II REGIONAL SECTION

Introduction

The Communicable Disease Prevention and Control Project has produced this report on the situation of malaria in the Americas using information submitted officially by Member Countries to the Pan American Health Organization (PAHO). This is an official reference document intended for use by Member Countries, academic institutions, partner agencies and the global community.

This issue of the report presents information submitted for 2008, and provides a means for analyzing gains to date with respect to the goal of the Roll Back Malaria Initiative(RBM), which aims to reduce incidence of disease by at least 50% between 2000 and 2010.

In an effort to provide a more detailed understanding of the disease in the Region, the report has been modified to include a new format, a more detailed presentation of certain parameters, and graphics to illustrate several aspects of endemicity.

The document includes a general overview of the state of malaria in the Americas and specific sections analyzing the information available for each endemic country. The report also includes a section on cases found in non-endemic countries, where surveillance is essential to prevent reintroduction and/or reestablishment of disease transmission. In addition to providing information about each country as a whole, the report emphasizes data available at the local level, which, depending on the country, corresponds to municipalities, cantons or districts (called administrative level 2 –ADM2- in this report). The additional information allows the reader to analyze the geographic distribution of the disease and to understand implications of control efforts.

This report is part of the effort by the Health Surveillance and Disease Prevention and Control Area of PAHO to systematize the handling of information regarding communicable diseases in the Region. The goal is to improve the quality and timeliness of regionally-reported data and to help countries with the systematic counting and reporting of cases. Above all, we hope the report will encourage the use and analysis of information by national disease prevention and control programs.

The production of the report coincides with an effort by the World Health Organization (WHO) Global Malaria Program to systematize and optimize information management both nationally and globally. As such, efforts were made to coordinate the collection of information for 2008 to simultaneously meet WHO and PAHO needs.

Now that several countries in the Region have achieved significant reductions in the burden of malaria, and that some of these countries are ready to engage in elimination efforts, this report provides information that may support those efforts and a refocusing of certain programs.

There are limitations inherent to this type of report. Some, for example, may be misinterpretations due to problems in the data, while other could be errors in analysis resulting from forcing data collected in different countries into a single format. We hope, consequently, that this report will also spur reflection on improvements in data collection, analysis and use.

The data included in this report allow for an analysis of gains in the Region, and of remaining challenges to achieving: 1) the goal set by the RBM for 2010 and 2) the UN Millennium Development Goal (MDG) which proposes that the burden of malaria be reduced by 75% between 2000 and 2015.

Methodology, Scope and Limitations of the Report

The data analyzed in this report were submitted to the PAHO by its Member States in response to a request for information sent to health authorities in each country by PAHO in April 2009. The data were collected in spreadsheets (MSExcel®) designed by the WHO Global Malaria Program for the standardized collection of information from every endemic country. The format used by WHO corresponds to the one used by the Global Malaria database, an initiative which seeks to systematize malaria information management and to promote the monitoring of epidemiological and operational program indicator, in coordination with regional offices globally.

As a result of the focus on global parameters, some tables included variables that are not used by control programs in the Region; on the other hand, some parameters that PAHO and Member Countries had been monitoring over the years were missing. Consequently, countries were asked to complete a supplementary form with variables unique to the Region.

The information was processed using computerized information systems for tabulation, graphics and maps. A draft, including text, graphs and analysis, was prepared for each country, and sent to its health authorities for review, correction and addition of missing information, if required. Once those changes were introduced, the document was formatted for final editing.

While the Global Malaria Report prepared by WHO in 2008 used estimates of disease burden based on 2006 data, this report provides a descriptive analysis of the state of the disease in 2008 using only the data supplied by each country's Health Ministry. The WHO estimates were based on formulas that adjusted the number of cases reported by each country to correct for the effects of underreporting and limited access to services.

The aforementioned estimates produced by WHO led to figures that were considered high and an overestimate of the disease burden in the Region. The concerns raised by the Global Report are nonetheless important; limited coverage of reporting, and limited access to services continue to be critical problems in malarial areas. This aspect of control programs is not addressed in detail in this report, and should be considered a weakness. The issue of access to diagnosis and treatment should be of major concern to malaria control programs; however, the data submitted by countries in the Region allow for only a partial analysis of the problem.

Maps to show the distribution of malaria cases were created using data collected at the countries' second level of political-administrative division. In some countries, this level corresponds to municipalities, in others, to cantons or districts. Case data were analyzed according to place of origin in order to gain a better understanding of the geographic distribution of transmission and a more reliable approximation of incidence rates. However, information submitted by some countries was instead collected by place of diagnosis. This should be taken into account when interpreting the numbers presented here, particularly annual parasite index (API) shown in maps for ADM2.

With respect to analysis of the geographic distribution of malaria, the images and cartography used for mapping should not be interpreted as an expression of views held by the PAHO concerning the legal status of any country, territory, city or area, its authorities or its borders.

The time series were created using data about cases and deaths previously provided to PAHO by each country. In some cases, public health ministries updated these data during the compilation and verification phase. The time series begin in 2000, the baseline year for RBM goals for 2010, as well as for the 2015 MDG targets.

Data regarding the population at risk of contracting malaria correspond to estimates produced using methodologies that may vary both within and among countries from year to year. Consequently, the changes observed may not have a clear relationship with the changes in the epidemiological situation. Due to this difficulty with populations considered at risk, the report does not place much emphasis on the analysis of these data. For the same reason, the national malaria API was calculated for each country using as a denominator its total population as reported in the document *Health Situation in the Americas: Basic Indicators – 2008*[1] published by PAHO.

For the maps and figures for ADM2 level, the population provided by the countries to PAHO/WHO was used as a denominator for API calculation. In most cases, it consists of the total population of each of these administrative units. In this section of the analysis, appropriate precautions should be taken when interpreting conditions in countries that provided case information by place of diagnosis rather than by place of origin.

Information regarding age, urban or rural origin, ethnicity, pregnancy and access to diagnosis within 72 hours of the onset of symptoms was requested from the countries through an additional form developed by PAHO to complement the information requested by WHO. Several countries do not collect these data, and the corresponding graphs will reflect that fact. Some countries have individual patient record databases, but did not have 100% coverage for 2008. For those countries, some parameters were obtained from the databases and extrapolated to the total number of cases registered by the program. The values thus obtained were considered representative of the situation at the national level, given that the information available in the databases corresponds to almost the total number of malaria cases in the country.

The analysis of program interventions emphasizes diagnostic and treatment activities, coverage through indoor residual spraying (IRS), and the use of insecticide treated nets. Diagnosis and treatment are analyzed along five dimensions: i) management of the diag-

---

[1] Pan American Health Organization. Health Situation in the Americas: Basic Indicators 2008. OPS/HDM/HA/08.01. Washington, DC. 2008.

nosis of febrile patients and the positivity rate in 2008 relative to previous years; ii) the lapse of time between the onset of symptoms and diagnosis; iii) the use of rapid diagnostic tests vis-à-vis microscopy; iv) the use of artemisinin-based combination therapy (ACT) in relation to the behavior of *P. falciparum* cases in Amazon countries; and (v) the use of antimalarial drugs in comparison to the number of reported cases. The last point allows a discussion of treatment practices on clinical presumption.

The analysis of these parameters was limited because some countries failed to provide the information or because the information provided was flawed in some way. For example, the comparison between the number of treatments distributed vis-à-vis the number of cases with parasitological diagnosis was limited because, in many cases, the countries reported the number of diagnosed cases as the number of treatments distributed instead of reporting values for the amount of medication consumed.

The length of time between the onset of symptoms and access to diagnosis, which gives an objective look at timeliness and coverage of the system, should be one of the most carefully monitored variables, but it is a parameter that is used only by a minority of countries in the Region.

Lack of information also limited analysis with regard to the use of rapid diagnostic tests. In some countries, this variable is not yet provided in the individual case reporting system, and no information is collected regarding inventories of tests used and examinations performed. This shortcoming should spur reflection regarding the need for malaria programs to properly manage the use of rapid tests, a relatively new treatment tool.

In some cases, data about (IRS) coverage referred to the number of households sprayed, while, in others, it described the number of people protected. Therefore, for each country that provided a number of households, the value was multiplied by five to achieve an estimate for the number of people protected. In the Regional analysis, comparisons were made between the use of IRS and long lasting insecticide-treated nets (LLIN). In order to make comparisons among countries, a ratio of coverage of the intervention to the number of cases in 2008 was calculated. For IRS, the number of people protected by IRS spraying in 2008 was divided by the number of cases in the same year. This ratio was multiplied by 10, yielding the total number of people protected per 10 cases of malaria in 2008.

Assuming a lifetime of at least three years for LLINs, the coverage for 2008 can be estimated as the number of nets distributed between 2005 and 2008. This total was divided by the number of cases in 2008, and multiplied by 10 to get an estimate of the number of LLINs distributed per 10 cases of malaria in 2008.

These estimates of intervention coverage allowed for an objective comparison of the scope of preventive actions relative to the magnitude of the disease in each country. This standard was chosen in lieu of working with each country's at-risk population as a denominator, because of a lack of standardization in the method by which the countries determine their population at risk.

General Description of the Malaria Situation in the Region

In 2008, 560,221 malaria cases were reported in the Americas, 30% less than the number reported to the Pan American Health Organization by Member States in 2007. Transmission of this disease, which disables and compromises the quality of life of an important segment of the continent's population, has decreased significantly in the Region since 2005.

Since documenting the interruption of transmission in several countries in the 1960s, 21 countries currently have endemic transmission of malaria: Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Guyana, French Guyana, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Suriname and Venezuela. Recent trends suggest that some countries, such as Argentina, El Salvador, Mexico, and Paraguay, will likely continue to advance toward elimination of the disease in coming years.

Malaria transmission in the Region can more easily be analyzed by grouping countries into four subregions that share eco-epidemiological characteristics and social determinants.

The countries that share the Amazon forest form a subregion by the same name. The highest numbers of cases occur in this subregion, which contributed 89% of the continent's total disease burden in 2008. Among Amazon countries, Brazil has the highest proportion of cases. It reported 315,553 cases in 2008, or 56% of the total number of cases in the Americas (Figures 2 and 3). Mexico, together with the countries of Central America, forms a subregion with lower transmission levels, a prevalence of over 96% of *P. vivax* malaria and *P. falciparum* strains sensitive to chloroquine. Colombia, which has large areas with environmental and social stressors conducive to malaria transmission, has had the second-highest number of malaria cases in the continent for several years. It represents an important link between the two subregions. The Island of Hispaniola (the Dominican Republic and Haiti) is another important subregion. It is the only territory within the Caribbean Islands with malaria transmission. Because 100% of its cases are due to strains of *P. falcipaum* (Figure 2), malaria represents a serious public health challenge, a potential risk for tourism and a danger, through case dissemination, to countries that have been free from malaria transmission. Argentina and Paraguay, in the south of the continent, fall into yet another group. This last group is characterized by very low *P. falcipaum* malaria transmission in focalized areas.

Main Focus of Transmission

Amazon

The high burden of malaria cases in Brazil is a strong determinant of the malaria situation in both the smaller group of countries in the Amazon basin and the Americas in general. In Brazil, the number of malaria cases fell significantly in 2008, continuing a downward trend that began in 2005. The number of cases also fell in Bolivia, Colombia, Ecuador, Peru, and Venezuela in 2008. Except for Colombia and Ecuador, the burden of malaria is determined by the social and environmental processes in the Amazon basin. In contrast, the disease burden in Colombia and Ecuador is primarily caused by transmission in communities living along the Pacific Coast and, particularly in Colombia, in the Uraba Region, close to the country's border with Panama (Figure 1).

The primary malaria vector in the Amazon subregion is the mosquito *Anopheles darlingi*. Its capacity as a vector, along with the manners of occupation of space and exploitation of the jungle, determines the intensity of disease transmission. Population dynamics resulting from settlement and development processes in many Brazilian municipalities are determinants of the

Disease Burden and Geographical Distribution

Figure 1. Number of cases by ADM2 level, Region of the Americas 2008

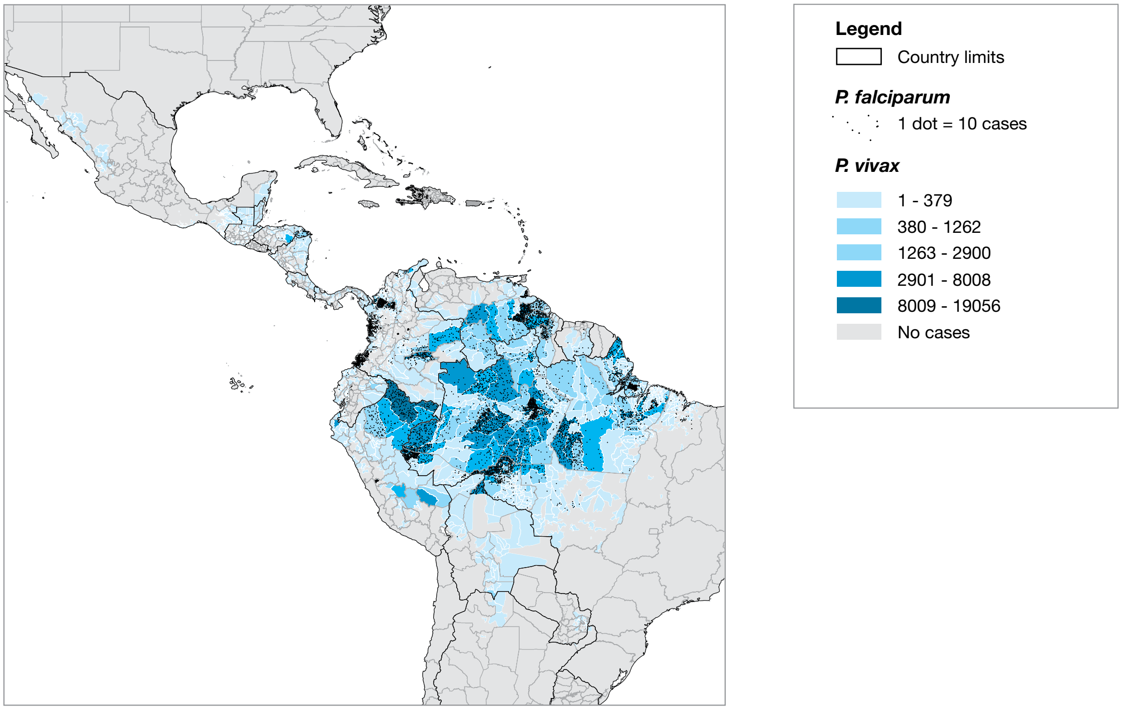
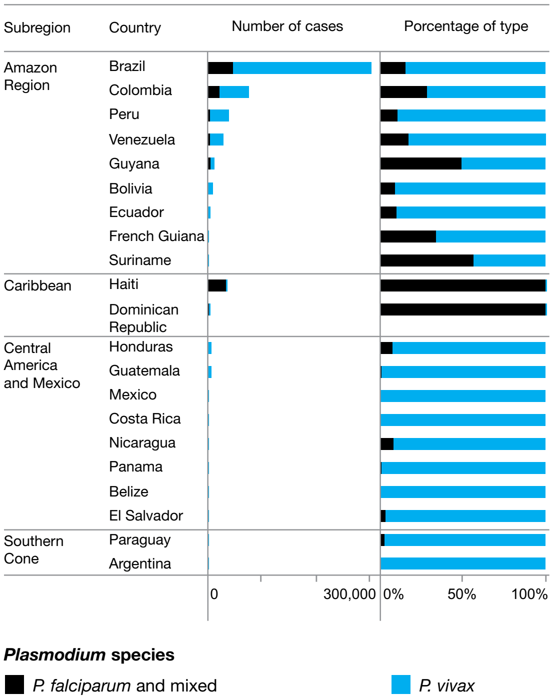


Figure 2. Number of malaria cases by country and species, Region of the Americas 2008



Country	*P. falciparum* and mixed	*P. vivax*	Total
Brazil	49,181	266,371	315,630
Colombia	22,392	56,838	79,230
Peru	4,492	37,722	42,214
Venezuela	5,540	26,437	32,037
Guyana	5,741	5,920	11,815
Bolivia	836	8,912	9,748
Ecuador	491	4,495	4,986
French Guiana	1,105	2,149	3,264
Suriname	838	639	1,490
Haiti	36,769	6	36,774
Dominican Republic	1,839	1	1,840
Honduras	610	7,615	8,225
Guatemala	50	7,148	7,198
Mexico	0	2,357	2,357
Costa Rica	0	966	966
Nicaragua	61	701	762
Panama	4	740	744
Belize	0	538	538
El Salvador	1	32	33
Paraguay	7	333	341
Argentina	0	106	106
rand otal	129,957	430,026	560,298

