

## Supplementary Information

### Recent trends in global insecticide use for disease vector control and potential implications for resistance management

Henk van den Berg, Haroldo Sergio da Silva Bezerra, Samira Al-Eryani, Emmanuel Chanda, Bhupender N. Nagpal, Tessa B. Knox, Raman Velayudhan, Rajpal S. Yadav

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## Supplementary Methods

**Estimation of spray coverage.** Data on recommended application rates were obtained from WHO<sup>1,2</sup>, and were supplemented where needed with current manufacturers' data, as follows (in g/m<sup>2</sup>): alpha-cypermethrin: 0.025, bifenthrin: 0.0375, cyfluthrin: 0.035, cypermethrin: 0.5, deltamethrin: 0.0225, etofenprox: 0.2, lambda-cyhalothrin: 0.025, permethrin: 0.5 (pyrethroids); DDT: 1.5 (organochlorine); bendiocarb: 0.4, propoxur: 1.5 (carbamates); fenitrothion: 2; malathion: 2, pirimiphos-methyl: 1 (organophosphates); and clothianidin: 0.3 (neonicotinoid). For other, less commonly used active ingredients, the application rates were projected by the average of available data for active ingredients within each insecticide class. Most larvicide compounds are unique active ingredients not recommended or used for vector adulticiding. An exception is pirimiphos-methyl that has been recommended for use in both IRS (at 1 g/m<sup>2</sup>) and larviciding (at 275 g/ha); the ratio of the recommended application rates for IRS versus larviciding was used to convert the spray utility of other larvicides as required for calculation of the standard spray coverage as follows (in g/m<sup>2</sup>): temephos: 0.31; fenthion: 0.24; chlorpyrifos: 0.065 (organophosphates); diflubenzuron: 0.23; methoprene: 0.11; pyriproxyfen: 0.027 (insect growth regulators); *Bacillus sphaericus*: 1.35; *Bacillus thuringiensis israelensis*: 0.76 (bacterial larvicides); and spinosad: 0.11 (spinosyn).

**Assessment of insecticide resistance management.** To study the degree of reactive resistance management, two data types were paired per country per year: publicly available data on insecticide susceptibility, and insecticide use data. For the first data type, country-specific data on insecticide susceptibility of *Anopheles* spp. determined in WHO tube tests with discriminating concentrations of insecticides were obtained from WHO's database<sup>3</sup>. It was assumed that anophelines tested in each country were malaria vectors, and that samples had been taken from representative sites. The mean percent mortality in bioassay results was calculated per country per year. For the second data type, the presence/absence of data on insecticide use (not limited to pyrethroids) for IRS in malaria control was determined per country per year. Country-year combinations eligible for inclusion in the analysis were those with, both, bioassay data and insecticide use data presented (data pairs). Subsequently, the bioassay data were categorized as 'confirmed resistance' in country x and year y, with <90% mortality in mosquitoes, versus 'no confirmed resistance', with ≥90% mortality including suspected resistance and full susceptibility<sup>4</sup>. Insecticide use data were categorized as 'pyrethroids in use' (i.e. pyrethroids used for IRS in malaria control in country x and year y) versus 'no pyrethroids in use'. To enhance temporal representation of countries over the study period, countries were eligible for inclusion only if they had at least one data pair in the period 2010–2014 and one data pair in the period 2015–2019.

## Supplementary Notes

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**Table S1.** Targeted countries, with population size and annual responses, and calculation of annual weighting factor.

Region <sup>a</sup>	Targeted country	Population (mln) <sup>b</sup>	Responding countries by year									
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
<b>A. Population and survey responses by country</b>												
AF	Algeria	43.1										
AF	Angola	31.8			1	1	1					
AF	Benin	11.8	1	1	1	1	1	1	1	1	1	
AF	Botswana	2.3	1	1	1	1	1	1	1	1	1	1
AF	Burkina Faso	20.3	1	1	1	1	1				1	1
AF	Burundi	11.5		1	1							
AF	Cabo Verde	0.5										
AF	Cameroon	25.9										
AF	Central African Republic	4.7										
AF	Chad	15.9				1	1					
AF	Comoros	0.9										
AF	Congo	5.4										
AF	Democratic Rep. of Congo	86.8										
AF	Côte d'Ivoire	25.7	1	1	1	1	1	1	1	1	1	1
AF	Djibouti	1.0	1	1	1	1	1	1	1	1	1	1
AF	Egypt	100.4										
AF	Equatorial Guinea	1.4										
AF	Eritrea	3.5	1	1	1	1	1	1	1	1	1	1
AF	Eswatini	1.1	1	1	1	1	1	1	1	1	1	1
AF	Ethiopia	112.1	1	1	1	1	1	1	1	1	1	1
AF	Gabon	2.2										
AF	Islamic Rep. of the Gambia	2.3	1	1	1	1	1					
AF	Ghana	30.4	1	1	1	1	1	1	1	1	1	1
AF	Guinea	12.8										
AF	Guinea-Bissau	1.9										
AF	Kenya	52.6								1	1	
AF	Lesotho	2.1										
AF	Liberia	4.9										
AF	Libya	6.8										
AF	Madagascar	27.0	1	1	1	1	1	1	1	1	1	
AF	Malawi	18.6										
AF	Mali	19.7	1	1	1	1	1	1	1	1	1	1
AF	Mauritania	4.5										
AF	Mauritius	1.3	1	1	1	1	1					
AF	Morocco	36.5	1	1	1	1	1	1	1	1	1	1
AF	Mozambique	30.4	1	1	1	1	1	1	1	1	1	1
AF	Namibia	2.5	1	1	1	1	1	1	1	1	1	1
AF	Niger	23.3	1			1	1					
AF	Nigeria	201.0	1	1		1						
AF	Rwanda	12.6	1	1	1	1	1	1	1	1	1	1

