INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

An economic analysis of the costs of indoor residual spraying in 12 PMI countries, 2008–2010

September 27, 2011

This publication was produced for review by the United States Agency for International Development. It was prepared by RTI International.

An economic analysis of the costs of indoor residual spraying in 12 PMI countries, 2008–2010

Prepared for
United States Agency for International Development

Prepared by
Jeffrey Sine, Rajeev Colaco, and Hannah Frawley
RTI International
3040 Cornwallis Road
Post Office Box 12194
Research Triangle Park, NC 27709-2194

Acknowledgements

This analysis required information from several sources and could not have been completed without the support and assistance from many people. The indoor residual spraying (IRS) project is a logistically and managerially complex undertaking. First and foremost, we would like to acknowledge and thank the numerous individuals, numbering in the thousands, whose tireless efforts are devoted year after year to plan, execute, and evaluate IRS campaigns in the 12 countries included in this analysis. Among them are spray operators who spend long, intense days in hot, protective gear carrying heavy equipment to bring this life-saving intervention to the homes of millions of Africans—more than 13 million of them in 2010 alone. This also includes the many community educators and mobilizers who visit every home to raise awareness among households about IRS and advise them about preparations for the spray team visit so that the intervention can be safely applied. We thank the logistics experts who spend days in the field meticulously determining the number and location of structures to be sprayed and the corresponding amounts of equipment and commodities required for each spray campaign. It includes the many spray team supervisors and zone and district leaders who support the spray operators and community mobilizers and oversee the quality of the work being conducted. It includes the environmental compliance monitors who continuously look for ways to improve the quality and safety of IRS; and the many civil servants in each country, from the national to the district level, who provide critical support needed to complete a successful campaign. We also thank the many IRS and IRS 2 task order (TO) 1 project staff whose efforts also contribute importantly to successful IRS campaigns.

We also thank the many people who were more directly involved in mobilizing the data needed for this analysis, reviewing results, and providing advice that made the numbers more understandable and meaningful. Jennifer Rios, supported by Jill Tenace, mobilized the massive amount of data on RTI's expenditures. Isaac Thomas sorted out data from project subcontracts, both international and at the country level. These data form the underpinnings of this analysis. We also thank Carl Henn for his tireless efforts and support to our country teams to mobilize additional information about soak pit construction, insecticide resistance monitoring, and IRS solid waste disposal. We thank Project Director John Chimumbwa, who readily provided advice, support, and guidance.

At the country level, our chiefs of party, who are on the front lines of IRS, provided invaluable information and insight. These include Elie Bankineza, Nelson Cuamba, Dereje Dengela, Napolean Graham, Hector Jalipa, Adama Kone, Stephen Magesa, Martin Netsa, David Rasolofondranohatra, and Jean-Luc Taton. We also benefited from the country-specific knowledge of our technical program managers— Lenna Neat, Jake O'Sullivan, and Scott Torres—and project administrative specialists—Nicole De Gier, Jennifer Kiiru, Rebecca Price, and Ricel Valdes.

Table of Contents

Page

Acknowledgements iii

Abbreviations v

I. Background 6

II. Approach and Methods 7

III. Results 10

IV. Summary and Conclusions 19

Annex 1 – Inflation, GDP Deflator (annual %)[a] 21

Annex 2 - Values for Figures 1 - 4 22

Annex 3 – Detailed Country Costs 23

Abbreviations

CCN	Cooperating country national
IEC	Information, education, and communication
IRS	Indoor residual spraying
M&E	Monitoring and evaluation
NMCP	National Malaria Control Program
NRO	Nairobi Regional Office
PMI	United States President's Malaria Initiative
PPE	Personal protective equipment
STTA	Short-term technical assistance
TCN	Third country national
TO	Task order
US	United States
USAID	United States Agency for International Development

I. Background

The United States President's Malaria Initiative (PMI) has been supporting indoor residual spraying (IRS) and other interventions to reduce the burden of malaria in high burden countries since 2005. In these countries, PMI's multidimensional support has resulted in a measureable decrease in the prevalence and incidence of malaria. With the effectiveness of IRS and other interventions having been demonstrated, information about costs continues to be important to inform decisions about program investments. From a budgeting perspective, cost information is an important driver of decisions about how much money will be allocated to each intervention. This is particularly important because resources are limited to fund expansion of existing country programs and to initiate programs in new countries. From an economic perspective, it is desirable to identify an investment strategy that provides the optimal impact on malaria burden. That is, what are the relative cost–benefit or cost-effectiveness ratios of the major intervention options?

In previous analyses of data on 2008 and 2009 expenditures for IRS[1], we found that the distribution of total costs across defined standard program elements varied considerably. Variation in costs per structure sprayed was also noted and this was most likely a consequence of both differences across countries in the types of structures targeted and the definition of "structure". IRS costs, measured by cost per person protected, were generally in line with those found by other researchers who studied costs under varying implementation settings.

It was surmised that some inter-country differences were a consequence of the different operational status of country programs; for instance in each year some countries were in "start-up" mode while others had recent prior experience implementing IRS. Differences in program conditions (e.g., distance from central country office to targeted regions, topography, population density in terms of inhabitants per structure and spatial separation of structures,[2] local input costs [such as labor, facility rental, goods and supplies, and other costs of doing business]), and the types and quantity of inputs contributed by host-country counterparts were also assumed to be contributing factors in inter-country cost differences observed.

In this report, we present an analysis of the costs associated with PMI-supported indoor residual spraying (IRS) in 12 countries from 2008 to 2010.[3] Results are intended to help guide decision-makers in allocating resources for IRS; analyze trends

[1] All data pertained to country IRS programs RTI had been supporting under the PMI/U.S. Agency for International Development (USAID) IRS task order (TO) 1 project. For results from 5 of the country programs in 2008, see Sine, Jeffrey, and Amy Doherty. 2010. *Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC) Task Order 1: Analysis of 2008 Expenditures in Five Indoor Residual Spraying Task Order One Countries*. Prepared by RTI International for PMI/USAID. Other results for 2008 and 2009 were not published.

[2] Worrall, E, S.J. Conner, and M.C. Thomson. 2008. "Improving the cost-effectiveness of IRS with climate informed health surveillance systems." *Malaria Journal*, 7:263.

[3] In 2010, PMI/USAID support was provided through IRS TO1 as well as through the new IRS 2 TO1. Relevant costs from both task orders are included in this analysis.

in costs within a country and across cost categories over time; and determine if economies of scale apply. This analysis takes our previous expenditures analyses one step further in that we have amortized capital costs and applied deflators to improve comparability across time. Still, caution must be applied when attempting to make comparisons among countries and within countries over time based on costs alone.