Figure 3. Number of malaria cases by ADM2 level, Region of the Americas 2008

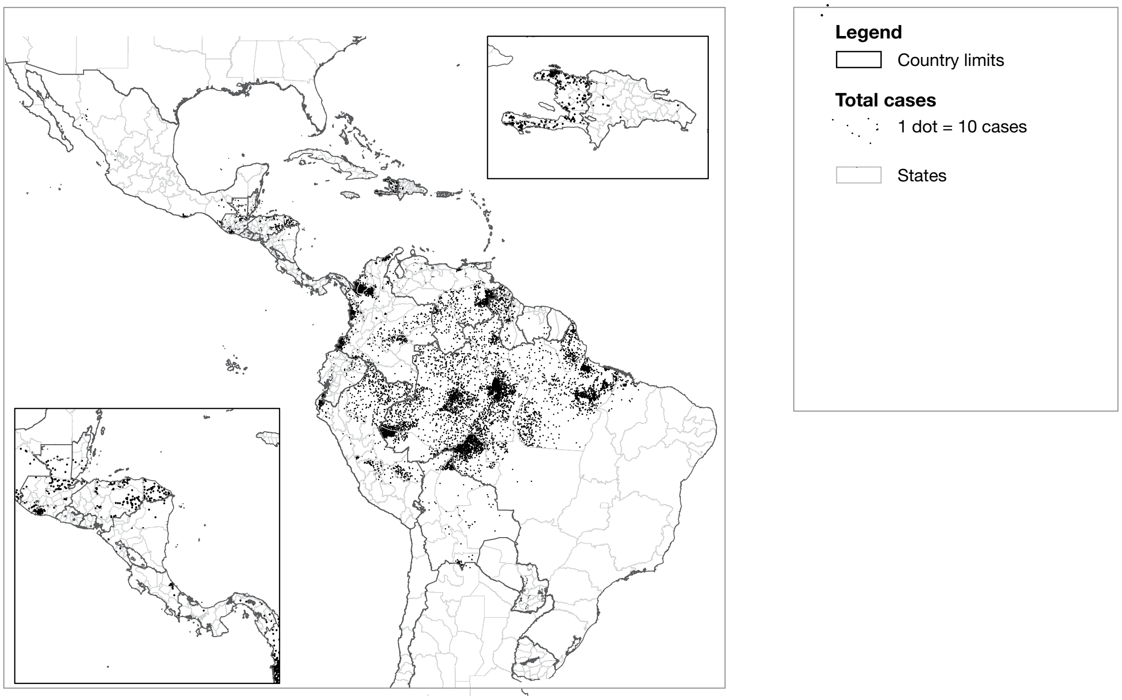
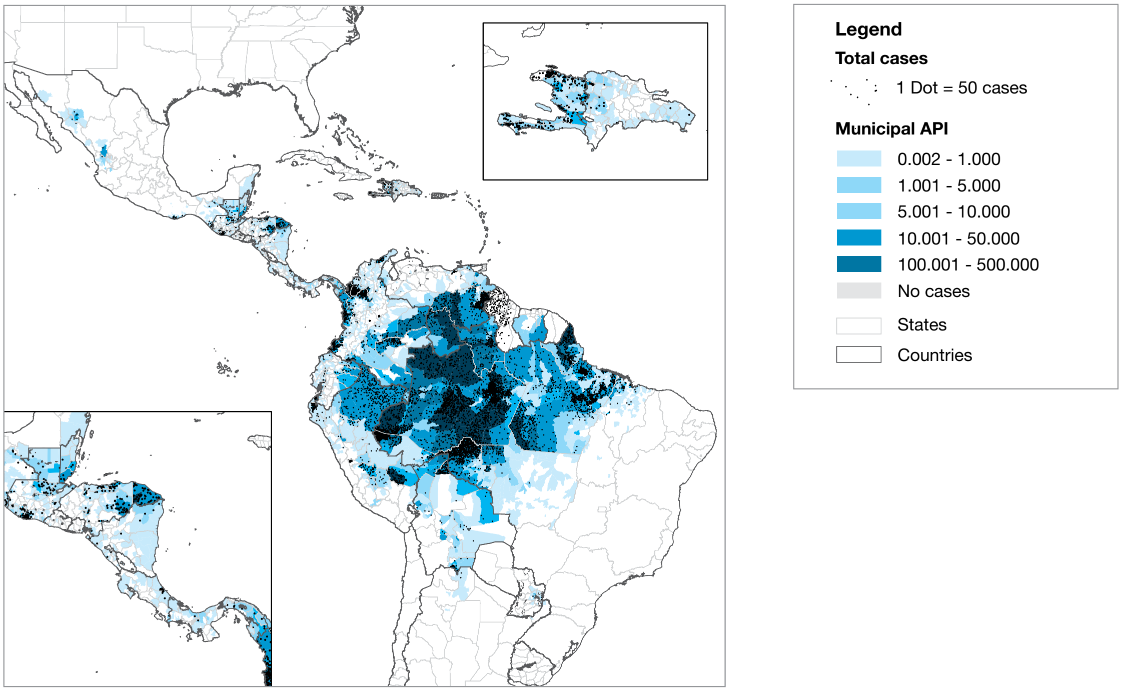


Figure 4. Number of malaria cases and API by ADM2 level, Region of the Americas 2008



main transmission foci. Municipalities with large cities, such as Manaus, in the State of Amazonas, and Porto Velho in the State of Rondonia (Figure 6) greatly influence the situation. In western Brazil, near the border of the State of Acre with the departments of Loreto and Ucayali in Peru, there is another significant focus of transmission. In this area, three municipalities in the Jurua Valley had the highest disease burden in the country in 2006, but have experienced a significant decline in the number of cases over the last two years.

In the Departments of Beni and Pando in the northern part of Bolivia, the highest concentration of malaria cases in the country is found (Figure 6) in areas of chestnut harvesting. In the same region, in the State of Rondonia (Brazil), malaria transmission has historically involved several municipalities, but especially the Municipality of Porto Velho. This is an area with large hydroelectric projects, which, if not properly managed, may increase rates of malaria transmission.

The States of Para and Amapa, in northeastern Brazil, include several malaria foci related to settlement projects, mining activities and forest harvesting. These transmission foci in the Northeast appear, on the map, to merge with transmission areas in French Guiana and in Suriname (Figure 6), closely related to gold mining activities in the area. Several focal areas in these three countries are associated with migration related to mining activities. Gold mining is also associated with most cases in Guyana and in eastern Venezuela, where the municipality of Domingo Sifontes reported 43% of the total malaria cases in the country in 2008 (Figure 6).

Between 2005 and 2007, the number of cases fell in both Guyana and Suriname, but there was no significant change between 2008 and 2007. Furthermore, among countries in the Region, Guyana had the highest API of malaria in 2008, equal to 15 per 1,000 inhabitants (Figure 7).

Transmission foci are present in the Orinoco region, an ecosystem shared by Colombia and Venezuela. In Venezuela, this area is home to several communities, including indigenous populations in the State of Amazonas, and ranks second only to the aforementioned border with Guyana in terms of malaria. In Colombia, the central Department of Guaviare and the Municipality of Cumaribo have both been important areas of transmission in recent years, related to migration driven by illicit activities.

In the Northwest region of South America, the Andes separate the Amazon and the Orinoquia regions from other ecosystems that affect malaria transmission in Colombia. Thus the Uraba and Pacific Regions make up the most significant malaria areas in the country (Figures 4, 5 and 6). The Uraba and Lower Cauca are areas of armed conflict and forced displacements, both of which have contributed in recent years to the malaria endemicity, particularly *P. falciparum* malaria.

In 2008, intensive control efforts in the Department of Antioquia have yielded good results. The Pacific coastal regions of southern Colombia and northern Ecuador have similar ecological characteristics, but Colombia has a much higher burden of disease. The Departments of Choco, Cauca, Valle and Narino in Colombia, which are part of the rainforest, are inhabited by hard to reach communities and suffer from problems related to lawlessness and migration. The majority of the population in these areas is of African descent and is associated with a high proportion of cases of *P. falciparum* malaria. In recent years, the number of cases of malaria has decreased in the Departments of Narino and Valle in Colombia, and in the Province of Esmeraldas in Ecuador. The introduction of ACT, among other factors, has played an important role in these areas, where there is a predominance of *P.falciparum* malaria.

Focal areas in Ecuador were small in 2008, especially when compared to the persisting situation in several municipalities in Brazil and Colombia (Figure 6). The number of cases fell dramatically in northern Ecuador in 2008. Because the burden of disease had been highest here in the past, the drop heightened the importance of malaria in the Provinces of Guayas and El Oro in the south. In the latter province, most cases are concentrated in a district bordering Peru, where the local population lives in areas of *A. albimanus* breeding sites, such as those associated with the fish breeding industry.

In Peru, the Departments of Piura and Tumbes, in the north (Figure 6) rank second in importance to the Amazonian departments. Several localities in this area have transmission dynamics related to *A. albimanus* breeding sites in paddy fields. Intermittent irrigation was one of the innovative strategies adopted for malaria prevention in this area. In contrast to strains in the Amazonian departments, strains of *P. falciparum* in malaria endemic areas along the Pacific Coast are still sensitive to sulfadoxine-pyrimethamine. As a result, the malaria program adopted different treatment regimens in the two regions (different combinations with artemisinin derivatives) in 2001.

Central America and Mexico

In this subregion, malaria transmission stands out in Honduras and Guatemala (Figures 2, 3 and 4). Nonetheless, between 2000 and 2008, the number of cases of malaria decreased significantly in both countries, as well as in the rest of the subregion. In 2008, Mexico and the seven countries of Central America together reported 20,823 cases. All countries reported autochthonous cases in 2008, but the disease burden was much smaller than in previous years. In El Salvador, malaria incidence reached very low levels, with only 32 cases reported in 2008 (Figures 2).

No autochthonous cases of *P. falciparum* malaria were detected in Belize, Costa Rica, El Salvador, Mexico, or Panama (Figure 2). In Honduras and Nicaragua, where *P. falciparum* malaria is highly localized in the North Atlantic Autonomous Region (NAAR), 10% of cases in 2008 were due to that species. This proportion is similar to that found in Bolivia and Ecuador in the Amazon basin. Guatemala reported over 7,000 cases of malaria, but only 50 by *P. falciparum* (0.7%).

Between 2007 and 2008, Panama reported a decrease of 42% in the total number of cases, and a drop of 100% in autochthonous cases by *P. falciparum* . The problem in highly endemic areas in the Colombian Regions of Uraba and Choco, where there is circulation of multidrug-resistant *P. falciparum* strains was already described. The area's geographic proximity to Panama (Figure 4), and the population flow from Uraba and the Colombian Pacific Coast to receptive areas in Panama and other countries is one aspect of malaria that requires greater surveillance, as well as cooperation among countries.

In Honduras, malaria transmission is related in particular to population movements in the Department of Gracias a Dios, where ecological and social factors arising from land occupation create areas that are ecologically favorable to the vector *A. albimanus*.

Figure 5. Number of cases by ADM2 in Central America, Mexico and northwest region of Colombia, 2008

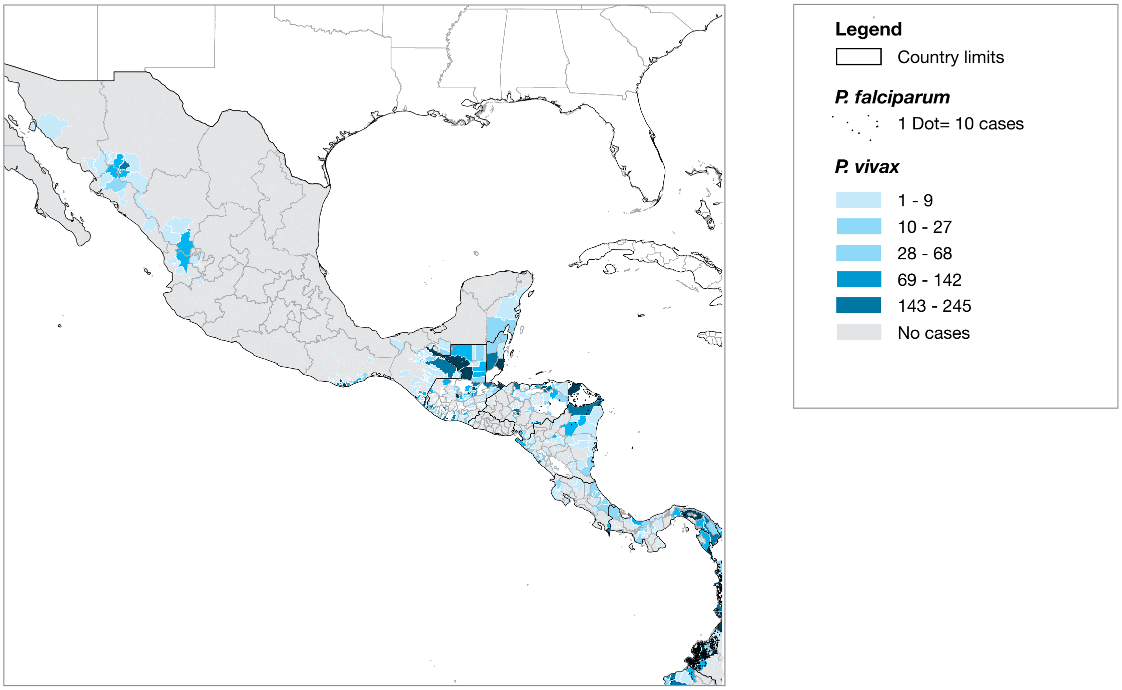
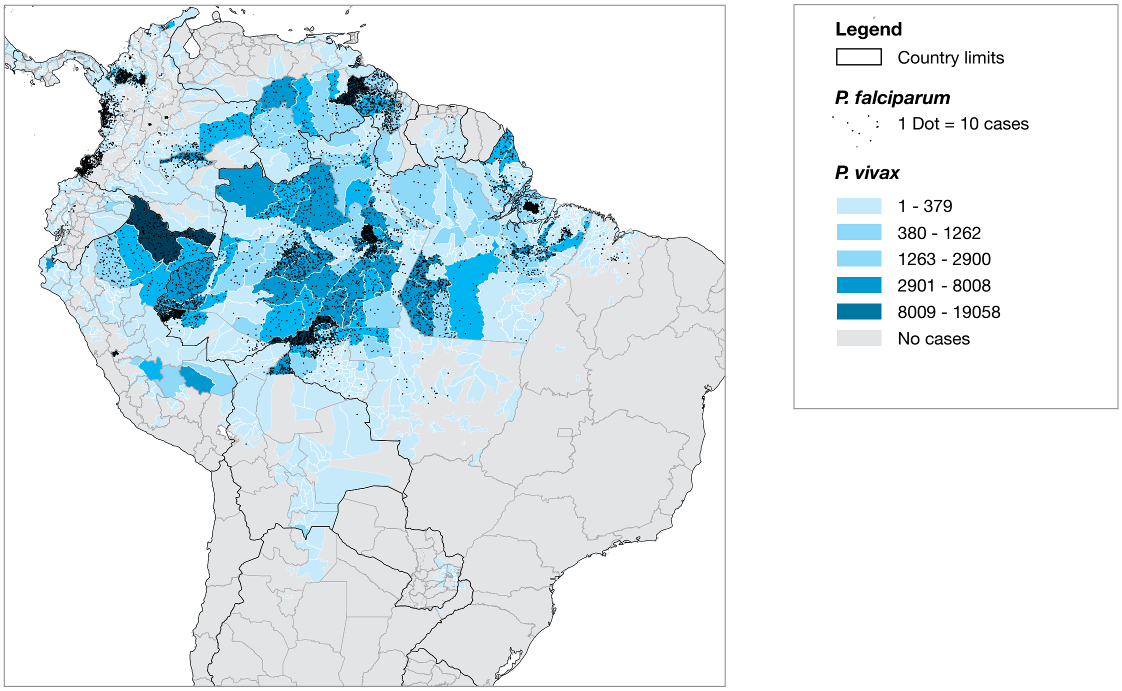


Figure 6. Number of cases by ADM2 in South American countries, 2008



Guatemala experienced a considerable reduction in number of cases between 2005 and 2007. The number of cases continued to fall by more than 50% between 2007 and 2008. This improvement is due to interventions financed by a Global Fund project in the country's northern departments. Nevertheless, transmission foci persist in several municipalities, as well as one locality on the Pacific coast, due to agriculture-related migration, and the proliferation of breeding sites that has resulted from environmental changes.

In 2008, Mexico maintained the low level of transmission achieved gradually over the last few years. In 2008, no cases of *P. falciparum* malaria were reported, and malaria transmission was especially focalized in the states of Chiapas and Oaxaca; few cases were reported in other states.

Island of Hispaniola

As already discussed, the Island of Hispaniola is the only territory in the Caribbean Islands were endemic malaria transmission exists. In 2008, Haiti reported 36,774 cases, the fourth heaviest burden of disease in the Region, after Brazil, Colombia and Peru (Figure 2). Its annual parasite index (API) for 2008, however, was 2.5 times that of the aforementioned countries. The high proportion of African descendants has been a determinant factor in the preponderance of *P. falciparum* malaria on the island; fortunately, the parasite strains are still sensitive to chloroquine. Between 2007 and 2008, Haiti saw an increase of 57% in its number of malaria cases. Meanwhile, in the Dominican Republic, where the problem is localized in areas bordering Haiti, the number of cases of malaria dropped by 32%. The increase reported in Haiti may be related to an improvement in the information system, and in the care given to cases in high-risk groups in recent years.

Southern Cone

In the continent's southern-most area, focalized malaria transmission can be found in Argentina and Paraguay, where incidence rates are very low, and where the disease is due exclusively to *P. vivax* (Figure 7). Paraguay observed an increase in cases in 2007 but, in 2008, the country reported its lowest incidence of malaria in a decade, as well as the absence of autochthonous *P. falciparum* cases, although seven imported cases were reported. Transmission is localized in four eastern districts, but over 20 districts reported cases. Argentina reported only 130 cases in 2008 (Figure 2) in a residual focal area in Salta Province, near the border with the Department of Tarija, in Bolivia (Figure 5).

Populations at risk of transmission and its determinants

The recent decrease in malaria incidence in the Region is an important public health achievement, as are improvements in national indicators. Nonetheless, a significant proportion of the population in the Americas is still at high risk for acquiring the disease. Specific communities also have very high incidence rates. The highest API at the municipality, district or canton (ADM2) level in 2008 was reported in Brazil (Figure 8). In the Anajas Municipality in Brazil, where transmission is associated with palm harvesting activities, the API was 452 per 1,000 inhabitants (Figure 8) in 2008. Bolivia, Brazil, Colombia, Honduras, Peru, Suriname and Venezuela reported municipalities with an API equal to or greater than 100 cases per 1,000 population (Figure 8).

Both environmental and social factors are determinants in these situations. In general, these are hard-to-reach communities where living and working conditions are favorable to malaria

Figure 7. Number of cases and API by country, Region of the Americas 2008

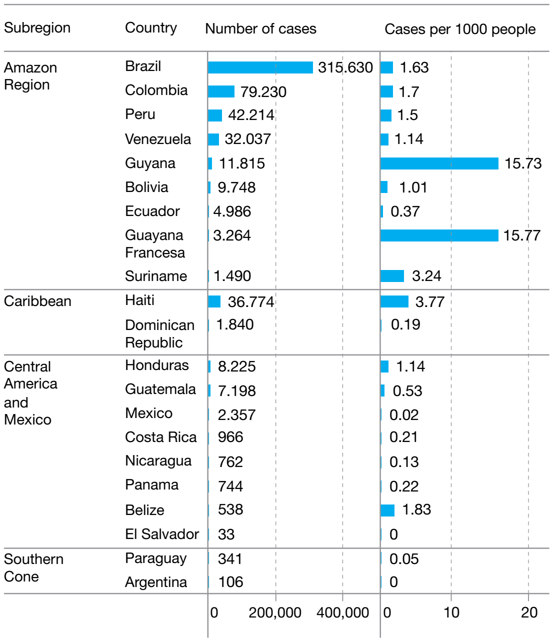
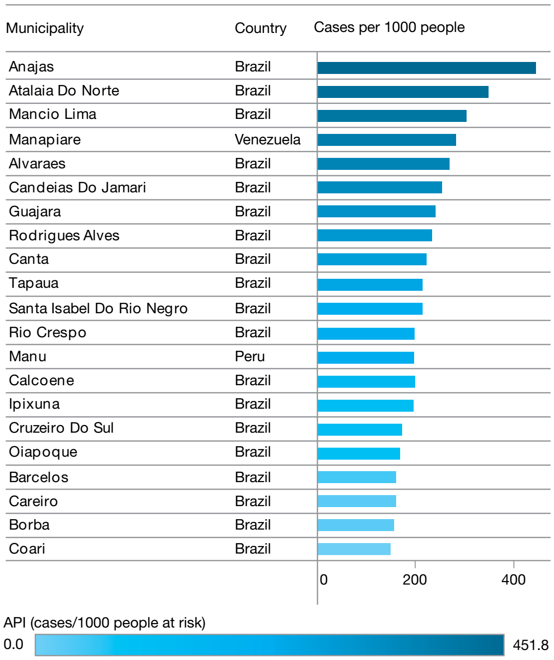


Figure 8. Top municipalities with highest API of malaria, Region of the Americas 2008



transmission. Although there are major differences in the ecosystems found from the Amazon forests to the Island of Hispaniola, they share many of the characteristics of their highly vulnerable populations: limited access to health services and limited local infrastructure; extreme poverty; and settlements in hard to reach, scattered, rural areas or marginal urban areas.