AF	Sao Tomé & Príncipe	0.2										
AF	Senegal	16.3	1	1	1	1	1	1	1	1		
AF	Seychelles	0.1										
AF	Sierra Leone	7.8										
AF	Somalia	15.4				1	1					
AF	South Africa	58.6	1	1	1	1	1	1	1	1	1	1
AF	South Sudan	11.1										
AF	Sudan	42.8	1	1	1	1	1	1	1	1		
AF	United Rep. of Tanzania	58.0	1	1	1	1	1	1	1	1	1	
AF	Togo	8.1	1									
AF	Tunisia	11.7	1	1	1	1	1					
AF	Uganda	44.3	1	1	1	1	1	1	1	1	1	1
AF	Zambia	17.9	1	1	1	1	1	1	1	1	1	1
AF	Zimbabwe	14.6	1	1	1	1	1	1	1	1	1	1
AP	Afghanistan	38.0			1		1	1			1	1
AP	Bahrain	1.6		1	1	1	1	1	1	1	1	1
AP	Bangladesh	163.0	1	1	1	1	1	1	1	1	1	1
AP	Bhutan	0.8	1				1	1	1		1	1
AP	Brunei Darussalam	0.4										
AP	Cambodia	16.5	1	1	1	1	1	1	1	1	1	1
AP	China	1433.8	1	1	1	1	1	1	1	1	1	1
AP	Cook Islands	0.0										
AP	Cyprus	1.2	1	1	1	1	1					
AP	Fiji	0.9	1	1	1	1	1	1	1	1	1	1
AP	India	1366.4	1	1	1	1	1	1	1	1	1	1
AP	Indonesia	270.6	1	1	1	1	1	1	1	1	1	1
AP	Islamic Rep. of Iran	82.9	1	1	1	1	1	1	1	1		
AP	Iraq	39.3	1	1	1	1	1	1	1	1	1	1
AP	Jordan	10.1	1	1	1	1	1	1	1	1	1	1
AP	Kazakhstan	18.6	1	1	1	1	1					
AP	Kiribati	0.1										
AP	D.P.R. Korea	25.7	1	1	1	1	1	1	1	1		
AP	Kuwait	4.2	1	1	1	1	1	1	1	1		
AP	Kyrgyzstan	6.4										
AP	Lao P.D.R.	7.2	1	1	1	1	1	1	1	1	1	1
AP	Lebanon	6.9	1	1	1	1	1	1	1	1	1	1
AP	Malaysia	31.9										
AP	Maldives	0.5	1	1	1	1	1	1				
AP	Marshall Islands	0.1										
AP	Fed. States of Micronesia	0.1										
AP	Mongolia	3.2										
AP	Myanmar	54.0	1	1	1	1	1	1	1	1	1	1
AP	Nauru	0.0										
AP	Nepal	28.6	1	1	1	1	1	1	1	1	1	1
AP	Niue	0.0										
AP	Oman	5.0	1	1	1	1	1					
AP	Pakistan	216.6	1	1	1	1	1	1	1	1	1	1
AP	Palau	0.0										