Comparability among countries may be limited for a number of reasons, including: differences in insecticide product used; variation in the size of sprayed structures; variations in rural/semi-urban mix of targeted areas and consequent accessibility and distance between houses; differences in market prices for inputs obtained in-country; and, in four cases included in this analysis, the number of rounds of IRS applied was two (rather than the standard one round per year)[4]. Comparability within a country over time may be limited because targeted areas may have changed and thus some start-up costs are reflected twice (e.g., geographical reconnaissance and soak pit construction), the number of rounds per year may change, insecticide class may change as a result of emerging resistance, and staffing patterns may change (e.g., international hires needed to replace local hires or vice versa).

Longitudinal tracking of the costs of IRS is also expected to contribute to an understanding of the prospects for sustainability, particularly in the context of achieving host-country self-reliance in managing, planning, implementing, and monitoring IRS programs.

II. Approach and Methods

We obtained, analyzed, and compared data from 2008 to 2010 for the countries shown in Table 1.

Table 1: Countries Included in this Analysis, by year

	2008	2009	2010
Angola	x	x	x
Benin	x	x	x
Burkina Faso			x
Ethiopia	x	x	x
Ghana	x	x	x
Liberia		x	x
Madagascar	x	x	x
Mali	x	x	x
Malawi	x	x	
Mozambique	x	x	x
Rwanda	x	x	x
Senegal	x	x	x

[4] Those were Senegal and Rwanda in 2009, Rwanda and Benin in 2010. Details are provided in the Results section of this report.

Retrospective financial records from RTI were used as the primary data source. (RTI, in partnership with the National Malaria Control Program [NMCP] in each country, was the common implementation entity for all programs included in this analysis.[5]) A comprehensive list of all 2008–2010 expenditures recorded by RTI was reviewed. Each item was assigned to an expenditure category per Table 1, and appropriate overhead/indirect cost factors were applied.

Next, all capital goods were identified and their costs were amortized over the assumed useful life of each good. (See Table 2 for a list of goods whose costs were amortized and for the period over which each type was amortized.) Finally, costs for all items were adjusted using published price deflators (see Annex 1 for a list of price deflators used) so that costs across years would be comparable in 2010 terms. All costs presented in this report are therefore reported in 2010 U.S. dollars. Observed program costs were then compared as follows:

- Intra-country comparison. We compared trends from 2008 to 2010 in costs per person protected and per structure sprayed to determine whether or not cost efficiencies were achieved. Changes in the distribution of program costs across standard cost categories were also examined to assess whether efficiencies were accruing differentially by cost category.
- Cross-country comparison. We also examined trends across countries to identify how consistent intra-country changes were across countries. We also arranged countries by program size (number of structures targeted) to determine whether or not economies of scale may be relevant to program cost.

Table 2: Cost Categories for IRS Cost Analysis

IRS Cost Category	Items	
Spray operations	Planning and logistic assessment activities Environmental compliance, including soak pit/evaporation tank construction Training Information, education, and communication (IEC), and community mobilization Warehousing	Short-term labor [a] Transportation Medical costs Mop-up operations Post-spray meetings Monitoring and evaluation (M&E) activities
Spray operations commodities	Insecticide Spray equipment and equipment repair kits	Personal protective equipment (PPE) Shipping
Local labor	• Cooperating country national (CCN) staff labor [b]	
Local (in-country) administration	Office leases, utilities, and maintenance Office furniture, equipment, and supplies	Services for office support Management travel and transportation
Short-term technical assistance (STTA) and U.S. costs	U.S. and Nairobi-based support services (e.g., communications, shipping, etc.)	Lodging, per diem, and other expenses related to international travel to project country
U.S./Nairobi labor	• U.S.- and Nairobi-based labor, including labor associated with in-country STTA	

[a] This category includes non-employee (seasonal) labor engaged to prepare for and conduct spray operations, including spray operators, IEC mobilizers, field supervisors, and data entry clerks.
[b] This category includes salaries of all cooperating country national staff (CCN) employed by IRS TO1 and IRS TO2.

[5] In Madagascar in 2010, due to the political crisis in Madagascar and the suspension of USG direct support to the Government of Madagascar since March 2009, the IRS program had limited coordination with the NMCP in 2010, compared to other countries. As of this writing, the suspension remains in effect.

Table 3: IRS Cost Items Amortized

IRS Cost Category	Items Amortized	Period of Amortization
Local (in-country) administration	Vehicles Computers, laptops, software, and information technology equipment (e.g., servers) Printers, scanners, and photocopiers Cameras and projectors Mobile phones and land line phones Generators, air conditioners, refrigerators, and microwave ovens Tables, chairs, bookshelves, and other office furniture	Vehicles – 5 years All other items – 3 years
Spray operations	Soak pits Evaporation tanks	3 years [a] 3 years
Spray equipment	Spray pumps	5 years
PPE	Helmets, goggles, visors, boots, non-disposable face masks Overalls, jackets	3 years 2 years

[a] Useful life of soak pits and evaporation tanks was assumed to be 3 years for most countries. Exceptions were as follows: (a) Madagascar —country team reported that soak pits are rebuilt each year because material is removed by the community after spray operations are completed; and (b) Ethiopia—evaporation tanks constructed in 2009 were used for that year only (the country switched to a pyrethroid in 2010 and built soak pits).

In 2008, one spray round was conducted in each country included in this analysis. In 2009 one round was conducted in all countries except Rwanda and Senegal. In those two countries, some of the structures targeted in 2009 were sprayed twice with a pyrethroid insecticide with a short active period (ICON-WP). In 2010, all countries sprayed each structure once, except Rwanda again where a subset was sprayed twice with ICON-WP, and Benin where structures were sprayed twice with a carbamate compound. As noted earlier, such differences in number of spray rounds applied per year to structures limits comparability of costs both across and within countries. Other issues of note with respect to the data are

- RTI program costs not directly related to IRS were omitted from this analysis; e.g., costs for insectary or research center refurbishment.
- Host countries contribute to IRS operations through in-kind contributions; for example, through labor provided by the Ministry of Health and NMCP staff, providing transportation to project events, and providing/donating warehouse space for IRS commodities (all countries). These costs are not included here.[6]
- RTI did not finance or purchase insecticide for Ethiopia and Mozambique; other arrangements were made to provide these goods. However, we obtained information on these costs and included it in this analysis to improve cross-country comparison of results.

