, 2010



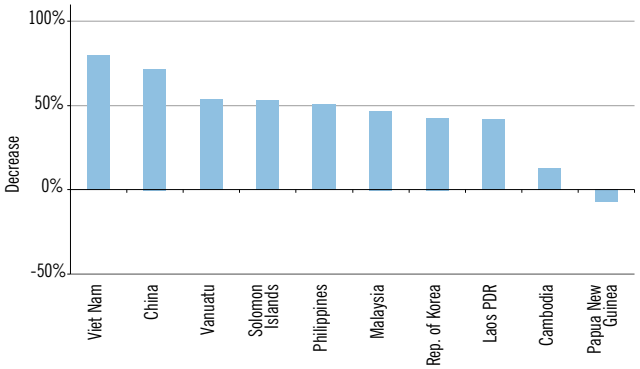
b) Percentage of cases due to P. falciparum, 2006-2010



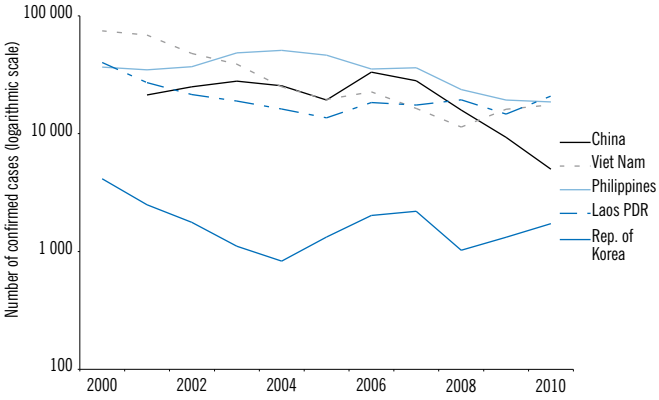
c) Annual blood examination rate, 2006–2010



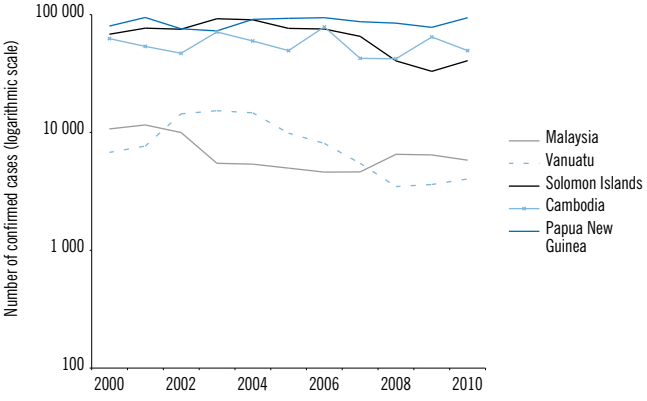
d) Percentage decrease in admissions and deaths, 2000–2010



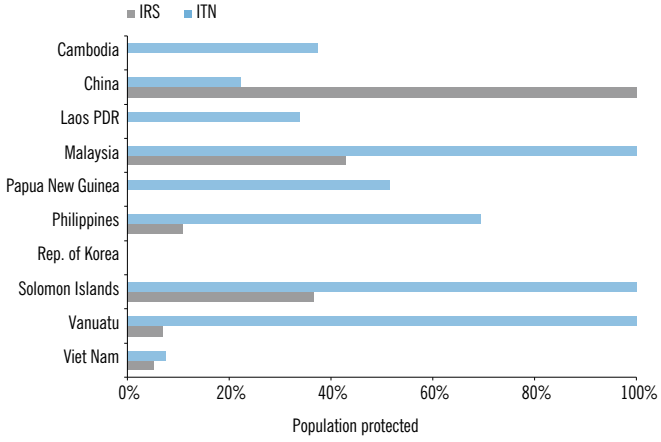
e) Countries with > 50% decrease in confirmed cases, 2000–2010



