Chapter 6.
Impact of malaria control

This chapter considers the type of evidence that can be used to examine whether the incidence of malaria has changed over time and whether changes are associated with malaria control interventions. It then summarizes the trends of malaria cases and assesses the evidence that malaria control activities have had an impact on malaria disease burden in each WHO Region.

6.1 Assessing the impact of malaria interventions

6.1.1 Investigating trends in the incidence of malaria

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. First, case reports are recorded continuously over time and can thus reflect changes in the implementation of interventions or other factors. Secondly, routine case and death reports are often available for all geographical units of a country. Thirdly, 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 morbidity 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 undertaken, 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 undertaken. It is useful to measure the annual blood examination rate, 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. To discern decreases in malaria incidence, the annual blood examination rate should ideally remain constant or be increased.[1] In countries progressively reducing their malaria endemicity, the population at risk also reduces, becoming limited to residual and new foci where malaria transmission is present, or where there is potentially a high risk due to receptivity. In addition, it is useful to monitor the percentage of suspected malaria cases that were examined with a parasite-based test. 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. This rate should be less severely distorted by variations in the annual blood examination rate than trends in the number of confirmed cases.
- Monitoring malaria admissions and deaths. 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.
- Monitoring the number of cases detected in the surveillance system in relation to the total number of cases estimated to occur in a country.[2] Trends derived from countries with high case detection rates are more likely to reflect trends in the broader

1. Some authorities recommend that the annual blood examination rate should exceed 10% to ensure that all febrile cases are examined; however, the observed rate depends partly on how the population at risk is estimated, and trends may still be valid if the rate is < 10%. Some authorities have noted that 10% may not be sufficient to detect all febrile cases. It is noteworthy that the annual blood examination rate in the Solomon Islands, a highly endemic country, exceeds 60%, with a slide positivity rate of 25%, achieved solely through passive case detection.

community. When examining trends in the number of deaths, it is useful to compare the total number of deaths occurring in health facilities with the total number of deaths estimated to occur in a country.

- Examining the consistency of trends. Unusual variation in the number of cases or deaths that cannot be explained by climate or other factors, or inconsistency between trends in cases and in deaths, can suggest deficiencies in reporting systems.
- Monitoring changes in the proportion of cases due to *P. falciparum* or the proportion of cases occurring in children < 5 years of age. While decreases in the incidence of *P. falciparum* malaria may precede decreases in *P. vivax* malaria, and there may be a gradual shift in the proportion of cases occurring in children < 5 years, unusual fluctuations in these proportions may point to changes in health facility reporting or to errors in recording.

The aim of these procedures is to rule out data-related factors, such as incomplete reporting or changes in diagnostic practice, as explanations for a change in the incidence of disease and to ensure that trends in health facility data reflect changes in the wider 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 promoting change, such as use of ITNs, are delivered throughout the community and not restricted to health facilities.

6.1.2 Assessing coverage with malaria interventions

Data on the number of ITNs distributed by malaria programmes and populations covered by IRS are supplied annually by ministries of health to WHO as part of reporting for the *World Malaria Report*. Such information may contain inaccuracies or gaps, particularly for earlier years. Hence, if data for earlier years are missing, it might be inferred incorrectly that preventive activities have recently been intensified. Nevertheless, for many countries, data from ministries of health are the only source of information on preventive activities and are consistent over the years. Data from nationally representative household surveys are available for selected countries, but these surveys are usually not undertaken frequently enough to allow assessment of trends in intervention coverage or to provide contemporary information. For sub-Saharan African countries, data from nationally representative household surveys and information on ITNs procured and distributed by NMCPs were combined to form an estimate of the percentage of households owning at least one ITN in years when household surveys were not available (Section 4.1). Information on access to treatment is less complete than data on ITNs and IRS, as few countries supply information on the number of courses of antimalarial medicines distributed in relation to the number of cases treated in the public sector. Information on preventive activities or treatment provided by the private sector is almost entirely absent. It is therefore not always possible to obtain a complete picture of the extent of control activities in a country.

6.1.3 Establishing a link between malaria disease trends and control activities

In establishing a causal link between malaria disease trends and control activities, one should consider what the disease trends would have been without application of the control activities and then assess whether the decrease in malaria observed is greater than that expected without control activities. A realistic view of what would have happened without control activities (i.e. counterfactual) cannot be established from the data currently available; however, it can be expected that, without a change in control activities, the malaria incidence might fluctuate in response to short-term climate variations but would otherwise show little change, as improved living conditions, environmental degradation or long-term climate change have only gradual effects (although there may be local exceptions). Thus, a plausible link with control efforts can be established if the disease incidence decreases at the same time as control activities increase, if the magnitude of the decrease in malaria incidence is consistent with the magnitude of the increase in control activities (a 50% decrease in the number of cases is unlikely to occur if malaria control activities cover only 10% of the population at risk) and if the decreases in malaria incidence cannot readily be explained by other factors.

Countries and territories for which there is evidence from good quality surveillance data of a large, sustained decrease (e.g. > 50% or > 25%) in the number of cases since 2000 are presented in **Table 6.1** by WHO Region. Information on the scale of malaria control interventions is also summarized, to identify countries with preventive programmes covering > 50% of the population at high risk and countries that undertake extensive case detection and treatment. Countries in which there is evidence of both a sustained decrease in cases since 2000 and extensive control activities are highlighted as providing evidence of an impact of malaria control activities. Selected high-burden countries in the WHO African Region are discussed individually. For other WHO Regions, the results of the analysis are shown in a standard set of graphs, as described in **Box 6.1,** section 6.3.

6.2 African Region: high burden countries

Of the 35 high-burden countries in the WHO African Region, trends in confirmed malaria cases could be analysed in only 4 countries/areas that have had consistent reporting on parasitologically confirmed cases from 2000 to 2009, i.e. Eritrea, Rwanda, Sao Tome and Principe, and Zanzibar (United Republic of Tanzania). The majority of the other high burden countries in the Region have until recent years treated malaria in children < 5 years of age presumptively, and only have data on suspected malaria cases. Even if a country has increased parasitological diagnosis in recent years, such as Senegal, the lack of consistent historical data on confirmed cases before and after scale-up of interventions prevents an analysis of trends.

Owing to the absence of data on confirmed cases, data on malaria admissions and deaths were also analysed. Although in many instances cases are not confirmed by parasitological diagnosis they have a higher positive predictive value for malaria than outpatient

2. The *World Malaria Report 2008* described methods for estimating the total number of malaria cases in a country on the basis of the number of reported cases and taking into account variations in health facility reporting rates, care-seeking behaviour for fever as recorded in household surveys and the extent to which suspected cases are examined with laboratory tests.

TABLE 6.1

SUMMARY OF PROGRESS IN REDUCING NUMBER OF MALARIA CASES BETWEEN 2000 AND 2009

Decrease in cases >50%	Decrease in cases 25-50%	Limited evidence of decrease
AFRICAN REGION		
Algeria		Angola
Cape Verde		**Benin**
Botswana		**Burkina Faso**
Madagascar		Burundi
Namibia		Cameroon
Sao Tome and Principe		Central African Republic
South Africa		Chad
Swaziland		Congo
Eritrea		Côte d'Ivoire
Rwanda		**Democratic Rep. Congo**
Zambia		Equatorial Guinea*
		Ethiopia†
		Gabon
		Gambia*
		Ghana
		Guinea
		Guinea-Bissau
		Kenya*
		Liberia
		Malawi
		Mali
		Mauritania
		Mozambique
		Niger
		Nigeria
		Senegal
		Sierra Leone
		Togo
		Uganda
		United Rep. of Tanzania*
		Zimbabwe

Decrease in cases >50%	Decrease in cases 25-50%	Limited evidence of decrease
REGION OF THE AMERICAS		
Argentina	**Brazil**	Costa Rica
Belize	Colombia	Dominican Republic
Bolivia (Plurinational State)	Guyana	French Guiana
Ecuador		Haiti
El Salvador		Peru
Guatemala		Panama
Honduras		Venezuela (Bolivarian Rep.)
Mexico		
Nicaragua		
Paraguay		
Suriname		
SOUTH-EAST ASIA REGION		
Bhutan	India	Bangladesh
Dem. People's Rep. Korea		Indonesia
Nepal		Myanmar
Sri Lanka		Timor-Leste
Thailand		
EUROPEAN REGION		
Azerbaijan		
Georgia		
Kyrgyzstan		
Tajikistan		
Turkey		
Uzbekistan		
EASTERN MEDITERRANEAN REGION		
Afghanistan		**Djibouti**
Iraq		Pakistan*
Iran (Islamic Rep.)		Somalia
Saudi Arabia		**Sudan***
		Yemen*
WESTERN PACIFIC REGION		
China	**Malaysia**	**Cambodia***
Lao People's Dem. Rep.	Phillipines*	Papua New Guinea
Republic of Korea	**Vanuatu**	
Solomon Islands		
Viet Nam		

Countries in bold show evidence of wide scale implementation of malaria control activities to >50% of the population at high risk. For high burden African countries Djbouti, Somalia and Sudan ITN coverage was derived from a model as described in Section 4.1

* The country reports some progress sub-nationally where interventions have been intensified.

† The number of reported cases and admissions has remained low since 2005.

suspected cases. Data were obtained from either: *(i)* health management information systems (Eritrea, Sao Tome and Principe, Rwanda, Zambia, and Zanzibar, United Republic of Tanzania[3]) or *(ii)* WHO rapid impact assessments which examined data from outpatient records and admissions and laboratory registers for randomly selected district hospitals for 2000–2009 (Ethiopia and Madagascar).

ERITREA. A large reduction in the malaria burden has been achieved in Eritrea in recent years. Although the numbers of probable and confirmed malaria cases decreased from 126 000 in 2001 to 22 000 in 2009 (83% decrease), microscopically confirmed malaria cases decreased by only 32% (from 9700 to 6600). This is because the cases examined by microscopy more than doubled over this period. The slide positivity rate fell from 43% to 8%, which may more reliably reflect a decrease in case incidence but the rate could be influenced by the inclusion of more cases with a lower probability of infection as the number of cases examined increases. The number of malaria admissions decreased from 10 900 to 4200 over the same period (61% decrease) and reported malaria deaths from 133 to 23 (83% decrease) (**Fig. 6.1**). The reduction in disease burden is associated with the scale-up of malaria control efforts in the country. More than a million ITNs were distributed over the years 2000–2006, and in 2004 about 80% of households living in areas at high risk for malaria owned a net. The NMCP delivered another 564 000 LLINs during 2007–2009, enough to cover 31% of the population at high risk, complemented by focal IRS, protecting on average 212 000 people at high risk per year since 2000. Enough ACTs were provided to treat all malaria

3. In recent years malaria control activities have led to reduced malaria transmission in Eritrea, Sao Tome and Principe, and Zanzibar (United Republic of Tanzania). These countries/areas may therefore be considered as having low transmission. However, they are included among the high-transmission countries since they were classified as such in 2000 before they intensified malaria control activities. Their receptivity for malaria transmission remains very high (given the abundance of vectors and climate suitability) and failure to maintain the intensity of malaria control efforts could result in resurgence of malaria with major public health consequences.

patients attending public health facilities. Although progress has been sustained since 2001 there was a small increase in confirmed cases, admissions and deaths in 2009.

ETHIOPIA. Although a functional surveillance system exists at the district level, aggregation of data at national level on malaria cases and deaths from all the health facilities is often incomplete and underestimates the true number of cases attending public health facilities. Therefore, a review of health facility records was conducted in all 62 hospitals located at altitudes < 2000 m (where malaria transmission occurs). A total of 44 hospitals maintained adequate records for the period 2002–2009. The numbers of malaria admissions and deaths in the hospitals follow a similar pattern to nationally reported data, rising to a peak in 2003 and subsequently falling (**Fig. 6.2**). Given the variable levels of admissions and deaths from 2002 to 2004, and the potential reasons for the variability, it is difficult to specify a baseline value for the number of admissions and deaths, and hence any percentage decrease in admissions and deaths to 2009. If the epidemic peak of 2003 is excluded, the annual numbers of malaria admissions and deaths for 2007–2009 are 31% and 50% lower than values for 2002 and 2004 respectively. The lower levels of admissions and deaths after 2004 are associated with an expansion in the malaria control programme; more than 25 million ITNs were delivered between 2005 and 2009 targeting 40 million people at high risk. The NMCP also undertakes IRS, which has increased in scale to protect 28 million in 2008 from a base of between 2.8 and 6 million from 2002 to 2007. ACTs were made available to all public facilities in 2004 and to community levels through health extension workers in 2007; these workers are mandated to diagnose malaria using RDTs and to treat confirmed malaria patients with ACTs. It is not known whether the lower levels of hospital admissions and deaths after 2004 would have occurred without these malaria interventions, but the major malaria epidemics of the past seem to have been avoided in the last 5 years. A slight increase in malaria admissions was recorded in 2009.

MADAGASCAR. The entire population of Madagascar, 19.6 million in 2009, is at some risk of malaria. About 1.4 million ITNs had been distributed between 2001 and 2005. Malaria control activities increased in scale from 2006 onward with 1.6 million ITNs delivered in 2006 followed by another 2 million over the period 2007–2009. Approximately 550 000 persons at risk were protected by IRS each year in 2005–2007. The number increased to 1.2 million per year in 2006 and 2007 and more than 6.5 million per year in 2008 and 2009. ACTs were adopted as policy for malaria treatment in 2006 and provided free of charge from 2007 with more than 500 000 treatment courses distributed in 2007 and 2008 and approximately 400 000 in 2009, sufficient to treat all patients reported to have attended public health facilities in 2008 and 2009.

Two data sets were analysed to examine malaria trends: *(i)* information from a WHO rapid impact assessment which collected data from 45 randomly selected health facilities in high-transmission areas and 15 in the transitional, epidemic-prone zone – of the 60 facilities, 35 had complete data for at least 8 years and were used for analysis – and *(ii)* routinely reported data from the national HMIS. Until 2006 the trend in malaria admissions followed that of non-malaria admissions, but in 2007 and subsequent years it was much lower (**Fig. 6.3**). Similar trends are seen in nationally reported data although the decreases have been larger in recent years.

