World Health Organization

Global Insecticide Use for Vector-Borne Disease Control

A 10-YEAR ASSESSMENT (2000–2009)

Fifth Edition

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1. INTRODUCTION

Vector control is an important element of strategies used to control major vector-borne diseases globally, and chemical control remains the most widely used approach. In recent years, interventions using insecticides have been scaled up in many countries.

The need to develop effective systems for pesticide management has been emphasized to ensure judicious use of insecticides, manage insecticide resistance, and reduce risks to human health and the environment, within the context of an integrated vector management (IVM) approach (WHO 2010a; Matthews et al. 2011; van den Berg et al. 2011; WHO 2011a). Consequently, it is essential that the actual use of insecticides by vector control programmes in WHO's Member States is routinely monitored and reported. WHO published the first report on such uses in 2002 and since then has issued updates periodically. A shortcoming of previous assessments has been the lack of data from some of the most populous countries with vector-borne disease control programmes.

This report provides an overview of the first 10 years of global insecticide use. A unique feature is the high coverage of reports from countries endemic for or at risk of major vector-borne diseases in WHO's regions, including from the most populous countries with vector-borne disease control programmes. Trends and patterns in insecticide use are presented and discussed in the report.

The report is intended for use by national programmes in order to inform decisions about the use of insecticides to control vector-borne diseases; for information exchange and regional collaboration; and as a basis for managing chemicals. The target audience

also covers regional and international organizations, civil society organizations and the pesticide industry. The information provided is expected to inform:

- international agreements on pesticides and toxic chemical substances;
- guidance on judicious, effective use and low-risk use of insecticides;
- guidance for the management of insecticide resistance;
- policy development and policy reform in relation to management of public-health pesticides at national, regional and global levels;
- investments in the development of alternative methods of vector control.

2. METHODS

2.1 Collection of information

In October 2010, WHO provided a standard data reporting form to its six regional offices: the Regional Office for Africa (Harare), the Regional Office for the Americas (Washington DC), the Regional Office for the Eastern Mediterranean (Cairo), the Regional Office for Europe (Copenhagen), the Regional Office for South-East Asia (New Delhi) and the Regional Office for the Western Pacific (Manila). The regional offices distributed the form to WHO's representatives in targeted Member States (*Annex 1*). The focal points for malaria and other vector-borne diseases facilitated the collection and validation of data in each country through the ministry of health.

The Member States selected for this study were countries, territories excluded, with established vector control programmes. A total of 143 countries were targeted, representing a total human population of 5.49 billion (*Table 1*).

The survey excluded Australia, most European countries (except for 8 countries), Japan and North America. Nonetheless, it is known that some of the excluded countries had

Table 1. Number of targeted countries, and their populations, responding to the data reporting request, by WHO region

	Countries						Populations (mln)		
		Responded[a]							
WHO Region	Targeted	1-4	5-9	10	Total		Targeted	Responded	
African	46	19	12	6	37	(80%)	805	680	(85%)
Americas	32	11	13	8	32	(100%)	570	570	(100%)
Eastern- Mediterranean	21	3	6	9	18	(86%)	580	562	(97%)
European	8	1	0	7	8	(100%)	135	135	(100%)
South-East Asia	11	1	3	6	10	(91%)	1,760	1,737	(99%)
Western Pacific	25	7	6	7	20	(80%)	1,639	1,629	(99%)
Total	143	42	40	43	125	(87%)	5,489	5,314	(97%)

[a] Indicated are numbers of countries that responded with 1-4, 5-9 or 10 annual reports over the 10-year period, 2000–2009

in some specific situations used insecticides for vector control, for example, against West Nile virus in North America. New Zealand was included in the study because of its known vector control programme against Ross River virus.

Using the data reporting form, countries were requested to provide data for 2008–2009, and to provide missing or updated data, where appropriate, for the preceding years 2000–2007. Where countries did not provide updated data, the data previously submitted to WHO were used in the 10-year analysis.

2.2 Observations on reporting

Of the 143 countries targeted, 125 countries (87%) reported data, representing 97% of the total population of all targeted countries (*Table 1*). China and India, the most populous countries, were among the respondents. It is therefore safe to assume that the 10-year data provide a comprehensive indicator of global coverage.

The response rate was 80% for the African Region, 100% for the Region of the Americas, 86% for the Eastern Mediterranean Region, 100% for the countries targeted in the European Region, 91% for the South-East Asia Region and 80% for the Western Pacific Region.

The consistency of annual reporting varied among countries. During the 10-year period, 42 countries provided 1–4 annual reports (representing a total population of 0.75 billion); 40 countries provided 5–9 annual reports (representing a total population of 0.68 billion) and 43 countries provided all 10 annual reports (representing a total population of 3.88 billion) (*Table 1*). For the most recent years, the number of responding countries was 93 in 2008 and 92 in 2009. *Annex 2* provides a complete list of responding countries by reporting period.

2.3 Description of insecticides

Classes of insecticides
The following classes of insecticides are differentiated (WHO 2006):

- organochlorines, of which DDT (dichlorodiphenyltrichloroethane) is the only insecticide reportedly used in vector control;
- organophosphates, such as fenitrothion, malathion and temephos;
- carbamates, such as bendiocarb and propoxur;
- pyrethroids, such as alpha-cypermethrin, bifenthrin, cyfluthrin, cypermethrin, cyphenothrin, deltamethrin, etofenprox, lambda-cyhalothrin and permethrin;
- insect growth regulators, such as diflubenzuron, methoprene, novaluron and pyriproxyfen;
- bacterial larvicides, such as *Bacillus thuringiensis israelensis* and *B. sphaericus*.

Application rate

In residual spraying, the application rate refers to the amount of active ingredient (AI) applied to spray 1 m^2. In space spraying, the application rate is generally given as the amount of AI applied per hectare. WHO has published the list of insecticide compounds for use in indoor residual spraying and space spraying and their recommended application rates in gram (g) of active ingredient (AI) per square metre (m^2) or hectare (ha) (Najera and Zaim 2002).

A distinction can be made between two categories of insecticides: (i) organochlorines, organophosphates and carbamates; and (ii) pyrethroids. For residual spraying, insecticides in the first category are mostly recommended for use at the application rate of around 1.5 g AI/m^2, but the most commonly-used pyrethroids are recommended at the application rate of only around 0.025 g AI/m^2; a factor of 60 lower. This approximate conversion factor also applies to insecticides commonly used in space spraying.

Hence, pyrethroids are generally effective at an application rate 60 times lower than most compounds in the other category. For example, 1 kg of AI of deltamethrin would have the same spray coverage as 60 kg AI of malathion or DDT. This distinction is essential for interpreting the data presented in this document.

Insecticide formulations

The most common formulations of synthetic insecticides used for particular applications are:

- larvicidal treatments with emulsifiable concentrates and granules;
- residual treatments with wettable powders, suspension concentrates and capsule suspension; and with water dispersible granules;
- treatment of mosquito nets with aqueous formulations such as suspension concentrates, capsule suspensions and oil-in-water emulsions; use of formulations of emulsifiable concentrates to treat mosquito nets is discouraged, except for that of permethrin 10% emulsifiable concentrate (Zaim et al. 2000);
- space spraying with emulsifiable concentrates, oil-in-water emulsions or ultra-low-volume liquids.

Methods of application

The main methods of applying vector-control insecticides are residual spraying, space spraying, treatment of nets and larviciding (WHO 2006).

Indoor residual spraying refers to all methods of indoor spraying with residual insecticides, targeted at killing indoor-resting vectors. Perifocal treatment refers to a form of residual treatment, outdoors or indoors, used in dengue control whereby the walls of containers or other structures are sprayed (WHO 2009a). In this report, data on indoor residual spraying and perifocal spraying have been combined as “residual spraying”.

Space spraying of insecticides is targeted to achieve a rapid reduction of adult vector density. Space spraying has been used extensively to control epidemics of mosquito-borne diseases such as dengue.

Treatment of nets refers to the application of residual insecticides to treat bednets, by adding a repellent and killing effect to the protective physical barrier offered by the net. Pyrethroids are the only class of insecticides currently recommended for use in nets. The distribution of long-lasting insecticidal nets constitutes a considerable additional amount of pyrethroid insecticides, which was not taken into account in this survey.

Larviciding is the use of chemical or biological insecticides to treat the larval breeding sites of vectors. This generally refers to the aquatic breeding sites of mosquitoes. Larviciding has little residual effect.

In addition, few countries have reported dusting as a method of application to control plague.