[6] Information on in-kind costs was collected from nine of the countries included in the analysis reported here. The value of those costs was found to be low, between 0.8 and 4.6 percent of the total costs (in-kind plus costs funded by PMI/USAID through RTI). Moreover, in each year on average more than 40 percent of the value of these in-kind contributions was estimated to have been from water provided by households to spray operators for mixing insecticide.

In the remainder of this report, the seven countries with programs that sprayed more than 150,000 or more structures in 2010 are referred to as "large program" countries and the five that sprayed fewer than 150,000 structures are referred to as "small program" countries.[7]

III. Results

A. Spray Operations Performance Indicators

Table 4 presents key IRS performance indicators for countries included in this analysis.

Table 4: IRS Performance Indicators

Country	Year	Structures sprayed	People protected	People per structure[a]	No. sachets used per structure	Size of structures sprayed (sq meters)[b]	Number of Spray Rounds	Insecticide Used
Ethiopia	2008	316,829	1,000,526	3.2	0.37	81.5	1	DDT
	2009	459,402	1,539,163	3.4	0.43	95.5	1	DDT
	2010	646,870	2,064,389	3.2	0.46	101.1	1	Pyrethroid
Mozambique	2008	412,923	1,457,142	6.3	0.66	144.7	1	DDT/Pyrethroid
	2009	571,194	2,263,409	4.0	0.72	159.3	1	DDT/Pyrethroid
	2010	618,290	2,945,721	4.8	0.84	183.9	1	DDT/Pyrethroid
Madagascar	2008	216,749	1,319,690	6.1	0.58	126.9	1	Pyrethroid
	2009	216,060	1,274,809	5.9	0.57	125.1	1	Pyrethroid
	2010	576,320	2,895,058	5.0	0.34	74.6	1	Pyrethroid/Carbamate
Ghana	2008	254,305	601,973	2.4	0.27	59.5	1	Pyrethroid
	2009	284,856	708,103	2.5	0.25	55.5	1	Pyrethroid
	2010	342,876	849,620	2.5	0.21	46.6	1	Pyrethroid
Rwanda	2008	189,756	885,957	4.7	0.55	120.3	1	Pyrethroid
	2009	191,051	866,002	4.5	0.61	133.2	Round 1	Pyrethroid
	2009	295,174	1,329,340				Round 2	Pyrethroid
	2010	63,395	280,832	4.5	0.69	151.2	Round 1	Pyrethroid
	2010	303,659	1,365,949				Round 2	Pyrethroid
Senegal	2008	153,942	645,346	4.2	0.31	67.7	1	Pyrethroid
	2009	21,589	113,544	3.8	0.33	72.1	Round 1	Pyrethroid
	2009	176,279	661,814				Round 2	Pyrethroid
	2010	254,559	959,727	3.8	0.35	76.2	1	Pyrethroid
Benin	2008	142,814	521,738	3.7	0.15	32.3	1	Carbamate
	2009	156,233	512,491	3.3	0.14	31.0	1	Carbamate
	2010	166,910[c]	636,448	3.1	0.16		Round 1	Carbamate

[7] These definitions were determined on the basis of finding about cost per person and per structure which suggests that a cut off exists somewhere between 150,000 and 175,000 structures sprayed where there is a step increase in program unit costs. See Section III, D.

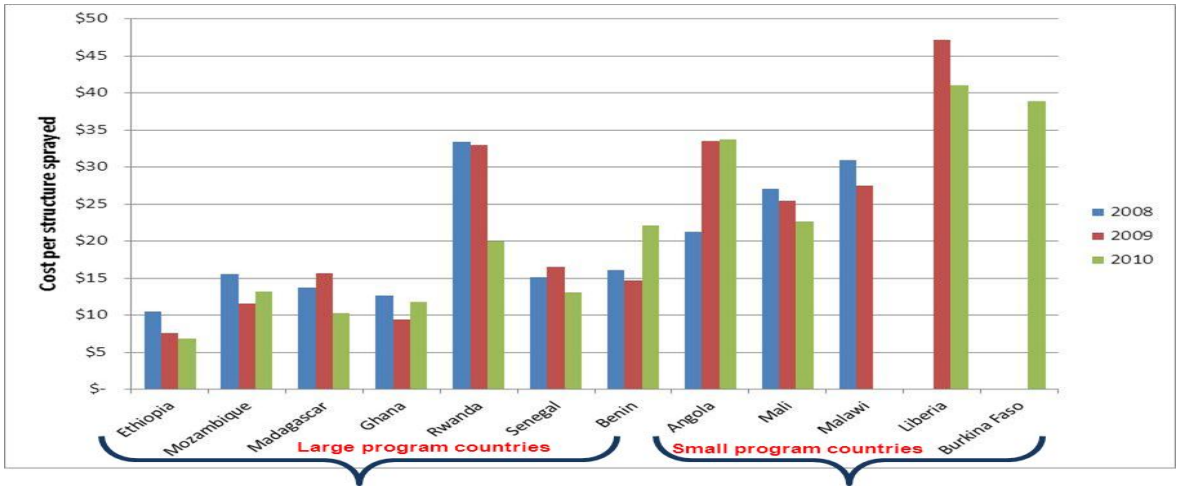
Country	Year	Structures sprayed	People protected	People per structure[a]	No. sachets used per structure	Size of structures sprayed (sq meters)[b]	Number of Spray Rounds	Insecticide Used
	2010	200,036	623,904			35.4	Round 2	Carbamate
Angola	2008	136,051	685,908	5.0	0.47	104.3	1	Pyrethroid
	2009	102,731	485,974	4.7	0.53	115.7	1	Pyrethroid
	2010	135,856	649,842	4.8	0.56	122.7	1	Pyrethroid
Mali	2008	107,638	420,580	3.9	0.27	58.4	1	Pyrethroid
	2009	126,922	497,122	3.9	0.19	42.8	1	Pyrethroid
	2010	127,273	440,815	3.5	0.35	77.2	1	Pyrethroid
Malawi	2008	24,764	106,450	4.3	0.57	126.2	1	Pyrethroid
	2009	74,772	299,744	4.0	0.56	122.2	1	Pyrethroid
Liberia	2009	20,393	163,149	8.0	0.7	154.0	1	Pyrethroid
	2010	48,347	420,537	8.7	0.90	197.8	1	Pyrethroid
Burkina Faso	2010	33,897	118,691	3.5	0.41	90.2	1	Carbamate

[a] People per structure is computed as the reported total number of people protected during the IRS campaign and the total number of structures sprayed.
[b] Size of structure is imputed here as the average surface area sprayed, which is equal to the number of sachets used per structure multiplied by 220 square meters (the average assumed surface area covered by one sachet).
[c] Two spray rounds were conducted in Benin in2010 to cover each structure twice. In the first round, 166,910 structures were sprayed. During the second round, 200,036 structures were sprayed because spray operations performance improved (i.e., a higher coverage rate was achieved) and new structures were found.