RWANDA. The population of Rwanda was 10 million in 2009. During a nationwide campaign targeting children < 5 years of age in 2006, 1.96 million LLINs were distributed, and a further 1.16 million LLINs were distributed in 2007, increasing the percentage of the population potentially covered by nets to 70%. No ITNs were distributed in 2008; 800 000 were delivered in 2009. The number of people protected by IRS rose from 705 000 in 2007 to 1.4 million in 2009. ACTs were distributed nationwide between September and October 2006, at the same time as the mass distribution of LLINs. The DHS conducted in 2007–2008 showed that 56% of households owned an ITN and 56% of children < 5 slept under a net.

Rwanda recorded sharp decreases in the number of confirmed malaria cases, admissions and deaths in 2007 and for much of 2008 after the intensification of control activities (**Fig. 6.4, 6.5**). Towards the end of 2008 and early 2009, however, there was a nationwide increase in the number of confirmed malaria cases, admissions and deaths although the increase in admissions and deaths did not appear to be as large as that of the total number of cases. There was a 25% increase in the number of patients tested in 2009, but this is smaller than the 77% increase in confirmed malaria cases, and the slide positivity rate increased from 18% in 2008 to 25% in 2009. National-level rainfall and temperature anomalies were not associated with the resurgences[4]. A substantial proportion of LLINs were distributed 2–3 years ago and it is possible that the effectiveness of LLINs has become reduced with ageing of nets.

In response to the resurgence in uncomplicated malaria cases and to meet the universal LLIN coverage targets, the NMCP started mass distribution of new LLINs to selected districts according to malaria risk mapping (two per household), providing 184 000 in December 2009 and 581 000 in March 2010. In April 2010, a further 1.6 million new LLINs were distributed to all children < 5 years of age nationwide during a measles vaccination campaign. As a result of these initiatives the resurgence in malaria cases appears to have been reversed. From October to December 2010, another 2.1 million LLINs will be distributed to ensure that all households have two LLINs and that further increases in malaria cases and deaths are avoided.

SAO TOME AND PRINCIPE. The population of Sao Tome and Principe was 165 000 in 2009. IRS protected 140 000 people in 2005, 126 000 in 2006, 117 000 in 2007 and 137 000 in 2009. No IRS was undertaken in 2008. By 2007, nationwide ITN coverage was among the highest in Africa: 78% of households owned at least one ITN, and 54% of children < 5 years of age slept under an ITN. ACT was introduced for treatment of malaria in 2005, and the number of treatment courses distributed in 2005–2008 was enough to cover all reported cases.

The annual number of confirmed malaria cases in 2005–2008 was 84% lower than in 2000–2004, and in the same periods the slide

4. Data on the following climatic factors were examined: *(i)* Tropical Rainfall Measuring Mission (TRMM) rainfall estimates (*3*); *(ii)* satellite-based land surface temperature (LST) (*4*); and *(iii)* air temperature Climate Anomaly Monitoring System (CAMS) products (*5*). For each product, the average quarterly reading over the period of 2001–2008 was used to calculate a baseline, and this baseline was then used to calculate anomalies for the period 2001–2009. These anomalies were then compared with malaria case counts in each quarter by calculating Spearman rank correlations of case counts with each climatic variable in both real-time and with a one quarter lag. Additionally, multivariable regression analysis was used to simultaneously examine the effects of rainfall and temperature on malaria case increases.

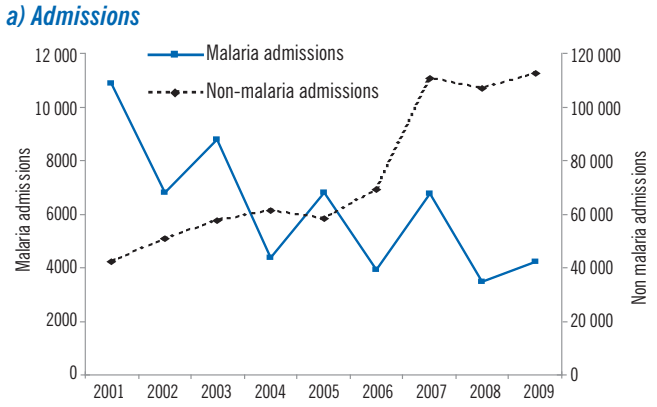


Figure 6.1 Malaria and non malaria admissions and deaths in Eritrea, 2001–2009

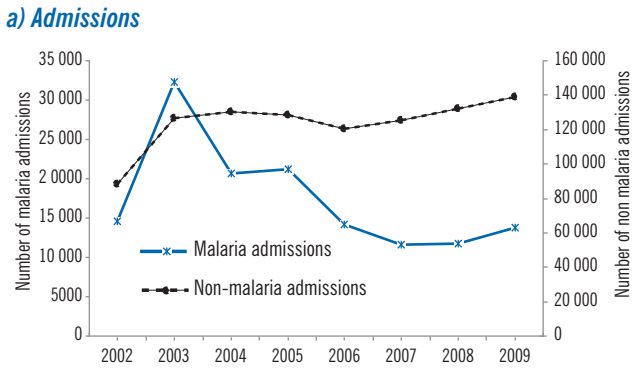


Figure 6.2 Malaria and non malaria admissions and deaths in Ethiopia, 2002–2009

NOTE: Data from 44 hospitals below 2000 m. Excludes Nov. and Dec. of each year owing to missing data in 2009

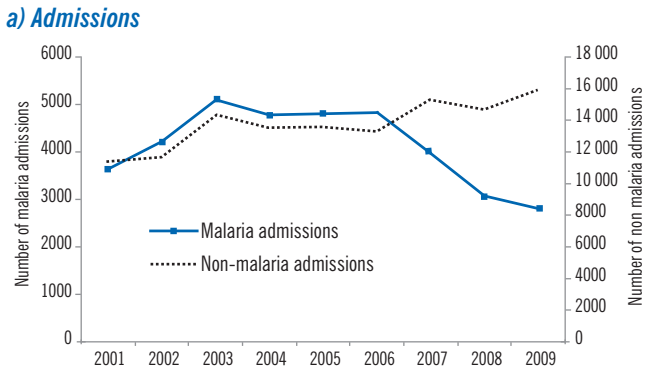


Figure 6.3 Malaria and non malaria admissions and deaths in Madagascar, 2001–2009

NOTE: Data from 35 health facilities. Excludes Nov. and Dec. of each year owing to missing data in 2009

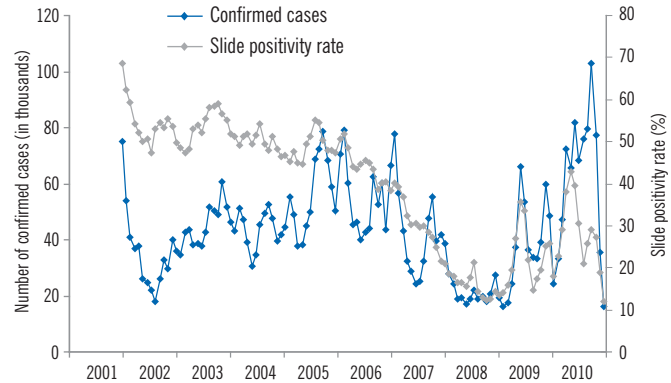


Figure 6.4 Confirmed malaria cases and slide positivity rate, Rwanda, 2001–2010

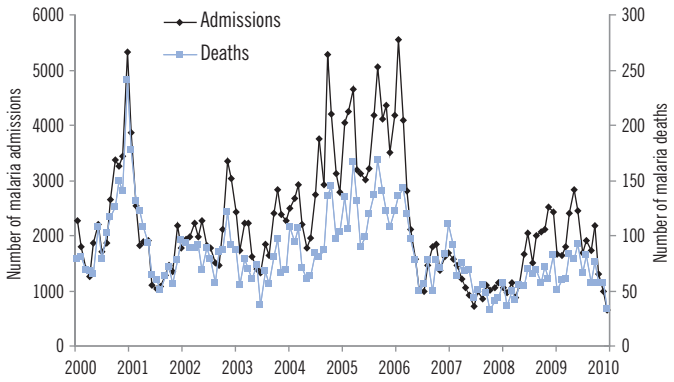


Figure 6.5 Malaria admissions and deaths, Rwanda, 2000–2010

positivity rate fell from 47% to less than 13% (**Fig. 6.6**). The annual number of admissions due to malaria was 87% lower in 2005–2008 than in 2000–2004, while the percentage of admissions for malaria fell from an average of 62% in 2000–2004 to 23% in 2005–2008. Similarly, the number of malaria reported deaths in 2005–2008 was 86% lower than in 2000–2004, and the percentage of deaths due to malaria in health facilities fell from 23% to 4%.

Until 2008, the data show a strong association between interventions and impact (*5*). However, in 2009 the number of confirmed malaria cases increased from 1647 to 3893, a 140% increase since 2008. Malaria-related admissions rose from 850 to 950 (up 44%) and malaria-related deaths from 16 to 23 (up 44%). The increase in 2009 followed a year when IRS had not been carried out, although the percentage of households owning at least one ITN remained high in 2009 (76% from a national survey). Once the increase in cases was detected by the surveillance system, emergency IRS was implemented and malaria cases decreased during the second half of 2009.[5]

ZAMBIA. Between 2001 and 2008 the number of admissions and deaths due to malaria had shown a consistent decrease (**Fig. 6.7**), which was associated with increased malaria control activities (*World Malaria Report 2009*). The magnitude of the decrease observed in health facility data was similar to changes observed in household survey data. For example, the numbers of malaria admissions and deaths among children < 5 years of age decreased by 57% and 62%, respectively, while the number of admissions for anaemia decreased by 47%. Parasite prevalence among children < 5 decreased by 53% between 2006 and 2008 (from 21.8% to 10.2%), and the percentage of children with severe anaemia (< 8 g/dl haemoglobin) decreased by 68% (from 13.3% to 4.3%). The consistency of trends between data sources suggested that the decreases were real and that health facility data could provide reliable information on changes in malaria incidence and mortality.

In 2009 the downward trend in malaria admissions and deaths levelled off nationally but there were small increases in malaria admissions in 5 of 9 provinces and a major resurgence in Eastern and Luapula provinces, where malaria admissions more than doubled when compared with 2008 numbers (**Fig. 6.8**). The change in malaria admissions has been paralleled by changes in parasite prevalence in children < 5 as measured by malaria indicator surveys undertaken in 2006, 2008 and 2010 (*6,7,8*) (**Fig. 6.9**). In Eastern province, parasite prevalence dropped from 22.8% in 2006 to 9.3% in 2008 but rose to 22.6% in 2010. In Luapula province, parasite prevalence decreased from 37.5% in 2006 to 21.8% in 2008, but rose to 53.5% in 2010. In other provinces the rise in parasite prevalence is less pronounced. The surveys in both provinces were conducted in May during each of the 3 years.

Household ITN ownership declined from 69.8% in 2008 to 50% in 2010 in Luapula province, but remained relatively high in Eastern province (74.8% in 2008 and 76.1% in 2010), so decreasing ITN coverage does not account for the malaria resurgence observed in both provinces. A large proportion of nets were delivered 2–3 years before the resurgence and it is possible that their effectiveness has deteriorated owing to decay of insecticide and physical deterioration of nets. Rainfall increased in both provinces in the quarter prior to the resurgence. The impact of malaria control on malaria admissions, cases and deaths was less in Luapula and Eastern provinces than in other provinces before the resurgence.

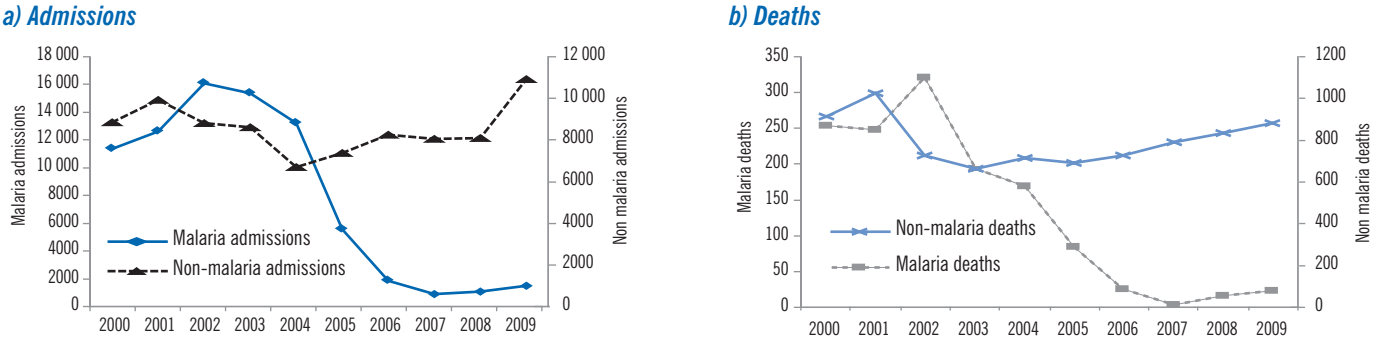


Figure 6.6 **Malaria and non-malaria admissions and deaths in Sao Tome and Principe, 2000–2009**

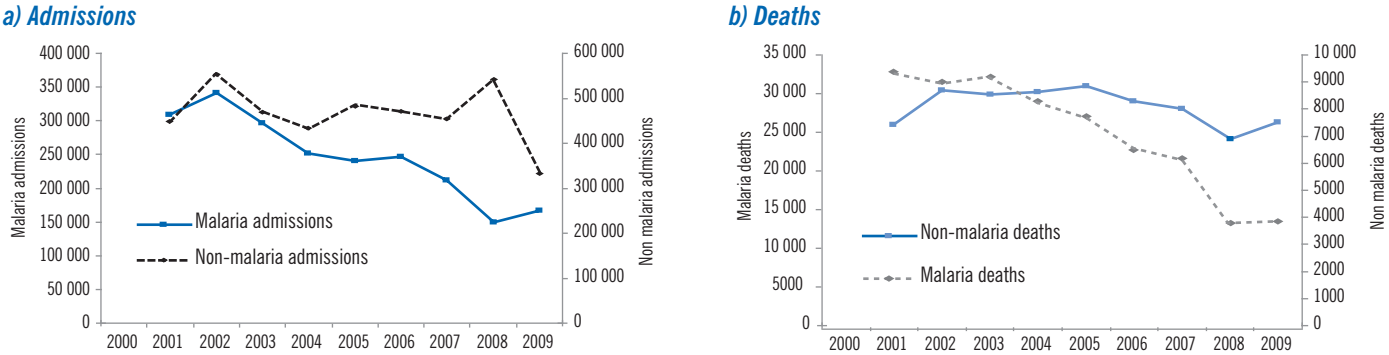


Figure 6.7 **Malaria and non-malaria admissions and deaths in Zambia, 2000–2009**