2.4 Data analysis

Two types of analysis were conducted: (i) analysis of the 10-year average data and (ii) analysis of the annual trends.

An assumption was made in the analysis that if a country reported for a particular year, that report was considered comprehensive, that is, the report covered all uses of insecticides for vector control. For example, if in 2004 a country reported on using larviciding but not indoor residual spraying, it was assumed that there was zero use of indoor residual spraying. Conversely, if in 2005 the country failed to report, this was considered as missing data.

These considerations were taken to allow for the optimal calculation of average use, both for 10-year average data and for yearly averages in the trend analysis. Nevertheless, it is important to note that a bias could still have occurred. For example, the activities of national malaria control programmes are more structured, and attract more resources, than those of some other vector-borne diseases. This difference might have had implications for the quality of data reporting.

The 125 responding countries represented 96.8% of the total population of all targeted countries (5.49/5.31 billion). This is considered a close enough approximation of total coverage and, therefore, the 10-year average data adequately represent the global use of insecticides for vector control.

In the analysis of data per year, however, there was a higher incidence of missing values than for the 10-year average data. In fact, the rate of reporting increased slowly over the years. Hence, a correction was needed to assess trends in global use. If not corrected, global insecticide use in the first year would be an under-estimate in relation to global insecticide use in the past years.

Consequently, in the analysis per year, a correction was made as follows: for each year, the countries that responded were identified and their combined population determined, using WHO health statistics (WHO 2010b). Their combined population was then divided by the total population of all 143 targeted countries, given in Table 1, to produce the proportion of the total population that had been targeted. Subsequently, the data on insecticide use for that year were divided by the above proportion to produce an estimate for global insecticide use in that year. As a result, the proportion of the targeted population in any one year (2000–2009) ranged from 0.81 to 0.91; the proportion was lower in the first years and increased towards the end.

For example, if in 2001 the total reported use of organophosphates was 20 tonnes and the reported data represented 80% of the targeted population, then global use in 2001 was estimated at 20 divided by 0.8, which is 25 tonnes.

A detailed analysis was conducted for four major vector-borne diseases, which were selected on the basis of the total volume of insecticides used against them:

- malaria, caused by protozoan Plasmodium parasites transmitted by Anopheles mosquitoes;
- dengue, an arboviral disease transmitted by Aedes mosquitoes;
- leishmaniasis, caused by protozoan *Leishmania* parasites transmitted by phlebotomine sandflies;
- Chagas disease, caused by protozoan *Trypanosoma cruzi* parasites transmitted by triatomine bugs.

Some countries reported that methods of applying insecticides were used against more than one disease (for example, malaria and dengue, or malaria and Chagas disease); this involved the use of either organophosphate or pyrethroid insecticides. Use of insecticides against multiple diseases constituted only 2% and 3% of the global use for organophosphates and pyrethroids, respectively. In such cases, it was not possible to calculate the amounts used for each individual disease.

To determine the amounts used for each disease, the mixed-purpose use was also included. For example, the amounts used for malaria control were determined by adding the use for malaria, the use for malaria and dengue, and the use for malaria and leishmaniasis. To determine the use in dengue control in this example, the use for malaria and dengue was also included. Hence, the use for malaria and dengue was counted twice, because it was used against both diseases. This approach was chosen because of its importance in showing the total use of insecticides against a specific disease.

2.5 Limitations

The main limitation of the study was the assumption made in the data analysis that countries reporting for a particular year had reported comprehensively. Central authorities that were asked to complete the data reporting form may not have had

access to all data on insecticides used for vector control. For example, there is reason to believe that their use in programmes decentralized to the district or province has been under-reported given the complexity of accessing these data at the central or national level.

3. RESULTS

3.1 All uses in vector control

3.1.1 Global use in the WHO regions

The 10-year average data show that 4429 metric tonnes of active ingredient of organochlorines, 1375 tonnes of organophosphates, 30 tonnes of carbamates and 414 tonnes of pyrethroids were used annually for global vector control during the period 2000–2009 in WHO's six Regions (*Table 2*).

Table 2. Use of insecticides for vector control in WHO's regions, as reported to WHO, averaged during the period 2000–2009, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

	Residual spraying[b]				Space spraying		Treatment of nets	Larviciding		All application methods			
WHO Region	OC	OP	C	PY	OP	PY	PY	OP	PY	OC	OP	C	PY
African	805	19	19	24	0.1	0.0	12	1	0.3	805	20	19	36
Americas	0.2	97	4	164	276	66	0.4	82	-	0.2	455	4	230
Eastern Mediterranean	-	26	5	15	2	5	1	20	1	-	47	5	22
European	-	2	0.3	1	-	1	0.0	1	-	-	3	0.3	2
South-East Asia	3,623	483	2	39	15	1	4	49	-	3,623	547	2	45
Western Pacific	0.3	1	-	39	292	27	14	9	0.0	0.3	302	-	80
Total	4,429	627	30	282	584	100	31	163	2	4,429	1,375	30	414

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

The majority (82%) of organochlorines were used in the South-East Asia Region, predominantly India; 18% was used in the African Region. DDT was the only reported organochlorine compound used in residual spraying.

The use of organophosphates was reported from all WHO regions using three methods of application: residual spraying, space spraying and, to a lesser extent, larviciding. The highest use of organophosphates was in South-East Asia, followed by the Americas and the Western Pacific.

Compared with other classes of insecticides, the use of carbamates was limited, and mainly to residual spraying in the African Region; carbamates have reportedly not been used in the Western Pacific Region.

Pyrethroids were used in all four major methods of application: 68% (282/414 tonnes) of pyrethroid for residual spraying, 24% (100/414 tonnes) for space spraying, and the remainder for treatment of nets and larviciding. In terms of tonnes of active ingredient, pyrethroids are not the most used insecticides, but in terms of spray coverage they were by far the most used insecticides. The Region of the Americas accounted for 56% (230/414 tonnes) of global use of pyrethroids.

Figure 1 shows the proportions of insecticides used globally for vector control, by each class of insecticide and expressed in spray coverage (not tonnes of active ingredient). A 60-times conversion factor was used for pyrethroids (see Methods section). The graph is highly relevant because it shows that pyrethroids, amounting to a minor fraction in terms of tonnes of active ingredient, constituted as much as 81% of global insecticide use in terms of spray coverage (in m^2 or ha). In other words, global insecticide spray coverage is largely dominated by pyrethroids.

The dominance of pyrethroid insecticides used for vector control is worrisome because it exerts a high selection pressure for the development of resistance in vector populations. Genes conferring resistance against pyrethroids have been spreading in vector populations, particularly in populations of vectors of malaria and dengue (WHO 2011b; Ranson et al. 2008).

There is particular concern because a major tool in malaria control, the use of long-lasting insecticidal nets (LNs), depends solely on the action of pyrethroids. Hence, it is critical that the susceptibility of malaria vectors to pyrethroids is preserved. Indeed, it has been recommended not to use pyrethroids for indoor residual spraying where there is high coverage with treated nets (WHO 2011b).

Figure 1. Proportion of vector control insecticide use, by global shares of organochlorines (OC), organophosphates (OP), carbamates (C) and pyrethroids (PY) expressed in spray coverage (not amount of active ingredient).

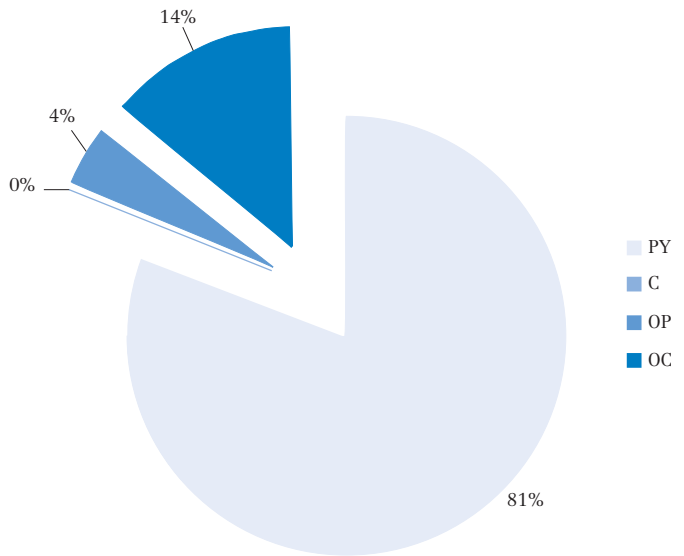
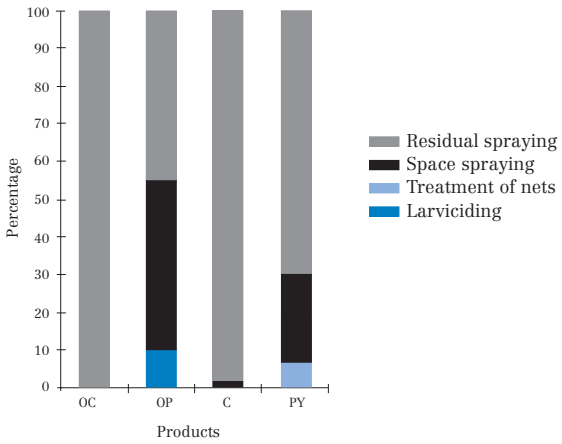


Figure 2 shows the relative contribution of each class of insecticides to the methods of application. Clearly, the four classes of insecticides were used quite differently. Organochlorines and carbamates were reportedly used almost only for residual spraying, predominantly indoors. Organophosphates were used for residual spraying, space spraying and larviciding. Pyrethroids were used for residual spraying and space spraying as well as the treatment of nets.