Generally, environmental factors are related to land occupation, land use and the lack of sustainable environmental management, along with the deterioration of ecosystems due to the indiscriminate extraction of natural resources. These determinants, combined with the vulnerability of the population, lead to perpetual transmission.

In some countries, the determinants of malaria are well defined. For example, in Bolivia, the chestnut harvesting cycle in the departments of Pando and Beni and the social situations it generates clearly correlate with the seasonal and geographical spread of malaria in the country. In Brazil, the living conditions of communities involved in palm harvesting on the Island of Marajo, State of Para, is correlated with malaria transmission. In some areas of Colombia, malaria is related to illegal crops, as well as with the forced displacement of populations. In the Department of Piura in northern Peru, rice cultivation is associated with the disease. A proliferation of fish farms in marginal areas of cities in the Brazilian Amazon has resulted in transmission peaks in recent years. Gold mining is the main determinant of malaria in French Guiana, Guyana, Suriname, and Venezuela and a number of Brazilian municipalities, largely by generating a constant flow of people and parasites within and between these countries.

Major infrastructure projects in the Amazon and other rainforests of the Region have historically been determinants of malaria incidence, and they continue to be risk factors. In 2008, Brazil put measures in place in order to prevent an increase in malaria due to the future construction of hydroelectric dams on the Madera River, in the State of Rondonia, where there has been an important malaria focus for many years.

The main determinants of malaria foci in the Americas are well known, and tend to be similar from one place to the next. However, in order to plan services aimed at interrupting the transmission chain and controlling malaria, it is essential to understand the dynamics of transmission in each focus, in other words, the specifics of the disease, its key determinants, characteristics of infected individuals and the convergence of these elements with the vector. Transmission is perpetuated by routine human activities and by the ecology of each endemic area; malaria control programs interested in selecting the most appropriate intervention prioritize these variables.

There are currently countries whose endemic situation could advance progress towards a pre-elimination phase. Program reorientation should include better data collection and utilization to provide an understanding of the transmission dynamics specific to each focal area.

Malaria transmission in gold mining areas deserves special attention as it represents foci that are difficult to control, and are potential hot spots for dissemination of antimalarial drug resistant *P. falciparum* strains due to the permanent flow of people. Extreme poverty contributes to malaria transmission and is the standard of living in mining areas. The assault by mining on the environment impacts *Anopheles'* breeding sites. Exposure to mosquito bites also increases as a result of the unprotected nature of dwellings, and their proximity to out-of-control breeding sites. Limited access to health care services completes the scenario. Restructuring the health system around mining activities, which are frequently illegal, has proven to be a challenge. In the absence of diagnosis and treatment for malaria, self-medication and the use of non-recommended drugs have emerged. The indiscriminate use of single drug therapies with artemisinin derivatives and the self-administration of incomplete treatments in these areas could determine the spread of anti-malarial drug resistance in the Region. The lack of diagnosis and treatment may also result in the sale and use of counterfeit or poor quality medicines.

Guyana and French Guiana had remarkably high API, with 15.7 cases per 1,000 inhabitants (Figure 7), in part, due to mining activities. These rates are also high because the number of cases is high, while the population in both countries is rather small.

In 2008, Haiti had the second-highest API (3.8 cases per 1,000 inhabitants), followed by Suriname (3.2 per 1,000 inhabitants) (Figure 7). They are followed by Colombia, which, in spite of having a denominator of 44 million inhabitants, has an API close to 2 per 1,000 population. Brazil, Belize, Peru, Venezuela, Honduras and Bolivia follow, in that order, with national APIs between 1.63 and 1.01 per 1,000 inhabitants in 2008.

Variations in Malaria Morbidity and Mortality in the Region

The number of malaria cases in the Region fell sharply between 2007 and 2008 (Figures 9 and 13). The number of cases saw a decrease of 53% between 2008 and 2000 (Figures 10, 15a, 15b). Changes in the burden of disease between 2000 and 2008 are illustrated in Figures 15a and 15b. Figure 15c contrasts the situation in the Region

Variation in Morbidity and Mortality, 2000 - 2008

Figure 9. Number of cases by species, 2000-2008

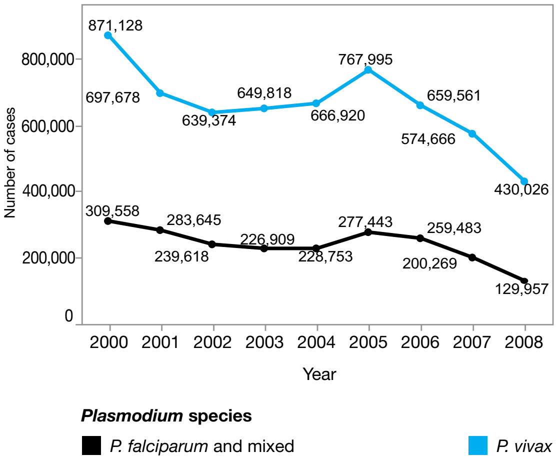


Figure 10. Annual variations in number of cases, 2000-08

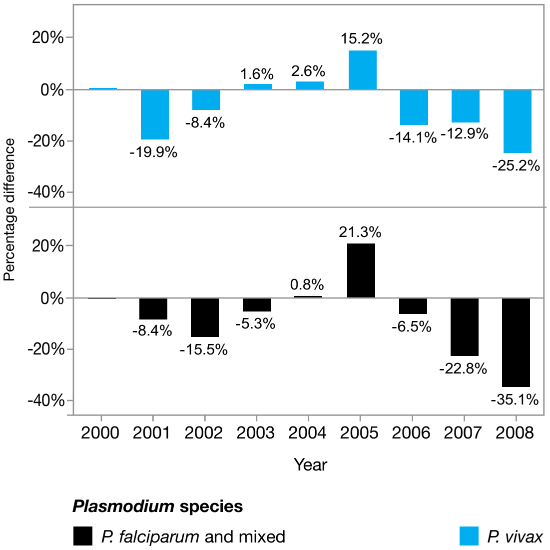


Figure 11. Number of deaths due to malaria, 2000-2008

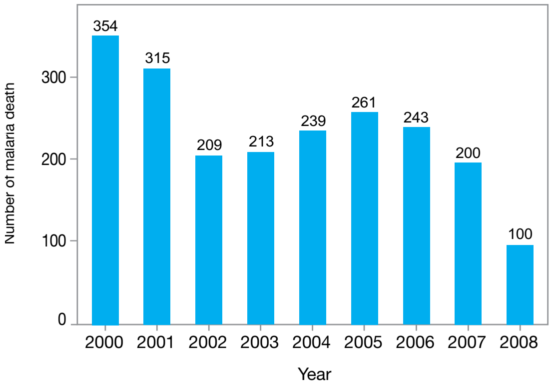


Figure 12. Annual variation in mortality, 2000-08

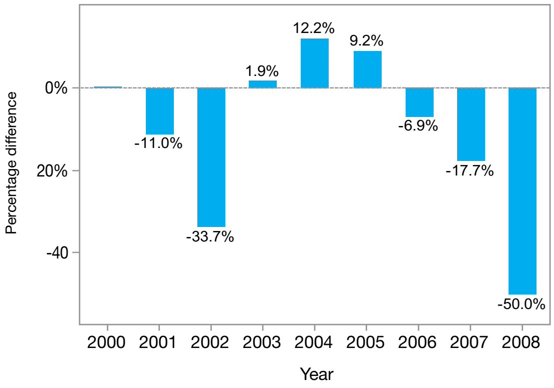
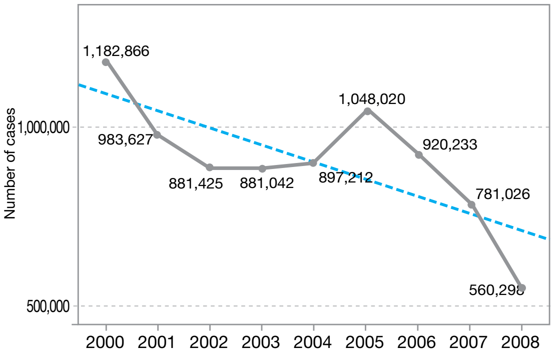


Figure 13. Number of malaria cases reported in the Americas, per year 2000-2008



against the goals of Roll Back Malaria (50% reduction by 2010) and the Millennium Development Goals (75% reduction by 2015).

The downward trend began in 2005. That year several countries had peaks in transmission, including: Belize, Brazil, Costa Rica, Dominican Republic, Guatemala, Guyana, and Haiti (Figure 14b). Brazil experienced an increase of more than 138,000 cases from the previous year (Figures 14a and 14b), but, since 2005, has sustained lower rates of transmission. A reduction in the number of cases in Brazil has a significant impact on the Region and, to a large degree, impacts reduction at the regional level (Figure 14a). Nonetheless, there was a considerable decline in most other countries as well (Figure 15). For example, countries with significant caseload reductions between 2007 and 2008 include: Paraguay (75%), Guatemala (53%), Argentina (49%), Colombia (48%), and Nicaragua (44%) (Figure 14b). The number of malaria cases increased in Haiti and Suriname in 2008. The increase in Suriname was preceded by a dramatic decrease in its number of cases in 2006 (64%) and 2007 (75%) (Figure 14b). One should keep in mind that, when the number of cases is very low, a slight increase in absolute numbers may result in a significant increase in rates.

At the Regional level, the decrease in the number of cases by *P. vivax* malaria (25%) and *P. falciparum* malaria (35%) was similar (Figure 10). This is in contrast to the change between 2006 and 2007, when cases by *P. vivax* malaria fell by only 13%, while those by *P. falciparum* fell by 23%. The decrease of *P. falciparum* malaria was associated with increased use of ACT in the Amazon region in 2007. Therapeutic efficacy studies carried out in every Amazon country between 2001 and 2006 found high levels of treatment failure with antimalarial drugs in use at the time. This led to the introduction of ACT.

Mortality decreased by 50% between 2008 and 2007 (Figure 12), and by 75% when compared to mortality rates from 2000. In 2008, 91 deaths were reported (Figure 11), but data for countries with no deaths reported could not be verified in time for the preparation of this annual report. Malaria deaths in Brazil and Colombia fell by 50%. The decreased number may be a result of the drop in the number of cases by *P. falciparum* malaria. No deaths were reported in Haiti.

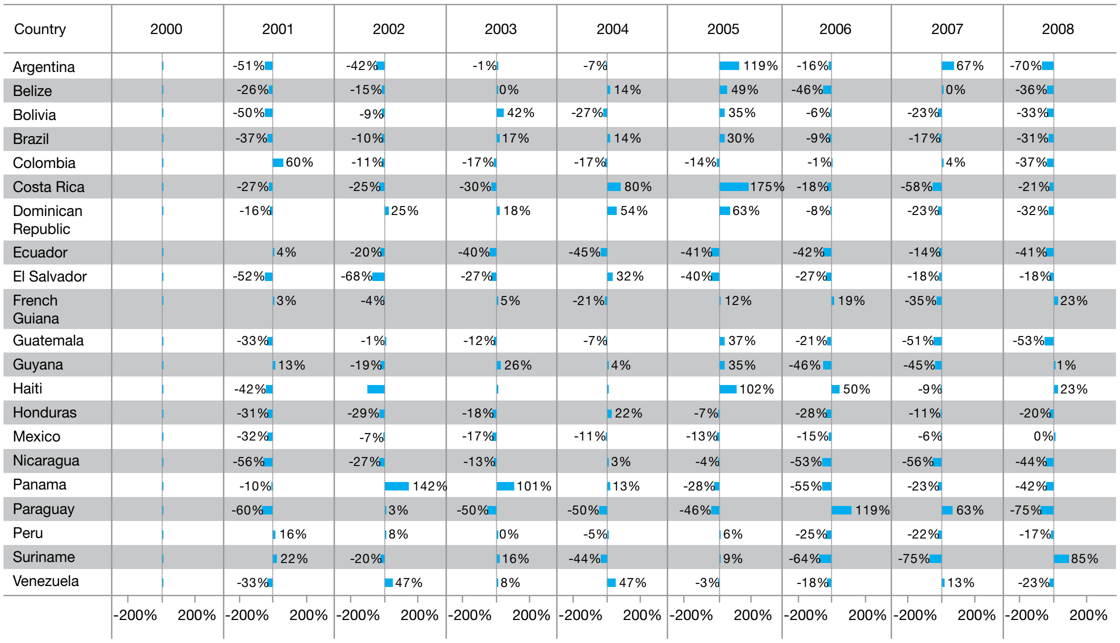
Geographical Distribution of Malaria in 2008

In order to understand the magnitude of the malaria problem in each country, the operational implications of the magnitude for control efforts and the possibility of elimination, it is necessary to analyze the degree to which transmission is localized or dispersed. The analysis at ADM2 level shows that Brazilian and Colombian municipalities weigh largely on the total burden of the disease in the continent.

In 2008, 1,963 municipalities reported at least one case of malaria, but only about half that number (937 municipalities) reported more than 10 cases in 2008 (Figure 17). In 2008, 283 Regional municipalities reported 250 cases of malaria or more (Figure 17). Although in recent years the spread of malaria has been reduced and has been limited in some countries to very well defined foci with very specific determinants, malaria remains a health problem in a considerable number of municipalities. Malaria by *P. falciparum* is more focalized. In 2008, 394 municipalities reported over 10 cases each, while 109 municipalities reported in excess of 250 cases in the same year (Figure 18).

Figure 14. Annual variation in the number of cases per country per year, from 2000 to 2008

Figure 15. Annual variation in the number of cases (percentage difference), by country and year, from 2000 to 2008



When ADM2s are listed in descending order based on the number of reported cases in each, and their proportion of the total number of cases in the Region is calculated, 50% of the disease burden of the Region in 2008 was reported by only 44 municipalities in six countries: Brazil, Colombia, Guyana, Haiti, Peru and Venezuela (Figure 16). In terms of pinpointing the problem and efforts to focus high impact actions on specific territories in the Region, however, it is even more important that only 12 ADM2s (10 Brazilian municipalities, plus the municipalities of Sifontes in Venezuela and Maynas in Peru) contributed 25% of the Regional burden (Figure 16). The municipalities of Manaus and Porto Velho in Brazil, together, account for 8% of all malaria cases in the Americas. Both are important centers of migration and economic activity in the States of Amazon and Rondonia. The urban area in the Municipality of Manaos has almost 2 million inhabitants and, despite a high degree of urban and infrastructure development, disorganized settlements on its periphery contribute to the persistence of malaria transmission.

In 2008, just 54 municipalities in the Americas reported more than 2,500 cases; this constitutes 55.6% of the malaria burden in the Region (Figure 16). These include 37 Brazilian municipalities, nine Colombian municipalities, three municipalities in Peru, two in Venezuela, and one each from Haiti, Guyana and Bolivia.

In the Municipality of Sifontes in Venezuela, malaria transmission is associated with gold mining. The Municipality is among the larger foci in the Region and has the highest proportion of cases by *P. falciparum* (3,726 cases). The Municipality of Tierralta, Colombia, which in recent years has reported the highest number of cases in the country, had problems with its diagnosis network in 2008, but still reported more than 5,000 cases (Figure 16).