5. Lee *et al.* Potential threat of malaria epidemics in a low transmission area, as exemplified by São Tomé and Príncipe. *Malaria Journal 2010,* 9:264. http://www.malariajournal.com/content/9/1/264

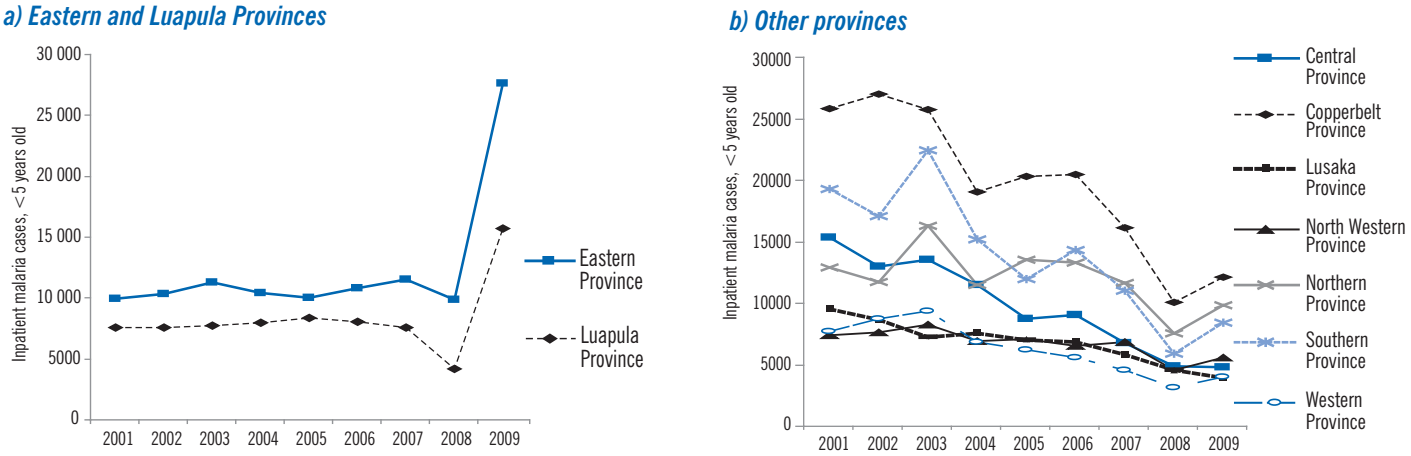


Figure 6.8 Malaria admissions <5 years of age, Zambia, 2001–2009 by province

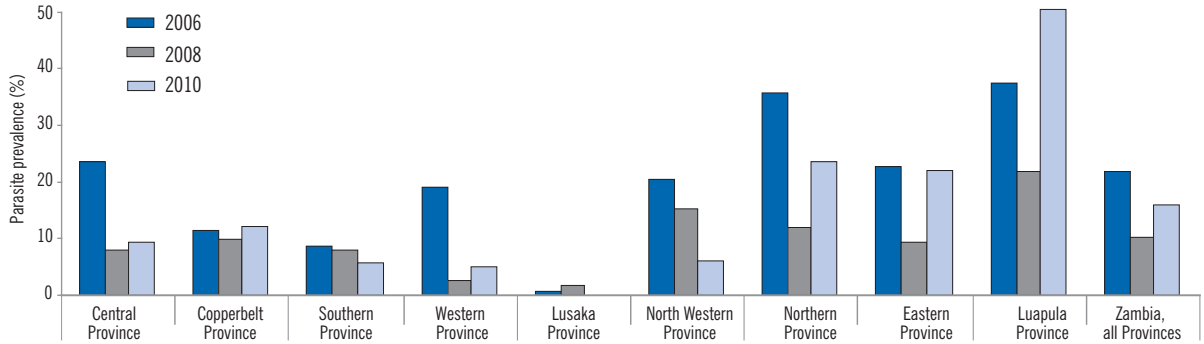


Figure 6.9 Parasite prevalence in children <5 years of age, Zambia 2006, 2008, and 2010

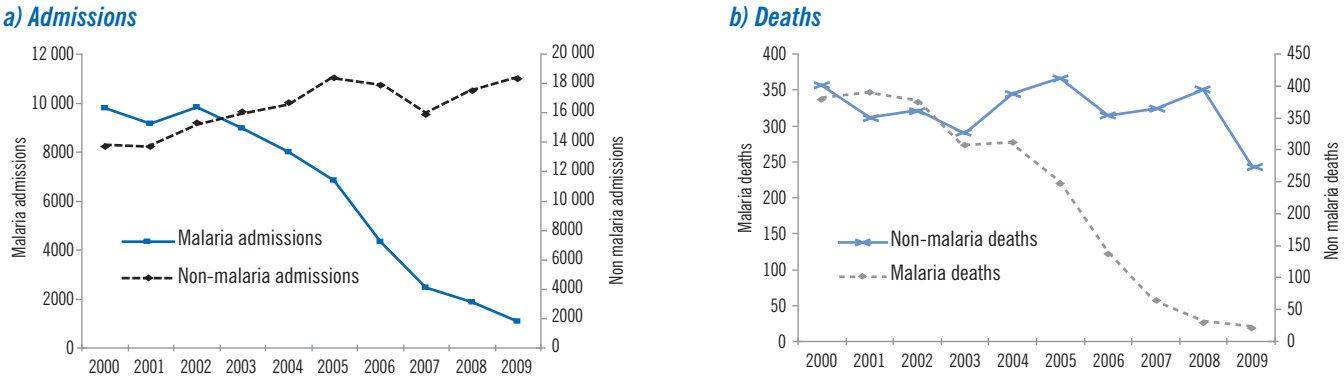


Figure 6.10 Malaria and non-malaria admissions and deaths in Zanzibar, United Republic of Tanzania 2000–2009

ZANZIBAR, UNITED REPUBLIC OF TANZANIA. The islands of Zanzibar (UR Tanzania) had a population of 1.3 million in 2009. ACTs have been made freely available in all public health facilities since September 2003. Approximately 245 000 LLINs were distributed in 2006, enough to cover 40% of the population, and a further 502 000 were distributed in 2007–2009, enough to cover the entire population. IRS has been carried out annually since 2006 with each round covering nearly all households.

The numbers of malaria admissions and deaths decreased substantially between 2003 and 2009. In 2007–2009, the numbers of malaria admissions and deaths were 81% lower than those recorded in 2000–2002 (**Fig. 6.10**). In contrast the number of admissions for conditions other than malaria was 21% higher. The numbers of malaria deaths recorded in 2007–2009 were 90% lower than in 2000–2002 while deaths from conditions other than malaria were just 7% lower.

The dramatic decrease in the number of admissions for malaria in Zanzibar was associated with high coverage of antimalarial interventions. The decrease could also be due in part to improved diagnosis of cases as RDTs began to be more widely used from 2005. Other evidence for an impact of malaria interventions comes from a detailed investigation in one district, where among children < 5 years there were substantial reductions in *P. falciparum* prevalence, malaria-related admissions, blood transfusions, crude mortality and malaria-attributed mortality following the introduction of ACTs in 2003 (*6*).

6.3 African Region: low-transmission countries

Of the countries in the African Region that are considered to have low levels of malaria transmission, Algeria is in the elimination phase and recorded only 93 indigenous cases between 2000 and 2009. In Botswana, Cape Verde, Namibia, South Africa, Swaziland and Zimbabwe, malaria is highly seasonal, and transmission is of much lower intensity than in the rest of sub-Saharan Africa. The vast majority of cases are due to *P. falciparum* (**Fig. 6.11b**). Five countries (Botswana, Cape Verde, Namibia, South Africa and Swaziland) recorded sustained decreases of more than 50% in the numbers of confirmed cases between 2000 and 2009 (**Fig. 6.11e**). Four of these countries also reported decreases in the number deaths due to malaria (**Table 6.2**). Cape Verde moved into the pre-elimination phase in 2010. In Zimbabwe, the number of confirmed malaria cases has fluctuated between 16 000 and 117 000 between 2004 and 2009, partly because of changes in the number of cases examined by microscopy. It is therefore not possible to identify any trends in malaria incidence in Zimbabwe. There was a large decrease in the number of recorded malaria deaths in Zimbabwe between 2002 and 2009, while the total number of deaths reported from all causes appears to have increased over this time.

The scale of IRS has remained fairly constant over the past 8 years; Botswana, Namibia, South Africa and Swaziland protected more than 70% of their populations at risk per year during 2007–2009. Zimbabwe has also increased the proportion of the population at risk protected by IRS to more than 60% in 2009. These countries have deployed sufficient courses of ACTs to treat all patients attending public health facilities.

In summary, 4 of the 5 low-transmission countries in southern Africa (Botswana, Namibia, South Africa and Swaziland) showed more than 50% decreases in the numbers of malaria cases between 2000 and 2009. Cape Verde also showed sustained decreases from 2000 to 2008 enabling it to enter the pre-elimination phase of malaria control. It recorded a rise in cases in 2009 which was principally due to increased case detection efforts. All of these countries implemented malaria interventions on a large scale. It is not possible to determine whether the number of cases in Zimbabwe is increasing, stable or decreasing, but preventive activities appeared to cover more than 50% of the population at high risk in 2008, and the number of malaria-related deaths has dropped substantially.

TABLE 6.2

NUMBER OF MALARIA DEATHS reported by low transmission countries, 2000–2009

	Botswana	Cape Verde	Namibia	South Africa	Swaziland	Zimbabwe
2000				424		
2001	29	0	1728	81	62	
2002	23	2	1504	96	46	1844
2003	18	4	1106	142	30	1044
2004	19	4	1185	88	28	1809
2005	11	2	1325	63	17	1916
2006	40	7	571	87	27	802
2007	6	2	181	37	17	401
2008	12	2	171	43	10	232
2009	6	2	46	45	13	14

BOX 6.1

EXPLANATION OF GRAPHS

Population at risk: population at high risk for malaria is that living in areas where the incidence is more than 1 per 1000 per year (defined at the second or lower administrative level). The population at low risk for malaria is that living in areas with less than 1 case of malaria per 1000 per year (see technical notes).

Percentage of cases due to P. falciparum*:* percentage of confirmed cases in which *P. falciparum* or a mixed infection was detected.

Annual blood examination rate: number of slide examinations carried out each year in relation to the population at risk for malaria, expressed as a percentage (see technical notes).

Confirmed cases reported as a percentage of total estimated: total number of confirmed cases in relation to the estimated number of malaria cases in a country. The estimated number of cases is calculated by taking into account: *(i)* the completeness of reporting from health facilities, *(ii)* the extent to which people with fever use public health facilities for treatment, and *(iii)* the extent to which public health facilities undertake case confirmation (see technical notes). The width of the bars reflects uncertainty around the estimate of the number of cases.

Change in number of reported cases: the number of confirmed malaria cases is shown on the vertical axis, with each country indexed at 100 in 2000 (or a later year if data were not available for 2000); i.e. a value of 200 in 2005 indicates that the number of cases in 2005 was twice that reported in 2000 and represents a 100% increase. Countries with evidence of a decrease are generally those in which there has been a consistent decrease in the number of cases and consistency in reporting of malaria cases (e.g. stable annual blood examination rate). Countries for which there is little evidence of a decrease are those that do not show a decrease in the number of cases or where there have been irregular variations in surveillance data (e.g. annual blood examination rate falling, or unexplained variations in the percentage of cases due to *P. falciparum*).

IRS and ITNs delivered: the vertical scale shows the percentage of the population at risk for malaria potentially covered by preventive programmes with IRS and ITNs. It is assumed that each net delivered can cover two people, that conventional nets are re-treated regularly, and that each net is not replaced before 3 years. It is also assumed that IRS and ITNs target different populations. The percentage of the population potentially covered is therefore the maximum possible covered by the interventions delivered. 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 is calculated as: 100 x (number of ITNs delivered in past 3 years + number of people protected by IRS in current year) ÷ population at high risk. Note that this indicator can exceed 100% if interventions are also applied to populations at low risk or if some high-risk populations are covered both by ITNs and IRS.

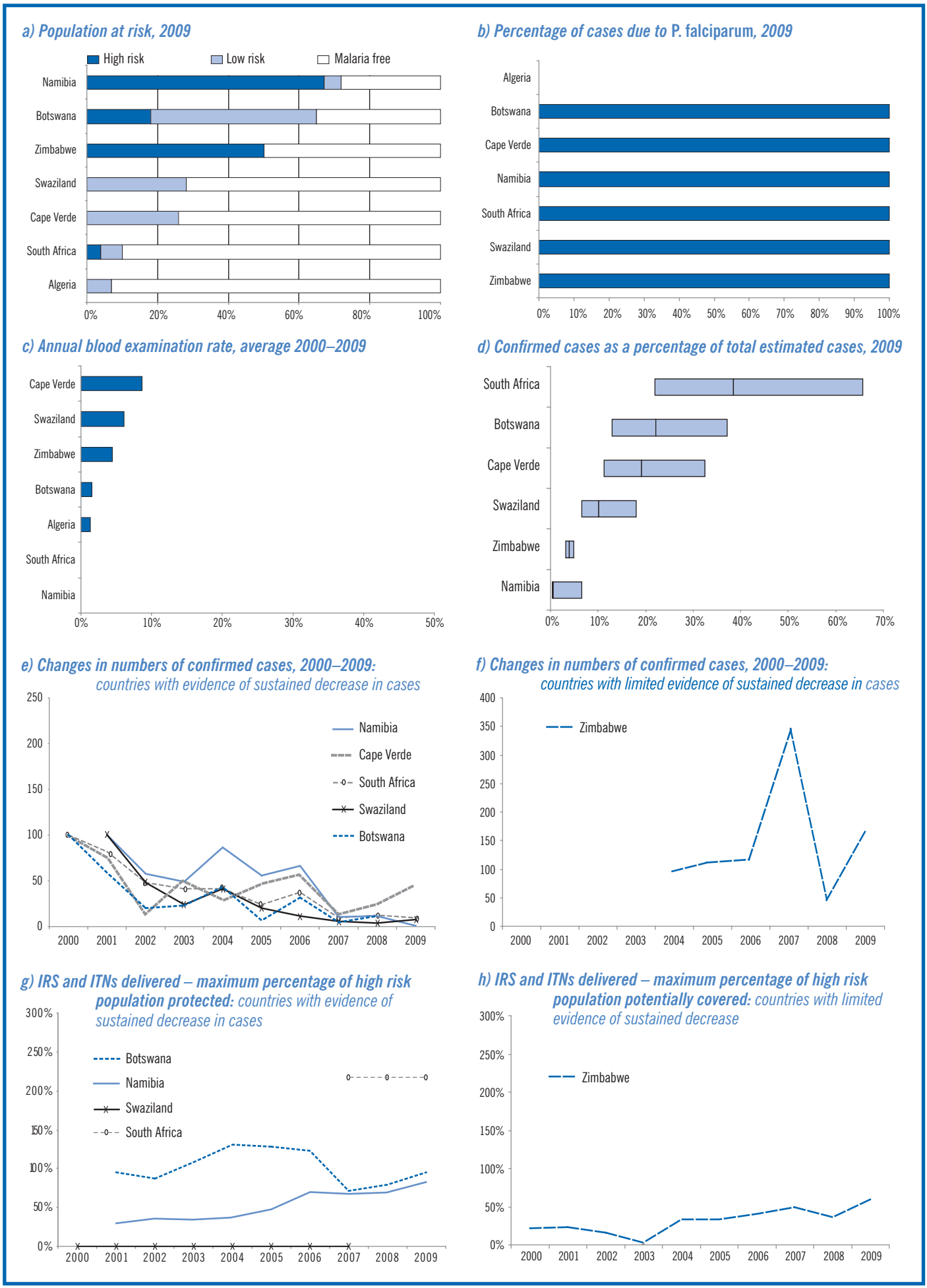


Figure 6.11 **WHO African Region – *low transmission countries***

6.4 Region of the Americas

Malaria transmission occurs in 23 countries and territories of the WHO Region of the Americas, with almost 20% of the total population at some degree of risk. Four of these countries (Argentina, El Salvador, Mexico, and Paraguay) are now in the elimination or pre-elimination phase; 2 countries (Bahamas, Jamaica) are preventing reintroduction of malaria after local outbreaks subsequent to importation of parasites.