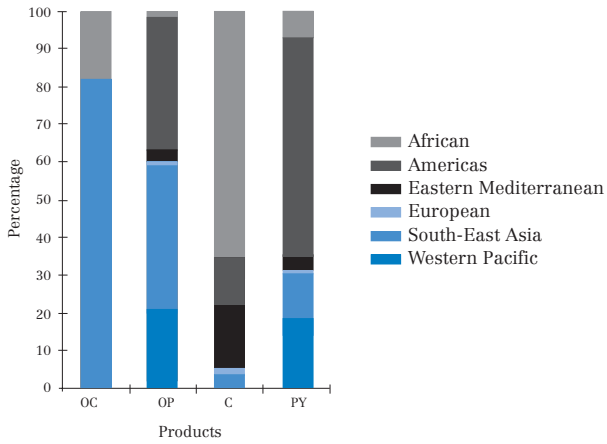
Figure 2. Proportion of each class of insecticide used in four main methods of application



C, carbamates; OC, organochlorines; OP, organophosphates; PY, pyrethroids

Figure 3 shows the relative contribution of each class of insecticides used in WHO regions. There are conspicuous differences among regions. For example, organochlorines were used only in the African and South-East Asia regions. Organophosphates were used mostly in the Americas, South-East Asia and Western Pacific regions. The small global use of carbamates was predominantly in the African Region. Most use of the pyrethroids, on the other hand, was in the Region of the Americas; the Western Pacific Region was the second largest user.

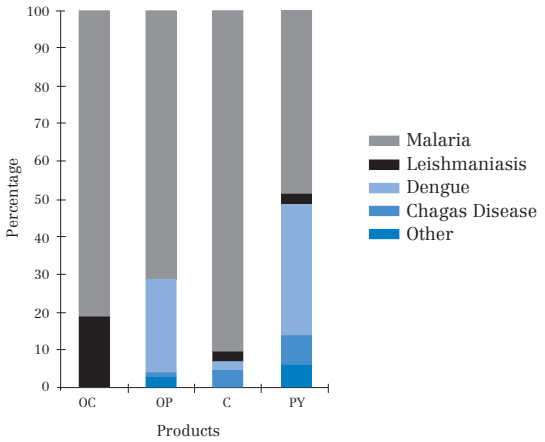
Figure 3. Proportion each class of insecticides used, by WHO Regions



C, carbamates; OC, organochlorines; OP, organophosphates; PY, pyrethroids

Figure 4 shows the relative use of the classes of insecticides for each major disease. Globally, organochlorines were used only against malaria and leishmaniasis. Organophosphates were mostly used against malaria and dengue; a minor fraction were used for other vector-borne diseases. Carbamates were almost exclusively used against malaria. Pyrethroids were used mainly to control malaria and dengue, with minor fractions used against Chagas disease and leishmaniasis.

Figure 4. Proportion of each class of insecticide used to control major vector-borne diseases



C, carbamates; OC, organochlorines; OP, organophosphates; PY, pyrethroids

3.1.2 Global use for individual diseases

Of all organochlorines, 81% (3604/4429 tonnes) was used against malaria; the remainder was used against leishmaniasis (*Table 3*). DDT was the only compound used. Organochlorines constituted a large part of insecticide use in terms of tonnes of active ingredient.

Organophosphates were applied mostly in residual spraying for use against malaria and in space spraying against malaria and dengue. Organophosphates were also the most commonly used insecticide class in larviciding.

Carbamate use was relatively low and reported only for residual spraying against malaria.

Pyrethroids were reportedly used against a number of vector-borne diseases. Their use was highest for control of malaria and dengue vectors. Use for dengue was likely under-reported. Other diseases targeted with pyrethroids were Chagas disease and leishmaniasis.

Countries generally reported the use of insecticides targeted at individual disease. In some cases, however, countries reported the use of insecticides against more than one disease. This constituted only a minor fraction of insecticides was targeted (2% and 3% of the global of use of organophosphates and pyrethroids, respectively), as discussed in the Methods.

Table 3. Global use of insecticides targeted at vector-borne diseases, as reported to WHO, averaged during the period 2000–2009, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

	Residual spraying[b]				Space spraying		Treatment of nets	Larviciding		All application methods			
Diseases	OC	OP	C	PY	OP	PY	PY	OP	PY	OC	OP	C	PY
Malaria	3,604	589	26	130	286	11	31	60	0.0	3,604	934	26	172
Malaria & Dengue	-	3	0.0	5	11	33	0.0	2	-	-	16	0.0	38
Malaria & (Chagas or Leishmaniasis)	-	11	0.1	4	0.4	0.5	0.0	-	-	-	11	0.1	5
Dengue	-	7	1	61	235	34	-	81	-	-	324	1	95
Dengue & other arboviruses	-	-	-	0.0	51	21	-	3	-	-	54	-	21
Leishmaniasis	825	1	1	20	-	0.0	-	-	-	825	1	1	20
Chagas disease	-	5	1	35	0.0	-	-	-	-	-	5	1	35
Lympathic filariasis	-	3	-	1	0.0	0.1	-	13	-	-	15	-	1
Gastro Intestinal Diseases	-	7	0.4	3	1	0.1	-	1	-	-	9	0.4	3
Bartonellosis	-	2	-	0.1	-	-	-	-	-	-	2	-	0.1
Plague	-	-	-	0.0	-	-	-	-	-	-	-	-	0.0
Onchocerciasis	-	-	-	-	-	-	-	0.2	0.0	-	0.2	-	0.0
Unspecified vector-borne arboviruses	-	1	-	22	-	1	-	2	1	-	3	-	24
Total	4,429	627	30	282	584	100	31	163	2	4,429	1,375	30	414

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

3.1.3 Trends

Global use of organochlorines has been high every year, without a clear trend (*Table 4*), indicating the use of DDT in the period after the POPs Treaty went into force in 2002 (UNEP 2002). Its reported use has been exclusively for indoor residual spraying, with DDT as the only compound.

Organophosphates were used extensively during the 1990s (WHO 2009b), but their use declined drastically after 2000. Use of carbamates has grown in recent years as a result of their increased use in residual spraying. Use of pyrethroids peaked sharply in 2002, largely because of their use in residual spraying in Brazil. The amounts used in space spraying have fluctuated from year to year, possibly in response to the global incidence of diseases in those years.

Figure 5 shows the trends of the three major groups of insecticides used.

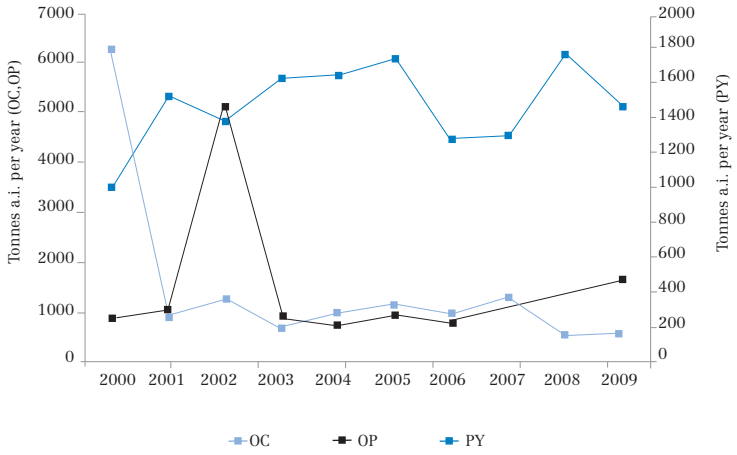
Table 5 shows the trends per WHO region. The use of organochlorines has increased substantially in the African Region, but declined again in 2009. Use of DDT peaked in 2008 in the region but reduced in 2009 in Ethiopia and Mozambique; Uganda stopped using DDT. The issue of DDT is discussed further in section 3.6.1 below.