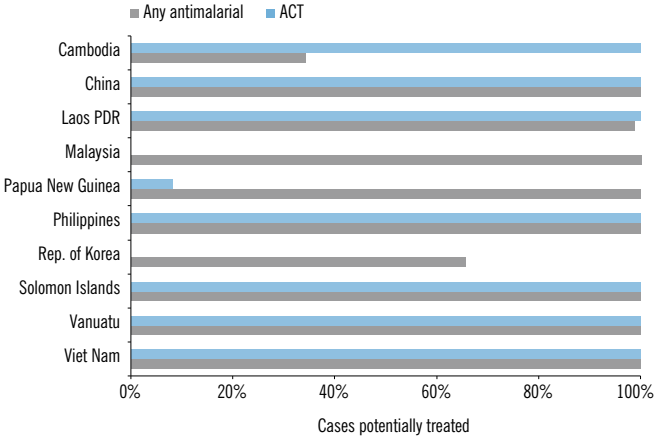
f) Countries with increase or < 50% decrease, 2000-2010



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 El Salvador Mexico Paraguay		Bahamas[1] Jamaica[1]	
Eastern Mediterranean	→	Iran Saudi Arabia	→ Egypt Iraq[1] Oman[2] Syrian Arab Republic	Morocco Unitied Arab Emirates
Europe		Azerbaijan Kyrgyzstan Tajikistan Turkey Uzbekistan	→ Georgia[1] Russian Federation[1]	→ Armenia Turkmenistan
South East Asia	DPR Korea Sri Lanka			
Western Pacififc	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.)

BOX 7.10
Prevention of malaria reintroduction in Mauritius

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 (623 local) and continued sporadic 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. arabiensis*. 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.

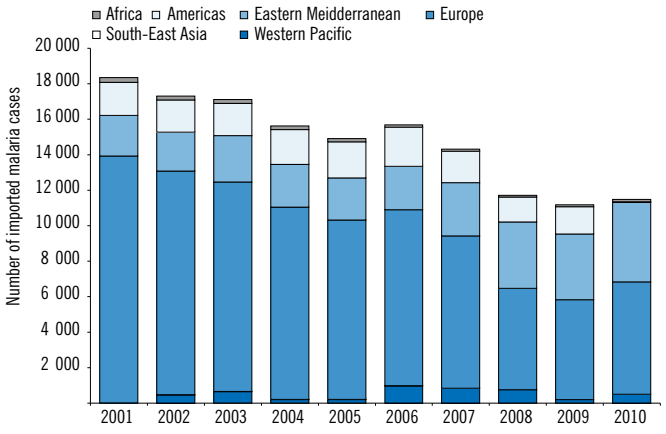
From 2005 to 2008, on average 36 imported cases were reported annually. Of these cases, 47% were identified through passive case detection in public and private clinics, 27% from further investigation of cases detected by health services, and 26% from the passenger screening programme.

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.

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.

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.

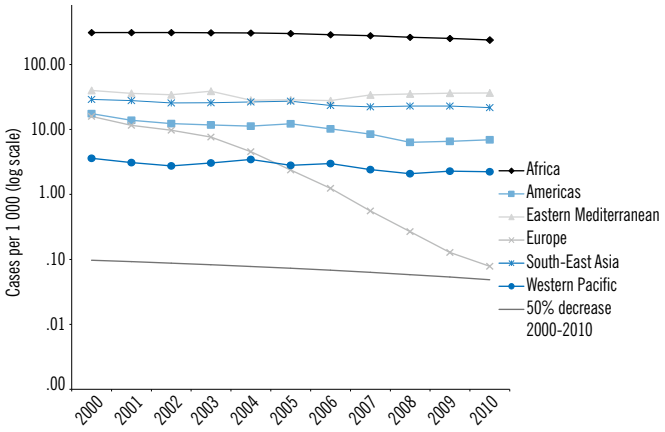
Disease burden and trends

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%).