AP	Papua New Guinea	8.8										
AP	Philippines	108.1										
AP	Qatar	2.8										
AP	Samoa	0.2										
AP	Saudi Arabia	34.3	1	1	1	1	1	1	1	1	1	1
AP	Singapore	5.8										
AP	Solomon Islands	0.7	1	1	1	1	1	1	1	1	1	1
AP	Sri Lanka	21.3	1	1	1	1	1	1	1	1	1	1
AP	Syrian Arab Rep.	17.1	1	1	1	1	1	1	1	1	1	1
AP	Tajikistan	9.3										
AP	Thailand	69.6	1	1	1	1	1	1				
AP	Timor-Léste	1.3							1	1	1	1
AP	Tonga	0.1										
AP	Tuvalu	0.0										
AP	United Arab Emirates	9.8	1	1	1	1	1	1	1	1	1	1
AP	Uzbekistan	33.0										
AP	Vanuatu	0.3										
AP	Viet Nam	96.5	1	1	1	1	1	1	1	1	1	1
AP	Yemen	29.2	1	1	1	1	1	1	1	1	1	1
LA	Antigua and Barbuda	0.1										
LA	Argentina	44.8	1	1	1	1	1	1				
LA	Bahamas	0.4	1	1	1	1	1	1	1	1		
LA	Barbados	0.3										
LA	Belize	0.4	1	1	1	1	1	1	1	1	1	1
LA	Bolivia (Plurinational St. of)	11.5	1	1	1	1	1	1	1	1	1	1
LA	Brazil	211.0	1	1	1	1	1	1	1	1	1	1
LA	Chile	19.0	1	1	1	1	1	1	1	1	1	1
LA	Colombia	50.3	1	1	1		1	1	1	1	1	1
LA	Costa Rica	5.0	1	1	1	1	1	1	1	1	1	1
LA	Cuba	11.3	1	1	1	1	1	1	1	1	1	1
LA	Dominica	0.1										
LA	Dominican Republic (the)	10.7	1	1	1	1	1	1	1	1		
LA	Ecuador	17.4	1	1	1	1	1	1	1	1		
LA	El Salvador	6.5	1	1	1	1	1	1	1	1		
LA	Grenada	0.1	1	1	1	1	1	1	1	1		
LA	Guatemala	17.6	1	1	1	1	1	1	1	1	1	1
LA	Guyana	0.8					1	1				
LA	Haiti	11.3				1		1	1	1	1	1
LA	Honduras	9.7										
LA	Jamaica	2.9										
LA	Mexico	127.6	1	1	1	1	1	1	1	1	1	1
LA	Nicaragua	6.5										
LA	Panama	4.2	1	1	1	1	1	1				
LA	Paraguay	7.0	1	1	1	1	1	1	1	1	1	1
LA	Peru	32.5	1	1	1		1	1	1	1		
LA	Saint Kitts & Nevis	0.1										
LA	Saint Lucia	0.2										
LA	Saint Vincent & Grenadines	0.1										

LA	Suriname	0.6									
LA	Trinidad & Tobago	1.4	1	1	1	1	1	1			
LA	Uruguay	3.5	1	1	1	1	1	1	1	1	
LA	Venezuela (Bolivarian Rep. of)	28.5									
<b>Excluded from analysis:</b>											
EE	Albania	2.9									
EE	Armenia	3.0	1	1	1	1	1	1			
EE	Azerbaijan	10.0									
EE	Bosnia & Herzegovina	3.3	1	1	1	1	1	1			
EE	Bulgaria	7.0									
EE	Croatia	4.1									
EE	Estonia	1.3									
EE	Georgia	4.0									
EE	Hungary	9.7									
EE	Republic of Moldova	4.0			1	1	1				
EE	Montenegro	0.6	1	1	1	1	1	1			
EE	North Macedonia	2.1	1	1	1	1	1	1			
EE	Romania	19.4									
EE	Russian Federation	145.9									
EE	Serbia	8.8									
EE	Ukraine	44.0									
WE	France	65.1									
WE	Greece	10.5									
WE	Israel	8.5									
WE	Italy	60.6									
WE	Portugal	10.2									
WE	Spain	46.7									
WE	Switzerland	8.6									
WE	Turkey	83.4									

#### B. Population and survey responses by region

AF	1306.3	28	27	27	30	29	21	21	22	21	17
AP	4282.8	29	29	30	29	31	29	26	25	24	24
LA	643.5	20	20	20	19	21	22	18	18	11	11
EE (excluded from analysis)	267.2	4	4	5	5	5	-	-	-	-	-
WE (excluded from analysis)	293.7	-	-	-	-	-	-	-	-	-	-
All	6793.5	81	80	82	83	86	72	65	65	56	52
All except EE and WE	6232.6	77	76	77	78	81	72	65	65	56	52

#### C. Calculation of annual weighting factor

Population of responding countries <sup>c</sup>	5450	5431	5300	5435	5345	5211	5051	5103	4919	4770
Population of targeted countries <sup>c</sup>	6233	6233	6233	6233	6233	6233	6233	6233	6233	6233
Annual weighting factor	0.874	0.871	0.850	0.872	0.858	0.836	0.810	0.819	0.789	0.765

<sup>a</sup>United Nations Regional Groups: AF, African; AP, Asia-Pacific; LA, Latin American & Caribbean; EE, Eastern European; WE, Western European & Others <sup>5</sup>

<sup>b</sup>World Population Prospects 2019, Dept Economic and Social Affairs, Population Division, United Nations, New York <sup>6</sup>

<sup>c</sup>All regions except EE and WE

**Table S2.** Use of active ingredients for vector control spraying operations in ranking order (pooled for diseases and years).\*