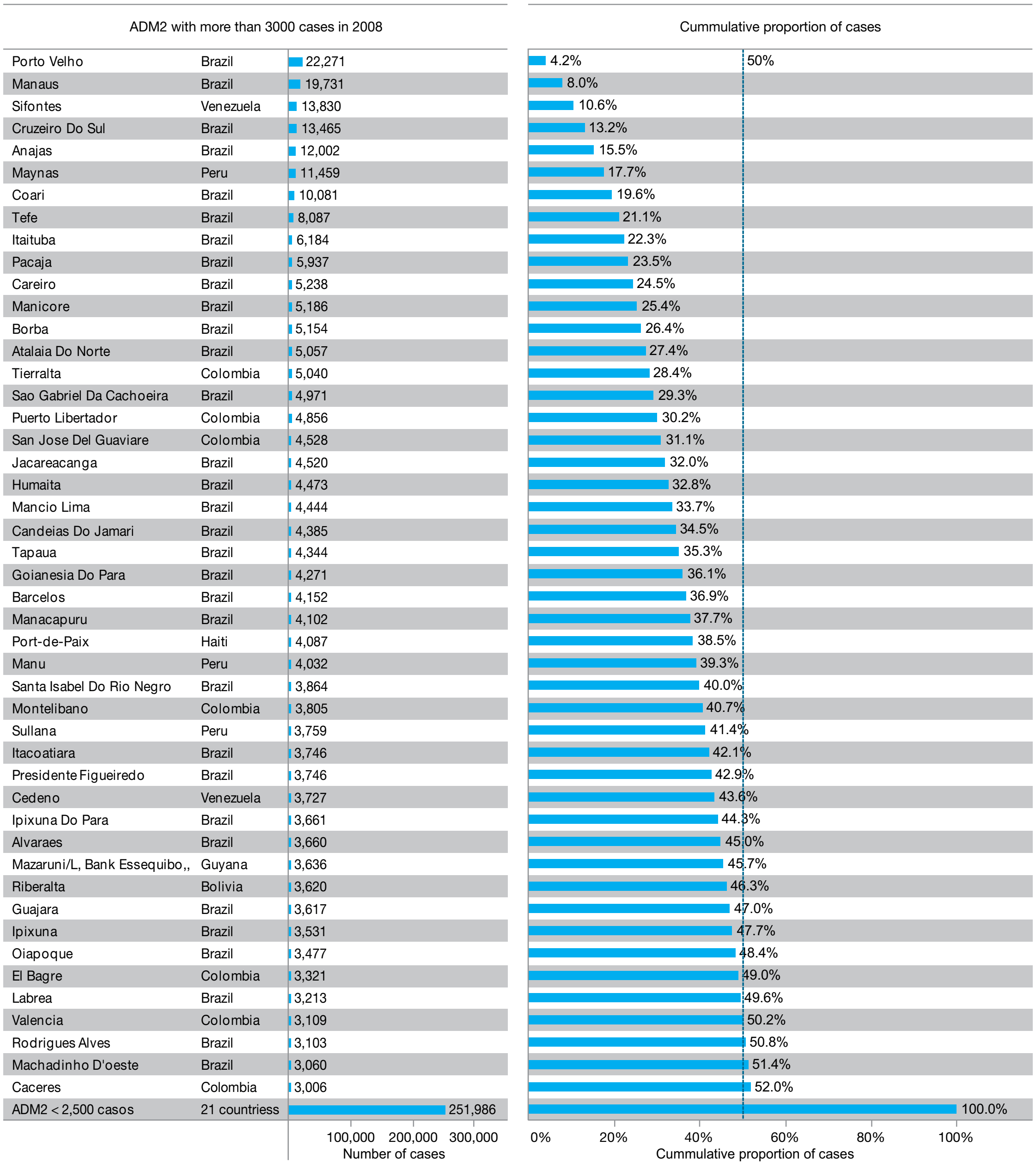
Municipal APIs, the total number of malaria cases and the proportion of these cases by *P. falciparum* were plotted on a Cartesian plane in order to identify which municipalities should be prioritized (Figure 19 and 20) . Those of the Amazon Region stand out. Remarkably, the Municipality of Anajas, Brazil, reported an API of 452 per 1,000 inhabitants, and over 12,000 annual cases, 17% of which were by *P. falciparum* in 2008. Other municipalities had lower APIs, but higher proportions of *P. falciparum* malaria, including: Sifontes in Venezuela, Atalaia do Norte and Santa Isabel do Rio Negro in the North of Brazil and Olaya Herra and Bajo Baudo in Colombia. In the quadrant with municipalities from the Amazon Region, the only extra-regional exception is Wampusirpi (Department of Gracias a Dios, Honduras), which reported 700 cases of malaria in 2008, 24% of which were caused by *P. falciparum*. It had an API of 117 per 1,000 inhabitants (Figure 20).

Dajabon, in the Dominican Republic, reported 534 malaria cases, all of them by *P. falciparum*. It had an API of 19 per 1000 inhabitants, well below the API for municipalities of the Amazon area in 2008. Dajabon is on the border with Haiti, where an international bridge in the locality of Ouanaminthe (Haiti) facilitates population movements between both countries.

Almost all endemic municipalities and cantons in Central America fell in a quadrant that groups municipalities that had APIs below 50 per 1,000 inhabitants, and fewer than 250 yearly cases (Figures 19 and 20).

Problems inherent to the incidence data collected place methodological limitations on this type of analysis. Problems arise from the fact that

Figure 16. Districts (ADM2) with the highest malaria burden and cummulative proportion of total cases, 2008



ADM2 with more than 3000 cases in 2008			Cummulative proportion of cases
Porto Velho	Brazil	22,271	4.2%
Manaus	Brazil	19,731	8.0%
Sifontes	Venezuela	13,830	10.6%
Cruzeiro Do Sul	Brazil	13,465	13.2%
Anajas	Brazil	12,002	15.5%
Maynas	Peru	11,459	17.7%
Coari	Brazil	10,081	19.6%
Tefe	Brazil	8,087	21.1%
Itaituba	Brazil	6,184	22.3%
Pacaja	Brazil	5,937	23.5%
Careiro	Brazil	5,238	24.5%
Manicore	Brazil	5,186	25.4%
Borba	Brazil	5,154	26.4%
Atalaia Do Norte	Brazil	5,057	27.4%
Tierralta	Colombia	5,040	28.4%
Sao Gabriel Da Cachoeira	Brazil	4,971	29.3%
Puerto Libertador	Colombia	4,856	30.2%
San Jose Del Guaviare	Colombia	4,528	31.1%
Jacareacanga	Brazil	4,520	32.0%
Humaita	Brazil	4,473	32.8%
Mancio Lima	Brazil	4,444	33.7%
Candeias Do Jamari	Brazil	4,385	34.5%
Tapaua	Brazil	4,344	35.3%
Goianesia Do Para	Brazil	4,271	36.1%
Barcelos	Brazil	4,152	36.9%
Manacapuru	Brazil	4,102	37.7%
Port-de-Paix	Haiti	4,087	38.5%
Manu	Peru	4,032	39.3%
Santa Isabel Do Rio Negro	Brazil	3,864	40.0%
Montelibano	Colombia	3,805	40.7%
Sullana	Peru	3,759	41.4%
Itacoatiara	Brazil	3,746	42.1%
Presidente Figueiredo	Brazil	3,746	42.9%
Cedeno	Venezuela	3,727	43.6%
Ipixuna Do Para	Brazil	3,661	44.3%
Alvaraes	Brazil	3,660	45.0%
Mazaruni/L, Bank Essequibo,,	Guyana	3,636	45.7%
Riberalta	Bolivia	3,620	46.3%
Guajara	Brazil	3,617	47.0%
Ipixuna	Brazil	3,531	47.7%
Oiapoque	Brazil	3,477	48.4%
El Bagre	Colombia	3,321	49.0%
Labrea	Brazil	3,213	49.6%
Valencia	Colombia	3,109	50.2%
Rodrigues Alves	Brazil	3,103	50.8%
Machadinho D'oeste	Brazil	3,060	51.4%
Caceres	Colombia	3,006	52.0%
ADM2 < 2,500 casos	21 countriess	251,986	100.0%

cases are not always reported by place of origin and the fact that the methods by which countries calculate populations at risk are not uniform.

Malaria in Priority Groups

Of the total number of malaria cases reported in the Region in 2008, 34% were among children 15 years of age or younger, and 11% were among children 5 years of age and younger (Figure 22). This shows that although malaria is strongly associated with outdoor labor activities that greatly affect young adult populations, an important proportion of cases occur in children and are associated with malaria transmission in the household. Belize, Haiti and Panama had the highest percentage of malaria cases among children (Figure 22). At the other end of the spectrum, Costa Rica, El Salvador and Guyana reported very few cases among children. Malaria in these countries is strongly associated with outdoor labor.

The proportion of cases in a locality that occurs among those 15 years of age or younger can be used to guide the focus of high impact interventions aimed at reducing household transmission. These interventions include the use of long lasting insecticidal bed nets and indoor residual spraying. However, incidence rates by age group can be difficult to monitor reliably as a result of the high mobility of relevant populations, and the resulting variations in population denominators.

Urban malaria demands special attention from control programs given the high burden of disease that it can generate, and the logistical and operational viability of preventive and control activities. Unfortunately, the information systems of malaria programs in the Region have not carefully monitored the urban or rural origin of cases. As a result, these data were missing for several countries. The accuracy of the data is questionable even among countries that reported the variable. Nonetheless, the information provided can be used to draw attention to this important situation.

Among those countries that did report the rural/urban origin of cases, less than 20% were of urban origin in 2008 (Figure 22). Furthermore, if the analysis only takes into account the population of these countries (492,352 cases, 88% of the Regional total), 13% of the total cases were of urban origin (64,237 cases). Nicaragua stands out - 66% of its cases were reportedly of urban origin (Figure 22). In countries with a heavy burden of disease, such as Brazil and Colombia, urban malaria makes up 13% and 15% of total cases, respectively, translating into a fairly significant number of cases. A clear understanding of urban transmission dynamics could serve as a guide for high impact interventions, which are more viable and less costly in urban areas. In 2008, municipalities such as Bajo Baudo, Tumaco and Guapi in Colombia reported the percentage of urban cases as 38%, 36% and 68%, respectively (Figure 50). A more sensitive surveillance system is needed in order to conduct analysis at the local level and to guide intervention activities that could have an impact on the total burden of malaria in the country. Given the availability of ACT and LLINs in the Region, control of urban *P. falciparum* malaria should become a priority for malaria control programs. Conducting socio-anthropological studies is crucial to gain an understanding of the transmission dynamics in these foci and to improve the effectiveness of interventions.

Malaria is a serious public health problem among indigenous communities in some countries in the Region. However, this is not adequa-

Figure 17. Districts (ADM-2) by number of malaria cases, 2008

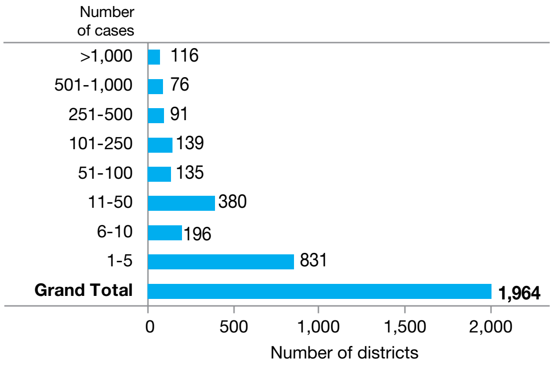


Figure 18. Districts (ADM-2) by number of *P. falciparum* cases, 2008

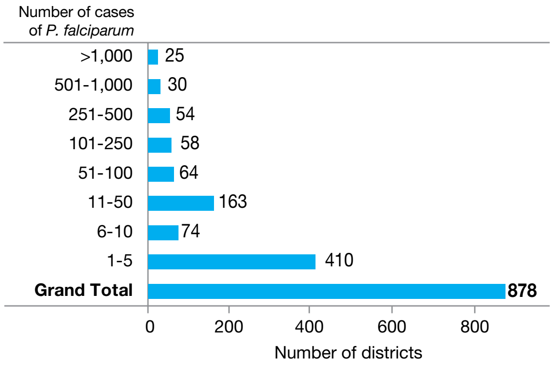


Figure 19. Districts/Municipalities by number of cases, API and percentage of *P. falciparum* cases, 2008

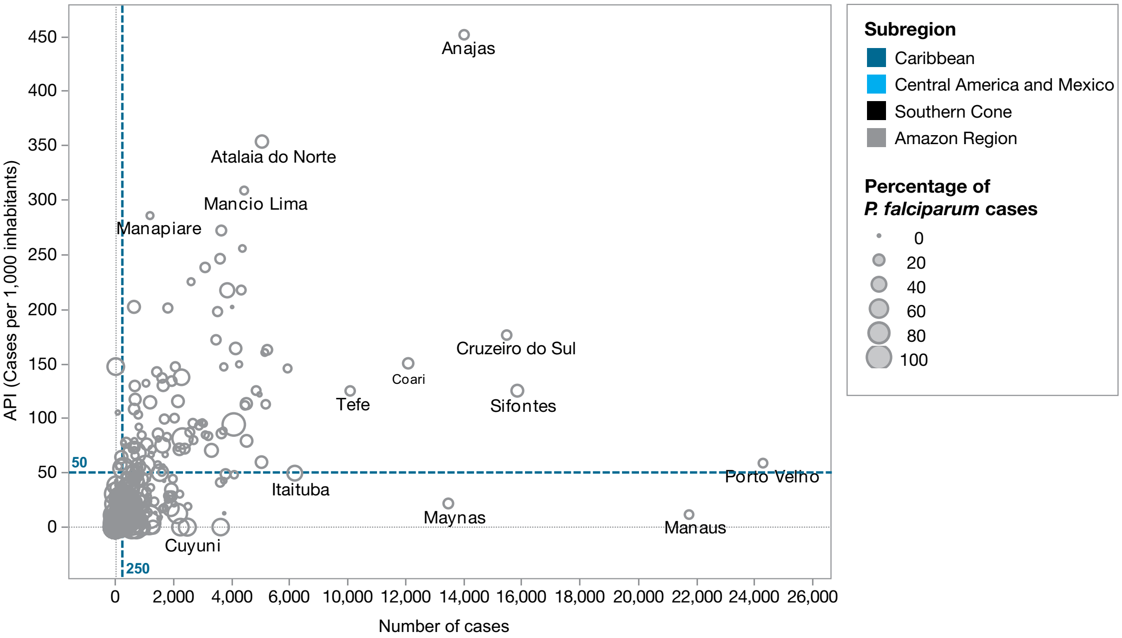


Figure 20. Districts (ADM2) by number of cases, API and percentage of *P. falciparum* cases (logarithmic scale), 2008

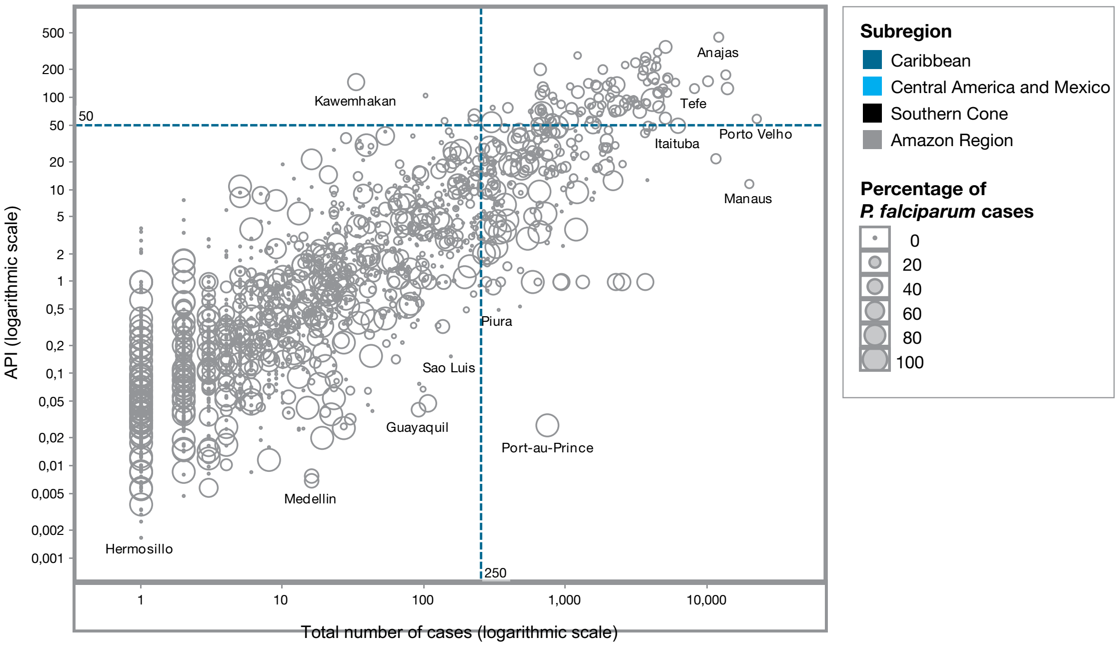


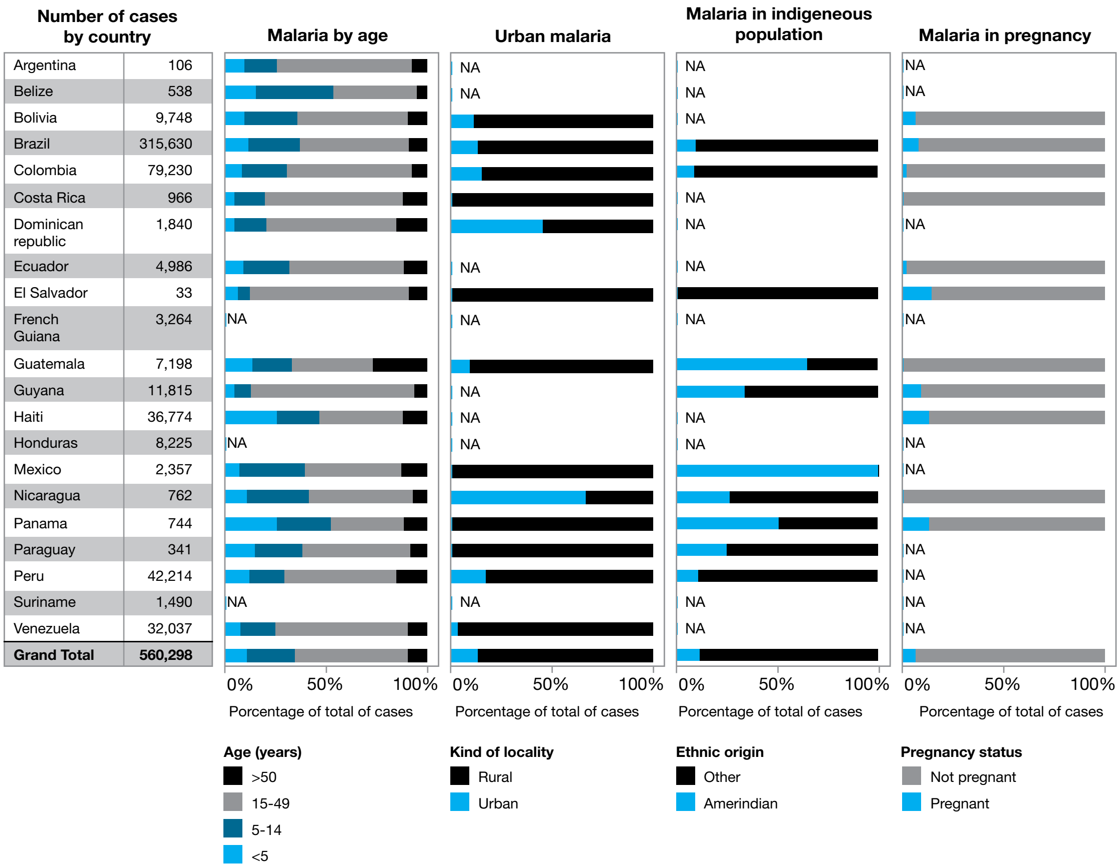
Figure 21. Number of districts (ADM2) by risk level, 2008

Number of districts with API > 9/1000 people at risk	
Belize	6
Bolivia	19
Brazil	155
Colombia	70
Costa Rica	1
Dominican Republic	18
Ecuador	11
Guatemala	16
Honduras	12
Mexico	3
Nicaragua	1
Panama	1
Paraguay	3
Peru	11
Suriname	8
Venezuela	14
Grand Total	**349**

Number of districts with API > 49/1000 people at risk	
Belize	6
Bolivia	2
Brazil	69
Colombia	18
Dominican Republic	17
Ecuador	5
Guatemala	9
Honduras	1
Nicaragua	1
Paraguay	2
Peru	1
Suriname	1
Venezuela	7
Grand Total	**139**

Number of districts with API > 99/1000 people at risk	
Bolivia	1
Brazil	38
Colombia	2
Honduras	1
Peru	1
Suriname	1
Venezuela	4
Grand Total	**48**

Figure 22. Malaria situation in priority groups, 2008



Number of cases by country

Argentina	106
Belize	538
Bolivia	9,748
Brazil	315,630
Colombia	79,230
Costa Rica	966
Dominican republic	1,840
Ecuador	4,986
El Salvador	33
French Guiana	3,264
Guatemala	7,198
Guyana	11,815
Haiti	36,774
Honduras	8,225
Mexico	2,357
Nicaragua	762
Panama	744
Paraguay	341
Peru	42,214
Suriname	1,490
Venezuela	32,037
Grand Total	**560,298**

MEF: Women of Childbearing Age

NA - Data not available

tely reflected in nationwide data. Malaria program information systems in many countries do not report information along this variable and, where they do, the quality of the data is unsatisfactory. In 2008, the proportion of malaria cases among indigenous populations was over 10% (Figure 22). When taking into account only the countries that reported this variable in 2008 (459,361 cases, 82% of the Region), it can be said that 11% of all cases occurred among indigenous populations in the Region as a whole (Figure 22). However, in Mexico, Panama and Guatemala, the proportion of malaria in native populations was 100%, 50% and 65%, respectively. Guyana, Nicaragua and Paraguay also reported that 34%, 26% and 25% of their total cases, respectively, occurred among native peoples (Figure 22). The magnitude of the problem in these countries can be explained by the fact that endemic areas are largely populated by indigenous people.