Table 4. Trend in the global use of insecticides for vector control, as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

Type of application	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residual spraying	OC	3,512	5,305	4,814	5,693	5,745	6,065	4,436	4,558	6,170	5,127
	OP	5,126	293	135	65	42	115	362	684	145	230
	C	12	5	7	8	11	19	18	33	49	30
	PY	124	200	1,374	184	153	137	166	176	155	261
Space spraying	OP	840	398	934	502	755	875	405	388	284	238
	PY	62	71	70	53	54	83	47	111	210	193
Treatment of nets	PY	58	23	18	29	7	43	11	29	38	14
Larviciding	OP	297	180	219	108	188	169	206	221	106	118
	C	0.3	-	-	-	-	-	-	-	0.0	0.0
	PY	1	1	-	-	-	1	6	6	-	-
Total	OC	3,512	5,305	4,814	5,693	5,745	6,065	4,436	4,558	6,170	5,127
	OP	6,263	871	1,288	675	985	1,159	973	1,293	536	585
	C	12	5	7	8	11	19	18	33	49	32
	PY	245	295	1,462	266	214	264	230	321	403	468

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Figure 5. Trends in the global use of organochlorines (OC), organophosphates (OP) and pyrethroids (PY) for vector control



Also in the African Region, the use of organophosphates has declined gradually, whereas the use of carbamates and pyrethroids has increased. The changes in pyrethroid use are considerable, especially given the 60-times higher spray coverage (in m^2 or ha) than for the other groups of insecticides. *Figure 6* shows the pattern of use of organochlorines and pyrethroids in the region: in 2009, use of organochlorines fell but increased for pyrethroids.

Table 5. Trend in the use of insecticides for vector control in WHO's regions, as reported to WHO, by class of insecticide, in tonnes of active ingredient per year[a]

WHO Region	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
African	OC	349	398	539	446	475	970	705	1,079	2,063	1,127
	OP	31	59	36	24	1	19	14	1	1	1
	C	1	1	-	5	6	14	11	19	21	23
	PY	4	10	11	14	4	43	14	14	29	98
Americas	OC	3	0.0	-	-	-	-	-	-	-	-
	OP	373	496	550	175	477	638	201	867	340	333
	C	8	1	1	5	3	2	0.5	1	13	9
	PY	134	198	1,353	142	90	101	76	169	231	201
Eastern Mediterranean	OP	102	63	45	27	24	26	54	64	19	22
	C	3	2	4	1	0.5	1	3	13	15	-
	PY	5	13	9	12	26	19	33	27	18	16
European	OP	8	7	6	8	4	-	2	1	-	-
	C	0.5	-	-	-	-	-	2	-	-	-
	PY	0.3	1	1	2	1	3	4	4	1	1
South-East Asia	OC	3,160	4,906	4,274	5,246	5,270	5,094	3,732	3,479	4,107	4,000
	OP	5,177	161	119	32	96	139	378	125	91	164
	C	1	2	2	2	2	3	1	-	-	-
	PY	27	37	49	53	57	65	50	18	55	87
Western Pacific	OC	-	2	1	0.3	1	0.1	-	-	-	-
	OP	571	85	531	409	383	338	329	238	85	65
	C	-	-	-	-	-	-	-	-	0.2	0.4
	PY	75	37	39	44	36	34	55	90	68	65

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

During 2004–2009, the use of organochlorines in the South-East Asia Region decreased by approximately one quarter. The decline amounts to around 1200 tonnes of DDT, a considerable amount. In the Western Pacific Region, the use of organophosphates has decreased substantially in recent years. Other notable patterns are the peak in pyrethroid use in the Region of the Americas (in 2002), largely attributable to high use in Brazil, and the decline in organophosphates in South-East Asia (from 2000).

Figure 7 shows the sharp increase in 2009 in the use of pyrethroids for indoor residual spraying against malaria vectors in the African Region. A total of 19 countries reported their use for indoor residual spraying in 2009, including a number of countries with high coverage rates of long-lasting insecticidal nets, an essential tool that depends solely on the action of pyrethroids.

Figure 6. Trends in the use of organochlorines (OC) and pyrethroids (PY) for vector control in WHO's African Region

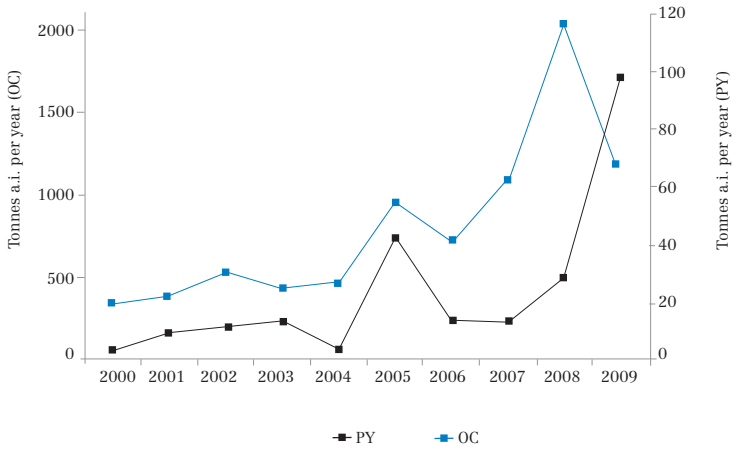
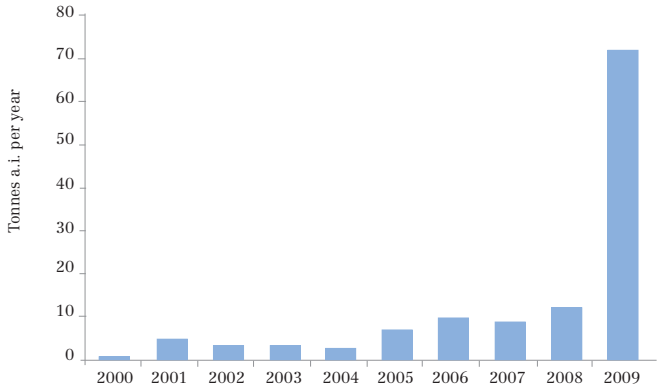


Figure 7. Trend in the use of pyrethroids for indoor residual spraying in WHO's African Region



To preserve the susceptibility of vectors to pyrethroids for as long as possible, WHO does not recommend use of pyrethroids for indoor residual spraying where there coverage of treated nets is high (WHO 2011b).

Table 6 shows trends in the use of insecticides by disease. Use of pyrethroids peaked in 2002, largely as a result of high use in Brazil, was reportedly due to targeting of pyrethroids against four major diseases: malaria, leishmaniasis, dengue and Chagas disease. Use of organochlorines against leishmaniasis reduced sharply in the South-East Asia Region from 2005.

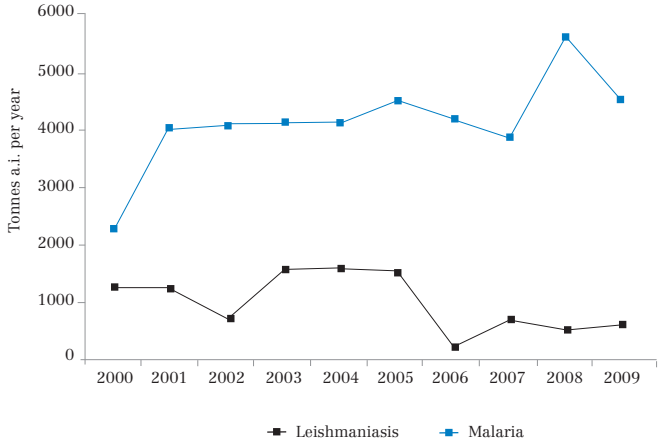
Figure 8 suggests a slightly increased trend in the global use of organochlorines (DDT only) against malaria vectors, largely attributable to the increase observed in the African Region. Conversely, global use of organochlorines against leishmaniasis has shown a substantially declining trend in recent years.