B. Costs per Structure Sprayed and per Person Protected

Calculating a cost per structure sprayed and per person protected provides a more standardized means to compare IRS costs across countries. Figure 1 shows the cost per structure sprayed for each country in 2008–2010.

Figure 1: Cost per Structure Sprayed, 2008–2010[8]



The seven leftmost countries on this figure are the large program countries where more than 150,000 structures were sprayed in each of the three years from 2008 to 2010. (Benin in 2008 is the exception where 143,000 were sprayed.) The five rightmost countries are the small program countries where fewer than 150,000 structures were sprayed in each year. Summary points on costs per structure sprayed are

- Costs appear to be higher for small program countries. With the exception of Rwanda (especially for 2008 and 2009), costs per structure sprayed were lower in the large program countries compared with the small program countries. The cost was close to or less than $15 per structure for all countries where more than 150,000 structures were sprayed, with the exception of Rwanda in all three years and Benin in 2010. The cost leaps to an average of more than $20 for all countries in each year where fewer than 150,000 structures were sprayed. The cost differences observed by program size are statistically significant at the $p<0.01$ level for both 2009 and 2010; they are less significant for 2008 ($p<.08$).[9]
- In six of the seven large program countries, costs per structure in 2010 were lower than in 2008. Benin, the smallest of this group is the exception. The increased costs in Benin in 2010 were driven in part by the switch from spraying each structure once each year in 2008 and 2009 to twice in 2010. Additionally, the CCN country program director was replaced by a more expensive third country national (TCN).

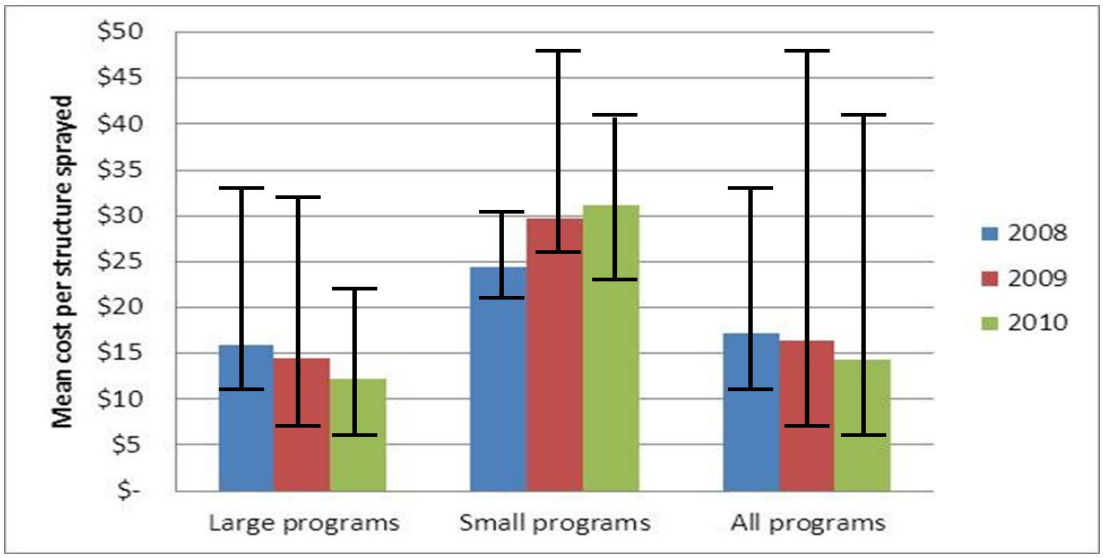
[8] In all except four cases represented on this graph, structures were sprayed once in the relevant year. In 2009, 65% of all structures sprayed in Rwanda were sprayed twice and 12% of all structures sprayed in Senegal were sprayed twice. In 2010, 21% of structures sprayed in Rwanda were sprayed twice. In Benin in 2010, each of the 166,910 structures sprayed in round 1 were sprayed again in round 2, and an additional 33,126 structures were sprayed during round 2. All figures on this graph show costs per unique structure, regardless of whether they were sprayed once or twice. Actual values are listed in Annex 2.

[9] Finding a statistically significant result here is quite extraordinary given the very small sample sizes—seven large program countries and four small program countries. It is a strong indication that program size does greatly influence program cost.

- In three of the four small program countries (Burkina Faso which sprayed only in 2010 was excluded), costs declined from the first year of operations. Angola was the exception.
- The high cost per structure sprayed observed for Liberia was in part a consequence of the very large average size of structures in that country (see Table 4).
- The high cost in Burkina Faso is not attributable to structure size; structures in that country are comparable in size to other PMI IRS countries. As noted earlier, the high cost here appears to be a consequence of the high costs of external support that was required in this start-up country. These costs accounted for more than 40 percent of total costs and they were spread across relatively few structures.

Figure 2 shows changes in the mean cost per structure sprayed for all countries and for the large and small program countries. Across all countries, the mean cost declined by 17 percent from 2008 to 2010. The decline was sharper among large program countries at 23 percent. Among the small program countries mean costs increased by 28 percent over the three-year period, with more than 80 percent of this increase occurring between 2008 and 2009.