Eleven of the 21 endemic countries in the Region reported a total of 5,740 malaria cases among pregnant women in 2008 (Figure 22), or 6% of the 91,105 malaria cases reported among women of childbearing age. Pregnant women were 13% of all women with malaria in Haiti and Panama, the countries with the highest proportion of pregnant women with the disease. Given that pregnancy does not increase women's susceptibility to he disease, the occurrence of malaria among pregnant women as a proportion of all women of reproductive age should be similar to the general fertility rate of a given country. Proportions far below this rate suggest underregistration of the event and, consequently, indicate a lack of special care for pregnant women, who require careful management and rigorous follow-up. Periodic monitoring of the proportion of cases of malaria among pregnant women helps programs detect focal areas or reporting units where these special cases might not be getting proper care.

In Haiti, the significant number of cases reported among pregnant women (506 cases) may be related to the efforts of various governmental and non-governmental programs to improve maternal and child health care. This may also explain the high proportion of cases in children that are 15 years of age or younger.

Surveillance, Prevention and Control of Malaria

Diagnosis and Treatment

Slide Positivity Rates (SPR) varied among countries of the Region in 2008 (Figure 23) and ranged from 0.1% in Nicaragua to 21.8% in Haiti. Countries with the lowest SPRs were El Salvador (0.0%), Nicaragua (0.1%), Mexico (0.2%), Panama (0.4%), Paraguay (0.4%) and the Dominican Republic (0.5%) (Figure 23). In the Amazon subregion, where SPRs were much higher, Ecuador had the lowest rate with 1.3 positive cases per 100 slides examined. Low SPRs may be due to a control program with intensive active case detection or to an extensive network of health agents who refer febrile patients for testing at diagnostic services. On the other hand, extremely low SPR may also be due to unfocused surveillance strategies, which can lead to an overloading of the system without any improvement in the early detection of cases, which is necessary to disrupting transmission.

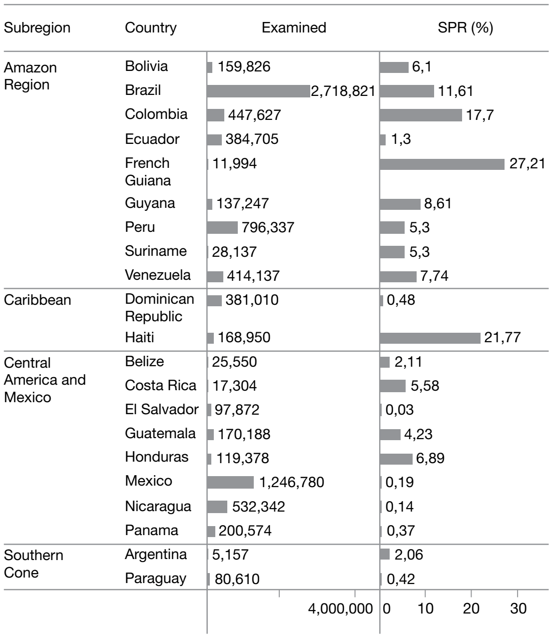
High SPR may point to a treatment and diagnosis strategy that is based primarily on passive case detection, mainly at microscopy centers where patients have a very high probability of being diagnosed with malaria. Early detection of malaria cases through a sensitive, yet efficient, surveillance system that functions in coordination with health services is the main strategy for malaria control. The high therapeutic efficacy of drug schemes currently used in the Region, and the low transmission intensity in many focal areas in the Americas, are elements that support this strategy. Therefore, control programs should focus their efforts on early diagnosis and treatment strategies to achieve efficiency, sustainability and high epidemiological impact.

The use of rapid diagnostic tests (RDT) for malaria in the Americas in 2008 was limited in comparison to the number of slides examined. During that period, 109,442 RDTs were used while 8,025,168 slides were examined (Figure 26), although it is possible that the use of RDT was underreported in some countries. The level of used has changed little from recent years, in spite of the fact that RDT is considered a good option for diagnosis in areas where microscopy networks are difficult to establish and maintain.

Timely access to parasitological diagnosis is a variable monitored by only a few malaria programs of the Region. Although it should be consistently monitored, most of the countries do not systematically record the date of onset of symp-

Diagnosis

Figure 23. Total slides examined and Slide Positivity Rate (SPR), 2008



Subregion	Country	Examined	SPR (%)
Amazon Region	Bolivia	159,826	6,1
	Brazil	2,718,821	11,61
	Colombia	447,627	17,7
	Ecuador	384,705	1,3
	French Guiana	11,994	27,21
	Guyana	137,247	8,61
	Peru	796,337	5,3
	Suriname	28,137	5,3
	Venezuela	414,137	7,74
Caribbean	Dominican Republic	381,010	0,48
	Haiti	168,950	21,77
Central America and Mexico	Belize	25,550	2,11
	Costa Rica	17,304	5,58
	El Salvador	97,872	0,03
	Guatemala	170,188	4,23
	Honduras	119,378	6,89
	Mexico	1,246,780	0,19
	Nicaragua	532,342	0,14
	Panama	200,574	0,37
Southern Cone	Argentina	5,157	2,06
	Paraguay	80,610	0,42

Figure 24. Time span between onset of symptoms and diagnosis

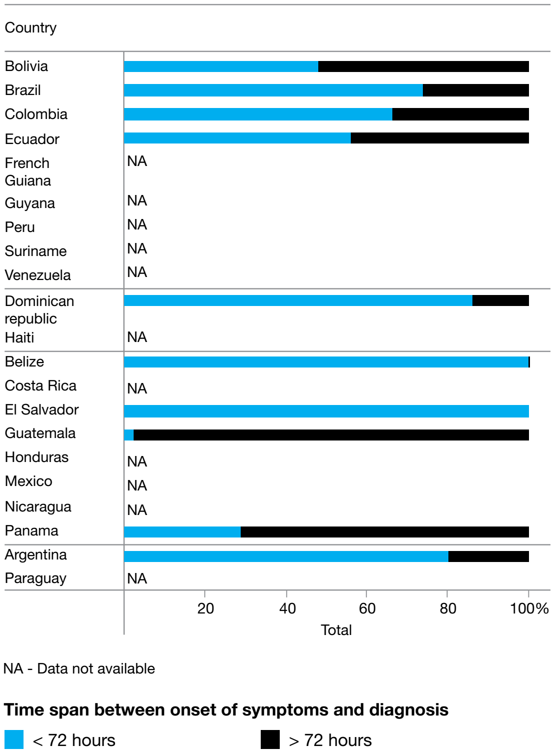
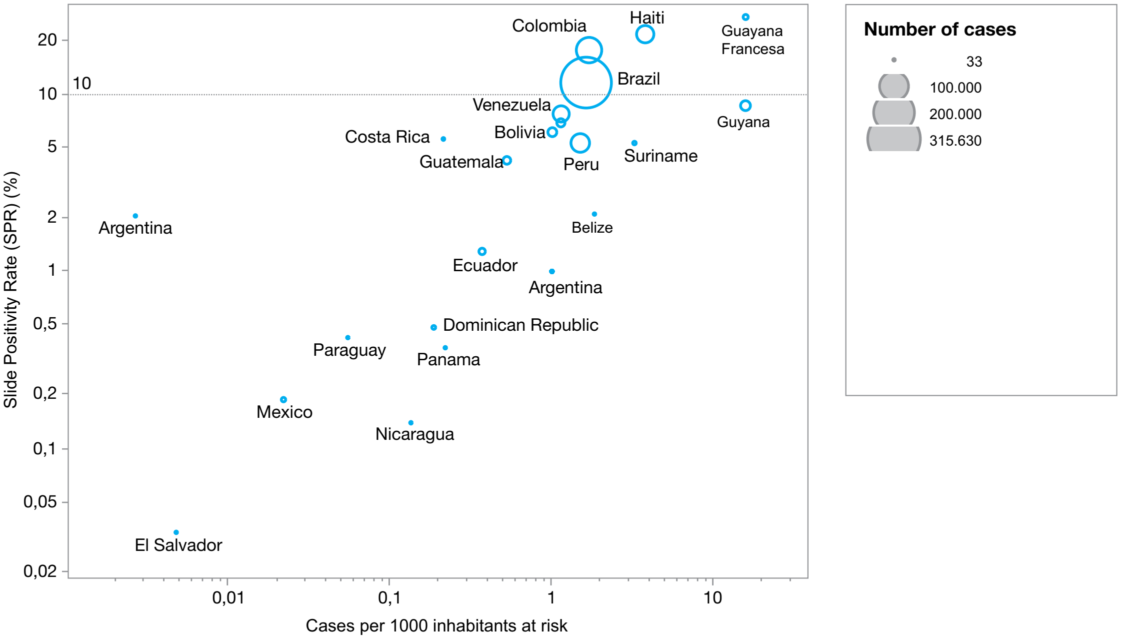


Figure 25. Correlation between Slide Positivity Rate and API in 2008



toms or the date of diagnosis. In places where this is done, databases are not designed to enter individual case records that would otherwise allow tabulation and periodical analysis of this indicator. In 2008, 10 countries provided information on the number of cases diagnosed within 72 hours of the onset of symptoms (Figure 24). Of a total of 418,448 cases reported in these countries, 294,766 (70.4%) were diagnosed within 72 hours of the onset of symptoms. However, as is the case with other variables, Brazil weighs significantly on the total number of cases and influences these figures as well. Based on 10 countries with information, on average, 45% of persons with malaria had access to diagnosis within three days of the onset of symptoms. Brazil has the best standards for timely access with 74% of cases diagnosed in the same 72 -hour period. This is an important accomplishment of the Brazilian health system, considering the wide spread of malaria and the large size of its endemic territory. On the contrary, despite the remarkable decrease in the number of cases in Central America, available information suggests that access to malaria parasitological diagnosis continues to be delayed. Care is mainly based on the administration of presumptive treatment and subsequent confirmation by blood slide examination. The availability of a more timely parasitological diagnosis in endemic areas, and especially for *P. falciparum* malaria, is crucial for reducing the burden of disease, and in disease elimination conditions, in order to provide a rapid response to case investigation.

Providing early treatment is the most effective strategy for reducing malaria transmission. Gametocytes, the sexually reproductive forms of the parasite responsible for transmission to the anopheles mosquito, take several days to appear in the blood. This provides a parasitological window during which transmission can be interrupted by the early introduction of treatment. Malaria programs can count on the advantage that ACTs have in reducing gametocytemia during the early days after treatment.

In 2001, Peru and Bolivia introduced ACT as the first-line of treatment for uncomplicated *P. falciparum* malaria (Figure 29). In 2002, the eight Amazon countries formed the Amazon Network for the Surveillance of Antimalarial Drug Resistance (RAVREDA), which, supported by the AMI (Amazon Malaria Initiative) project and funded by United States Agency for International Development (USAID), promoted the assessment of treatment schemes used in the subregion. As a result, those endemic countries that share territories in the Amazon forest changed their treatment policies in order to introduce ACT as the first-line of treatment for *P. falciparum* malaria.

Presently, Brazil, Colombia, Guyana and Suriname use the combination of artemether and lumefantrine (AL) as a first-line of therapy. Bolivia, Peru and Venezuela use an artesunate and mefloquine (AS+MQ) combination, while Ecuador and the coastal areas of Peru use artesunate and sulfadoxine-pyrimethamine (AS+SP).

Malaria by *P. falciparum* has seen a marked decrease in the Region in recent years (Figure

Figure 26. Cases diagnosed by microscopy and RDT, per year, 2000-2008

Year	Microscopy	RDT
2000	9,660,007	0
2001	9,205,341	0
2002	8,980,381	0
2003	8,700,893	0
2004	8,722,302	0
2005	11,724,957	6,000
2006	8,311,975	32,173
2007	8,007,613	44,173
2008	8,144,546	109,442

Treatment. Introduction of ACTs

Figure 27. Number of *P. falciparum* malaria cases, 2000-2008

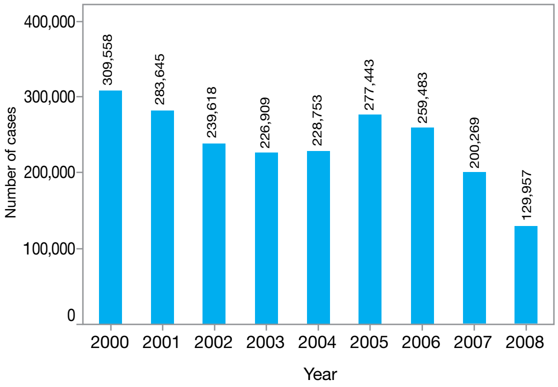


Figure 28. Proportion of malaria cases by species, 2000-2008

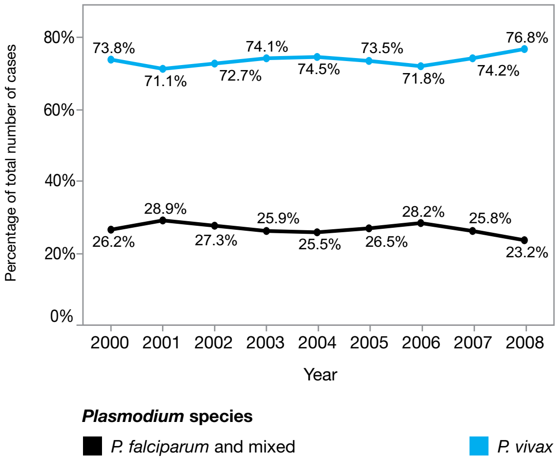
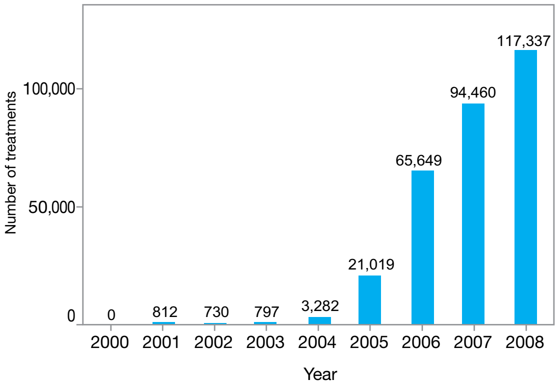


Figure 29. Number of malaria cases treated with ACT by year, 2008-08

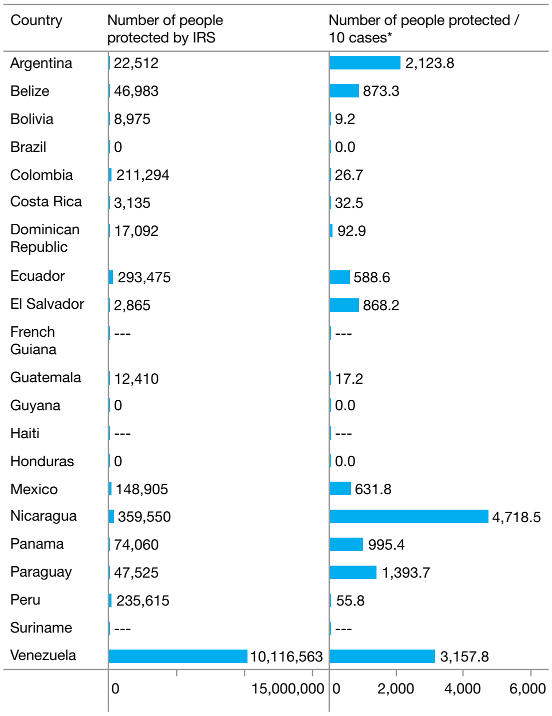


27). Although there are multiple determinants of the disease, the effect of policy changes in many of the endemic areas of these countries has been so evident that at least part of the decrease must be attributed to the new medication.

The number of cases by *P. vivax* malaria has also fallen since 2005, which could draw into question the contribution of ACT to the decrease in the number of *P. falciparum* cases. However, the decrease in the latter has been more pronounced than in the case of *P. falciparum* malaria (53% and 43%, respectively, for the Region as a whole). In Brazil the decrease between 2005 and 2008 was 68% for *P. falciparum* and 40% for *P. vivax,* and in Colombia it was 48% and 27%, respectively, during the same period. In Guyana, Suriname and Colombian departments with a high proportion of falciparum malaria, the decline was marked in the years following the introduction of ACT. In contrast, in Venezuela, despite the introduction of ACT in 2007, the number of *P. falciparum* cases increased.