Rank	Insecticide compound	Insecticide class	Region			All
			African	Asia-Pacific	Latin American & Caribbean	
1	DDT	organochlorine	206.27	1822.34	0.00	2028.61
2	Deltamethrin	pyrethroid	719.44	615.81	545.09	1880.35
3	Lambdacyhalothrin	pyrethroid	580.59	414.94	108.66	1104.19
4	Alphacypermethrin	pyrethroid	35.44	770.10	446.79	1252.33
5	Bendiocarb	carbamate	437.17	31.95	244.87	713.99
6	Malathion	organophosphate	355.43	1.22	15.75	372.40
7	Pirimiphos-methyl	organophosphate	0.08	33.60	397.70	431.38
8	Pyriproxifen	insect growth regulator	24.89	89.04	163.70	277.63
9	Temephos	organophosphate	0.00	41.13	270.40	311.53
10	Propoxur	carbamate	103.03	3.52	110.48	217.03
11	Spinosad	spynosyn	105.57	3.50	0.00	109.07
12	Clothianidin	neonicotinoid	0.00	46.11	86.71	132.81
13	<i>Bacillus thuringiensis israelensis</i>	bacterial larvicide	0.14	48.29	49.83	98.26
14	Chlorpyrifos	organophosphate	0.00	3.07	81.29	84.35
15	Bifenthrin	pyrethroid	7.94	11.81	28.99	48.75
16	Permethrin	pyrethroid	0.00	8.78	47.55	56.33
17	Cypermethrin	pyrethroid	0.00	34.45	0.00	34.45
18	Diflubenzeron	insect growth regulator	0.12	14.43	32.86	47.41
19	Beta-cypermethrin	pyrethroid	0.39	19.47	20.30	40.17
20	Cyfluthrin	pyrethroid	0.32	27.02	0.62	27.96
21	Etofenprox	pyrethroid	1.40	7.37	19.40	28.17
22	Cyphenothrin	pyrethroid	0.00	14.89	0.00	14.89
23	Fenthion	organophosphate	0.00	9.29	0.26	9.68
24	Beta-cyfluthrin	pyrethroid	0.00	7.10	0.00	7.10
25	Phoxim	organophosphate	0.00	6.80	0.00	6.80
26	Phenothrin	pyrethroid	0.00	0.00	5.60	5.60
27	Fenitrothion	organophosphate	0.00	2.30	0.00	2.30
28	Novaluron	insect growth regulator	0.00	0.00	4.39	4.39
29	Dichlorvos	organophosphate	0.00	0.00	3.51	3.51
30	Pyrethrum	pyrethroid	0.00	0.00	3.49	3.49
31	<i>Bacillus sphaericus</i>	bacterial larvicide	0.00	1.52	0.00	1.52
32	d-tetramethrin+cyphenothrin	pyrethroid	0.00	1.26	0.00	1.26
33	Tetramethrin	pyrethroid	0.00	0.89	0.00	0.89
34	Transfluthrin	pyrethroid	0.00	0.25	1.18	1.43
35	Permethrin-allethrin	pyrethroid	0.00	0.53	0.19	0.73
36	Imidacloprid	neonicotinoid	0.00	0.00	1.12	1.12
37	Methoprene	insect growth regulator	0.00	0.00	0.93	0.93



38	S-bioallethrin	pyrethroid	0.00	0.19	0.00	0.19
39	Pyrethrin	pyrethroid	0.00	0.13	0.00	0.13
40	Deltamethrin+S-bioallethrin+Piperonyl butoxide	pyrethroid	0.00	0.11	0.00	0.11
41	Chlorpyrifos-ethyl	organophosphate	0.10	0.00	0.00	0.10
42	Zeta-cypermethrin	pyrethroid	0.00	0.00	0.18	0.18
43	Diazinon	organophosphate	0.00	0.04	0.00	0.04
44	Cyfluthrin+Tetramethrin	pyrethroid	0.00	0.01	0.00	0.01

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\*Results expressed in standard spray coverage (per million m<sup>2</sup>)

**Table S3.** Global use of vector control insecticides, presented by intervention types and year (pooled for diseases).\*

Year	Intervention method				
	ITN	ITN-kit	Residual spraying	Space spraying	Larviciding
2010	7804.26	419.30	8328.99	641.11	605.16
2011	6047.71	599.33	12060.84	843.15	529.92
2012	5276.79	436.53	8421.97	619.34	728.93
2013	10681.60	57.77	8077.07	1212.33	493.79
2014	13331.09	39.68	8733.75	1477.64	1296.49
2015	13033.82	32.24	6885.17	1506.39	1336.16
2016	9864.13	133.80	5969.08	1399.26	1290.33
2017	17243.07	35.72	5331.47	996.14	801.59
2018	14424.59	32.48	5605.18	701.73	842.05
2019	19148.49	122.58	3860.40	2184.33	854.92

\*Results expressed in standard spray coverage ( $10^6$  m<sup>2</sup>)

**Table S4.** Vector control insecticide use by insecticide class, presented by region, year, and insecticide class (pooled for diseases).