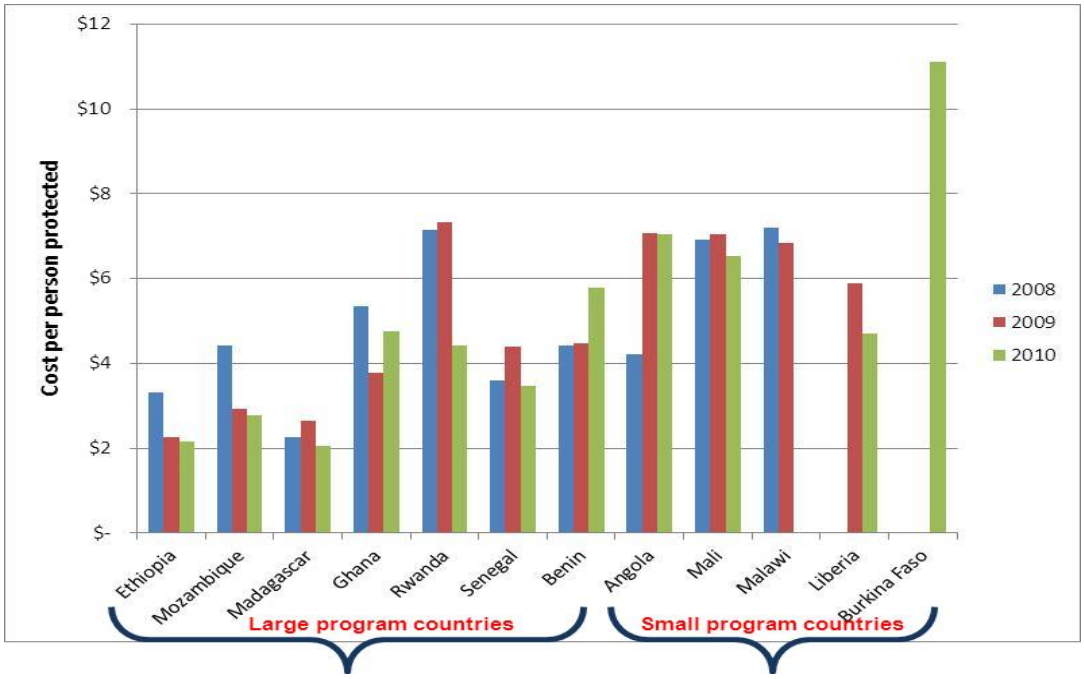
Figure 2: Change in Mean Cost per Structure Sprayed, 2008 to 2010 [a]



[a] Vertical lines on each bar represent the range of costs for each group.

Figure 3 shows the cost per person protected for each country in 2008–2010.

Figure 3: Cost per Person Protected, 2008-2010

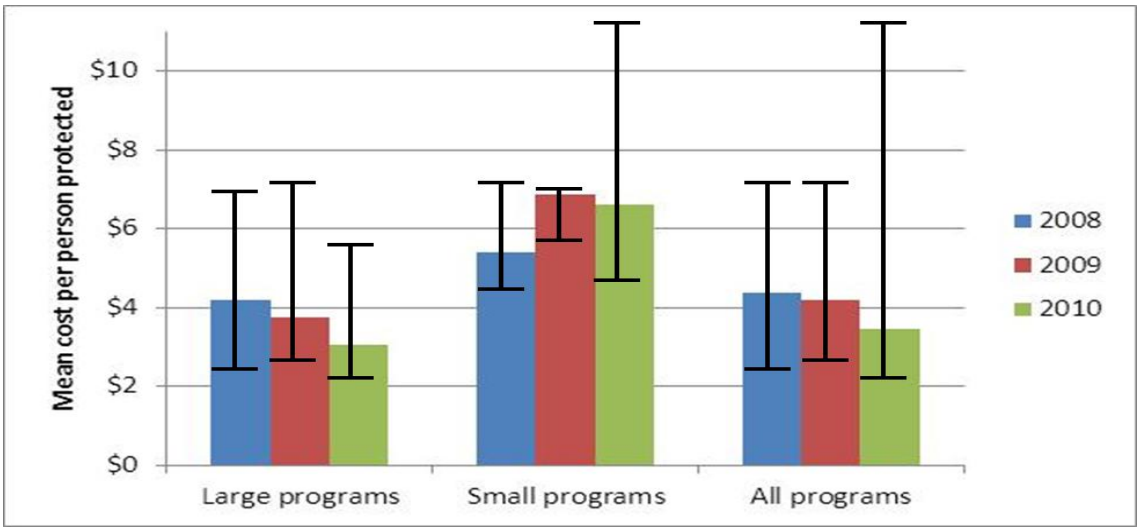


A bi-modal pattern similar to that observed on costs per structure sprayed is observed here. Costs were generally lower in the large program countries than in the small program countries. Differences in cost per person between small and large programs are also significant (at the $p<.01$ level) for 2009 and 2010 and not significant for 2008. Other summary points include:

- Costs per person declined from 2008 to 2010 in six out of the seven large program countries. Benin was again an exception. Costs per person also declined in three of four small country programs, Angola being the exception.
- In Liberia, costs per person protected— unlike per structure sprayed—are on par with other small program countries, providing further evidence that the higher costs per structure sprayed (compared with other small program countries) is linked to the large size of the average structure relative to other countries. (The average number of people living in each structure in Liberia in 2010 was 8.7 compared with 3.9 for the other countries.)
- The cost per person protected in Burkina Faso is considerably higher than in any other country, as was the case for cost per structure sprayed. As noted earlier, this appears to be in large part driven by the high need for external support for this small, start-up program.

Figure 4 compares mean costs per person protected in large and small program countries and shows the trend for each group from 2008 to 2010.

Figure 4: Change in Mean Cost per Person Protected, 2008–2010[a]



[a] Vertical lines on each bar represent the range of costs for each group.

Patterns in the change in mean costs per person protected are similar to those for mean costs per structure sprayed. Across all countries, the mean cost declined by 27 percent from 2008 to 2010. Among large program countries, the mean cost declined by 27 percent with about one-third of the decline occurring from 2008 to 2009 and the rest occurring from 2009 to 2010. Among small program countries, there was a 22 percent increase in the mean cost per person protected over the three-year period, with all the increase occurring from 2008 to 2009. Despite the high cost in Burkina Faso, the mean cost in 2010 among these programs declined slightly (4%) from their high point in 2009.

C. Distribution of Expenditures across Cost Categories

Table 3 shows aggregate changes in the use of resources across major cost categories for large and small country programs. Among the large programs, there was remarkable stability from 2008 to 2010 in how resources were used. Spray operations as a proportion of total costs show a small decline over time, but insecticide shows a small increase. There also appears to be a downward trend among large programs in their need for external support as reflected by the 50 percent decline in the "STTA and U.S. costs" category. It may be too early to draw such a conclusion as 2008 and 2009 were similar and only in 2010, one year, do we see an apparent change.

Among small programs, 2009 appears to have been an aberrant year for spray operations. The proportion of resources used for this category increased considerably in 2009 but returned to 2008 levels in 2010. Other notable findings for this group of countries is that local administrative costs declined by almost half while external support (via STTA and U.S. and Nairobi-sourced labor) increased by two-fold or more.