Table 6. Trend in the global use of insecticides targeted at the four major vector-borne diseases, as reported to WHO, by class of insecticide, in tonnes of active ingredient per year[a]

Disease	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Malaria	OC	2,274	4,082	4,091	4,151	4,131	4,542	4,231	3,862	5,670	4,529
	OP	5,792	477	797	494	654	648	740	960	159	218
	C	8	3	3	6	11	19	17	33	36	23
	PY	133	149	507	174	154	216	158	234	283	338
Dengue	OC	-	-	-	-	-	-	-	-	-	-
	OP	316	391	489	189	340	488	260	389	383	366
	C	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	9.6	0.7
	PY	84	110	583	75	55	86	69	152	222	189
Leishmaniasis	OC	1,238	1,223	722	1,542	1,614	1,523	205	696	500	597
	OP	-	-	14	5	1	8	13	2	-	-
	C	3	3	8	6	4	6	4	4	2	4
	PY	7	15	130	9	9	4	11	10	18	11
Chagas disease	OC	-	-	-	-	-	-	-	-	-	-
	OP	8	70	27	5	5	25	-	-	-	-
	C	0.1	0.0	0.0	-	-	-	-	-	3	6
	PY	21	39	260	34	14	11	8	9	8	9

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Figure 8. Trends in the global use of organochlorines for vector control of malaria and leishmaniasis



3.1.4 Insecticide compounds

Table 7 shows the major compounds for each class of insecticides used to control the vectors of malaria and dengue. Clearly, DDT is the only organochlorine reportedly used in vector control. Malathion is the most commonly used organophosphate to control the vectors of both diseases.

Dichlorvos, or DDVP (WHO Hazard category Ib), was used during 2000–2009 for space spraying. However, such use has not been evaluated by the WHO Pesticide Evaluation Scheme. Temephos,for larviciding was used more to control dengue vectors than malaria vectors.

Bendiocarb and propoxur were the only carbamates reportedly used against the two diseases, but mainly against malaria.

Cypermethrin is by far the most commonly used pyrethroid for dengue control. Several other pyrethroids are also commonly used in malaria control. The reported use of pyrethroids does not include those pyrethroid insecticides that are used to manufacture long-lasting insecticidal nets.

Table 7. Global use of major insecticide compounds for control of malaria and dengue, as reported to WHO, averaged during the period 2000–2009, in tonnes of active ingredient per year and by WHO-recommended classification of active ingredient by hazard

Class of insecticide[a]	Compound	WHO Hazard classification	Malaria	Dengue
OC	DDT	II	3,604	-
OP	Malathion	III	603	176
	Dichlorvos (DDVP)	Ib	222	20
	Temephos	III	37	90
	Fenitrothion	II	30	18
C	Bendiocarb	II	23	0.1
	Propoxur	II	4	1
PY	Cypermethrin	II	50	69
	Alpha-cypermethrin	II	43	6
	Deltamethrin	II	25	2
	Lambda-cyhalothrin	II	19	1
	Permethrin	II	15	7

[a] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

3.2 Malaria

The 10-year data on the global use of insecticides to control malaria vectors by WHO region are shown in *Table 8*. The average annual use (in terms of active ingredient) for malaria control was 3604 tonnes of organochlorines, 961 tonnes of organophosphates, 27 tonnes of carbamates and 217 tonnes of pyrethroids. The data show high use (in terms of tonnes of active ingredient) of organochlorines and organophosphates for malaria control in the South-East Asia Region. Use of pyrethroids is high in most regions, especially given their low application rate and, thus, their spray coverage achieved (see Methods).

Table 8. Global use of insecticides used against malaria by WHO regions, as reported to WHO, averaged during the period 2000–2009, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

	Residual spraying[b]				Space spraying		Treatment of nets	Larviciding		All application methods			
WHO Region	OC	OP	C	PY	OP	PY	PY	OP	PY	OC	OP	C	PY
African	805	19	19	21	0.1	-	12	1	0.1	805	20	19	33
Americas	0.2	83	2	55	84	39	0.4	6	-	0.2	173	2	94
Eastern Mediterranean	-	15	4	10	1	5	1	18	1	-	34	4	17
European	-	2	0.3	1	-	1	0.0	1	-	-	3	0.3	2
South-East Asia	2,798	482	2	39	0.1	0.0	4	35	-	2,798	518	2	43
Western Pacific	0.3	-	-	14	212	0.2	14	1	-	0.3	213	-	28
Total	3,604	602	27	140	297	45	31	62	1	3,604	961	27	217

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Trends in insecticides used for malaria control are presented in *Table 9* by method of application. The trends show a slight increase in organophosphates used in residual spraying. Use of organophosphates declined as a result of their decreased use in residual spraying, space spraying and larviciding. Use of carbamates has recently increased in residual spraying. Moreover, there has been a substantial increase in the use of pyrethroids owing to their use in residual spraying. The number of countries that reported using insecticides in their malaria control programmes (including for multi-disease purposes) increased from around 59 in 2009 to 67 in 2009.

Table 9. Trend in the global use of insecticides used against malaria as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year. The number of countries reporting used of insecticides in their malaria control programmes is indicated for each year[a]

Type of application	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residual spraying	OC	2,274	4,082	4,091	4,151	4,131	4,542	4,231	3,862	5,670	4,529
	OP	5,117	284	108	54	31	78	350	672	144	195
	C	8	3	3	6	11	19	17	33	36	23
	PY	65	96	456	109	114	110	108	108	112	230
Space spraying	OP	590	106	588	409	509	472	271	239	4	5
	PY	9	29	33	35	30	58	26	87	127	93
Treatment of nets	PY	58	23	18	30	11	48	19	34	44	14
Larviciding	OP	86	87	101	31	114	97	120	49	10	19
	C	-	-	-	-	-	-	-	-	0.0	0.0
	PY	-	-	-	-	-	0.4	5	5	-	-
Total	OC	2,274	4,082	4,091	4,151	4,131	4,542	4,231	3,862	5,670	4,529
	OP	5,792	477	797	494	654	648	740	960	159	218
	C	8	3	3	6	11	19	17	33	36	23
	PY	133	149	507	174	154	216	158	234	283	338
Number of countries		59	60	58	60	57	65	66	60	62	67

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Trends in insecticide use against malaria are presented separately for each region in *Table 10*. Particularly noteworthy is the increasing pattern and decline in 2009 in use of organochlorines in the African Region. Also important is the recent rise in pyrethroid use for malaria control. Pyrethoid resistance to anopheline vectors is emerging in a number of countries reporting use in indoor residual spraying; several countries have achieved high coverage of populations with pyrethroid-treated nets (PMI 2011; Ranson et al. 2011; Ranson et al. 2009). Another clear trend is the decline in organophosphate use against malaria in the Eastern Mediterranean and Western Pacific regions.

Table 10. Trend in the use of insecticides against malaria, by WHO regions and as reported to WHO, by class of insecticide, in tonnes of active ingredient per year[a]

WHO Region	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
African	OC	349	398	539	446	475	970	705	1,079	2,063	1,127
	OP	30	59	36	24	1	19	14	1	1	1
	C	0.1	-	-	-	6	14	11	19	21	23
	PY	3	9	11	14	4	43	13	11	24	93
Americas	OC	3	0.0	-	-	-	-	-	-	-	-
	OP	115	157	171	22	168	211	73	601	49	39
	C	7	0.4	1	4	3	2	0.4	1	0.0	0.0
	PY	32	60	418	63	46	63	43	134	133	112
Eastern Mediterranean	OP	102	63	45	22	23	19	34	47	19	16
	C	0.0	0.4	1	-	-	0.2	2	12	15	-
	PY	5	13	8	10	21	17	26	23	18	16
European	OP	8	7	6	8	4	-	2	1	-	-
	C	0.5	-	-	-	-	-	2	-	-	-
	PY	0.3	1	1	2	1	3	4	4	1	1
South-East Asia	OC	1,922	3,683	3,552	3,704	3,656	3,571	3,527	2,783	3,608	3,402
	OP	5,017	142	97	24	89	86	354	123	90	161
	C	1	2	2	2	2	3	1	-	-	-
	PY	27	36	48	53	58	67	55	22	61	86
Western Pacific	OC	-	2	1	0.3	1	0.1	-	-	-	-
	OP	520	49	441	395	370	314	263	187	-	0.1
	C	-	-	-	-	-	-	-	-	-	-
	PY	66	30	20	33	24	25	18	40	45	29

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

3.3 Dengue

Data for the 10-year period 2000–2009 for global use of insecticides against vectors of dengue are presented in *Table 11*. The average annual use (active ingredient) was 394 tonnes of organophosphates and 154 tonnes of pyrethroids. The most use occurred in the Region of the Americas, where large quantities of pyrethroids were deployed in residual spraying and space spraying (since pyrethroids are effective at much lower dosages than organophosphates). Nonetheless, use of organophosphates was also high; the most use was in space spraying. A significant amount of organophosphates was also used in larval control of dengue vectors. Use of carbamates was limited to almost 1 tonne for residual spraying in the region (not presented in the table).