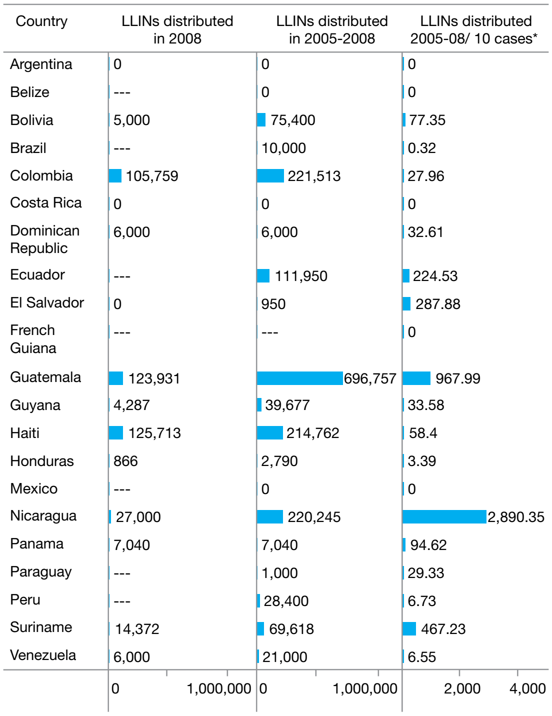
Prevention and Vector Control

Figure 30. Indoor residual spraying (IRS) coverage, 2008



--- Data not available
* People protected per 10 malaria cases in 2008

Figure 31. Long lasting insecticide treated bednet (LLIN) coverage, 2005-2008



--- Data not available
* LLIN distributed between 2005-2008 per 10 malaria cases in 2008

Prevention and Vector Control

The use of LLINs has begun to spread, particularly with the approval of several regional Global Fund projects. In 2008, 538,918 LLINs were distributed across the Americas. These nets, along with those distributed between 2005 and 2007, total 1,726,652 nets that should still be protecting the dwellings where they were installed (Figure 31). Besides preventing human contact with anopheles, bed nets also reduce human contact with other vectors, such as sand flies and mosquitoes of the species *Culex quinquefasciatus*, which are both a nuisance and vectors of lymphatic filariasis.

The largest number of LLINs was distributed in Haiti and Guatemala in 2008, followed by Ecuador and Colombia (Figure 31). Analysis that considers LLIN coverage in the past four years, relative to the number of cases reported in 2008, indicates that Nicaragua had the highest coverage, with a cumulative number of 2,890 LLINs per 10 cases reported in that year (Figure 31). Guatemala, Suriname and Ecuador follow, in that order. El Salvador, Bolivia and Panama also had high LLIN coverage in the same year.

In 2008, with support of the AMI project, some countries of the Amazon subregion (Brazil, Bolivia, Colombia and Ecuador) developed a strategy for distribution of LLINs in high-risk ADM-2. The method consisted of promoting strict compliance with requirements that lead to the highest impact and improved efficiency bed

Prevention and Finances

Figure 32. Indoor residual spraying coverage by year, 2000-08

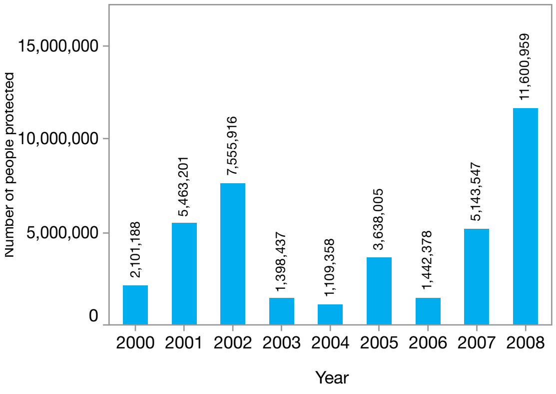


Figure 33. Number of LLINs distributed by year, 2000-08

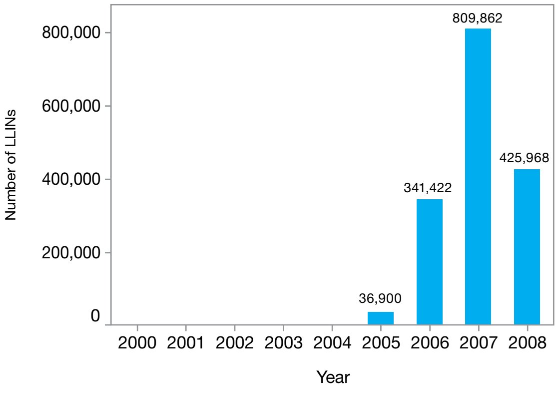
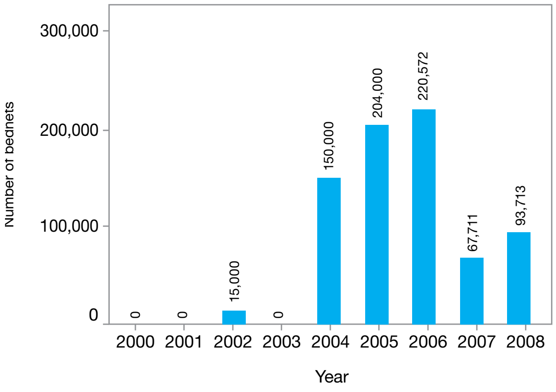
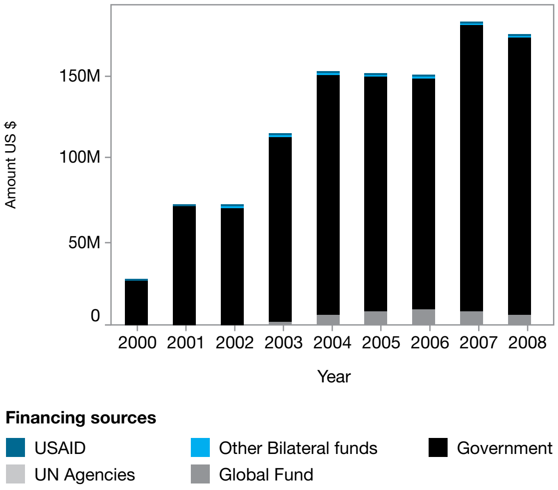


Figure 34. Number of ITNs distributed by year, 2000-08



* LLINs not included

Figure 35. Sources for malaria control funds by year, 2000-08



nets. The intervention included entomological assessments to characterize changes in vector behavior. The implementation methodology was adopted by several Global Fund projects in the Region. The PAMAFRO project along the border of Colombia and Ecuador is one such example. A significant epidemiological impact was documented after just one year of LLIN implementation.

Indoor residual spraying (IRS) with insecticides remains a widely used intervention in most countries of the Region. In 2008, Nicaragua reported that IRS had protected 359,550 people, or approximately 4,718 protected persons per 10 malaria cases in the country (Figure 30). Argentina, Belize, Ecuador, Mexico, Panama, Paraguay and Venezuela also had significant IRS coverage relative to the number of cases each reported in 2008. In Ecuador the number of cases fell significantly, but spraying coverage stayed relatively constant, so coverage was higher relative to the number of cases reported. Despite reports of abundant spraying in Brazil, no numbers were reported for 2008. The low residual effect of pyrethroids currently used in IRS is an important reason for constraint for some countries.

Despite the wide use of IRS in the Region, recent discussions among entomologists have highlighted frequent, incorrect practices. Analyses conducted as part of the AMI project in 2005, showed that IRS was applied without regard to household coverage or the cycle frequency required. The disconnect between entomology and implementation in the field is frequent in many countries, and the residual effect of insecticides, which is critical for its efficacy, has not been appropriately monitored. Due to the low residual effect of pyrethroids, IRS strategies using those products are difficult to sustain, especially in scattered localities with low disease burden where the operational cost of IRS is extremely high. In 2008, however, under the AMI project, lessons from Brazil and Colombia were promoted to show the impact IRS can have when efforts are focused on localities with a high burden of disease and when coverage requirements and periodicity were guaranteed. The department of Choco, Colombia, also showed important operational advantages to the use of organophosphates. In Brazil, a strategy that combined targeted residual spraying with LLINs eliminated the need for spatial application of insecticides during 2008.

Given that dengue fever, which is transmitted by the *Aedes aegypti* mosquito, is endemic in most countries of the Region, some countries use ultra-low volume (ULV) fumigation to combat this vector. Unfortunately, some malaria control programs have adopted this practice to combat anopheles, against which it has no impact.

Malaria control programs in Central America and Mexico consolidated their experiences with community participation in 2008. Under the Regional Program of Action and DDT/GEF Project, community participation was used to improve the environment and dwellings to reduce anopheles breeding grounds and improve insecticide use.

Program Funding

In 2008, for most of the malaria-endemic countries in the Americas, State funding was the main source of financing for malaria control programs (Figure 35). Haiti, where financing depended almost entirely on financing by the Global Fund, was an exception. In Guyana and Nicaragua too, Global Fund projects carried an important weight of the total financing of programs. As of 2008, 11 of the 21 endemic countries in the Region had benefited from projects financed by the Global Fund. Bolivia, Guatemala, Guyana, Haiti, Honduras, Nicaragua and Suriname have had national projects approved, while Colombia, Ecuador, Peru and Venezuela have each benefited from the PAMAFRO project.

For the Eighth Round of the Global Fund projects in 2008, proposals were approved for projects in Bolivia, Brazil, Colombia, Dominican Republic and Ecuador, thus creating a favorable situation for consolidation, over the next few years, of achievements made in reducing malaria transmission in the Region.

During 2008, the USAID-funded AMI project completed seven years of operation, with significant accomplishments in technical cooperation and malaria surveillance in the countries of Amazon subregion. The project in those countries has been coordinated by PAHO, with active participation from other institutions, including: the United States Centers for Disease Control and Prevention (CDC), Management Sciences

Malaria in Non-endemic Countries

Figure 36. Number of caes by country of detection of case, 2000-2008*

	Year								
Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Anguila	0	0	0	0	---	---	0	---	0
Antigua & Barbuda	0	0	0	0	0	---	---	1	1
Bahamas	2	4	1	3	2	1	49	6	14
Barbados	---	5	---	---	---	3	---	---	---
British Virgin Islands	0	0	0	---	0	---	0	---	0
Canada	462	445	366	376	375	348	318	---	---
Cayman Islands	3	0	---	---	---	2	1	---	---
Chile	7	0	5	7	7	5	3	5	---
Cuba	53	0	29	30	26	9	33	35	19
Dominica	0	0	0	0	---	---	---	0	---
Grenada	---	0	---	---	---	1	0	0	0
Guadalupe	7	7	12	---	7	---	6	---	12
Jamaica	7	6	7	9	141	88	194	199	22
Martinique	7	11	12	16	10	---	10	---	14
Montserrat	0	0	0	0	---	---	0	---	0
Puerto Rico	1	0	1	1	0	1	2	3	2
Santa Lucia	3	0	2	1	---	---	---	0	---
St. Kitts & Nevis	0	0	0	0	---	---	---	---	0
St. Vicente & the Grenadines	0	0	0	0	---	---	0	0	1
Trinidad & Tobago	17	0	8	10	15	8	8	14	14
Turks & Caicos Islands	0	0	---	---	---	---	---	---	---
Uruguay	2	0	24	90	54	27	15	---	12
US Virgin Islands	1	2	---	0	---	0	---	0	0
USA	1.402	1.383	1.337	1.278	1.324	1.528	1.564	1.505	1.298
Grand Total	1,974	1,863	1,804	1,821	1,961	2,021	2,203	1,768	1,409

--- Data not available

for Health (MSH), United States Pharmacopeia (USP), Links Media and Research Triangle Initiative (RTI). In 2008, USAID funding for this project was approximately US$ 2 million. Although the specific country amounts are not significant in the context of the programs' operational costs, the funding has made it possible to introduce strategic changes in control programs of participating countries.

The DDT/GEF project in Mexico and Central America funded by the UN Environment Program (UNEP), with the Global Environment Facility (GEF) organization, operated between 2003 and 2007 with cumulative funding of approximately US$ 13 million.

Other donors that supported malaria programs in the Region during 2008 include the European Union, the Carter Center and the Bill and Melinda Gates Foundation.

Figure 37. Number of cases by country, 2008*

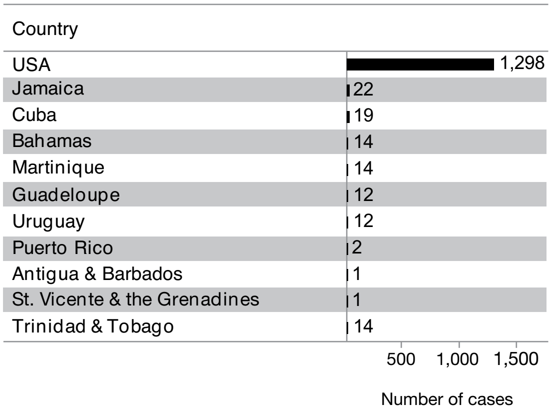


Figure 38. Number of cases by region / country of origin, 2008

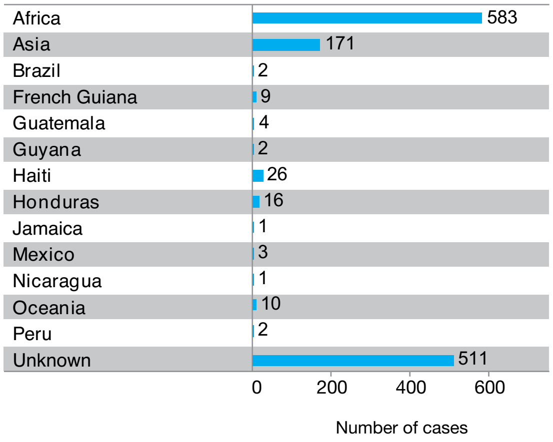


Figure 39. Number of malaria cases in Non-endemic countries, 2000-08

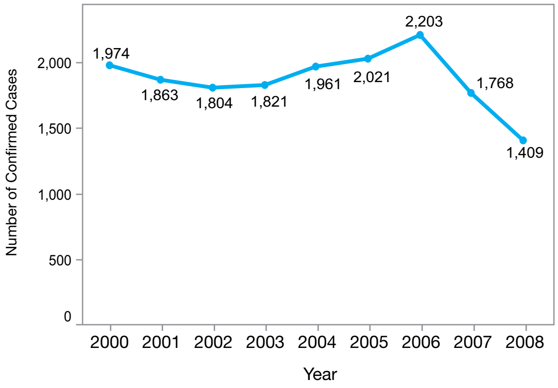
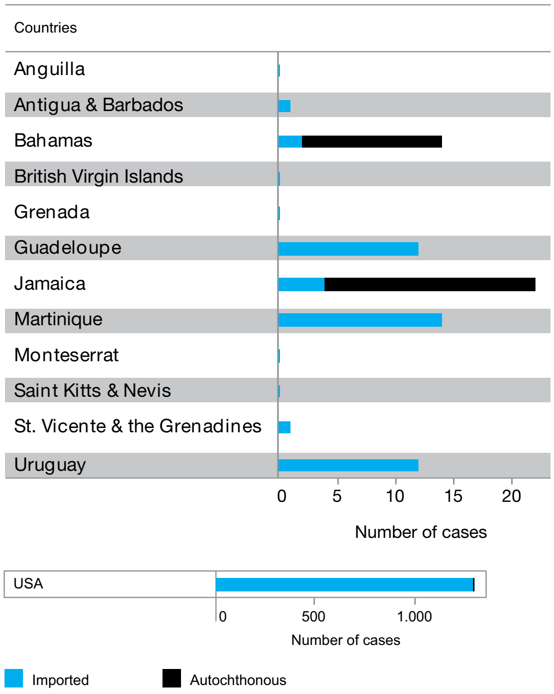


Figure 40. Imported and autochthonous cases by country, 2008*



Malaria in Non-Endemic Countries

Cumulatively, the countries in the Americas that are not endemic for malaria reported 1,321 cases of the disease in 2008. The United States of America reported the highest number of cases, and Canada the second highest, among non-endemic countries. Cases in these countries are generally imported and occur among travelers returning from endemic countries, immigrants from those countries or military personnel. In 2008, only the Bahamas and Jamaica reported autochthonous cases of malaria (Figure 47). The remaining cases were mostly of African origin. Among countries in the Americas from which cases were imported, French Guyana and Haiti ranked as the top two (Figure 48), but in 2008, this analysis did not include cases from Canada or the United States. In 2007, Africa was the leading source of cases in the United States and contributed 64.4% of them. Another 21.9% of cases came to the country from Asia. In that same year, other countries in the Americas accounted for 11.3% of the imported cases reported in the United States. Of those cases, 78.6% originated in Central America or the Caribbean region. An analysis of data beginning in 2000 signals two peaks in the number of cases reported in non-endemic countries. These were due to outbreaks in Jamaica in 2004, and in the Bahamas in 2006 (Figure 39). Both countries have controlled the outbreaks and are working on preventing the reintroduction of malaria into their territory. Jamaica reported 18 autochthonous cases of malaria in 2008.

These recent outbreaks of malaria in non-endemic countries underline the importance of surveillance, especially in areas of tourism and in areas with favorable ecological conditions for malaria transmission.

Surveillance of Antimalarial Drug Resistance

Since 2001, the therapeutic response to malaria treatment in the Americas has been monitored within the framework of Amazon Network for the Surveillance of Antimalarial Drug Resistance (RAVREDA) activities. In this last decade, 80 efficacy studies have been carried out; their results have been used by Amazon countries to modify treatment policies for uncomplicated *P. falciparum* malaria (Figures 41 to 46). Currently, all countries sharing the Amazon basin use ACT as a first line of therapy. (See also the section on Surveillance, Prevention and Control of Malaria, Diagnosis and Treatment, above.)

The surveillance strategy for the Region proposes that malaria programs conduct monitoring studies every two years for early detection of possible changes in the therapeutic response. Some countries were already completing the interval proposed after initial studies were conducted between 2002 and 2006. The marked reduction in the number of cases by *P. falciparum* has precluded any new efficacy studies.

In 2008, only Guyana conducted an efficacy study of *P. falciparum* drug efficacy (Figure 40). In October of that year, the second therapeutic efficacy test (TET) of the artemether + lumefantrine combination was completed. The study lasted 14 months, and evaluated the therapeutic response in 90 patients, 63 of which completed a follow-up. Therapeutic failure was observed in one patient, or 1.6% of the total (Figure 40). The results of this study in Guyana make a significant contribution to malaria programs that use Coartem® as their first-line of therapy. Although the therapeutic response continues to be appropriate after three years in use, it is important to note that parasitemia persisted on the third day of treatment in some study participants. This is in contrast to a previous study conducted in 2004, in which parasites were eliminated in 100% of the study participants on the third day of the follow-up. This is a significant finding in the light of information available from Southeast Asia, where slow parasitemia clearance following treatment with ACT has been detected.[2]

In Colombia, under an initiative not related to RAVREDA, an evaluation study of the country's official first-line of treatment (artemether + lumefantrine) has been initiated.