Table 3: Comparison of Average Proportion Spent on each Cost Category, 2008 and 2009, All Countries [a]

	Large programs			Small programs		
	2008	2009	2010	2008	2009	2010
Spray operations	52%	50%	49%	42%	51%	43%
Insecticide	13%	16%	18%	10%	7%	7%
Spray equipment	2%	2%	2%	1%	1%	1%
PPE	3%	2%	3%	2%	3%	3%
Shipping	4%	1%	2%	5%	2%	1%
Local labor	7%	7%	7%	10%	8%	9%
Admin-local	10%	9%	9%	20%	14%	11%
STTA & U.S. costs	4%	5%	2%	2%	5%	4%
U.S./Nairobi labor	6%	8%	7%	9%	10%	20%
Total [b]	100%	100%	100%	100%	100%	100%

[a] Weighted averages, based on number of structures sprayed in each country.
[b] Totals may not sum to 100% due to rounding.

Figures 5 and 6, for large and small program countries, respectively, show country specific cost distributions for each year. At this country-specific level, there was no clear pattern in year-to-year changes. The proportion devoted to spray operations increased from 2008 to 2009 in three large program countries (Ethiopia, Mozambique and Rwanda), decreased in three others (Madagascar, Senegal and Benin), and remained nearly constant one (Ghana). In two of the three countries that showed an increase from 2008 to 2009 (Mozambique and Rwanda), the proportion costs devoted on spray operations decreased from 2009 to 2010. In all three small program countries that sprayed in both 2008 and 2009, the proportion spent on spray operations increased across these years and decreased in two of them from 2009 to 2010. The only category that showed some consistency in trends is the combined total for spray equipment and PPE, where amortization smoothed allocation of capital portion of these costs across years, resulting in nearly constant proportions in each year for all countries.

Notable country-specific findings include

- Ethiopia, Mozambique, and Madagascar. As noted earlier, these countries sprayed similarly high numbers of structures in 2010, and their total costs did not reflect this similarity. On inspection of allocations across cost categories, we begin to see some possible explanations. Local administration and local labor costs are uniformly lower in Ethiopia, as are insecticide costs since structures are on average half as large in Ethiopia compared with Mozambique. Spray operations in Mozambique were on average 40 percent more costly than in Ethiopia and nearly 50 percent more costly than in Madagascar, also most likely reflecting the larger structure size there (requiring more spray operator time per structure) and the relatively higher cost of temporary labor.
- Benin. The disproportionate increase in cost noted earlier in 2010, is due to the shift in that year to two spray rounds per structure and due to the higher cost of

shifting country program leadership from a CCN to a TCN. As program size increases, the impact on cost of this two spray round requirement compounds. Also of note is the increasing cost for labor sourced outside the country (the U.S./Nairobi-based office [NBO in the figures] labor category) which was a consequence of shifting from a CCN chief of party (COP) to a third country national (TCN).

- Angola. The consistently increasing costs in Angola, despite a program size that remained the same in 2010 as it was in 2008, is attributable to a shift in program leadership from a CCN to a TCN, increased STTA from outside the country, increased local labor (i.e., full-time, year-round program staff) and spray operations costs.

Figure 5: Distribution of IRS Expenditures across Program Cost Categories (countries with ≥ 150,000 structures sprayed in 2010)

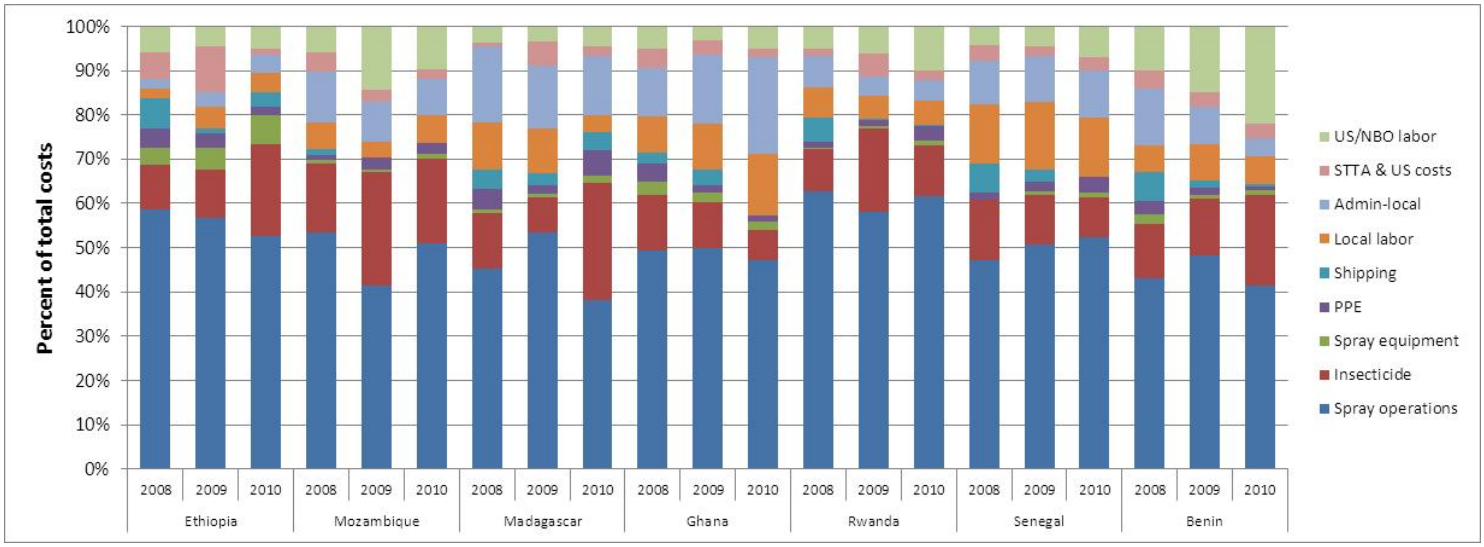
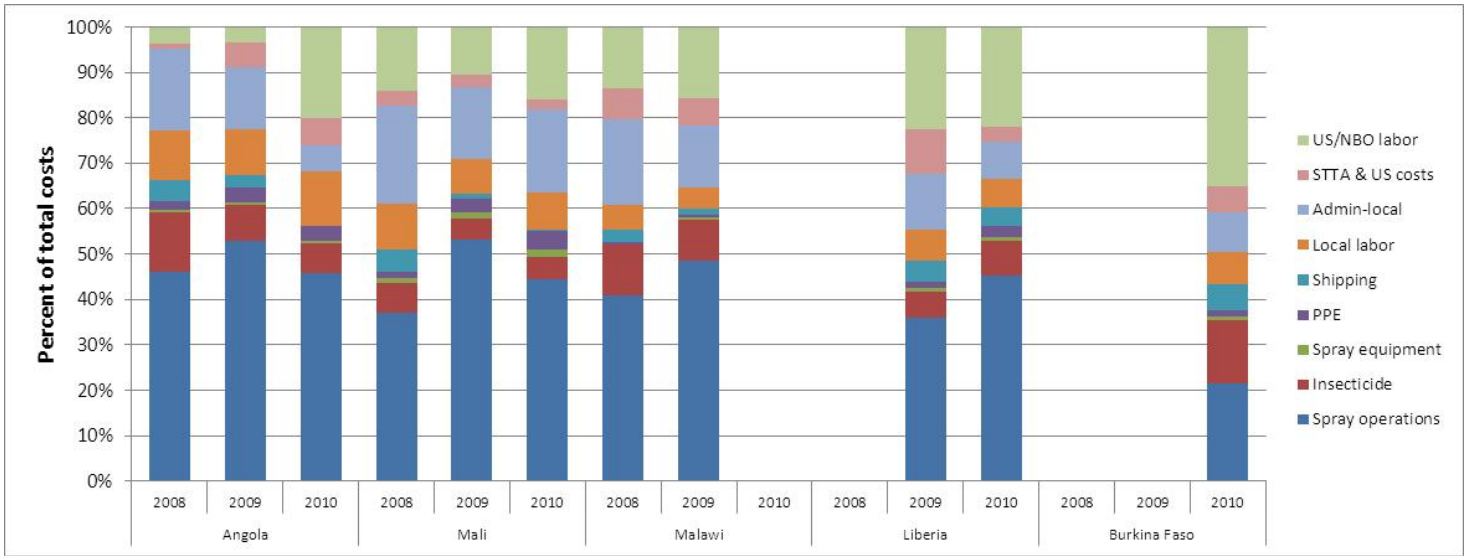