Region	Year	Insecticide class*						
		Pyrethroids (ITN)	Pyrethroids (other)	Organo-chlorines	Organo-phosphates	Carbamates	Neonico-tinoids	Other classes**
African	2010	6766.30	2472.76	240.50	42.88	211.47	0.00	3.87
	2011	4398.57	2245.66	266.67	36.62	436.48	0.00	0.04
	2012	4031.54	1935.98	146.16	56.16	1125.75	0.00	0.34
	2013	9404.84	1592.60	182.36	87.72	1317.98	0.00	0.56
	2014	11726.99	1325.45	163.37	250.55	897.58	0.00	0.01
	2015	11389.07	1226.08	162.81	337.46	1099.08	0.00	0.01
	2016	8374.29	1040.99	235.08	731.58	182.52	0.00	0.15
	2017	13875.12	731.18	250.38	1048.46	131.04	0.00	0.27
	2018	11988.95	353.50	242.19	847.45	0.08	387.87	0.00
2019	14910.60	528.41	173.14	366.09	0.00	667.81	38.08	
Asia-Pacific and Latin American & Caribbean	2010	1457.26	2997.60	2240.05	610.14	522.63	0.00	233.37
	2011	2248.47	7018.12	2456.11	545.51	281.14	0.00	147.58
	2012	1681.77	2919.61	2423.18	710.15	164.81	0.00	288.11
	2013	1334.53	3117.72	2363.61	829.60	133.83	0.00	157.19
	2014	1643.77	3017.53	2199.23	838.04	1799.55	0.00	1016.58
	2015	1676.98	2774.03	1683.77	960.32	326.31	0.00	1157.86
	2016	1623.63	2565.81	1562.93	1048.42	211.48	0.00	1079.72
	2017	3403.66	2240.71	1213.63	723.01	216.97	0.01	573.55
	2018	2468.12	2589.47	1228.99	732.72	112.90	0.35	653.36
	2019	4331.32	2458.16	851.95	1099.75	138.57	43.94	571.82

\*Results expressed in standard spray coverage (10<sup>6</sup> m<sup>2</sup>)

\*\*Bacterial larvicides, insect growth regulators and spinosyns

**Table S5.** Vector control insecticide use, excluding use in ITNs, by disease.

Disease	Region	Year	Insecticide class*					Other classes**
			Pyrethroids	Organo-chlorines	Organo-phosphates	Carbamates	Neonico-tinoids	
Malaria	African	2010	2430.50	240.50	42.29	211.47	0.00	3.14
		2011	2212.76	266.67	36.17	421.18	0.00	0.03
		2012	1933.46	146.16	55.82	1099.47	0.00	0.34
		2013	1576.08	182.36	87.37	1285.11	0.00	0.56
		2014	1285.92	163.37	250.06	871.92	0.00	0.00
		2015	1216.46	162.81	337.46	1045.83	0.00	0.00
		2016	1031.02	235.08	731.58	124.47	0.00	0.15
		2017	723.57	250.38	1048.46	70.06	0.00	0.18
		2018	353.27	242.19	847.45	0.08	387.87	0.00
	2019	526.07	173.14	365.88	0.00	667.81	0.00	
	Asia-Pacific	2010	1629.94	1662.18	53.07	0.00	0.00	92.30
		2011	1585.81	1564.09	51.31	0.00	0.00	30.12
		2012	1363.09	1522.81	95.46	3.94	0.00	37.56
		2013	1133.50	1342.95	54.07	7.65	0.00	17.81
		2014	1196.59	1379.08	60.84	29.74	0.00	270.91
		2015	1183.24	1635.92	22.31	48.25	0.00	248.42
		2016	1383.05	1562.93	11.18	47.79	0.00	20.53
		2017	1126.47	1213.63	7.64	58.18	0.00	13.56
		2018	1207.42	1228.99	4.53	19.57	0.00	17.97
	2019	1335.31	851.95	4.00	16.88	35.03	16.95	
	Latin American & Caribbean	2010	353.04	0.00	106.98	0.11	0.00	1.12
		2011	1624.23	0.00	79.46	0.13	0.00	1.52
		2012	342.01	0.00	70.16	0.08	0.00	9.84
		2013	298.64	0.00	71.35	0.25	0.00	1.44
		2014	267.95	0.00	78.41	0.11	0.00	0.53
		2015	298.50	0.00	94.19	29.67	0.00	0.54
		2016	96.43	0.00	6.88	0.06	0.00	0.74
2017		120.96	0.00	8.49	0.16	0.00	0.61	
2018		68.11	0.00	5.56	0.20	0.00	1.12	
2019	81.00	0.00	5.37	0.22	0.00	1.64		
Dengue	African	2010	6.53	0.00	0.59	0.00	0.00	0.73
		2011	3.15	0.00	0.45	0.00	0.00	0.00
		2012	2.52	0.00	0.34	0.00	0.00	0.00
		2013	2.76	0.00	0.36	0.00	0.00	0.00
		2014	7.14	0.00	0.49	0.00	0.00	0.00
		2015	5.92	0.00	0.00	0.00	0.00	0.00
		2016	9.97	0.00	0.00	0.00	0.00	0.00
		2017	6.25	0.00	0.00	0.00	0.00	0.09
		2018	0.12	0.00	0.00	0.00	0.00	0.07
		2019	2.32	0.00	0.21	0.00	0.00	0.00