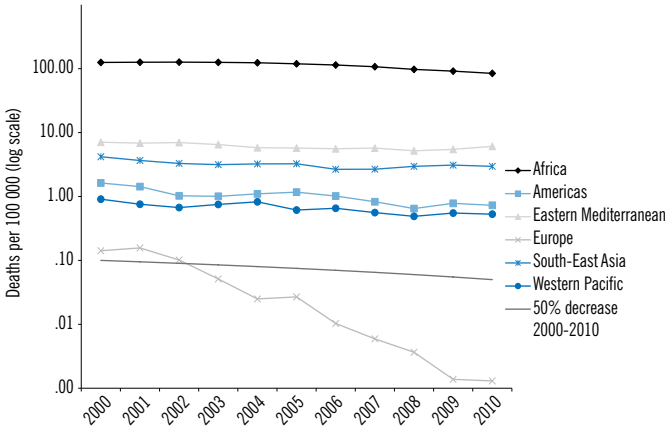
Deaths: There were an estimated 655 000 malaria deaths worldwide in 2010. It is estimated that 91% of deaths in 2010 were in the African Region, followed by the South-East Asia (6%) and Eastern Mediterranean Regions (3%). About 86% of deaths globally were in children under 5 years of age.

Figure 7.11 Estimated trends in malaria cases 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 global number of cases was estimated to have increased from 223 million in 2000 (5th–95th centiles, 170–297 million) to 237 million cases in 2005 in line with population growth and decreased subsequently due to the impact of malaria control (**Table 7.3**). The estimated number of malaria cases per 1000 persons at

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

TABLE 7.2
Estimates of malaria cases and deaths by WHO Region, 2010

	Estimated cases ('000s)				Confirmed cases reported	Reported/estimated
Region	Estimate	Lower	Upper	% *P. falciparum*		
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	0%	0.2	87%
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%

	Estimated deaths			
Region	Estimate	Lower	Upper	% <5
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%

TABLE 7.3
Trend in estimated number of malaria cases and deaths, 2000-2010

Number of cases (000's)

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% reduction since 2000
Africa	175 000	179 000	183 000	188 000	190 000	191 000	189 000	187 000	182 000	179 000	174 000	1%
Americas	2 500	2 000	1 800	1 800	1 700	1 900	1 600	1 300	1 000	1 100	1 100	56%
Eastern Mediterranean	10 000	9 000	9 000	11 000	8 000	8 000	8 000	10 000	11 000	11 000	10 000	0%
Europe	38	28	24	19	11	6	3.1	1.4	0.7	0.3	0.2	99%
South-East Asia	33 000	32 000	30 000	31 000	32 000	33 000	29 000	28 000	29 000	30 000	28 000	15%
Western Pacific	3 000	2 600	2 300	2 600	2 900	2 400	2 600	2 100	1 800	2 000	2 000	33%
World	223 000	225 000	226 000	233 000	235 000	237 000	231 000	229 000	225 000	222 000	216 000	3%
Lower bound	**170 000**	**172 000**	**173 000**	**175 000**	**177 000**	**181 000**	**172 000**	**169 000**	**165 000**	**163 000**	**149 000**	
Upper bound	**297 000**	**301 000**	**304 000**	**310 000**	**316 000**	**319 000**	**310 000**	**304 000**	**298 000**	**292 000**	**274 000**	

Number of deaths

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% reduction since 2000
Africa	682 000	705 000	726 000	740 000	748 000	740 000	727 000	701 000	654 000	630 000	596 000	13%
Americas	2 300	2 000	1 500	1 500	1 600	1 800	1 500	1 300	1 000	1 200	1 200	48%
Eastern Mediterranean	17 000	17 000	18 000	17 000	16 000	16 000	16 000	16 000	15 000	16 000	15 000	12%
Europe	3	4	2	1	1	1	0	0	0	0	0	100%
South-East Asia	46 000	41 000	37 000	36 000	38 000	39 000	32 000	33 000	37 000	39 000	38 000	17%
Western Pacific	7 300	6 100	5 500	6 200	6 800	5 100	5 500	4 700	4 200	4 700	4 600	37%
World	755 000	771 000	789 000	801 000	810 000	801 000	782 000	756 000	711 000	691 000	655 000	13%
Lower bound	**575 000**	**588 000**	**600 000**	**612 000**	**625 000**	**621 000**	**607 000**	**597 000**	**567 000**	**554 000**	**539 000**	
Upper bound	**969 000**	**992 000**	**1 018 000**	**1 034 000**	**1 053 000**	**1 045 000**	**1 023 000**	**992 000**	**944 000**	**932 000**	**906 000**	