Overall, *P. vivax* accounted for 80% of all cases reported in 2009, but the percentage of cases due to *P. falciparum* was almost 100% in the Dominican Republic and Haiti (**Fig. 6.12b**). Reported cases in the Region decreased from 1.18 million in 2000 to 526 000 in 2009. Four countries (Brazil, Colombia, Haiti and Peru) accounted for 90% of the cases in 2009. Reductions of more than 50% in the number of reported cases between 2000 and 2009 were seen in 11 countries (Argentina, Belize, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Paraguay, Plurinational State of Bolivia, and Suriname) (**Fig. 6.12e**). Three countries (Brazil, Colombia and Guyana) had smaller reductions (25%–50%) in the number of confirmed malaria cases between 2000 and 2009; Guyana registered a small increase in 2009 compared to 2008.

In 4 countries the scale of preventive activities is sufficient to cover 50% or more of the population at high risk (Ecuador, Guatemala, Nicaragua and Suriname). Brazil has greatly extended the availability of diagnosis and treatment through a network of more than 40 000 health workers who reach individual households.

The number of confirmed cases in French Guiana showed little change between 2000 and 2008 (no data were reported in 2009). Three countries (the Bolivarian Republic of Venezuela, the Dominican Republic, and Haiti) reported increased numbers of cases between 2000 and 2009, with the highest increase seen in Haiti (3 times more cases in 2009 compared to 2000). The risk of malaria may have further increased in Haiti in 2010 as a result of the earthquake in January and widespread use of temporary housing, although the risk will also depend on climatic conditions.

In summary, 9 countries, Argentina, Belize, Ecuador, El Salvador, Guatemala, Mexico, Nicaragua, Paraguay, and Suriname, experienced a decrease in the number of cases of more than 50%, associated with intense malaria programme activity.

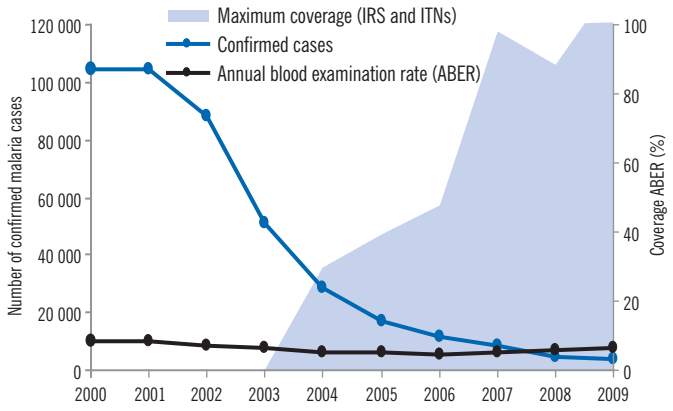
BOX 6.2

EXAMPLES OF SUCCESSFUL MALARIA CONTROL IN THE AMERICAS

ECUADOR. Confirmed malaria cases decreased from 105 000 in 2000 to 4120 in 2009, a reduction of 96%. The proportion of cases due to *P. falciparum* also decreased from 47% in 2000 to 13% in 2009. Today, only 4% of the 13.8 million population are at high risk for malaria (living in areas where incidence exceeds 1 case per 1000 per year). IRS has been the principal vector control method, covering an average of 344 500 people at risk per year in 2007–2009. The NMCP also distributed 458 000 LLINs free of charge in 2008–2009. These two interventions are sufficient to cover more than 100% of the population at high risk. Malaria diagnosis and treatment are provided free of charge for all age groups in the public sector; ACTs have been available for the treatment of *P. falciparum* malaria since 2005. Ecuador was awarded US$ 6.9 million from the Global Fund for Phase I of a project commencing in 2009. It also receives funds from UNICEF (US$ 80 000, 2009) and USAID (US$ 200 000, 2007–2008). The government has traditionally provided the majority of funding for malaria control (US$ 2.4 million in 2009), indicating strong national commitment to malaria control.

SURINAME. The number of confirmed malaria cases peaked in 2001 at 16 000 and has fallen steadily to 1700 in 2009, a 90% decrease. The number of reported malaria deaths fell from 24 in 2000 to zero in 2009, while the proportion of cases due to *P. falciparum* decreased from 84% to 22% in the same period. Today, only 11% of the 524 000 population is at risk of malaria. The annual blood examination rate was 54% in 2009 reflecting intensive efforts at case detection; the rate had been higher than 100% earlier in the decade, probably due to the high number of migrants from neighbouring countries treated in Suriname. The NMCP distributed 22 500 LLINs in 2007–2009, enough to cover 78% of the population at risk. IRS was also implemented selectively in focal areas. Suriname has benefited from substantial external funding for malaria control with US$ 4.5 million disbursed from Global Fund grants between 2006 and 2009.

a) Ecuador



b) Suriname

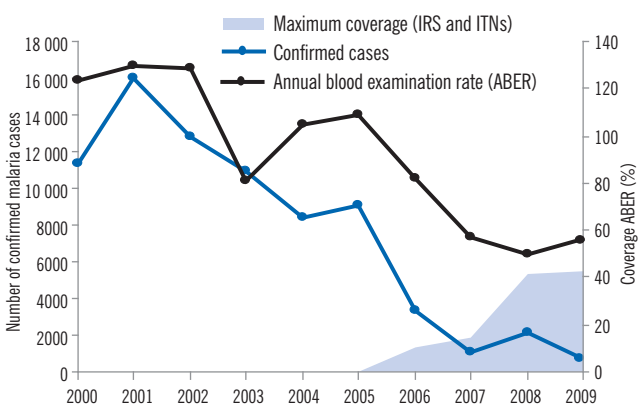


Figure Box 6.2 Trends in cases and malaria programme coverage, 2000–2009

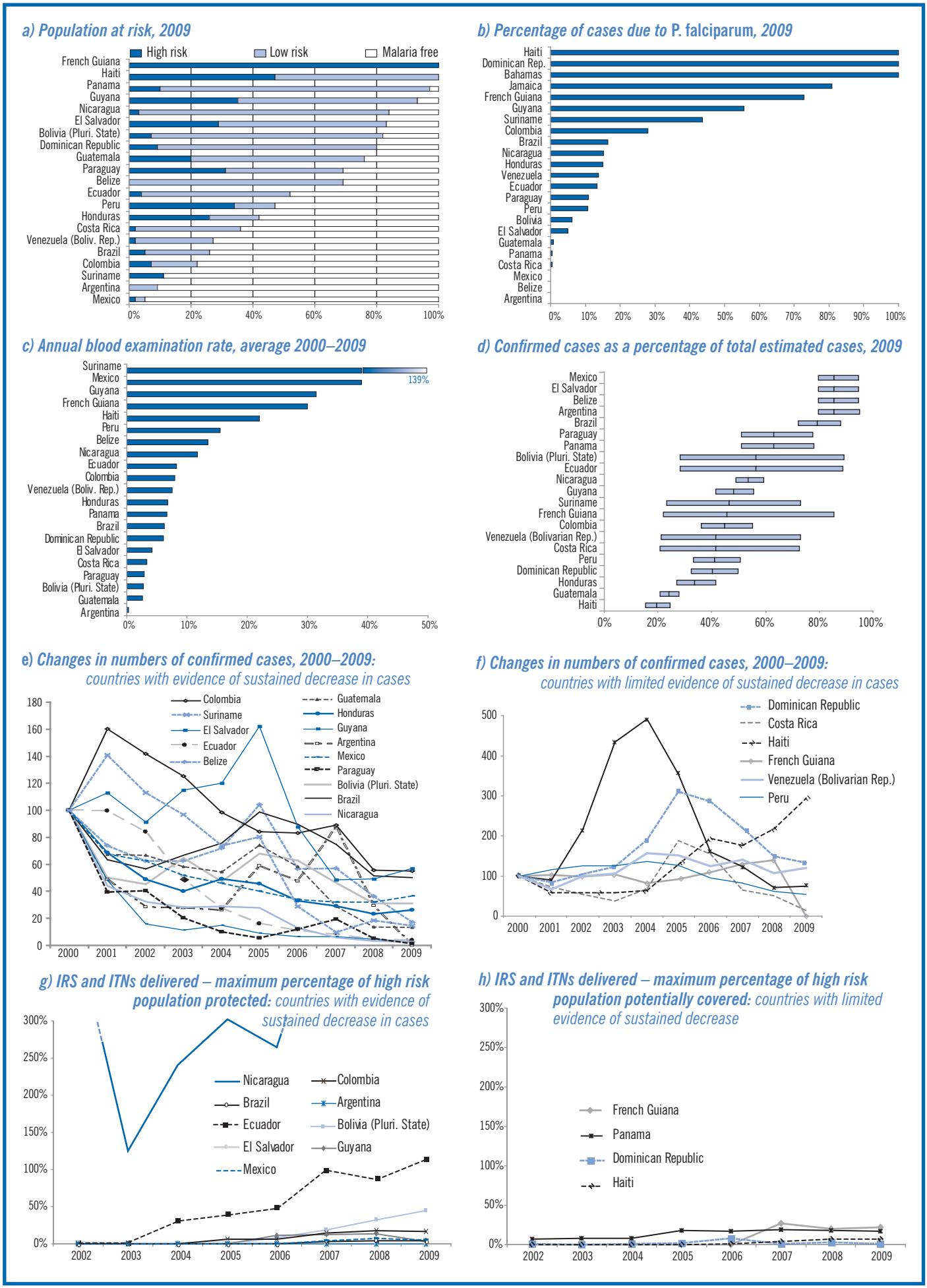


Figure 6.12 **WHO Region of the Americas**

6.5 South-East Asia Region

Of the 11 countries in the WHO South-East Asia Region, 10 are malaria-endemic; there has been no indigenous transmission of malaria in the Maldives since 1984. Approximately 60% of the total population in the Region is at some risk of malaria, with 20% at high risk (in areas with a reported incidence of more than 1 case per 1000 population per year). In 2009, 2.4 million parasitologically confirmed malaria cases and 3320 deaths were reported, a 7% decrease in cases since 2000. Three countries accounted for 94% of the reported cases in the Region in 2008 (India, 65%, Myanmar, 20% and Indonesia, 12%). Most cases in the Region are due to *P. falciparum*, although the proportion varies by country; transmission is due almost entirely to *P. falciparum* in Myanmar and Timor-Leste but exclusively to *P. vivax* in the Democratic People's Republic of Korea (**Fig. 6.13b**). Reductions of more than 50% in the number of reported cases in 2000–2009 were recorded in 5 countries (Bhutan, the Democratic People's Republic of Korea, Nepal, Sri Lanka and Thailand; **Fig. 6.13e**). The number of confirmed cases in India was 23% lower in 2009 than in 2000. There was evidence of widespread implementation of anti-malarial interventions in 3 countries that showed decreases in the number of cases (Bhutan, Sri Lanka and Thailand), although intervention coverage has been less than 50% in recent years in Sri Lanka and Thailand. Two countries in the pre-elimination stage actively follow up all suspected cases (Democratic People's Republic of Korea and Sri Lanka). The scale of preventive interventions appears to be limited in India and Nepal, with coverage of less than 30% of the population at high risk.

The remaining malaria-endemic countries reported either no change or an increase in the number of cases (Bangladesh, Indonesia, Myanmar and Timor-Leste), and the scale of control activities appeared to be small in relation to the total population at risk. Confirmed malaria cases in Myanmar increased by more than 16-fold between 2000 and 2009, due primarily to the increased availability of parasitological diagnosis by both microscopy and RDTs.

In summary, 4 countries (Bhutan, the Democratic People's Republic of Korea, Sri Lanka and Thailand) experienced a decrease in the number of malaria cases of more than 50% since 2000, associated with intensive malaria programme activity.