	Asia-Pacific	2010	31.73	0.00	48.92	0.00	0.00	89.19
		2011	32.16	0.00	64.30	0.79	0.00	28.09
		2012	111.87	0.00	51.40	0.31	0.00	34.28
		2013	267.28	0.00	112.38	0.32	0.00	15.55
		2014	532.73	0.00	186.11	1.21	0.00	268.89
		2015	368.73	0.00	88.34	0.00	0.00	248.51
		2016	311.78	0.00	83.09	0.12	0.00	24.04
		2017	299.00	0.00	104.24	0.14	0.00	18.68
		2018	781.49	0.00	114.59	23.31	0.00	27.31
		2019	487.58	0.00	214.05	8.69	0.00	37.21
	Latin American & Caribbean	2010	224.81	0.00	397.88	267.28	0.00	50.77
		2011	1569.94	0.00	350.37	131.23	0.00	87.84
		2012	291.57	0.00	493.09	76.77	0.00	206.42
		2013	552.69	0.00	591.75	86.65	0.00	122.39
		2014	425.48	0.00	512.67	935.72	0.00	476.25
		2015	413.81	0.00	755.48	209.74	0.00	660.38
		2016	163.87	0.00	947.27	156.60	0.00	1034.41
		2017	154.03	0.00	602.64	153.06	0.01	540.70
		2018	46.92	0.00	608.03	63.27	0.35	606.97
		2019	165.60	0.00	876.32	107.12	8.91	516.01
Leishmaniasis	African	2010	35.72	0.00	0.00	0.00	0.00	0.00
		2011	29.75	0.00	0.00	15.30	0.00	0.00
		2012	0.00	0.00	0.00	26.28	0.00	0.00
		2013	13.76	0.00	0.00	32.88	0.00	0.00
		2014	32.39	0.00	0.00	25.65	0.00	0.00
		2015	3.70	0.00	0.00	53.25	0.00	0.00
		2016	0.00	0.00	0.00	58.04	0.00	0.00
		2017	1.36	0.00	0.00	60.98	0.00	0.00
		2018	0.11	0.00	0.00	0.00	0.00	0.00
		2019	0.01	0.00	0.00	0.00	0.00	0.00
	Asia-Pacific	2010	258.08	577.87	0.00	13.04	0.00	0.00
		2011	343.65	892.02	0.06	14.79	0.00	0.00
		2012	331.50	900.36	0.04	11.44	0.00	0.00
		2013	416.36	1020.67	0.05	20.93	0.00	0.00
		2014	246.61	820.14	0.00	7.68	0.00	0.00
		2015	310.98	47.85	0.00	7.15	0.00	0.00
		2016	319.25	0.00	0.00	3.17	0.00	0.00
		2017	219.36	0.00	0.00	2.67	0.00	0.00
		2018	247.16	0.00	0.00	2.58	0.00	0.00
		2019	269.33	0.00	0.00	4.29	0.00	0.00
	Latin American & Caribbean	2010	229.53	0.00	1.65	0.00	0.00	0.00
		2011	309.48	0.00	0.00	0.00	0.00	0.00
		2012	210.46	0.00	0.00	0.00	0.00	0.00
		2013	193.74	0.00	0.00	0.00	0.00	0.00

		2014	129.97	0.00	0.00	0.00	0.00	0.00		
		2015	56.89	0.00	0.00	0.00	0.00	0.00		
		2016	118.11	0.00	0.00	0.00	0.00	0.00		
		2017	129.25	0.00	0.00	0.00	0.00	0.00		
		2018	105.25	0.00	0.00	0.00	0.00	0.00		
		2019	52.22	0.00	0.00	0.00	0.00	0.00		
Chagas disease	African	2010	0.00	0.00	0.00	0.00	0.00	0.00		
		2011	0.00	0.00	0.00	0.00	0.00	0.00		
		2012	0.00	0.00	0.00	0.00	0.00	0.00		
		2013	0.00	0.00	0.00	0.00	0.00	0.00		
		2014	0.00	0.00	0.00	0.00	0.00	0.00		
		2015	0.00	0.00	0.00	0.00	0.00	0.00		
		2016	0.00	0.00	0.00	0.00	0.00	0.00		
		2017	0.00	0.00	0.00	0.00	0.00	0.00		
		2018	0.00	0.00	0.00	0.00	0.00	0.00		
			2019	0.00	0.00	0.00	0.00	0.00		
		Asia-Pacific	2010	0.00	0.00	0.00	0.00	0.00	0.00	
				2011	0.00	0.00	0.00	0.00	0.00	
				2012	0.00	0.00	0.00	0.00	0.00	
				2013	0.00	0.00	0.00	0.00	0.00	
				2014	0.00	0.00	0.00	0.00	0.00	
				2015	0.00	0.00	0.00	0.00	0.00	
				2016	0.00	0.00	0.00	0.00	0.00	
				2017	0.00	0.00	0.00	0.00	0.00	
				2018	0.00	0.00	0.00	0.00	0.00	
			2019	0.00	0.00	0.00	0.00	0.00		
		Latin American & Caribbean	2010	270.47	0.00	1.65	242.20	0.00	0.00	
				2011	1552.85	0.00	0.00	134.20	0.00	0.00
				2012	270.02	0.00	0.00	72.26	0.00	0.00
				2013	255.51	0.00	0.00	18.03	0.00	0.00
				2014	218.19	0.00	0.00	825.08	0.00	0.00
				2015	141.88	0.00	0.00	31.49	0.00	0.00
				2016	173.32	0.00	0.00	3.75	0.00	0.00
			2017	191.64	0.00	0.00	2.77	0.00	0.00	
			2018	133.11	0.00	0.00	3.96	0.00	0.00	
		2019	67.12	0.00	0.00	1.37	0.00	0.00		