TABLE 7.4

Trend in estimated malaria incidence and mortality rates, 2000-2010

Cases per 1,000 at risk

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% reduction since 2000
Africa	321	320	319	318	315	308	297	286	271	259	246	23%
Americas	18	14	13	12	12	13	11	9	7	7	7	60%
Eastern Mediterranean	41	37	35	40	29	29	29	35	36	37	33	19%
Europe	16	12	10	8	5	2	1	1	0	0	0	100%
South-East Asia	30	29	26	27	27	28	24	23	24	24	22	25%
Western Pacific	4	3	3	3	4	3	3	2	2	2	2	38%
World	79	78	77	78	78	77	74	72	70	68	65	17%

Deaths per 100,000 at risk

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	% reduction since 2000
Africa	125.1	126.0	126.5	125.5	123.7	119.1	114.0	107.2	97.4	91.5	84.3	33%
Americas	1.6	1.4	1.0	1.0	1.1	1.2	1.0	0.8	0.6	0.8	0.7	55%
Eastern Mediterranean	7.1	6.8	7.0	6.5	5.8	5.7	5.6	5.7	5.2	5.5	4.9	31%
Europe	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	99%
South-East Asia	4.2	3.7	3.3	3.1	3.2	3.2	2.7	2.7	3.0	3.1	3.0	29%
Western Pacific	0.9	0.8	0.7	0.8	0.8	0.6	0.7	0.6	0.5	0.6	0.5	42%
World	26.6	26.8	26.9	26.9	26.8	26.1	25.1	23.9	22.1	21.2	19.8	26%

risk, which takes into account population growth over time, shows a reduction in case incidence of 17% globally between 2000 and 2010. Declines in case incidence are seen in every Region but are greatest in the European (100%), American (60%) and Western Pacific Regions (38%) (**Table 7.4, Fig. 7.11**).

The estimates of number of cases are similar to those published in the *World Malaria Report 2010* but some adjustments have been made according to feedback from country consultations and because of updated country reports, household surveys or population estimates.

Deaths: There were an estimated 655 000 malaria deaths worldwide in 2010 (5th–95th centiles, 539 000–906 000). It is estimated that 91% of deaths in 2010 were in the African Region, followed by the South-East Asian Region (6%), and Eastern Mediterranean Regions (3%). About 86% of deaths globally were in children (**Table 7.2**).

The estimated number of deaths has fallen in all regions between 2000 and 2010 although there is some fluctuation year by year (**Table 7.3**). In the African Region the number of deaths is estimated to have risen from 682 000 in 2000 to 748 000 in 2004 before decreasing to 596 000 in 2010 following a scale up of control activities. The trend in estimated number of deaths is similar to that for the estimated number of cases.

While the number of deaths in the African Region (and globally) increased between 2000 and 2004 the risk of death - or malaria mortality rate - remained relatively constant until 2004 and has decreased continuously between 2005 and 2010 with more pronounced decreases in more recent years (**Table 7.4, Fig. 7.12**). Malaria mortality rates decreased by 25% worldwide between 2000 and 2010 and by 33% in the WHO African Region.

The estimates of the number of deaths outside Africa are similar to those published in the *World Malaria Report 2010* but those for the WHO African Region differ substantially. This is for two reasons: (i) A downward revision of the total number of child deaths occurring globally made by the UN Inter-agency Group for Child Mortality Estimation (22); and (ii) Changes in the assignment in cause of death made by the Child Health Epidemiology Reference Group (CHERG), that affected the proportion of deaths attributed to malaria particularly at the beginning of the last decade. These methodological changes resulted in an overall lowering of the number of malaria deaths in the African Region of approximately 11% for 2009 and larger percentages in earlier years.

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 7.5**).

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 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 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 7.5, Figure 7.13**). 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 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.