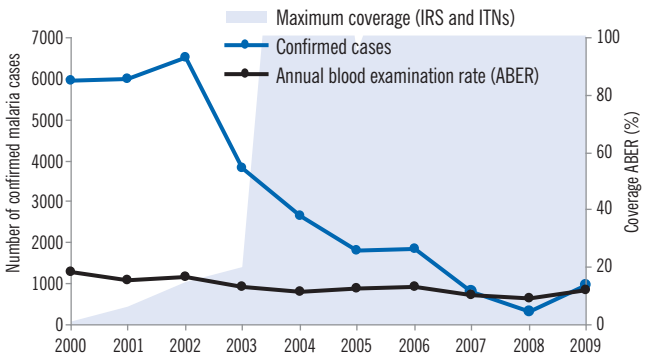
BOX 6.3

EXAMPLES OF SUCCESSFUL MALARIA CONTROL IN THE SOUTH-EAST ASIAN REGION

BHUTAN. Approximately 74% (493 000) of the total population (688 000) is at risk of malaria. Malaria occurs primarily in 15 districts that border India. The number of confirmed malaria cases has fallen from 5982 in 2000 to 972 in 2009, a decrease of 84%. In 2009, 58% of cases were due to *P. falciparum*. Only 4 malaria deaths were reported in 2009. An average of 145 000 people were protected each year with IRS in 2004–2009, and 132 000 ITNs were distributed. A household survey conducted in malaria endemic districts in 2009 indicated that 94% of households owned at least one ITN. ACTs were adopted for treatment of *P. falciparum* malaria in 2005 and are made available through public sector health facilities free of charge; there are few private sector treatment facilities in Bhutan. Government financing for malaria control averaged US$ 225 000 per year in 2005–2009. Over the same period disbursements from the Global Fund averaged US$ 600 000 per year and contributions from UN agencies and bilateral donors averaged US$ 204 000.

SRI LANKA. The number of confirmed malaria cases decreased from 210 000 in 2000 to 558 in 2009 and the proportion of cases due to *P. falciparum* from 28% to 5%. The number of reported deaths fell from 77 in 2000 to zero in 2009. A key strategy to reduce malaria cases has been the use of Malaria Mobile Clinics (MMCs) comprising at least 3 health personnel and a 4-wheel-drive vehicle to make services available to populations that do not have access to health facilities. Diagnosis was initially confirmed by trained microscopists but microscopy was supplemented with RDTs when MMCs were extended to areas lacking trained microscopists. IRS had been the principal method of vector control with an average of 50% of the population at risk protected in 2001–2004. ITNs were introduced as a complementary measure for populations at high risk. Government expenditures for malaria averaged US$ 1.6 million per year in 2005–2009 while disbursements from the Global Fund averaged US$ 2.4 million over the same period. The country is now in the pre-elimination phase of malaria control.

a) Bhutan



b) Sri Lanka

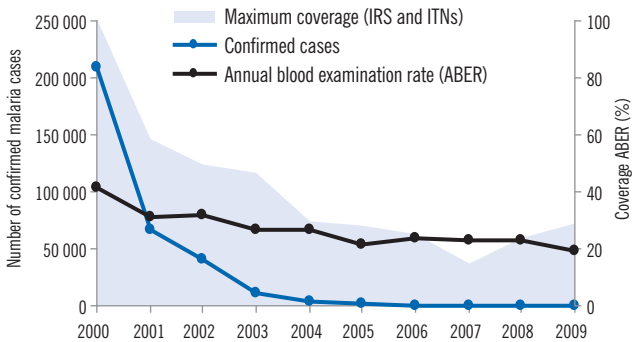


Figure Box 6.3 Trends in cases and malaria programme coverage, 2000–2009

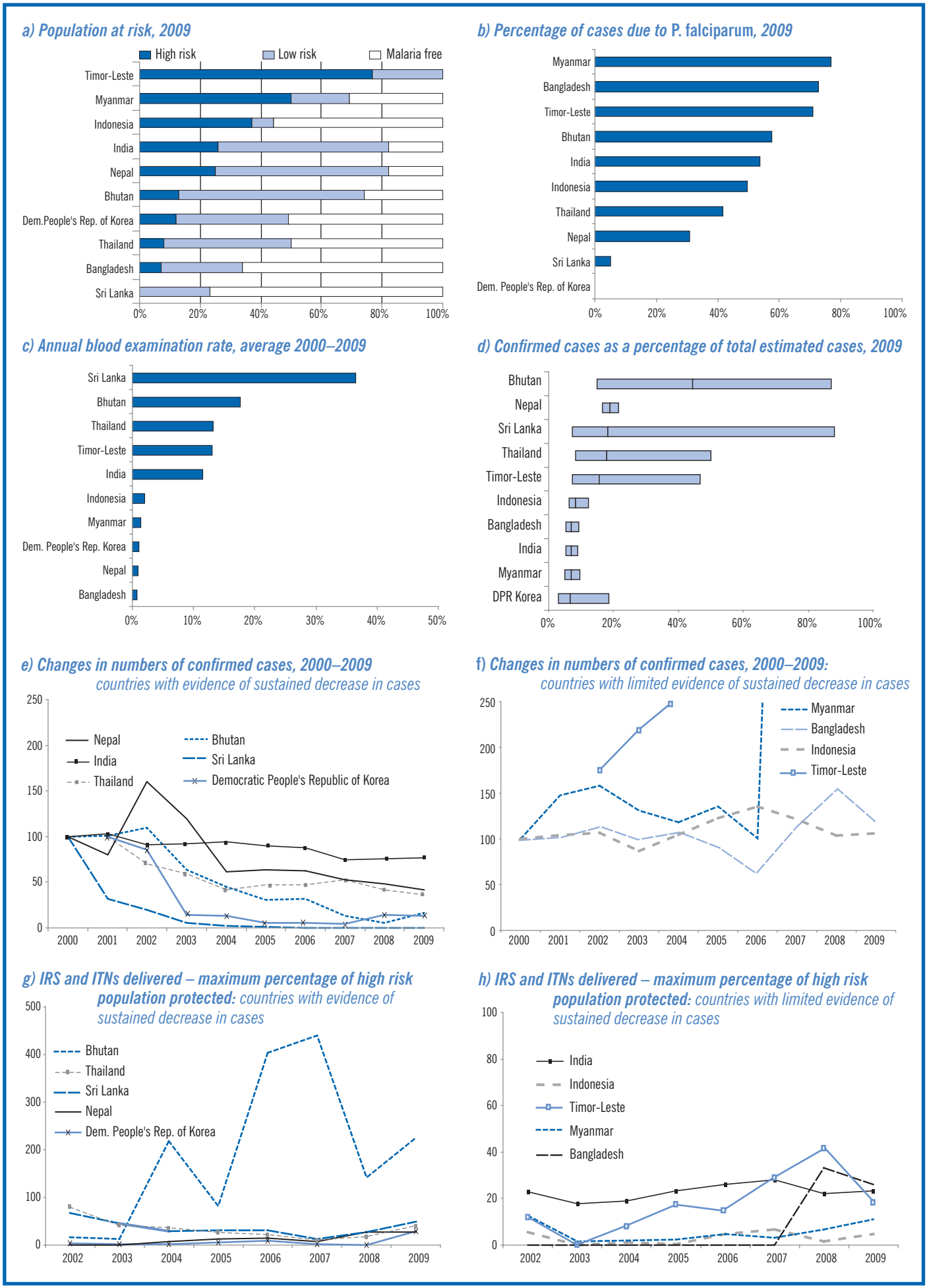


Figure 6.13 **WHO South-East Asia Region**

6.6 European Region

Indigenous malaria cases were reported in 5 countries in the WHO European Region in 2009: Azerbaijan, Georgia, Kyrgyzstan, Tajikistan and Turkey. Armenia and Turkmenistan continue to report zero locally-acquired cases and Turkmenistan was certified as malaria-free in October 2010. Uzbekistan reported zero local cases for the first time in 2009 while Tajikistan reported zero locally-acquired *P. falciparum* cases in 2009. Thus in 2009 all locally-acquired cases in the Region were due to *P. vivax*. Overall, the number of indigenous cases reported in the Region decreased from 32 385 in 2000 to 285 in 2009. All countries registered a decrease of more than 90% in the number of cases since 2000 except Kyrgyzstan that had a 67% reduction with only 4 cases in 2009, after a peak of 2744 cases in 2002 (**Fig. 6.14e**).

IRS is the primary means of vector control in all countries, applied with strict total coverage of all residual and new foci of malaria, aimed at interrupting transmission over the target area as soon as possible and preventing its re-establishment. The intensity of activity is evident in all of the countries – more than 80% coverage of preventive interventions in populations at high risk and more than 20% annual blood examination rate (**Fig. 6.14c,g**). ITNs are used as a supplementary intervention, particularly in Tajikistan. All suspected cases are examined by microscopy and all confirmed cases are treated; information on their origins is traced for further epidemiological classification of malaria foci.

Countries make concerted efforts to prevent the spread of malaria across neighbouring country borders. In 2005, all 9 malaria-affected countries in the Region at that time (including the Russian Federation) endorsed the Tashkent Declaration (*9*), the goal of which is to interrupt malaria transmission by 2015 and eliminate the disease in the Region. Since 2008, national and inter-country strategies on malaria have been revised to address cross-border collaboration and other new challenges for malaria elimination.

In summary, 5 of the 6 endemic countries reported local cases in 2009, all with sustained decreases of more than 50% in the number of cases since 2000. No indigenous *P. falciparum* cases were reported in 2009, for the first time since the resurgence of malaria in the early 1990s. All malaria-endemic countries in the Region have active control programmes.

BOX 6.4

CROSS-BORDER COLLABORATION ON MALARIA ELIMINATION: AZERBAIJAN – GEORGIA

Cross-border collaboration is of special importance in the context of malaria elimination, where there is a risk of spread of malaria between countries and neighbouring regions. Over 1 million people live in districts on the Azerbaijan–Georgia border, including over 600 000 in 7 districts in Azerbaijan and 416 000 in 6 districts in Georgia. There are close political, economic and cultural ties between the countries with ethnic Azerbaijanis living in Georgia and ethnic Georgians living in Azerbaijan and frequent population movements across the border.

Azerbaijan and Georgia both made a commitment to eliminate malaria by endorsing the Tashkent Declaration in December 2005. In 2008 both countries developed National Malaria Elimination Strategies and shifted national malaria programmes from control to elimination.

The first meeting on inter-country coordination on malaria elimination between Azerbaijan and Georgia was held in Baku on 19 March 2009, under the auspices of EURO. The meeting resulted in a Joint Statement on inter-country cooperation on malaria elimination in Azerbaijan and Georgia. The parties to the Joint Statement agreed to ensure regular exchange of information, synchronize action plans, ensure early notification of any changes, establish a joint working group, appoint focal points in each country, coordinate mobilization of additional resources, and take actions to create greater awareness of the successes of malaria elimination programmes. Joint activities started in May 2010 including IRS programmes in border areas.

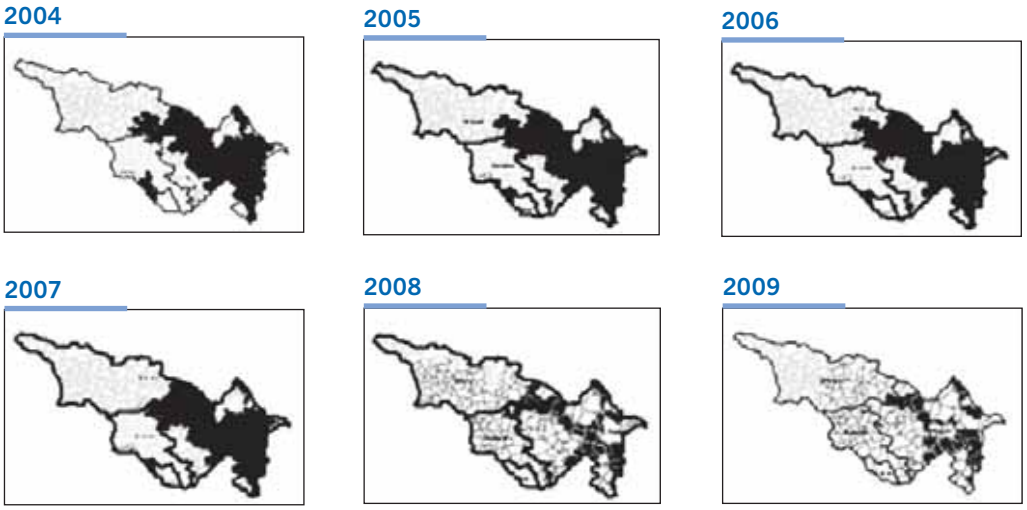


Figure Box 6.4 Distribution of malaria in Armenia, Azerbaijan and Georgia, 2004–2009