\*Results expressed in standard spray coverage (10<sup>6</sup> m<sup>2</sup>)

\*\*Bacterial larvicides, insect growth regulators and spinosyns

**Table S6.** Pyrethroid resistance versus pyrethroid use per country. Presented are the results per country (anonymized) per year. Confirmed resistance implies <90% mortality of anophelines in insecticide susceptibility bioassays for pyrethroids <sup>3</sup>; 0, no confirmed resistance; 1, confirmed resistance. Pyrethroids in use refers to the use in IRS for malaria control; 0, no pyrethroids in use; 1, pyrethroids in use.

Year	Country code	Confirmed resistance	Pyrethroids in use
2010	9	1	0
2010	13	0	1
2010	14	1	0
2010	19	1	1
2010	30	1	0
2010	32	1	1
2010	35	1	1
2010	40	0	1
2010	42	0	1
2010	50	0	1
2010	52	1	1
2010	58	0	1
2010	60	0	1
2010	69	0	1
2010	71	1	1
2010	74	0	1
2010	75	1	1
2010	77	1	1
2010	86	0	1
2010	87	0	1
2011	9	1	0
2011	11	0	1
2011	13	0	1
2011	14	1	0
2011	32	1	1
2011	35	1	1
2011	50	1	1
2011	59	0	1
2011	60	0	1
2011	65	1	1
2011	69	0	1
2011	71	1	1
2011	74	0	1
2011	75	1	1
2011	77	1	1
2011	83	1	0
2011	86	0	1
2011	88	1	1

2011	89	0	1
2012	9	1	0
2012	14	1	0
2012	19	1	1
2012	32	1	1
2012	35	1	1
2012	40	0	1
2012	42	0	1
2012	50	0	1
2012	52	1	0
2012	58	0	1
2012	59	0	1
2012	60	0	1
2012	65	1	1
2012	69	0	1
2012	70	0	1
2012	71	1	0
2012	74	0	1
2012	75	1	0
2012	77	1	1
2012	83	1	0
2012	86	0	1
2012	87	0	1
2012	88	1	1
2012	89	0	1
2013	9	0	0
2013	13	0	1
2013	19	1	1
2013	30	0	0
2013	32	1	1
2013	35	1	0
2013	40	1	1
2013	42	0	1
2013	50	0	1
2013	52	1	0
2013	58	0	1
2013	59	0	0
2013	60	0	1
2013	65	1	1
2013	69	1	1
2013	71	1	0
2013	75	1	1
2013	77	1	1
2013	78	0	1



2013	83	1	0
2013	86	0	1
2013	87	1	1
2013	88	1	0
2013	89	1	1
2014	9	1	0
2014	13	1	1
2014	19	1	1
2014	22	1	0
2014	30	1	1
2014	32	1	0
2014	35	1	0
2014	40	0	1
2014	42	0	1
2014	50	0	1
2014	58	0	1
2014	59	0	1
2014	60	0	1
2014	65	1	1
2014	71	1	0
2014	74	0	1
2014	75	1	1
2014	77	1	0
2014	78	1	1
2014	86	0	1
2014	87	1	1
2014	88	1	0
2014	89	1	1
2014	91	0	1
2015	9	1	0
2015	11	0	1
2015	19	1	1
2015	32	1	0
2015	35	1	0
2015	40	1	1
2015	42	0	1
2015	50	0	1
2015	52	1	0
2015	58	0	1
2015	59	0	1
2015	69	1	0
2015	71	1	0
2015	74	0	1
2015	75	1	1