Between 2007 and 2008, the AMI also funded prospective evaluations of the clinical and parasitological responses of study participants treated for falciparum malaria with chloroquine in Nicaragua and Honduras. The Nicaraguan study found no therapeutic failures among its 30 study participants. In Honduras, one treatment failure (2%) was detected among the 67 study participants who completed the 28-day follow up. These two studies were carried out according to WHO methodology, even though meeting sample size requirements presented a serious challenge. Nonetheless, both evaluations managed to lose very few participants.

In spite of the low number of cases of *P. falciparum* malaria in Middle America, there is a risk that cases of this type will be imported from the Amazon region or from other areas of the world. Although existing information suggests that 4-aminoquinolines are still highly effective in treating the strains circulating in these countries, the availability of ACT emergency stock must be carefully managed in order to treat cases imported from areas where there is multidrug resistance. Furthermore, setting up a strategy for monitoring the therapeutic response as part of existing surveillance of *P. falciparum* malaria should be a priority.

Countries with the possibility of moving towards the potential elimination of *P. falciparum* malaria, such as some in Central America that have very few cases of this type of malaria, should provide supervised treatment, and all cases should be subject to a systematic follow-up with clinical and parasitological monitoring for at least 28 days after the onset of treatment.[3]

In September 2008, PAHO, with the support of USAID and in coordination with other WHO regions, held a meeting of experts in Washington, DC to discuss a surveillance strategy for *P. falciparum* resistance in low transmission situations. Both the difficulty of conducting studies in the Amazon region and the specific situation in Central America were discussed. A recommendation was made to maintain effective surveillance that allows for detection of the emergence and spread of resistance.

Results achieved under the work model used by the RAVREDA-AMI project, including modifications to therapeutic regimens, led to a redefinition of the project's objectives. Thus, in 2004, new areas of work were developed with the

---

[2] WHO. Containment of Malaria Multi-Drug Resistance on the Cambodia-Thailand border. Report of an informal consultation Phnom Penh, 2007

[3] WHO. Methods for surveillance of antimalarial drug efficacy. 2009

access, quality and use of medications in mind. During 2008, with technical support from Management Sciences for Health and the US Pharmacopeia, efforts were aimed at correcting deficiencies in processes of provision, distribution and the quality of antimalarial drugs, and in the use of medications in health care posts.

Information Analysis in Malaria Control Programs with Individual Record Database Systems

In recent years, some countries in the region have implemented malaria information systems with databases made up of individual case record entry. This has allowed for analysis of malaria behavior with a maximum degree of disaggregation.

It is crucial for program managers, as well as for resource and intervention planning at ADM1 and central levels, to understand the behavior of malaria in endemic foci. Planning and decision making around active case detection, diagnosis, treatment and vector control depend on localities being able to use information well. For local level analysis, the manual tabulation of data and continuous monitoring of behavior in those localities should suffice. In contrast, automated information management of individual case data is required for more technical management from a higher level.

For several years, the Brazilian Control Program has systematized data entry by every municipality in the Amazon Region into a central database via the Internet. The system has improved recently with regard to timeliness, data coverage and information analysis. Since 2006, the AMI Project has supported the creation of national databases in Ecuador, Guyana, and Suriname, as well as in local systems in Bolivia and Colombia.

In 2008, major progress was made in the consolidation of information systems in these countries. In Colombia, the Ministry of Social Protection and the National Health Institute boosted the implementation of individual notification for all events of public health concern. In this way, the Public Health Surveillance System (SIVIGILA) took an important step forward to benefit malaria control. By the end of 2008, over 78% of the information had been entered into the national database, and an even larger proportion of data that was not automated was reported in the new formats, even in more remote areas.

In the Departments of Beni and Pando in Bolivia, where most of the country's disease burden is concentrated, a database was implemented to register data for the two departments. It is now available in electronic format, and has a great analytical potential.

The Malaria Control Program in Ecuador developed a computerized system, called SIVEMAE, in 2005. The system has been modified and improved several times over the last three years and, in 2008, it reached a high mark of progress: 95% of reported cases in the country had been entered systematically into the database, which includes the necessary variables to guide decision making in malaria control.

Information systems in Guyana and Suriname, which already have databases of individual case records, continued to monitor malaria behavior and to support control strategy planning. Regional bureaus in Venezuela have maintained individual case record databases for the last few years. Peru had begun, by the end of 2008, feeding individual case records into a malaria surveillance database.

Figure 41. Therapeutic failure in *P. falciparum* malaria treated with chloroquine

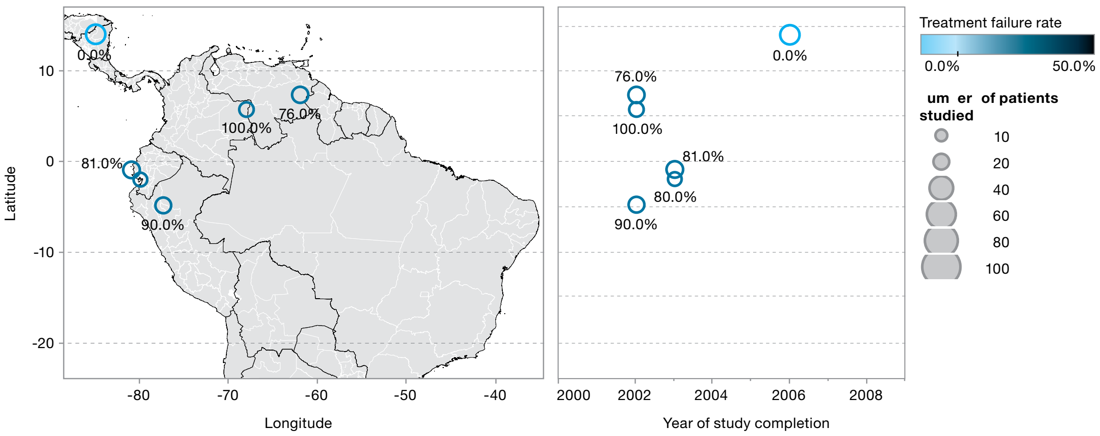


Figure 42. Therapeutic failure in *P. falciparum* malaria treated with amodiaquine

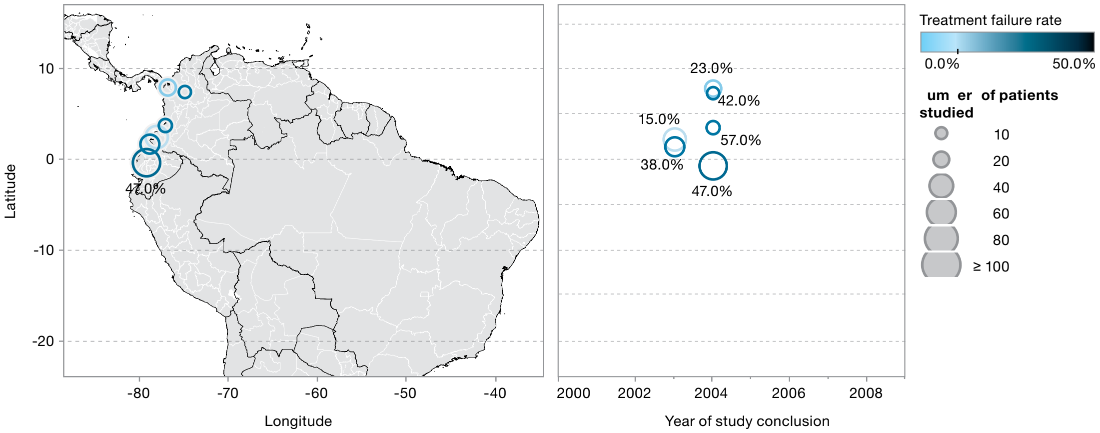


Figure 43. Therapeutic failure in *P. falciparum* malaria treated with sulfadoxine-pyrimethamine

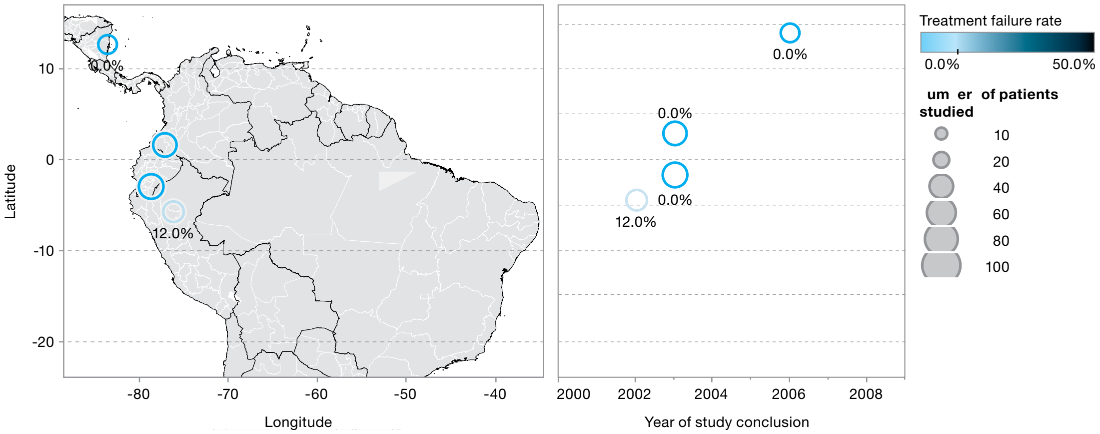


Figure 44. Therapeutic failure in *P. falciparum* malaria treated with Artesunate- Sulfadoxine-Pyrimethamine combination

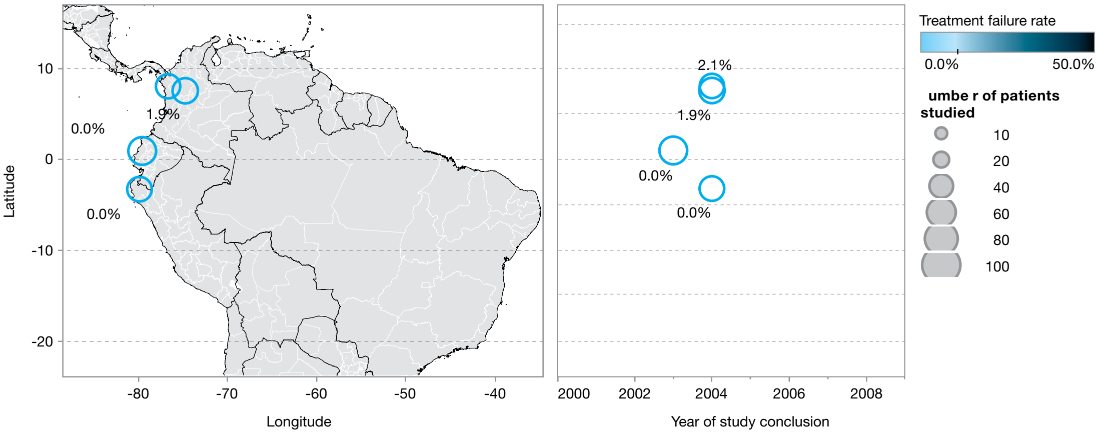


Figure 45. Therapeutic failure in *P. falciparum* malaria treated with Artesunate - Mefloquine combination

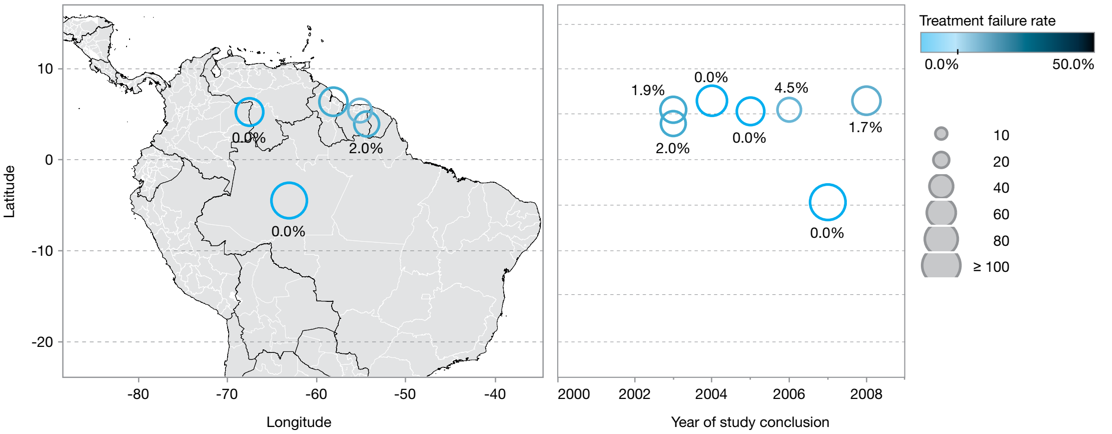


Figure 46. Therapeutic failure in *P. falciparum* malaria treated with Artemether - Lumefantrine combination

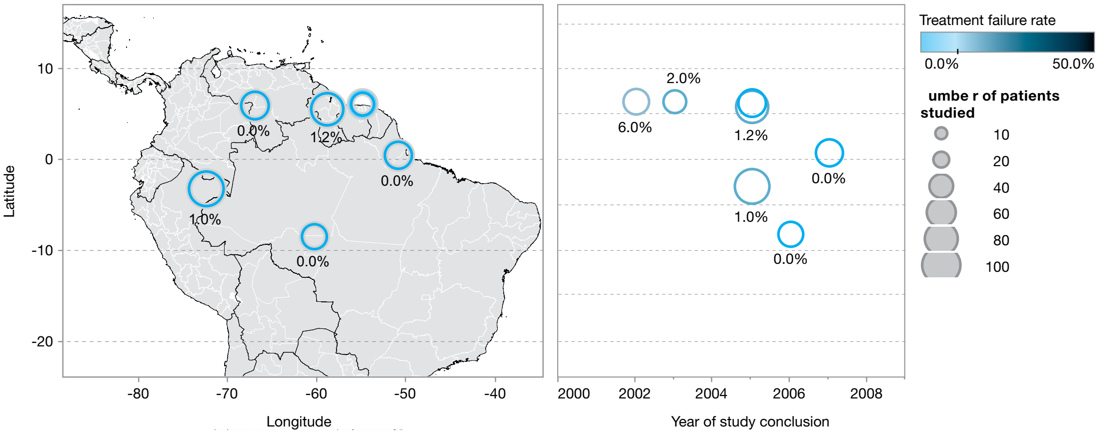


Figure 47. Example of analysis with data from malaria information system in Guyana, 2008

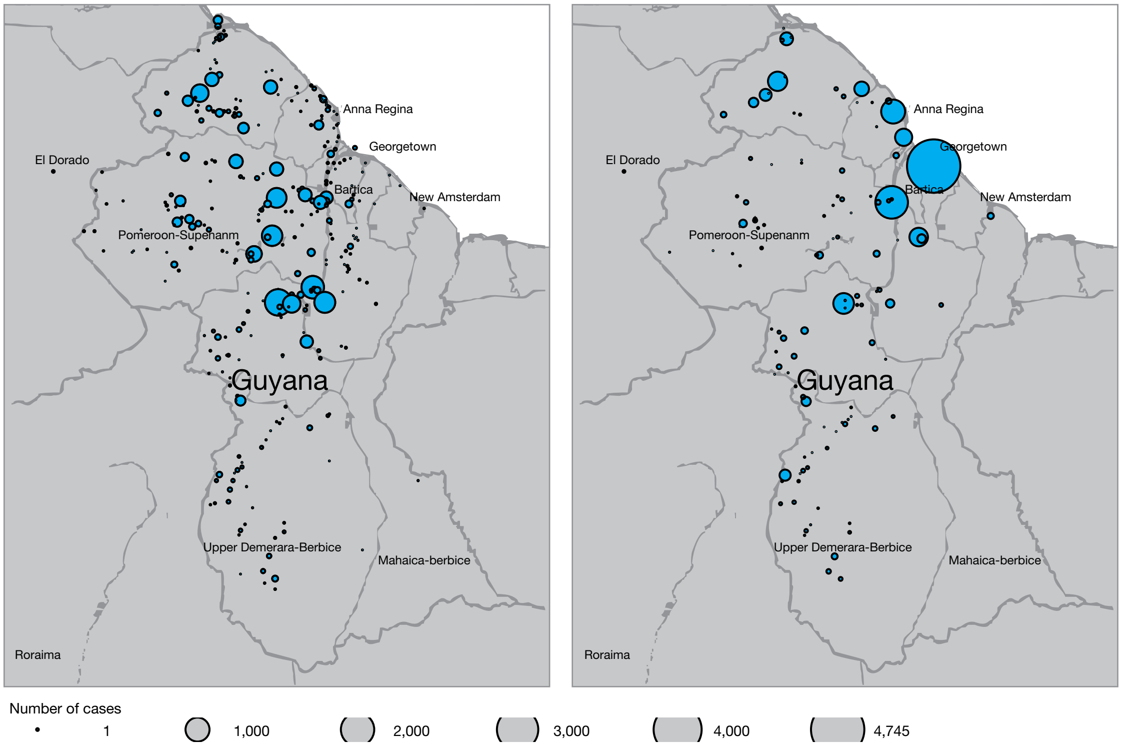


Figure 47a. Number of cases by place of infection (locality)

Figure 47b. Number of cases by place of diagnosis (locality)