Table 11. Global use of insecticides to control dengue vectors, by WHO region and as reported to WHO, averaged during the period 2000–2009, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

	Residual spraying[b]		Space spraying		Larviciding	All application methods	
WHO Region	OP	PY	OP	PY	OP	OP	PY
African	-	0.0	0.0	0.0	-	0.0	0.0
Americas	9	63	202	59	78	290	122
Eastern Mediterranean	-	-	-	0.2	0.0	0.0	0.2
South-East Asia	0.1	-	15	1	2	17	1
Western Pacific	1	4	80	26	7	87	30
Total	10	67	297	87	87	394	154

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OP, Organophosphates; PY, Pyrethroids.

Insecticide use for dengue vector control was much lower in the other regions. The Western Pacific Region reported generally higher use than in the South-East Asia Region. It is likely, however, that use has been under-reported in some countries.

Tables 12 and 13 present trends in the use of insecticides for dengue control by WHO region and according to method of application. Global use of pyrethroids peaked sharply in 2002, largely as a result of high use in Brazil. There are no clear general trends in patterns of use. The data fluctuate considerably from year to year, which may reflect fluctuations in global incidence of the disease. The number of countries that reported using insecticides in their dengue control programmes varied from 28 and 38; the number was highest in 2008.

Table 12. Trend in the global use of insecticides against dengue, as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year. The number of countries reporting insecticide use in their dengue control programmes is indicated for each year

Type of application	Class of insecticide[A]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residual spraying	OP	2	5	22	5	6	6	14	20	1	35
	C	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	10	1
	PY	31	52	530	34	18	13	37	61	20	14
Space spraying	OP	252	294	349	106	261	411	142	200	284	237
	PY	53	58	53	40	37	73	31	91	202	175
Larviciding	OP	61	92	118	77	74	71	104	169	98	94
	PY	-	-	-	-	-	0.2	2	0.2	-	-
Total	OP	316	391	489	189	340	488	260	389	383	366
	C	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	9.6	0.7
	PY	84	110	583	75	55	86	69	152	222	189
Number of countries		28	37	34	35	34	37	30	32	38	34

[a] OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Table 13. Trend in the use of insecticides against dengue, by WHO region as reported to WHO, and class of insecticide, in tonnes of active ingredient per year[a]

WHO Region	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
African	OP	-	-	-	0.0	-	-	-	-	-	-
	PY	-	-	-	0.0	0.0	0.0	-	0.0	0.0	0.0
Americas	OP	253	336	377	168	320	411	172	336	297	298
	C	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	10	1
	PY	75	102	562	63	41	73	46	131	198	152
Eastern Mediterranean	PY	-	-	0.0	0.0	0.0	0.1	3	2	-	0.0
South-East Asia	OP	11	19	22	7	7	53	25	2	1	3
	PY	0.4	0.5	2	1	1	3	2	2	0.4	0.4
Western Pacific	OP	51	36	90	14	13	24	64	50	85	65
	C	-	-	-	-	-	-	-	-	0.2	0.4
	PY	9	7	19	11	12	10	19	18	24	36

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

3.4 Leishmaniasis

Control of leishmaniasis vectors is dominated by the use of organochlorines in the South-East Asia Region and of pyrethroids in the Region of the Americas (*Table 14*). The average annual use (active ingredient) was 825 tonnes of organochlorines and 24 tonnes of pyrethroids. It is noteworthy that the 24 tonnes of pyrethroids provides more spray coverage area than the 825 tonnes of DDT if a 60-times conversion factor is applied (as discussed in the Methods).

Almost all insecticides used to control leishmaniasis are deployed by residual spraying. Insecticides are not used to treat nets in any national leishmaniasis control programmes in any country, despite the effectiveness of insecticide-treated nets in

Table 14. Global use of insecticides against leishmaniasis, by WHO regions as reported to WHO, averaged during the period 2000–2009, by method of application and class of insecticide, in tonnes of active ingredient per year[a]

	Residual spraying[b]				Space spraying	
WHO Region	OP	PY	OP	PY	OP	PY
African	-	-	-	3	-	-
Americas	-	-	-	17	-	0.0
Eastern Mediterranean	-	3	1	1	0.4	0.1
European	-	0.2	-	0.0	-	0.4
South-East Asia	825	-	-	3	-	-
Western Pacific	-	-	-	-	-	-
Total	825	4	1	24	0.4	0.5

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

controlling the disease's sandfly vectors. Pilot projects in several countries in the Eastern Mediterranean and South-East Asia regions have demonstrated a protective effect against both cutaneous and visceral leishmaniasis (WHO 2010c).

Tables 15 and 16 show the trends in insecticide use against leishmaniasis. The use of organochlorines has declined in recent years. Annually, 5–8 countries have reported

Table 15. Trend in the global use of insecticides against leishmaniasis, as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year. The number of countries reporting insecticide use in their leishmaniasis control programmes is shown for each year[a]

Type of application	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Insecticide use in residual spraying	OC	1,238	1,223	722	1,542	1,614	1,523	205	696	500	597
	OP	-	-	9	5	1	8	13	2	-	-
	C	3	2	3	1	0	0	1	-	-	-
	PY	7	15	134	14	12	9	13	14	25	17
Space spraying	OP	-	-	5	-	-	-	-	-	-	-
	C	-	-	-	-	-	-	-	-	0	2
	PY	0	0	1	-	-	-	2	2	-	-
Number of countries		5	8	7	6	6	6	8	8	8	7

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

Table 16. Trend in the global use of insecticides against leishmaniasis, as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year. The number of countries reporting insecticide use in their leishmaniasis control programmes is shown for each year[a]

WHO Region	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
African	PY	-	-	-	-	-	-	1	2	4	5
Americas	C	-	-	-	-	-	-	-	-	0.1	2
	PY	7	13	129	7	3	3	6	6	18	10
Eastern Mediterranean	OP	-	-	14	5	1	8	11	2	-	-
	C	3	2	3	1	0.5	0.4	1	-	-	-
	PY	0.1	2	2	2	5	1	3	2	0.0	0.0
European	OP	-	-	-	-	-	-	2	-	-	-
	PY	-	-	-	-	-	-	2	2	0.0	0.3
South-East Asia	OC	1,238	1,223	722	1,542	1,614	1,523	205	696	500	597
	C	-	1	5	4	3	6	3	4	2	2
Total	OC	1,238	1,223	722	1,542	1,614	1,523	205	696	500	597
	OP	-	-	14	5	1	8	13	2	-	-
	C	3	3	8	6	4	6	4	4	2	4
	PY	7	15	130	9	9	4	11	10	18	11

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OC, Organochlorines; OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

use of insecticides in leishmaniasis control programmes (including for multi-disease purposes). The African Region has recently reported use of pyrethroids, which may indicate an increasing trend. The overall decline in the use of insecticides against leishmaniasis, however, is a result of usage patterns in the South-East Asia Region, notably India.

3.5 Chagas disease

As Chagas disease is endemic only in the Region of the Americas, no insecticide use was reported targeting this disease in any other region (*Table 17*). The average annual use (active ingredient) was 13 tonnes of organophosphates and 36 tonnes of pyrethroids. Use of insecticides against Chagas disease was low compared with the other three major diseases. Usage was almost exclusively by residual spraying using pyrethroids, especially given the low application rate of pyrethroids resulting in 60-times higher spray coverage per kg of active ingredient than for most organophosphates. Use of carbamates was reported from two countries; one country used organophosphates. High reliance on pyrethroids to control the vectors of Chagas disease raises concerns about insecticide resistance. A high incidence of resistance to pyrethroids has been documented from Argentina (Picollo et al. 2005).

Table 17. Global use of insecticides against Chagas disease, WHO Region of the Americas as reported to WHO, averaged during the period 2000–2009, in tonnes of active ingredient per year

	Residual spraying[a]		
WHO Region	OP	C	PY
Americas	13	1	36

[a] OP, Organophosphates; C, Carbamates; PY, Pyrethroids

In 2002, there was a sharp peak in the use of pyrethroids to control the vectors of Chagas disease, largely as a result of high use in Brazil. From 2004, a decline in their use occurred (*Table 18*). Between 2000 and 2005, 8–11 countries reported using insecticides to control the disease. During 2006–2007 there was a brief spell where only 3–4 countries sprayed against Chagas disease, but that number has again climbed to 6–7 countries in the most recent years.