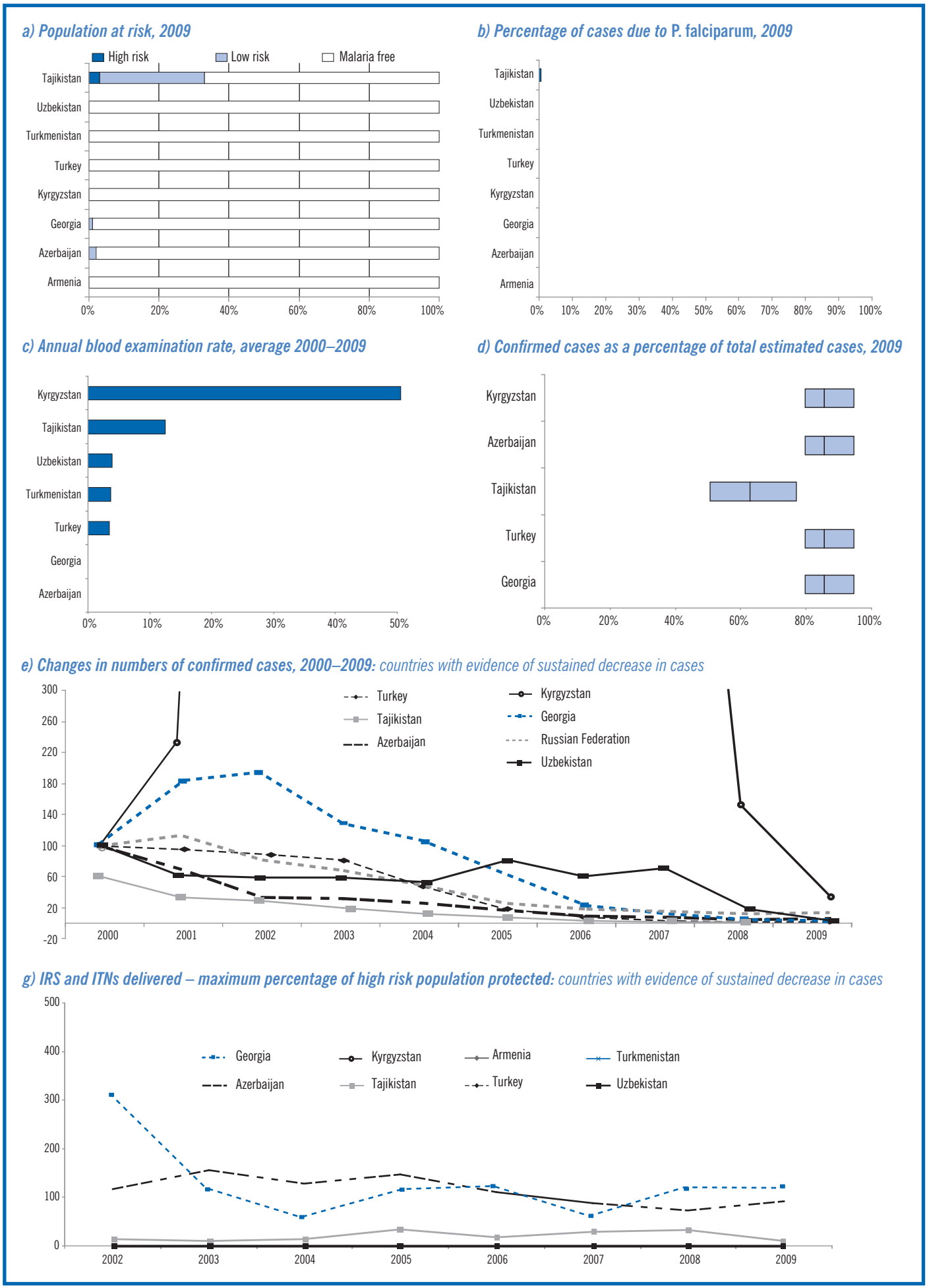


Figure 6.14 **WHO European Region**

6.7 Eastern Mediterranean Region

There are 6 countries with areas of high malaria transmission in the WHO Eastern Mediterranean Region (Afghanistan, Djibouti, Pakistan, Somalia, Sudan and Yemen), 3 countries with low, geographically limited malaria transmission and effective malaria programmes (Islamic Republic of Iran, Iraq and Saudi Arabia) and 4 countries that are in the phase of preventing re-introduction of malaria (Egypt, Morocco, Oman, and the Syrian Arab Republic). *P. falciparum* is the dominant species of parasite in Djibouti, Saudi Arabia, Somalia, Sudan and Yemen, but the majority of cases in Afghanistan and Pakistan, and a majority of cases in the Islamic Republic of Iran and in Iraq, are due to *P. vivax* (**Fig. 6.15b**). In 2009, the Region reported a total of 5.7 million probable and confirmed malaria cases of which only 1 million (18%) were confirmed parasitologically. Four countries accounted for 98% of the confirmed cases: Sudan, 70%; Pakistan, 17%; Afghanistan 6%; and Yemen, 5%.

Four countries reported reductions in malaria cases of more than 50% between 2000 and 2009 (Afghanistan, Islamic Republic of Iran, Iraq, and Saudi Arabia). Intensive control activities are carried out in the Islamic Republic of Iran, Iraq and Saudi Arabia, and these countries are now in the elimination or pre-elimination stage (**Fig. 6.15e**). Other countries in the Region have not reported consistent decreases in the number of cases (Djibouti, Pakistan, Somalia, Sudan and Yemen), although Sudan has extended the coverage of malaria preventive activities to more than 50% of the population at risk and has reported a reduction of cases in some parts of the country. Yemen has reported no local cases on Socotra Island and a reduction in parasite prevalence in Tihama populations. Data for Djibouti are only available for 2004–2008 and do not show a consistent trend.

In summary, 3 countries (Islamic Republic of Iran, Iraq, Saudi Arabia) showed evidence of a sustained decrease of more than 50% in the number of cases since 2000, associated with widespread implementation of malaria control activities.

BOX 6.5

CERTIFICATION OF MALARIA ELIMINATION IN MOROCCO

Recorded malaria in Morocco peaked at more than 350 000 cases in 1939 and remained high until 1947 when 303 000 cases and 548 deaths were reported. Since then the malaria burden has declined steadily in response to a combination of intensified control interventions, improved health service coverage and socio-economic development. Malaria has been a notifiable disease since 1967. Malaria due to *P. falciparum* was the first to disappear, with the last local case recorded in 1974, but transmission of *P. vivax* continued at low levels. In 1999, the Ministry of Health of Morocco, with the support of WHO/EMRO, re-oriented its malaria control programme towards elimination. Targeted control efforts and intensified surveillance temporarily interrupted local transmission (there were only 3 local cases due to *P. vivax* in 2000 and zero cases in 2001) but there was an outbreak in 2002 with 19 local cases in Chefchaouen province. Subsequent interventions and intensified surveillance brought the outbreak under control and the last local case of *P. vivax* was recorded in 2004. Since then, the country has recorded no locally-acquired cases of malaria, but receives an average of 109 imported cases annually, of which 88% are due to *P. falciparum*, mainly from sub-Saharan Africa. The programme has continued to spend approximately US$ 800 000 per year for maintaining interventions since 2007, 40% of this being for free diagnosis and treatment. In 2008, four years after interrupting local transmission, procedures towards certification of the achievement of malaria elimination were initiated. The country was certified free of malaria by the Director-General of WHO in May 2010. Increasing numbers of imported cases, illegal population movements and gradual attrition of malaria programme expertise are on-going challenges for the programme in keeping the country free of malaria, and preventing its reintroduction.

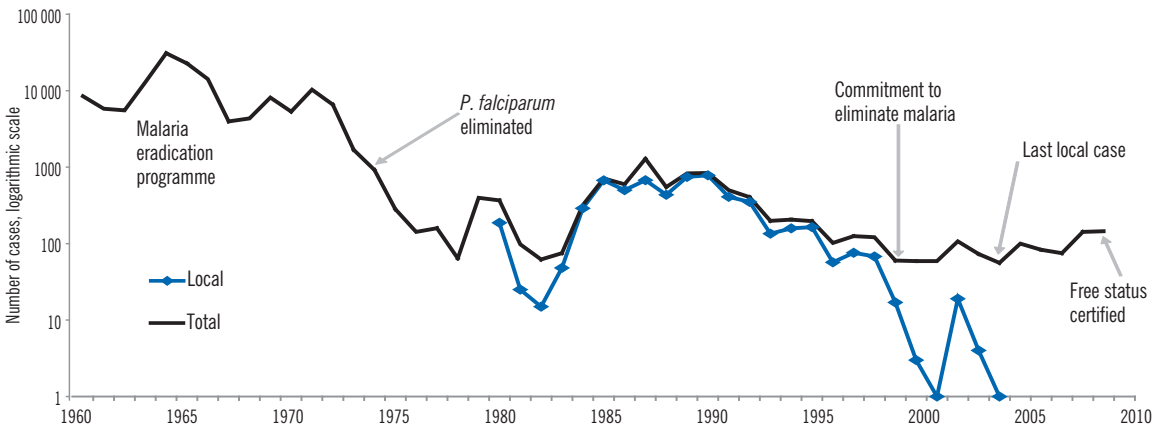
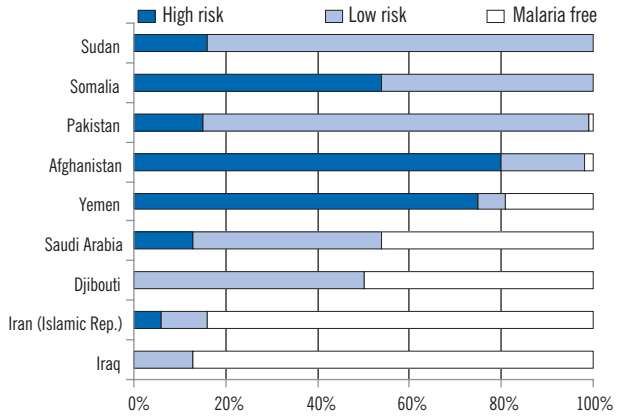
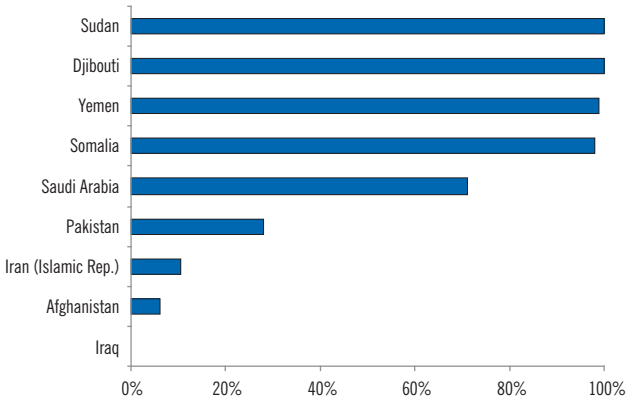


Figure Box 6.5 Trends in reported malaria cases in Morocco, 1960–2010

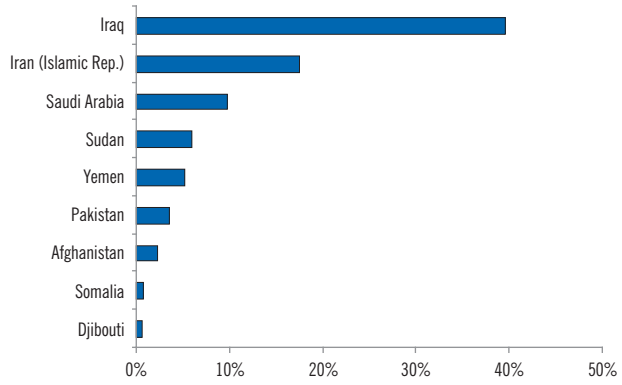
a) Population at risk, 2009



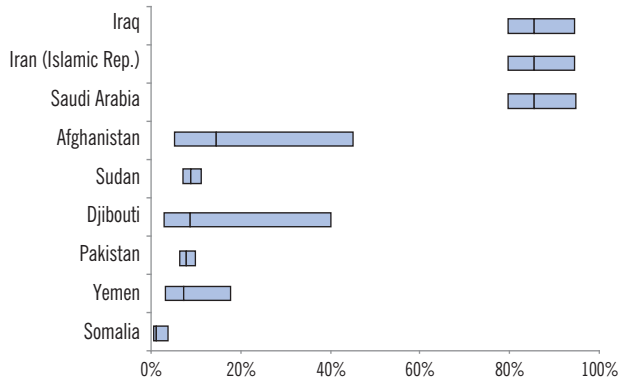
b) Percentage of cases due to P. falciparum, 2009



c) Annual blood examination rate, average 2000–2009

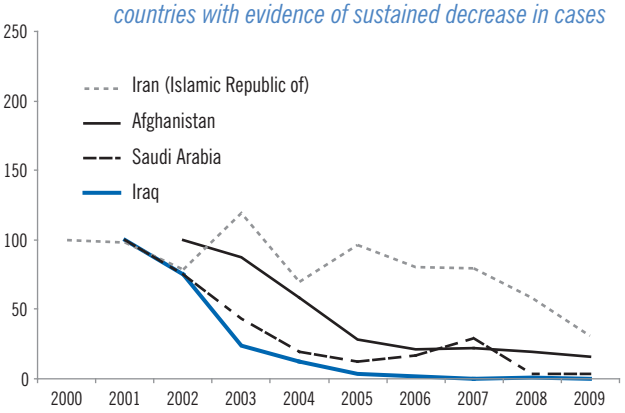


d) Confirmed cases as a percentage of total estimated cases, 2009



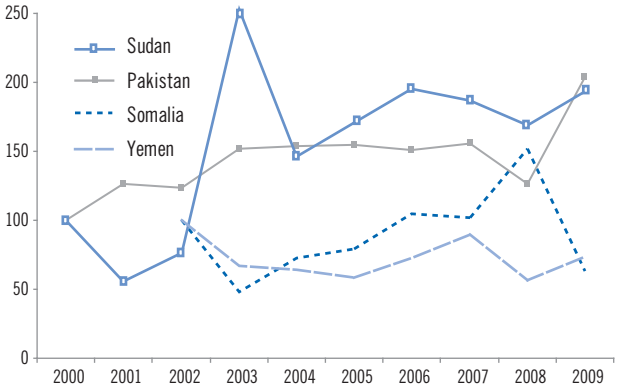
e) Changes in numbers of confirmed cases, 2000–2009

countries with evidence of sustained decrease in cases

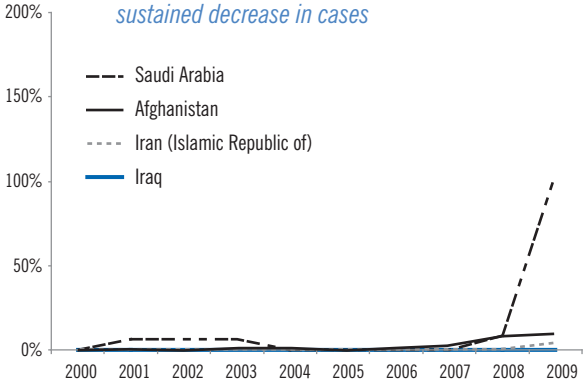


f) Changes in numbers of confirmed cases, 2000–2009

countries with limited evidence of sustained decrease in cases



g) IRS and ITNs delivered – maximum percentage of high risk population protected: *countries with evidence of sustained decrease in cases*



h) IRS and ITNs delivered – maximum percentage of high risk population protected: *countries with limited evidence of sustained decrease in cases*

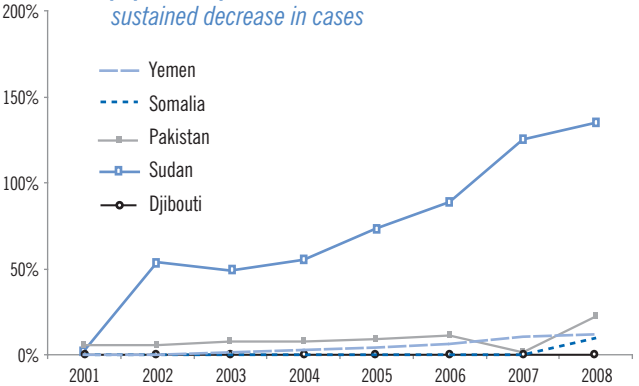


Figure 6.15 **WHO Eastern Mediterranean Region**

6.8 Western Pacific Region

Malaria transmission in the WHO Western Pacific Region is highly heterogeneous. It is intense and widespread in the Pacific countries (Papua New Guinea and Solomon Islands and, to a lesser extent, Vanuatu). It is highly focal in the countries and areas of the Greater Mekong sub-region, such as Cambodia, Yunnan (China), the Lao People's Democratic Republic and Viet Nam, occurring in remote forested areas and disproportionately affecting ethnic minorities and migrants. Malaria is restricted to particular geographical locations in Malaysia, the Philippines and the Republic of Korea. Most countries have both *P. falciparum* and *P. vivax*, but transmission is entirely due to *P. vivax* in the Republic of Korea and central areas of China (**Fig. 6.16b**).