Figure 6: Distribution of IRS Expenditures across Program Cost Categories (countries with ≤ 150,000 structures sprayed in 2010)



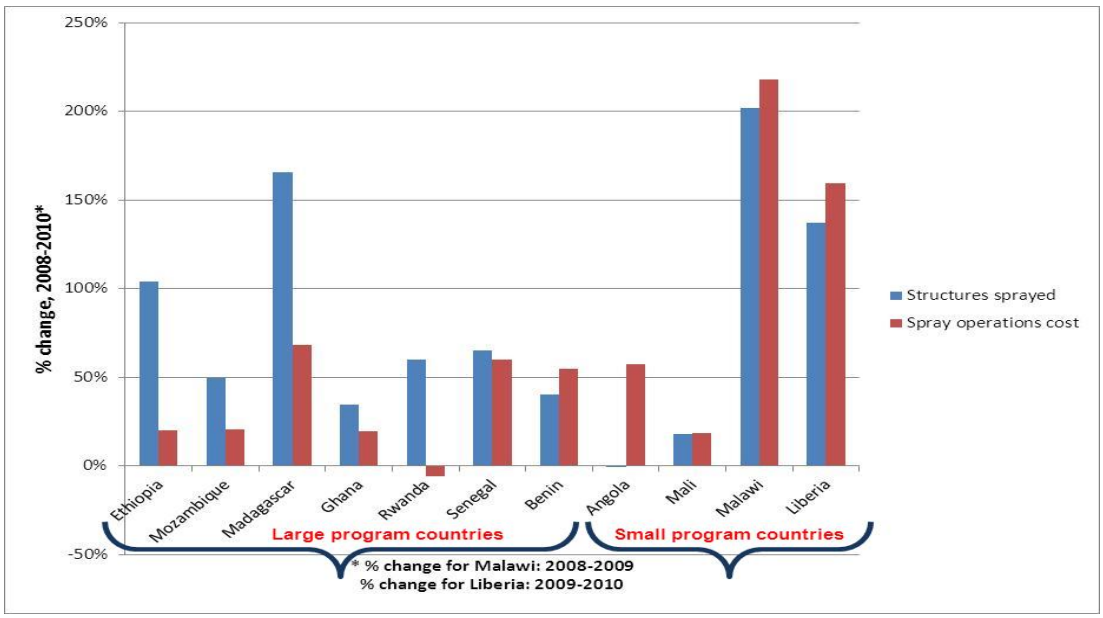
D. Changes in Costs Compared with Changes in Program Size

Comparing changes in the costs for selected cost categories with changes in program size can help to assess whether or not program efficiency is increasing. We compared program size changes from 2008 to 2010 with changes during this same period in the cost of spray operations (as a measure of technical efficiency) and changes in the costs of local administration (as a measure of administrative efficiency).

Technical Efficiency. Figure 7 compares changes in the cost of spray operations with changes in program size. In five countries out of the seven large program countries (Ethiopia, Mozambique, Madagascar, Ghana and Rwanda), the percent change in spray operations costs was appreciably lower than the percent change in program size, suggesting increased efficiency in how spray operations were conducted. In Senegal, the difference in percent changes were nearly the same and in Benin, the percent change in the cost of spray operations exceeded the percent change in program size, as noted earlier perhaps related to the need to spray each structure twice each year.