Table 18. Trend in the global use of insecticides against Chagas disease, as reported to WHO, by method of application and class of insecticide, in tonnes of active ingredient per year. The number of countries indicating insecticide use in their Chagas disease control programmes is indicated for each year[a]

Type of application	Class of insecticide[b]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Insecticide use in residual spraying	OP	8	70	27	5	5	25	-	-	-	-
	C	0.1	0.0	0.0	-	-	-	-	-	3	6
	PY	21	39	260	34	14	11	8	9	8	9
Number of countries		8	11	7	8	10	11	3	4	6	7	7

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0". [b] OP, Organophosphates; C, Carbamates; PY, Pyrethroids.

3.6 Use of selected insecticides

3.6.1 DDT

Globally, the annual use (by active ingredient) of DDT fluctuated between 3512 and 6170 tonnes between 2000 and 2009. In the African Region, the number of countries that reported use increased from 4 in 2000 to 9 in 2008 (*Table 19*). Accordingly, use of DDT has increased in the African Region, as depicted in *Figure 6* (see section 3.1.3). Countries with the largest use in Africa are Ethiopia, Mozambique, Namibia and South Africa.

From 2008 to 2009, there was a sudden decrease in the reported use of DDT in the African Region. This was attributed to reduced or discontinued use in several countries. Ethiopia, which has long been the region's largest user of DDT, reported a peak in use in 2008, but replaced DDT with pyrethroids after susceptibility tests recorded major levels of insecticide resistance (UNEP 2010). Also, Uganda used DDT in 2008 but subsequently stopped its use. Mozambique reported reduced use of DDT in 2009.

Table 19. Trend in the use of DDT, by WHO regions as reported to WHO, by disease targeted and country, in tonnes of active ingredient per year[a]

WHO Region	Disease	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
African	Malaria	Eritrea	4	8	8	-	8	12	16	27	31	12
		Ethiopia	321	335	366	336	311	327	406	710	1,445	781
		Madagascar	23	-	55	56	37	-	-	-	-	-
		Mauritius	1	2	1	1	1	1	0.4	1	1	0.4
		Mozambique	-	-	-	-	-	366	82	124	352	104
		Namibia	-	53	95	48	31	48	61	88	23	92
		South Africa	-	-	13	6	76	70	70	78	77	70
		Swaziland	-	-	-	-	-	9	8	7	7	7
		Uganda	-	-	-	-	-	-	-	-	29	-
		Zambia	-	-	-	-	11	42	-	-	-	-
		Zimbabwe	-	-	-	-	-	96	61	44	97	61
Americas	Malaria	Ecuador	2	-	-	-	-	-	-	-	-	-
		Guyana	-	0.0	-	-	-	-	-	-	-	-
		Venezuela	1	-	-	-	-	-	-	-	-	-
South-East Asia	Malaria	India	1,885	3,670	3,551	3,701	3,654	3,569	3,526	2,783	3,607	3,402
		Myanmar	10	8	1	3	2	2	1	0.2	0.2	0.2
		Thailand	27	4	-	-	-	-	-	-	-	-
Leishmaniasis		Bangladesh	36	-	-	-	-	-	-	-	-	-
		India	1,202	1,223	722	1,542	1,614	1,523	205	696	500	597
Western Pacific	Malaria	Solomon Islands	-	2	1	0.3	1	0.1	-	-	-	-
Total			3,512	5,305	4,814	5,693	5,745	6,065	4,436	4,558	6,170	5,127

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0".

Reports of vector resistance to DDT are increasing in the region. Annual use of DDT has been more or less constant in Namibia and South Africa during the past years.

Use of DDT in the South-East Asia Region has declined slightly in recent years owing to decreased use in leishmaniasis control. India contributed 76–92% of global annual use during 2000–2009.

The data on the use of DDT and alternative insecticide compounds to control vector-borne diseases contained this report are particularly relevant in the context of the Stockholm Convention on Persistent Organic Pollutants (UNEP 2002).

3.6.2 Insect growth regulators

A total of 11 countries from five WHO regions reported the use of insect growth regulators to control vectors. Globally, the amounts used were small. Annually, average use (by active ingredient) was 1.2 tonnes for malaria control, 1 tonne for dengue control and 1 tonne for control of Ross River virus. No country reported using more than 1 tonne for average annual use (*Table 20*). Nonetheless, most insect growth regulators are effective at relatively low concentrations of active ingredient.

Insect growth regulators were used to control the larval vectors of malaria, dengue, lymphatic filariasis and Ross River virus. In New Zealand, use averaged 1 tonne per year, for control of Ross River virus, the only reported use of insecticides for vector control by that country.

Countries reported the use of five compounds of insect growth regulators. By kg of active ingredient, use was 58% (of methoprene), 34% (of diflubenzeron), 5% (of pyriproxyfen), 2% (of triflumuron) and 1% (of novaluron).

Table 20. Global use of insect growth regulators, by WHO regions as reported to WHO, averaged over during period 2000–2009, by disease targeted, in tonnes of active ingredient per year[a]

		Disease			
WHO Region	Country	Malaria	Dengue	Lymphatic filariasis	Ross River Virus
Americas	Argentina	-	0.1	-	-
	Brazil	-	0.2	-	-
	Colombia	-	0.0	-	-
	Dominican Republic	0.0	-	-	-
Eastern Mediterranean	Egypt	0.5	-	0.1	-
	Saudi Arabia	0.1	-	-	-
European	Turkey	0.5	-	-	-
South-East Asia	Indonesia	0.2	0.7	-	-
	Sri Lanka	0.0	-	-	-
Western Pacific	New Zealand	-	-	-	1.0
Total		1.2	1.0	0.1	1.0

[a] Insecticide amounts less that 0.05 tonnes are indicated as “0.0”.

Trends in the use of insect growth regulators suggest an increase during the past decade, but countries report that use is minor in comparison with other classes of insecticides (*Table 21*).

Table 21. Trend in the global use of insect growth regulators, by WHO regions as reported to WHO, in tonnes of active ingredient per year[a]

WHO Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Americas	-	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Eastern Mediterranean	-	0.1	0.1	-	0.0	0.0	0.7	0.6	-	0.4
European	0.4	0.4	0.6	1.0	1.0	1.0	0.2	0.2	-	-
South-East Asia	-	-	-	6.0	0.0	0.0	0.0	-	-	-
Western Pacific	-	-	0.2	1.8	0.8	1.8	0.1	0.1	1.2	0.2
Total	0.4	0.6	1.1	8.8	1.9	2.8	1.0	0.9	1.2	2.5

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0".

3.6.3 Bacterial larvicides

Reports of the amount of active ingredient of bacterial larvicides used by national programmes are not helpful, because products commercially available have different potency (international Toxic Unit) and, unlike chemical larvicides, there is no generally agreed method to estimate their active component. The only available option, therefore, is to present the use of bacterial larvicides in tonnes (or kilolitres) of formulated product, noting the potential differences in potency.

Use of bacterial larvicides was reported from all regions. Two species of *Bacillus* were used: *B. thuringiensis israelensis* and *B. sphaericus*. *B. thuringiensis israelensis* was used mainly for dengue control, with minor uses to control malaria, Ross River virus and other vector-borne diseases (*Table 22*).

B. sphaericus, on the other hand, was reportedly used exclusively against malaria. Its use has increased in recent years, and considerable amounts were reportedly used in 2008 and 2009.

Table 22. Trend in the global use of bacterial larvicides, as reported to WHO, by disease targeted, in tonnes (or kilolitre) of formulated product per year[a]

Species	Disease	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bacillus thuringiensis israelensis	Malaria	8	2	12	4	13	8	31	5	2	0.1
	Dengue	0.5	293	255	145	139	142	153	140	108	74
	Ross River virus	-	-	-	2	5	0.5	-	-	0.0	-
	Onchocerciasis	1	1	-	-	-	-	-	-	-	-
	Unspecified	-	-	0.1	-	-	-	26	20	2	2
	Total	9	295	267	151	156	150	209	165	113	76
Bacillus sphaericus	Malaria	-	26	0.2	3	209	103	141	161	211	302

[a] Insecticide amounts less that 0.05 tonnes are indicated as "0.0".