Approximately 247 000 confirmed cases were reported from the Region in 2009. Three countries (Papua New Guinea, 31%, Cambodia, 26% and Solomon Islands, 13%) accounted for the 71% of the reported confirmed malaria cases in the Region, although this does not reflect the true burden because only 13% of suspected cases attending health facilities are given a diagnostic test in Papua New Guinea. Five countries reported decreases > 50% in the number of confirmed cases between 2000 and 2009 (China, the Lao People's Democratic Republic, the Republic of Korea, Solomon Islands, and Viet Nam). There is evidence of widespread implementation of malaria control activities in all of these countries, either by vector control or enhanced case management. Estimated coverage of vector control interventions appears to be low in Viet Nam which may reflect the focal nature of malaria in the country. In addition, household surveys indicate that more than 90% of households own a mosquito net in both Cambodia (DHS 2005) and Viet Nam (MICS 2006) although only 5% and 19% respectively sleep under an ITN. Hence, ITN coverage derived from public sector deliveries of ITNs may underestimate prevention efforts in these countries.

Three countries reported decreases of 25%–50% in the number of cases between 2000 and 2009 (Malaysia, Philippines and Vanuatu) (**Fig.6.16e**); there is widespread coverage of vector control interventions in Malaysia and Vanuatu. In both Cambodia and Papua New Guinea there was little change in confirmed cases although Cambodia reported a reduction in malaria deaths from 608 in 2000 to 279 in 2009 (54% decrease).

In summary, 5 countries showed evidence of a sustained decrease of > 50% in the number of cases associated with large scale implementation of malaria control activities (China, Lao People's Democratic Republic, Republic of Korea, Solomon Islands, and Viet Nam).

BOX 6.6

PROGRESSING WITH PRE-ELIMINATION OF MALARIA IN MALAYSIA

Malaria cases in Malaysia are concentrated in the deep forested areas of Sabah and Sarawak on the island of Borneo; the incidence is low on the mainland at less than 0.1 case per 1000 population. The number of reported cases fell from 12 705 in 2000 to 7010 in 2009, of which 8% were imported.

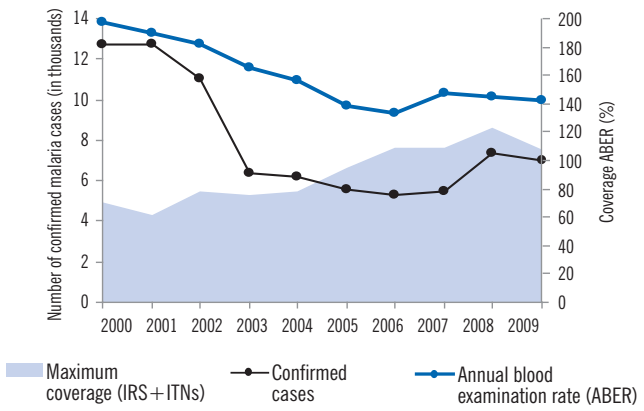
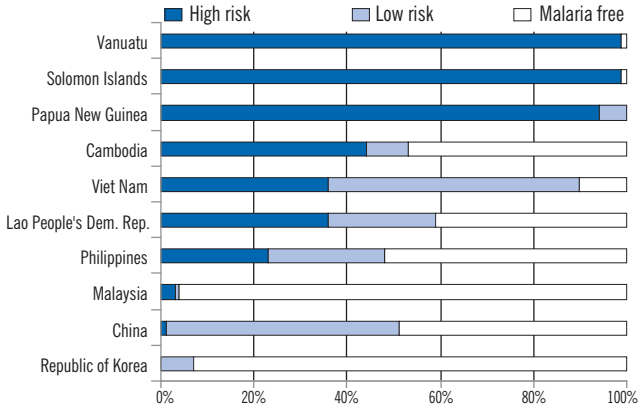


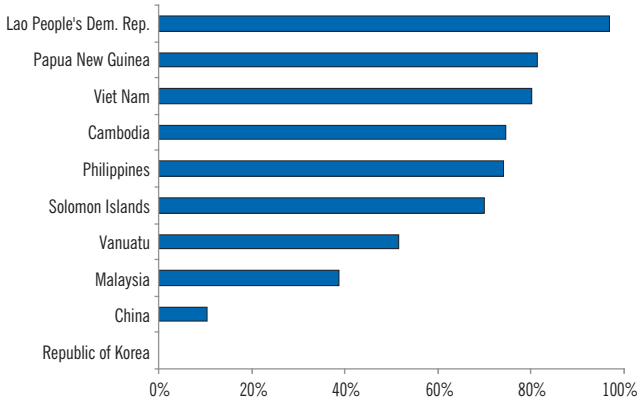
Figure Box 6.6 Trends in cases and malaria programme coverage in Malaysia, 2000–2009

With more than 1.5 million slides examined each year in a population at risk of approximately 1 million, the annual blood examination rate exceeds 100%; about 11% of cases are diagnosed through active case detection. Slide positivity rates have fallen from 0.7% in 2000 to 0.4% in 2008 as has the percentage of cases due to *P. falciparum* from 51% to 39%. In addition to early case detection and prompt treatment, Malaysia uses IRS and ITNs for malaria prevention and control. An average of 350 000 people were protected by IRS per year in 2007–2009 (35% of the population at risk) while 380 000 ITNs were delivered, sufficient to cover 75% of the population at risk assuming two people sleeping under each ITN. The NMCP is financed entirely by the Government of Malaysia. Reported expenditure in 2009 was US$ 24 million. Malaysia is in the pre-elimination phase of malaria control.

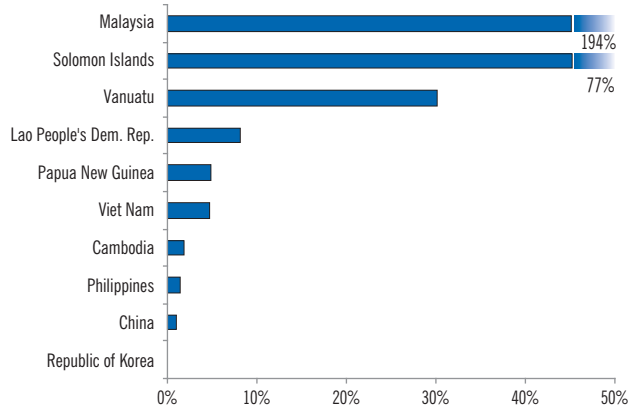
a) Population at risk, 2009



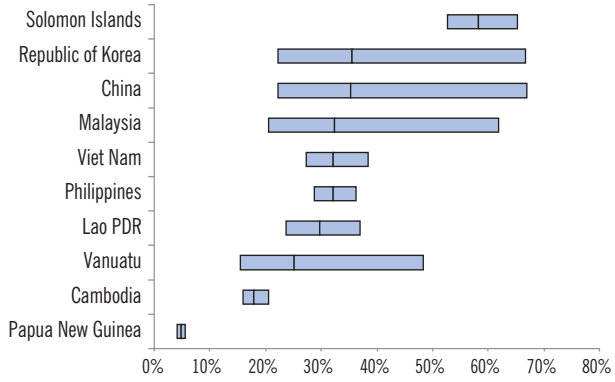
b) Percentage of cases due to P. falciparum, 2009



c) Annual blood examination rate, average 2000–2009

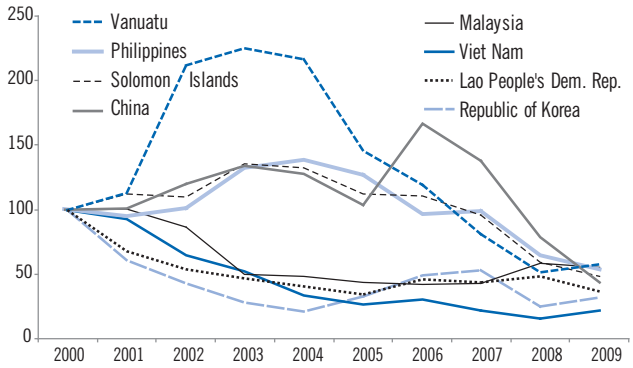


d) Confirmed cases as a percentage of total estimated cases, 2009



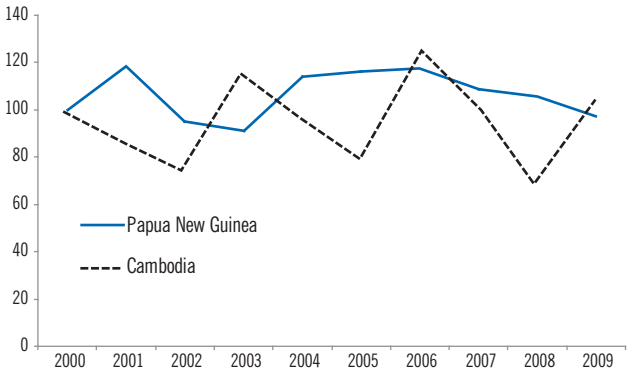
e) Changes in numbers of confirmed cases, 2000–2009

countries with evidence of sustained decrease in cases

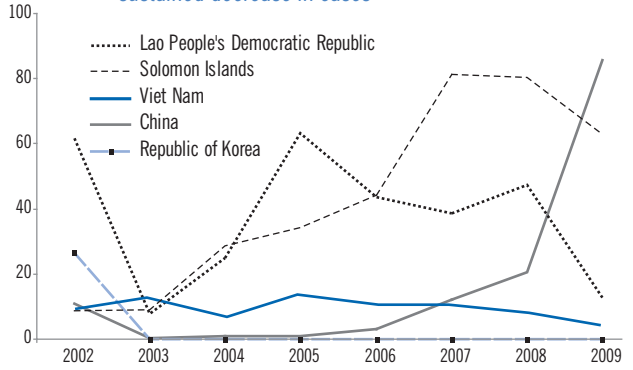


f) Changes in numbers of confirmed cases, 2000–2009

countries with limited evidence of sustained decrease in cases



g) IRS and ITNs delivered – maximum percentage of high risk population protected: countries with evidence of sustained decrease in cases



h) IRS and ITNs delivered – maximum percentage of high risk population protected: countries with limited evidence of sustained decrease in cases

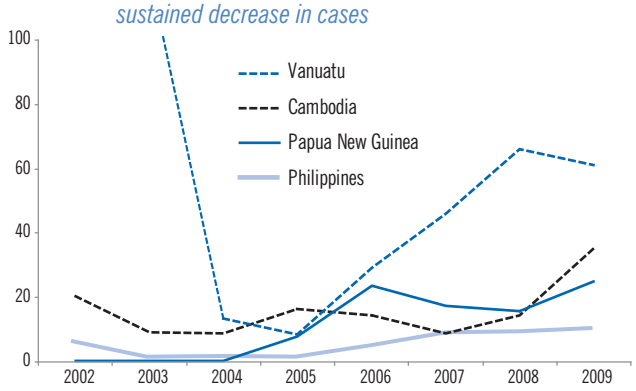


Figure 6.16 **WHO Western Pacific Region**

6.9 Malaria elimination and prevention of reintroduction

There has been continued progress towards malaria elimination in several countries in 2009 and 2010. Uzbekistan reported zero locally acquired cases in 2009 and no locally acquired *P. falciparum* cases were reported from the European Region in 2009. Morocco and Turkmenistan were certified free of malaria in 2010 and Cape Verde entered the pre-elimination stage in 2010. **Figure 6.17** shows the current classification of countries in the pre-elimination, elimination and prevention of reintroduction phases as of 1 December 2010.

For certification to be accorded, a defensible, plausible argument has to be made that, beyond reasonable doubt, the chain of local human malaria transmission by *Anopheles* mosquitoes has ended in the entire country at a given time, and that good quality surveillance systems are in place and capable of detecting local transmission if it occurred. The burden of proof of elimination falls on the country requesting certification. Inspection and evaluation are carried out by a team of experts led by WHO. The team makes a recommendation on certification based on an assessment of the current situation and the likelihood that elimination can be maintained. The final decision on granting certification rests with the WHO Director-General. Countries that obtain certification are added to the *WHO Official Register* of areas where malaria elimination has been achieved, and the certification is published in the WHO *Weekly Epidemiological Record*.

A total of 27 countries and territories have gone through the certification process over the past 27 years and are entered in the *WHO Official Register* as having eliminated malaria (**Table 6.3**). Certified countries continue reporting on an annual basis to WHO on the maintenance of their malaria-free status. Outbreaks of falciparum malaria in a normally or recently malaria-free country are reported to WHO immediately, so that WHO can provide assistance where needed and can alert international travellers visiting the affected areas that they should take suitable preventive measures. To protect international travellers, WHO posts reports of falciparum malaria outbreaks in "malaria-free" countries in the *Weekly Epidemiological Record* and on the *International travel and health* web site (www.who.int/ith).

An indication of the re-establishment of transmission would be the occurrence of three or more malaria infections that are linked in space and time to mosquito-borne transmission in the same geographical focus within the country, for two consecutive years for *P. falciparum*, and for three consecutive years for *P. vivax*. WHO reports such instances in the annual updates of *International travel and health*. The risk of re-establishment of transmission fluctuates with the degree of importation of parasites into an area (vulnerability), the likelihood that imported parasites will encounter favourable conditions for onward transmission (receptivity), and the watchfulness of the public health services for any occurrence of malaria in an area in which it had not existed or from which it had been eliminated, and the application of necessary measures against it (vigilance).

Over the period 1981–2007, the 11 countries in the European Region that were certified as having achieved malaria elimination reported a total of 35 754 imported malaria cases, i.e. 1324 cases annually on average (range: 728–2222). Almost half of these cases were reported by Italy (15 180, i.e. 562 annually on average, range 143–1006). Despite this high importation rate, Italy had only two instances of local transmission: one case in 1997 and two cases in 2007, all due to *P. vivax*.