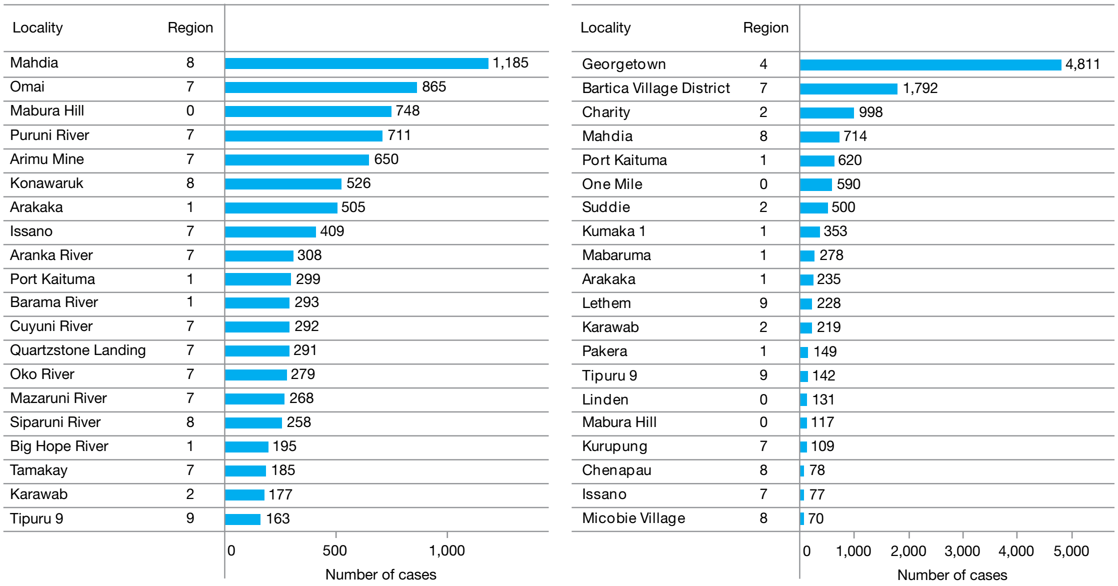


Figure 47c. Locality of origin of infection, in descending order (top 20)

Figure 47d. Locality of diagnosis of case, in descending order (top 20)

Locality	Region	
Mahdia	8	1,185
Omai	7	865
Mabura Hill	0	748
Puruni River	7	711
Arimu Mine	7	650
Konawaruk	8	526
Arakaka	1	505
Issano	7	409
Aranka River	7	308
Port Kaituma	1	299
Barama River	1	293
Cuyuni River	7	292
Quartzstone Landing	7	291
Oko River	7	279
Mazaruni River	7	268
Siparuni River	8	258
Big Hope River	1	195
Tamakay	7	185
Karawab	2	177
Tipuru 9	9	163

Locality	Region	
Georgetown	4	4,811
Bartica Village District	7	1,792
Charity	2	998
Mahdia	8	714
Port Kaituma	1	620
One Mile	0	590
Suddie	2	500
Kumaka 1	1	353
Mabaruma	1	278
Arakaka	1	235
Lethem	9	228
Karawab	2	219
Pakera	1	149
Tipuru 9	9	142
Linden	0	131
Mabura Hill	0	117
Kurupung	7	109
Chenapau	8	78
Issano	7	77
Micobie Village	8	70

Figures 47 to 50 illustrate some of the potential of malaria information systems that are based on individual case records. These information systems allow for the recording and tabulation of the locality of infection and diagnosis, and make the information available for timely program management. Figure 47 shows how such information may be analyzed, using Guyana's database as an example. The geographic coordinates of localities have been included in the malaria program database according to place of infection and place of diagnosis. This allows for a very detailed spatial analysis of the disease. These data in particular show that a significant proportion of cases are being diagnosed at a place other than the place of origin, and reveal a need for an improvement in diagnostic services.

This level of analysis is critical not only to guiding diagnosis and treatment, but for strengthening health services in general. It is also essential in guiding vector control. For example, the selection of localities for vector control should begin with a stratification exercise to assist in the identification of localities with high morbidity and numbers of foci. Concerning vector control, managing information through databases facilitates the relation of individual case information to the results of entomological studies.

The level of expertise in medical entomology in national malaria programs of the Region needs revamping. Understanding the transmission dynamics in malaria foci in order to focus intervention requires that, apart from improving epidemiological information management, reliable information be available regarding vector behavior and variations in entomological parameters in response to interventions.

In Bolivia, the information system recently developed for the Departments of Beni and Pando, which will be extended to the rest of the endemic area in 2009, registers several dates related to the case and care received within the health system. An analysis of the number of days that pass between the onset of symptoms and the various stages of care allows for an assessment of diagnosis timeliness, and supports identification of the stage during which deficiencies in diagnosis and treatment are most likely to occur. Figure 48 shows the comparative analysis of the time elapsed between the onset of symptoms, blood slide examination, examination reading and subsequent treatment, and reveals that for many municipalities the greatest challenge lies in the provision of timely diagnosis. The period of time between when a blood slide is taken and treatment is initiated is short, but providing early access to diagnosis constitutes a challenge for the control program and health services.

Another example of automated information management comes from Ecuador, where the system records, among other variables, each case's parasitemia on the day of diagnosis. When comparing the cantons of origin according to this parameter, it is possible to identify simultaneously those places with a large proportion of cases with high parasitemia and those with a long interval of time between the onset of symptoms and reading of blood slides (Figure 49). This can help define strategies to improve access to diagnosis, including community acceptance.

Using data from SIVIGILA in Colombia, figure 50 illustrates how information management, using individual record databases, allows easy cross-referencing of information among variables, with the necessary level of disaggregation. This type of analysis is important for an ADM1, for example, to monitor the number of

---

3 WHO. Methods for surveillance of antimalarial drug efficacy. 2009

Figure 48. Examples of analysis with data from the malaria information system in Bolivia, 2008

Figure 48a. Cases by municipalities and time taken between various stages of diagnosis and treatment of malaria cases

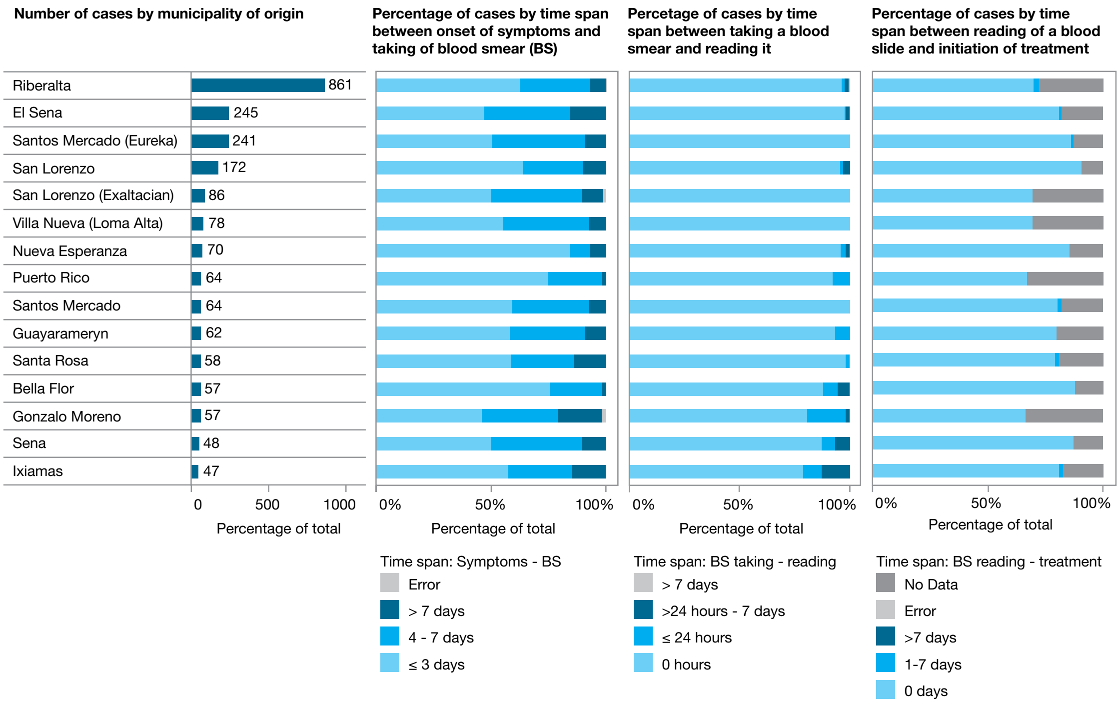
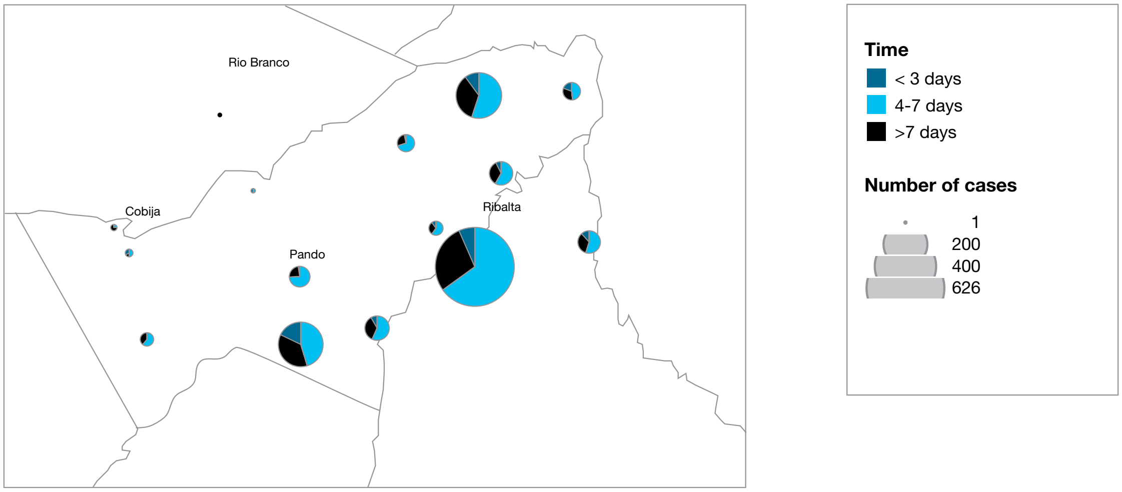


Figure 48b. Cases by time between onset of symptoms and initiation of treatment, 2008



cases originating in one ADM2 and diagnosed in another. These analyses can be done at any level of disaggregation, if the database stores individual case records.

Another useful tool is the simultaneous management of information tables on different aspects of malaria control related to individual case record databases through the use of codes for locality and diagnostic facility. This option increases analytic possibilities, and allows for the creation of an information system that covers every aspect of malaria control.

When data are appropriately typified by their locality of origin and analyzed by means of relational databases, the monitoring of urban malaria, which should be a priority for control programs, can be greatly improved.

Reporting individual cases and structuring data flow to feed surveillance databases are the most complex steps in the computerization of the system. Both training in data analysis and establishing a culture of data use are weak in the Region and need to be improved. In recent years, efforts have been made to provide health services with the c ysis. In the countries of the Amazon region, these efforts were supported by the AMI project.

In 2008, significant progress was made in Bolivia, Brazil, Colombia and Ecuador. In these countries automated analysis protocols were developed. They include data visualization and tabulation tools that are now available to malaria programs at the central level and in some ADM1. During this period, PAHO has worked

Figure 49. Example of analysis with data from malaria information system in Ecuador, 2008

Figure 49a. Cases of malaria parasitemia level and the time of diagnosis by canton

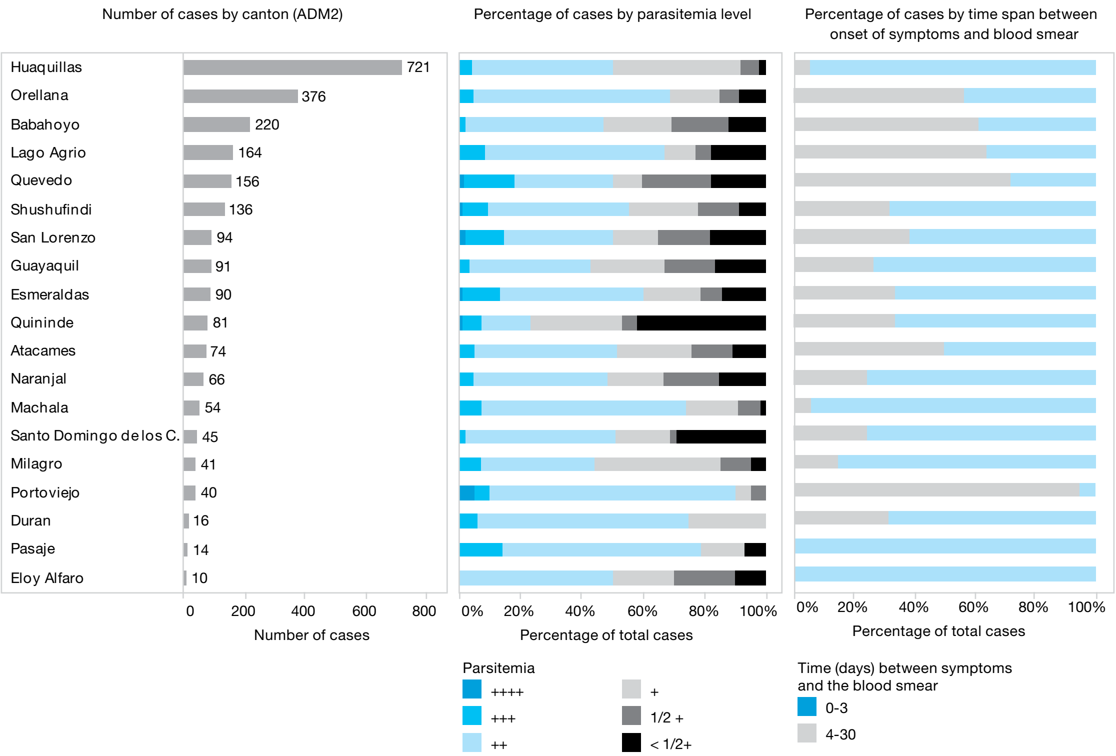
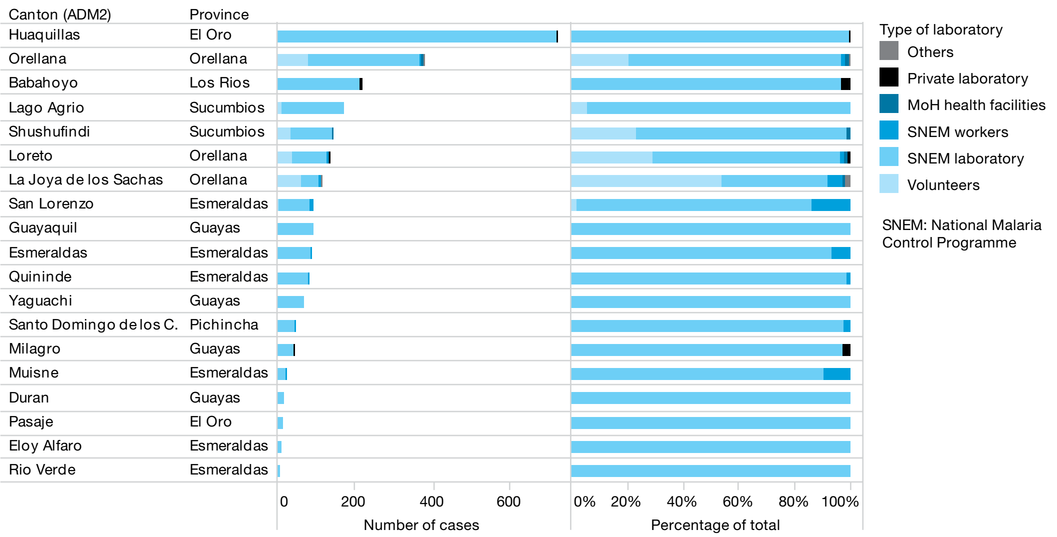


Figure 49b. Number and percentage of cases by canton (ADM2) and type of laboratory, 2008



with these countries to develop the capacity to generate automatic reports as the database is updated. Support was also provided to design figures and tables that illustrate time and spatial variations of the main program parameters. These parameters include diagnosis and treatment management indicators for ADM1, ADM2 or specific health units. Differences across municipalities in the proportion of cases diagnosed within 72 hours of the onset of symptoms, the proportion of *P. falciparum* malaria cases or changes in the proportion of cases of urban transmission, are all indicators that become easy to monitor and that may support the establishment of new goals for program management at various levels.

It is expected that countries with Global Fund projects will mobilize resources to improve health information management systems, which will, in turn, improve malaria program information systems.

The possibility that some countries in the Region will be able to reorient control programs toward malaria elimination or, at least, the elimination of *P. falciparum* transmission, underscores the need for individual case record databases and for the better use of information. The first program realignment requires: 1) that malaria transmission be limited to endemic foci; 2) that transmission dynamics in each foci be more fully understood; and 3) that the capacity to implement surveillance of individual cases exists.

Improvements in surveillance and information management are essential in the context of the elimination. However, in that respect, it should be recalled that the passage from control to elimination with a view to malaria eradication were initiated in the Americas in 1955, until the strategy was abandoned. As such, in addition to adopting the new tools available today, we must promote an analysis of the errors and lessons learned.

Figure 50. Examples of analysis with data from malaria information system in Colombia, 2008

Figure 50a. Number of cases by municipality (ADM2) of origin and municipality of diagnosis

		Municipality (ADM2) of diagnosis / Depatment (ADM1) of diagnosis																			
		Bajo Baudo (Pizarro)	Caceres	Caucasia	Cumaribo	El Bagre	El Retorno	Mutata	Necoli	Olaya Herrera	Puerto libertador	Rioacha	Roberto Payan	San Jose del Uaviare	San Pedro de Uraba	Taraza	Tierralta	Rioacha	Roberto Payan	San Jose del Uaviare	San Pedro de Uraba
Municipality of origin	Department	Choco	Antoquia	Antoquia	Vichada	Antoquia	Guaviare	Antoquia	Antoquia	Narino	Cordoba	La Guajira	Narino	Guaviare	Antoquia	Antoquia	Cordoba	Narino	Antoquia	Cordoba	Antoquia
Bajo Baudo (Pizarro)	Choco	1,734																			
Caceres	Antioquia		2,693	242		1										37					19
Caucasia	Antioquia			548		10									1	1	3				5
Cumaribo	Vichada				834																
El Bagre	Antioquia			219		2,983					1					9					5
El Retorno	Guaviare						866							28							
Mutata	Antioquia							690							1				2		
Necocli	Antioquia			2					1,098						7				9		
Olaya Herrera	Nariño									1,929								8			
Puerto Libertador	Cordoba			1							2,886					2	2				
Riohacha	Guajira											1,198									
Roberto Payan	Narino									10			890					12			
San Jose del Guaviare	Guaviare													4,394			1				
San Pedro de Uraba	Antioquia								1						1,631				1		
Taraza	Antioquia			37		2										798					1
Tierralta	Cordoba					3					1					2	4,394				1
Tumaco	Narino																	1,631			
Turbo	Antioquia							3							289				4,394		
Valencia	Cordoba														5	2				1.276	
Zaragoza	Antioquia			79		263					1					10					2.258

Figure 50b. Number of urban and rural malaria cases by municipality (ADM2) of origin in Colombia, 2008