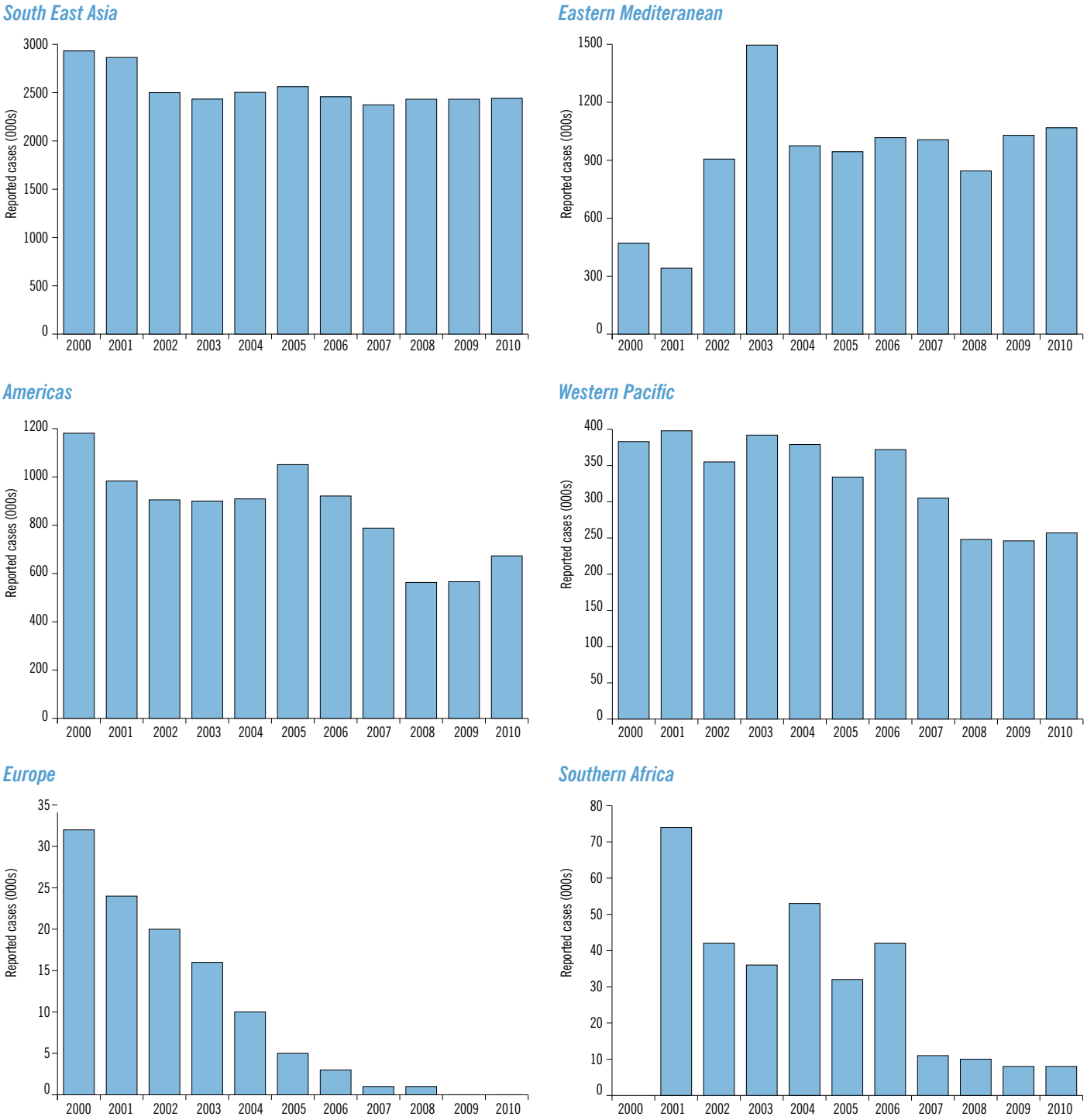
Cross-country comparisons of routine surveillance data are a weak instrument for assessing the effects of malaria control, but specific studies in selected countries have provided some good examples of the link between intervention and impact. These examples include Nicaragua in the Americas, Saudi Arabia 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.

TABLE 7.5

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

Figure 7.13 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.

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