The other country in this group with local mosquito-borne transmission since 1981 is Bulgaria: a total of 18 *P. vivax* malaria cases occurred in 1995–1996. Currently the most vulnerable country in the *Register* is the United Arab Emirates, which reported 18 240 imported malaria cases over the period 1999–2008 (range: 1322–2629 per year), linked to the high numbers of immigrant workers originating from endemic countries. For 2008, the importation rate amounted to nearly 6 malaria cases per 10 000 inhabitants, in a population of 4.485 million people. No local transmission has been reported in the United Arab Emirates since 1997.

6.10 Global estimates of malaria cases and deaths, 2000–2009

6.10.1 Methods

The global number of malaria cases in 2000–2009 was estimated by one of two methods.

1. *Countries outside the WHO African Region and low transmission countries in Africa*[6]. 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* (*10*), 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 then health service use was assumed to remain constant over time; analysis summarized in the *World Malaria Report 2008* indicated that the percentage of fever cases seeking treatment in public sector facilities varies little over time in countries with multiple surveys. For some countries NMCP data were missing or considered unreliable for selected years during the past decade (a total of 64 country years out of 690 country years). In such cases an estimate of the number of cases was constructed by sampling from the estimates for neighbouring years. Such a procedure results in an estimate that shows little change over time but which also produces a wide uncertainty interval around the point estimate.
2. *Other countries in the WHO African Region.* For some African countries the quality of surveillance data did not permit 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

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

TABLE 6.3

COUNTRIES ENTERED INTO THE *WHO Official register of areas where malaria elimination has been achieved*[1]

COUNTRY/AREA	REGISTRATION
Bolivarian Republic of Venezuela (northern part)	*June 1961*
Grenada and Carriacou	*November 1962*
Saint Lucia	*December 1962*
Hungary	*March 1964*
Spain	*September 1964*
Bulgaria	*July 1965*
China, *Province of Taiwan*	*November 1965*
Trinidad and Tobago	*December 1965*
Dominica	*April 1966*
Jamaica	*November 1966*
Cyprus	*October 1967*
Poland	*October 1967*
Romania	*October 1967*
Italy	*November 1970*
Netherlands	*November 1970*
United States of America and its outlying areas of Puerto Rico and the Virgin Islands	*November 1970*
Cuba	*November 1973*
Mauritius	*November 1973*
Portugal	*November 1973*
Former Socialist Federal Republic of Yugoslavia	*November 1973*
France, *Reunion*	*March 1979*
Australia	*May 1981*
Singapore	*November 1982*
Brunei Darussalam	*August 1987*
United Arab Emirates	*January 2007*
Morocco	*May 2010*
Turkmenistan	*October 2010*

1. Up to 1987, the *Register* was known as the *WHO Official register of areas where malaria eradication has been achieved.*

BOX 6.7

CERTIFICATION OF MALARIA ELIMINATION IN TURKMENISTAN

On 19 October 2010, Turkmenistan was added to the *WHO Official Register* of areas where malaria elimination has been achieved. Turkmenistan is the third country to be added to the list, after Morocco and the United Arab Emirates, since WHO certification procedures were re-initiated in 2004, after being abandoned in the 1980s.

By 1952 malaria in Turkmenistan was eliminated "as a major public health problem", and *P. falciparum* disappeared completely by the late 1950s. Over the period 1960–1980, sporadic cases of local *P. vivax* transmission were reported, and there was an increasing trend in imported malaria originating in Afghanistan during the 1980s. In the 1990s, the situation deteriorated because of neglect of the malaria problem and increased population movement. In 1998, 108 cases of malaria were detected in Kushka (now Serhetabad) *etrap* (district) of Mary *velayat* (province). To contain this outbreak, the most severe since 1960, the sanitary epidemiological service carried out emergency measures focussing on IRS and seasonal chemoprophylaxis.

In the 10 years 1999–2008, a total of 150 malaria cases were detected in Turkmenistan. The majority (78.6 %) of these occurred in relatively high risk areas in Mary (62 cases) and Lebap (56 cases) velayats (Tedjen-Murgab estuary and valley and Amudarya valley). The last autochthonous cases (i.e. acquired in Turkmenistan) were registered in 2004, and resulted in all probability from infections acquired during the 2002 or 2003 transmission seasons. By 2007, the Ministry of Health and Medical Industry decided to aim for certification of elimination, and in 2009, after 4 years without local transmission, procedures towards certification of the achievement of malaria elimination were launched. After following WHO standard operating procedures that include intensive external evaluation, certification was granted in October 2010.

PRE-ELIMINATION	ELIMINATION	PREVENTION OF RE-INTRODUCTION	Certified malaria-free and/or no ongoing local transmission for over a decade
Argentina	Algeria	Bahamas	
Cape Verde	Azerbaijan	Jamaica	
El Salvador	Georgia	Morocco →	Morocco
Paraguay	Iraq	Oman	
Iran (Islamic Republic of)	Kyrgyzstan	Russian Federation	
Malaysia	Republic of Korea	Syria	
Mexico	Saudi Arabia	Armenia	
DPR Korea	Tajikistan	Egypt	
Sri Lanka	Turkey	Turkmenistan →	Turkmenistan
	Uzbekistan		

In 2009, there were 8 countries in the pre-elimination stage; a ninth country, Cape Verde, was added in 2010. Morocco and Turkmenistan were certified as free of malaria by the Director-General of WHO in 2010.

Figure 6.17 Movement of countries between types of programme, 2009 and 2010

the expected impact of ITN and IRS programmes. The procedure was initially developed by the RBM Monitoring and Evaluation Reference Group in 2004 (*1*) and also described in *World Malaria Report 2008* (*10*).

The number of malaria deaths was estimated by one of two methods:

1. *Countries outside the WHO African Region and for low transmission countries in Africa*[7]. 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* (*10*). 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 Incremental Revision for 2004 (*11*). A case fatality rate of 0•45% is applied to the estimated number of *P. falciparum* cases for countries in the African Region and a case fatality rate 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 case fatality rate 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.
2. *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 (*12,13*). With an updated systematic review and addition of vital registration data from similar settings, the VAMCM now includes 123 study data points from 33 countries that meet the inclusion criteria . These data are mainly from high mortality and lower income countries. The VAMCM derives mortality estimates for malaria, as well as eight other causes (pneumonia, diarrhea, congenital malformation, other neonatal causes, injury, meningitis, measles, 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 2000–2009 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 method for estimating uncertainty differs from previously published work. The current round of estimates for 2000–2009 employs the bootstrap method 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.

7. Studies conducted in 1980 or later with a multiple of 12 months study duration, cause of death available for more than a single cause, with at least 25 deaths in children <5 years of age, each death represented once, and less than 25% of deaths due to unknown causes. Studies conducted in intervention groups in clinical trials, and verbal autopsy studies conducted without use of a standardized questionnaire or with inadequate description of methods were excluded from the analysis.

6.10.2 Disease burden and trends

Cases. In 2009 there were an estimated 225 million cases of malaria (5^{th}–95^{th} centiles, 169–294 million) worldwide (**Table 6.4**). down from an estimated 244 million cases in 2005. The global number of cases was estimated to have increased between 2000 and 2005 in line with population growth and decreased subsequently due to the impact of malaria control. The largest percentage reductions since 2005 were estimated to have occurred in the European Region (86%) followed by the Region of the Americas (42%) The vast majority of cases in 2009 (78%) were in the African Region, followed by the South-East Asia (15%) and Eastern Mediterranean Regions (5%).

Numbers for years prior to 2009 have been updated from previous publications. They are largely consistent with those given in the *World Malaria Report 2009* (*14*); they are accompanied by large uncertainty intervals, which overlap those of estimates published in previous years reports. Any differences with previously reported numbers, as observed for the Eastern Mediterranean and South-East Asia regions, should not be interpreted as evidence of a change in malaria burden but merely revisions to estimates which take into account updates to the number of reported cases or new household survey information.

Deaths. The global number of malaria deaths is estimated to have decreased from 985 000 in 2000 to 781 000 in 2009. The largest percentage decreases were seen in the Region of the Americas (48%); the largest absolute decline was observed in the African Region. It is estimated that 91% of deaths in 2009 were in the African Region, followed by the South-East Asia (6%) and Eastern Mediterranean Regions (2%). About 85% of deaths globally were in children under 5 years of age. The estimated numbers of deaths for prior years are consistent with those reported in the *World Malaria Report 2009* but are lower in the African Region principally because the effects of increased intervention are taken into account. The number of deaths in the South-East Asian Region is higher than previously estimated owing to increased estimates in India and Indonesia. The estimates are accompanied by large uncertainty intervals, which overlap those of previous estimates.

6.11 Conclusions

Reductions in malaria admissions and deaths in Africa. A total of 11 countries in the WHO African Region showed more than 50% reduction in either confirmed malaria cases or malaria admissions and deaths (**Table 6.1**). In all countries the decreases are associated with intense malaria control interventions. The trends shown in data routinely collected by NMCPs are consistent with those found in research studies in eastern, central and southern Africa (e.g. Eritrea, Equatorial Guinea, Ethiopia, Kenya, Rwanda, South Africa, UR Tanzania) and in the Gambia (*15–21*).

Resurgences in cases in Africa. There was evidence of an increase in malaria cases in three countries in 2009 that had previously shown decreases (Rwanda, Sao Tome and Principe, and Zambia). The reasons for these resurgences are not known with certainty. In Rwanda, national-level rainfall and temperature anomalies were

not associated with the resurgences. There was increased rainfall in Zambia, 2007–2008, but the increase in cases was pronounced in only two provinces. In Rwanda and Zambia a substantial proportion of ITNs were distributed 2–3 years before the resurgence and it is possible that the effectiveness of ITNs had become reduced owing to physical deterioration of nets and insecticide decay. Resistance to the pyrethroid insecticides used in ITNs is also a possible explanation, but information is not readily available as few countries undertake regular monitoring of insecticide resistance.

Actions needed to prevent and contain resurgences. Increases in malaria cases highlight the fragility of malaria control and the need to maintain control programmes even if numbers of cases have been reduced substantially. They also show that monthly monitoring of disease surveillance data both nationally and sub-nationally is essential. Since most countries in sub-Saharan Africa had inadequate data to monitor disease trends, greater efforts are needed to strengthen routine monitoring systems. Major epidemiological events could be occurring in other countries but are not being detected and investigated.

Reductions of cases outside Africa. A decrease of more than 50% in the reported number of cases of malaria between 2000 and 2009 was found in 32 of the 56 malaria-endemic countries outside Africa (**Table 6.3**), and downward trends of 25%–50% were seen in 8 other countries. The European Region has been the most successful with one country certified as malaria-free in 2010 and no cases of *P. falciparum* malaria in the entire Region in 2009 for the first time. In 27 of the 32 countries with more than 50% decreases in reported cases, the scale of preventive activities (ITNs and IRS) was sufficient to cover more than 50% of the population at high risk and/or the countries maintained strong systems for detecting and treating cases. In 5 of the 8 countries which had a decrease of 25%–50%, this was associated with intensified intervention. In contrast, only 2 of the 15 countries that showed no evidence of a decrease carried out large-scale implementation of malaria control activities.

Reductions in malaria outside Africa are greater in countries with lower burdens. The countries that recorded more than 50% decreases since 2000 in the numbers of cases accounted for only 14% of the total estimated cases outside Africa in 2000 (8.3 million cases out of 59 million estimated). The countries with the highest malaria burdens within each Region were less successful in reducing the numbers of cases of malaria nationally, which may be related to smaller per capita investments in malaria control.

Significant reductions in malaria burden are estimated to have occurred since 2000. The number of cases of malaria was estimated to have decreased globally from 244 million in 2005 to 225 million in 2009. The number of deaths due to malaria was also estimated to have decreased from 985 000 in 2000 to 781 000 in 2009. Decreases in malaria burden have been observed in all WHO Regions, with the largest percentage decreases noted in the European Region, followed by the Region of the Americas. The largest absolute decreases in cases and deaths were observed in Africa.

TABLE 6.4

ESTIMATES OF MALARIA CASES AND DEATHS BY WHO REGION, 2000–2009

CASES (in thousands)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Uncertainty bounds	
											lower	*upper*
African	173 000	178 000	181 000	185 000	187 000	188 000	187 000	186 000	181 000	176 000	117 000	241 000
Americas	2 800	2 300	2 200	2 100	1 900	1 900	1 700	1 500	1 100	1 100	1 000	1 300
Eastern Mediterranean	15 000	16 000	17 000	16 000	14 000	12 000	12 000	12 000	13 000	12 000	10 000	15 000
European	47	34	27	22	13	7	4	2	1	1	1	1
South-East Asia	38 000	38 000	35 000	35 000	37 000	39 000	34 000	32 000	34 000	34 000	28 000	41 000
Western Pacific	2 800	2 500	2 200	2 500	2 800	2 300	2 500	2 100	1 900	2 300	2 000	2 500
World	233 000	236 000	237 000	241 000	243 000	244 000	238 000	233 000	231 000	225 000		
lower bound	181 000	181 000	182 000	184 000	185 000	185 000	179 000	175 000	171 000	169 000		
upper bound	302 000	304 000	308 000	313 000	314 000	317 000	310 000	304 000	298 000	294 000		

DEATHS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Uncertainty bounds	
											lower	*upper*
African	900 000	893 000	885 000	880 000	870 000	853 000	832 000	802 000	756 000	709 000	554 000	892 000
Americas	2 400	2 300	1 400	1 400	1 500	1 600	1 600	1 400	1 100	1 300	900	1 700
Eastern Mediterranean	18 000	18 000	21 000	19 000	17 000	17 000	16 000	15 000	16 000	16 000	12 000	26 000
European	0	0	0	0	0	0	0	0	0	0	0	1
South-East Asia	58 000	55 000	51 000	50 000	52 000	50 000	48 000	43 000	48 000	49 000	37 000	63 000
Western Pacific	6 800	5 800	5 200	5 900	6 500	4 900	5 400	4 700	4 200	5 300	3 400	7 300
World	985 000	974 000	963 000	957 000	947 000	927 000	904 000	867 000	826 000	781 000		
lower bound	797 000	785 000	775 000	769 000	765 000	744 000	725 000	694 000	662 000	628 000		
upper bound	1 228 000	1 214 000	1 199 000	1 191 000	1 174 000	1 153 000	1 120 000	1 075 000	1 024 000	968 000		

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