2015	77	1	0
2015	78	0	1
2015	83	1	0
2015	86	0	1
2015	87	0	0
2015	88	1	0
2015	89	0	1
2015	91	1	1
2016	9	1	0
2016	19	1	1
2016	22	1	1
2016	30	1	1
2016	32	1	0
2016	35	1	0
2016	40	0	1
2016	52	1	0
2016	58	1	1
2016	59	1	1
2016	71	1	0
2016	74	0	1
2016	77	1	0
2016	83	1	0
2016	86	1	1
2016	87	1	0
2016	88	1	0
2016	91	1	1
2017	9	1	0
2017	13	1	1
2017	19	1	1
2017	35	1	0
2017	40	1	1
2017	50	1	0
2017	59	0	1
2017	65	1	1
2017	70	0	1
2017	75	1	1
2017	86	0	1
2017	87	1	0
2017	88	1	0
2018	13	1	1
2018	14	1	0
2018	19	1	1
2018	32	1	0
2018	40	0	1

2018	59	0	1
2018	60	0	1
2018	65	1	1
2018	74	0	1
2018	87	1	0
2019	11	0	1
2019	13	1	0
2019	30	1	0
2019	32	1	0
2019	35	1	0
2019	40	1	1
2019	52	1	0
2019	74	0	1
2019	87	1	0

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**Table S7.** Degree of insecticide resistance management for disease vector control. Values are shown of parameter *R* and its components of rotation, mosaic/combination spraying, and multiplicity of modes of action, per disease for individual eligible countries (anonymized) during two five-year periods.

Disease	Country code	Region*	Period 1: 2010–2014				Period 2: 2015–2019			
			Rotation (a)	Mosaic (b-1)	Multiplicity (c-1)	Total (R)	Rotation (a)	Mosaic (b-1)	Multiplicity (c-1)	Total (R)
Malaria	9	AF	1.00	0.10	0.50	1.60	0.00	0.00	0.00	0.00
	13	AF	1.00	0.40	0.50	1.90	3.00	0.30	1.50	4.80
	25	AF	1.00	0.60	1.00	2.60	2.00	0.60	2.00	4.60
	30	AF	3.00	0.29	1.50	4.79	2.50	0.17	1.00	3.67
	31	AF	0.00	0.50	0.50	1.00	5.50	0.30	2.50	8.30
	32	AF	2.00	0.60	1.00	3.60	1.00	0.13	1.00	2.13
	35	AF	2.00	0.20	1.00	3.20	1.00	0.25	1.00	2.25
	50	AF	0.50	1.20	1.50	3.20	2.50	0.63	2.50	5.63
	52	AF	2.50	0.10	1.50	4.10	1.00	0.25	1.00	2.25
	58	AF	4.00	1.00	1.50	6.50	3.50	1.10	2.00	6.60
	60	AF	0.00	0.50	0.50	1.00	1.50	0.80	1.50	3.80
	69	AF	1.00	0.40	1.00	2.40	1.00	0.13	0.50	1.63
	91	AF	2.00	0.70	1.50	4.20	0.00	0.50	0.50	1.00
	77	AF	3.00	0.40	1.50	4.90	1.00	0.25	1.00	2.25
	83	AF	0.00	0.00	0.00	0.00	1.00	0.25	0.50	1.75
	88	AF	1.00	1.30	2.00	4.30	3.00	0.40	2.00	5.40
	89	AF	0.00	1.10	0.50	1.60	1.00	2.00	2.50	5.50
	92	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8	LA	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	11	LA	1.00	0.20	1.00	2.20	0.00	1.00	1.00	2.00
	18	LA	0.00	0.00	0.00	0.00	2.00	0.00	1.00	3.00
	21	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	37	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	67	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	44	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	65	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	70	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	87	AP	1.00	0.40	1.00	2.40	1.00	0.20	2.00	3.20
	40	AP	0.00	1.50	1.50	3.00	0.00	1.50	1.50	3.00
	59	AP	4.00	0.50	1.50	6.00	0.00	0.00	0.00	0.00
61	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
74	AP	1.00	0.60	1.00	2.60	0.00	0.00	0.00	0.00	
86	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Dengue	92	LA	1.00	0.40	0.50	1.90	0.50	0.40	0.50	1.40
	8	LA	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	21	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23	LA	0.00	1.50	1.50	3.00	0.00	1.50	1.50	3.00
	37	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	54	LA	0.00	1.50	1.50	3.00	1.00	2.10	2.50	5.60
	67	LA	0.00	0.00	0.00	0.00	0.00	1.00	1.00	2.00
	65	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	70	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	40	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	41	AP	2.00	0.80	1.00	3.80	2.00	0.60	1.00	3.60
	74	AP	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	33	AP	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	19	AP	0.50	1.40	1.50	3.40	0.50	1.40	1.50	3.40
Leishmaniasis	43	AP	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	70	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	76	AP	1.00	0.20	1.00	2.20	0.00	0.00	0.00	0.00
	7	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	61	AP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chagas disease	92	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11	LA	0.00	1.00	1.00	2.00	0.00	1.00	1.00	2.00
	18	LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

\*AF, African; AP, Asia-Pacific; LA, Latin American & Caribbean

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