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ANNEX 1. STANDARD REPORTING FORM

Region: _____ **Country:** _____

Year	Compound	Class	Formulation	Concentration	Type of application	For control of	Amount of formulaion used	Amount of active ingredient

Completed by: _____ Name: _____

Postal address: _____

_____

_____

Tel: _____ Fax: _____ Email: _____

ANNEX 2. REPORTING PERIOD BY MEMBER STATES IN EACH WHO REGION

African Region	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Algeria	34,373,000							+	+	+	+
Angola	18,021,000						+	+			+
Benin	8,662,000			+	+	+	+			+	+
Botswana	1,921,000	+	+	+	+	+	+	+	+	+	+
Burundi	8,074,000							+			
Cameroon	19,088,000				+	+	+	+	+	+	+
Cape Verde	499,000	+									
Congo	3,615,000	+	+							+	+
Eritrea	4,927,000	+	+	+		+	+	+	+	+	+
Equatorial Guinea	659,000							+			
Ethiopia	80,713,000	+	+	+	+	+	+	+	+	+	+
Gambia	1,660,000	+			+	+	+				
Ghana	23,351,000							+			+
Guinea	9,833,000		+	+	+	+	+	+			
Kenya	38,765,000		+	+	+	+	+	+	+	+	+
Lesotho	2,049,000					+	+	+	+	+	+
Liberia	3,793,000										+
Madagascar	19,111,000	+	+	+	+	+	+	+	+	+	+
Malawi	14,846,000							+	+	+	+
Mali	12,706,000	+	+		+	+	+				+
Mauritania	3,215,000	+	+	+							
Mauritius	1,280,000	+	+	+	+	+	+	+	+	+	+
Mozambique	22,383,000						+	+	+	+	+
Namibia	2,130,000		+	+	+	+	+	+	+	+	+
Niger	14,704,000	+					+			+	+
Nigeria	151,212,000							+	+		+
Rwanda	9,721,000	+	+	+	+	+	+	+	+	+	+
Sao Tome and Principe	160,000	+						+			
Senegal	12,211,000								+	+	+
Seychelles	84,000				+	+	+				
South Africa	49,668,000			+	+	+	+	+	+	+	+
Swaziland	1,168,000						+	+	+	+	+
Tanzania, United Rep. of	42,484,000							+	+	+	+
Togo	6,459,000	+	+	+	+		+				
Uganda	31,657,000							+	+	+	+
Zambia	12,620,000					+	+	+			
Zimbabwe	12,463,000	+	+	+	+	+	+	+	+	+	+

Americas	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Argentina	39,883,000		+	+	+	+	+	+	+	+	
Bahamas	338,000		+	+	+						
Barbados	255,000	+	+							+	+
Belize	301,000		+	+	+			+	+	+	+
Bolivia	9,694,000	+	+	+	+					+	+
Brazil	191,972,000	+	+	+	+	+	+	+	+	+	+
Chile	16,804,000				+	+	+			+	+
Colombia	45,012,000	+	+	+	+	+	+			+	+
Costa Rica	4,519,000	+	+							+	+
Cuba	11,205,000	+	+	+	+	+	+	+	+	+	+
Dominica	67,000		+	+	+	+	+		+	+	+
Dominican Republic	9,953,000	+	+	+	+	+	+			+	+
Ecuador	13,481,000	+			+	+	+	+	+	+	+
El Salvador	6,134,000				+	+	+	+	+	+	+
Grenada	104,000	+									
Guatemala	13,686,000	+	+	+	+	+	+	+	+	+	+
Guyana	763,000		+	+	+	+	+	+	+	+	+
Haiti	9,876,000	+	+	+			+			+	+
Honduras	7,319,000	+	+							+	+
Jamaica	2,708,000		+	+	+	+	+			+	+
Mexico	108,555,000	+	+	+	+	+	+	+	+	+	+
Nicaragua	5,667,000	+								+	+
Panama	3,399,000	+	+		+	+	+			+	+
Paraguay	6,238,000	+	+		+	+	+			+	+
Peru	28,837,000	+	+				+				
Saint Kitts and Nevis	51,000	+									
Saint Lucia	170,000		+	+	+						
Saint Vincent & Grenadines	109,000	+	+	+	+						
Suriname	515,000									+	+
Trinidad and Tobago	1,333,000	+	+	+	+	+	+	+	+	+	+
Uruguay	3,349,000		+	+	+	+	+	+	+	+	+
Venezuela	28,121,000	+	+	+	+	+	+				

Eastern Mediterranean Region	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Afghanistan	27,208,000	+						+	+	+	+
Bahrain	776,000	+	+	+	+	+	+	+	+	+	+
Djibouti	849,000	+	+	+					+	+	
Egypt	81,527,000							+	+	+	
Iran (Islamic Republic of)	73,312,000	+	+	+	+	+	+	+	+	+	+
Iraq	30,096,000					+	+			+	
Jordan	6,136,000	+	+	+	+	+	+	+	+	+	+
Kuwait	2,919,000	+	+	+	+	+	+	+	+	+	+
Lebanon	4,194,000							+	+		
Morocco	31,606,000	+	+	+	+	+	+	+	+	+	+
Oman	2,785,000	+	+	+	+	+	+	+	+	+	+
Pakistan	176,952,000	+	+	+	+	+	+	+	+	+	+
Saudi Arabia	25,201,000	+	+	+		+	+	+	+	+	+
Somalia	8,926,000		+	+				+	+	+	+
Sudan	41,348,000	+	+	+	+	+	+	+	+	+	+
Syrian Arab Republic	21,227,000	+	+	+	+	+	+	+	+	+	
United Arab Emirates	4,485,000	+	+	+						+	+
Yemen	22,917,000	+	+	+	+	+	+	+	+	+	+

European Region	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Armenia	3,077,000	+	+	+	+	+	+	+	+	+	+
Azerbaijan	8,731,000	+	+	+	+	+	+	+	+	+	+
Georgia	4,307,000	+	+	+	+	+	+	+	+	+	+
Kyrgyzstan	5,414,000	+	+	+	+	+	+	+	+	+	+
Tajikistan	6,836,000	+	+	+	+	+	+	+	+	+	+
Turkey	73,914,000	+	+	+	+	+	+	+	+	+	+
Turkmenistan	5,044,000	+	+	+							
Uzbekistan	27,191,000	+	+	+	+	+	+	+	+	+	+

South-East Asia Region	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Bangladesh	160,000,000	+						+	+		
Bhutan	687,000	+	+	+	+	+	+	+	+		
India	1,181,412,000	+	+	+	+	+	+	+	+	+	+
Indonesia	227,345,000	+	+	+	+	+	+	+		+	
Maldives	305,000	+	+	+	+	+	+	+	+	+	+
Myanmar	49,563,000	+	+	+	+	+	+	+	+	+	+
Nepal	28,810,000	+	+	+	+	+	+	+	+	+	+
Sri Lanka	20,061,000	+	+	+	+	+	+	+	+	+	+
Timor-Léste	1,098,000						+	+	+	+	+
Thailand	67,386,000	+	+	+	+	+	+	+	+	+	+

Western Pacific Region	Population[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Brunei Darussalam	392,000				+	+	+			+	+
Cambodia	14,562,000	+	+	+	+	+	+	+	+	+	+
China	1,344,920,000	+	+	+	+	+	+	+	+	+	+
Cook Islands	20,000		+	+							
Fiji	844,000	+	+	+	+	+	+	+	+	+	+
Kiribati	97,000	+			+	+	+			+	+
Lao People's Democr. Rep.	6,205,000	+	+	+	+	+	+	+	+	+	+
Malaysia	27,014,000	+	+	+	+	+	+	+	+	+	+
Micronesia (Federated States of)	110,000							+	+		
Nauru	10,000							+	+	+	+
New Zealand	4,230,000			+	+	+	+			+	+
Palau	20,000				+	+	+	+	+		
Philippines	90,348,000	+	+	+	+	+	+	+	+	+	+
Korea, Rep. of	48,152,000							+	+		
Singapore	4,615,000	+	+	+			+	+	+	+	+
Solomon Islands	511,000		+	+	+	+	+	+	+	+	+
Tonga	104,000				+	+	+				
Tuvalu	10,000				+			+	+	+	
Vanuatu	234,000				+					+	+
Viet Nam	87,096,000	+	+	+	+	+	+	+	+	+	+

[a] Source: World Health Statistics 2008. Geneva, World Health Organization, 2008

WHO Pesticide Evaluation Scheme (WHOPES)
Departement of Control of Neglected Tropical diseases (NTD)

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