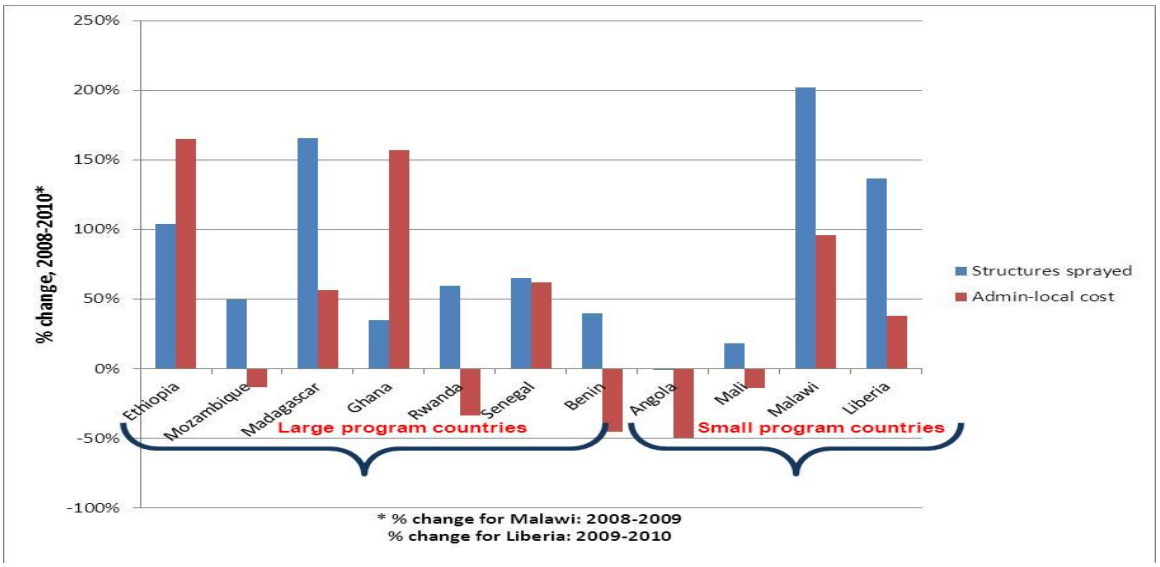
For small program countries, three of the four countries (Burkina Faso is omitted because IRS was applied only in 2010) showed a tendency towards lower efficiency, with growth in the cost of spray operations outstripping growth in the program size. This tendency was greatest in Angola where there was no change in program size from 2008 to 2010, but the increase in the cost of spray operations was greater than 50 percent. Mali was the only small program country where the percent change in spray operations cost was about the same as the percent change in program size.

Figure 7: Changes in Program Size Compared with Changes in Amount Spent on Spray Operations



Administrative Efficiency. Figure 8 compares changes in the local administrative costs with changes in program size. The picture is more mixed among the large program countries. For instance, Mozambique, Madagascar, Rwanda, and Benin show evidence of greater efficiency, with growth in program size exceeding growth in the cost of local administration. In contrast, in Ethiopia and Ghana, local administrative costs grew faster than program size and; in Senegal, the changes were commensurate with each other. All the small program countries showed evidence of increased administrative efficiency with the costs of local administration decreasing (in Angola and Mali) or increasing more slowly (in Malawi and Liberia) than growth in program size.

Figure 8: Changes in Program Size Compared with Changes in Amount Spent on Local Administration



IV. Summary and Conclusions

Findings from this analysis supplement those produced earlier for PMI-supported IRS programs implemented by its IRS and IRS 2 IQC projects. Moreover, these results shed light not only on a broader set of countries and contexts in which IRS is implemented; it also provides a longitudinal look at costs in 12 of those countries. With three years of data, patterns are beginning to emerge. Main findings are presented in this section.

Program Size Matters. At the country level, large IRS programs are less costly than small programs. It appears that somewhere around 150,000 structures is a tipping point on costs for IRS. Programs that spray more than 150,000 structures are less costly per structure sprayed and per person protected than those that spray fewer than 150,000 structures.

IRS Program Costs Are Declining over Time. Measured by mean costs per structure sprayed and per person protected, costs have declined steadily in these countries by about 25 percent from 2008 to 2010. Costs in small programs have on the other hand

increased over time, though the rate of increase appears to have slowed substantially from 2009 to 2010.

Some Economies of Scale Accrue as Large Programs Expand. This was observed for spray operations costs (technical efficiency). Time and experience may be playing a role in these economies of scale, as evidenced by the apparent lower growth rates for spray operations costs compared with program coverage growth rates in many of these large program countries. This growing efficiency will become increasingly important as a cost increase mitigation strategy as country programs switch to insecticide classes that require more than one application per structure each year. These technical efficiencies did not appear to accrue in small program countries.

Interestingly, the pattern was opposite for administrative efficiency, there being more evidence that administrative costs rose less rapidly than program growth rates in small program countries than in large program countries. Further investigation would be necessary to explain these differences in whether or not economies of scale are realized in the technical and administrative realms.

Distribution of IRS Program Costs Are Consistent across Time. Table 3 shows this consistency. For large programs, spray operations costs have declined slightly but steadily as a proportion of total annual program costs, whereas insecticide costs have increased as a proportion of total costs. Though market forces are certainly part of the explanation (the price of insecticide can change considerably from year to year and according to volume ordered), as more countries shift from a pyrethroid to the more expensive carbamate class of insecticide, this upward trend in the proportion of costs consumed by insecticide is likely to continue. As more programs shift away from pyrethroids, we can expect to see an increasing proportion of total costs being consumed by insecticide and spray operations, and as noted earlier, efficiency of spray operations will become increasingly important to hold down costs of IRS.

For small programs, the distribution of costs across cost categories was less stable over time, largely because of the increase in the average proportion allocated to local administration and to external assistance (i.e., STTA and in-country leadership from TCNs).

At the individual country level (Figures 5 and 6), allocation of resources across cost categories shows greater variation, both across time and across countries. Factors such as change in country leadership from CCN to TCN, shifts from vehicle rental to purchase for administrative transportation needs, and other factors influence these patterns and are likely to continue to do so.

Annex 1 – Inflation, GDP Deflator (annual %)[a]

Country Name	Country Code	2008	2009	2010
Angola	AGO	19.7	-7.4	26.6
Benin	BEN	7.1	0.9	1.8
Burkina Faso	BFA	5.8	3.1	4.0
Ethiopia	ETH	30.3	24.2	3.8
Ghana	GHA	20.2	16.7	14.0
Kenya	KEN	11.9	6.7	3.9
Liberia	LBR	10.4	7.8	11.3
Madagascar	MDG	8.9	8.4	8.1
Malawi	MWI	8.9	8.4	7.7
Mali	MLI	8.8	3.5	3.6
Mozambique	MOZ	8.4	5.3	12.7
Nigeria	NGA	11.0	-4.5	7.5
Rwanda	RWA	13.3	11.5	2.1
Senegal	SEN	6.2	-1.0	1.4
South Africa	ZAF	8.9	7.2	8.1
Tanzania	TZA	10.1	7.4	7.7
United States	USA	2.2	0.9	1.0
Zambia	ZMB	12.3	10.7	11.7

[a] From The World Bank, as of August 13, 2011: http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG

Annex 2 - Values for Figures 1-8

Values for Figure 1: Cost per Structure Sprayed, 2008-2010

Year	Ethiopia	Mozambique	Madagascar	Ghana	Rwanda	Senegal	Benin
2008	$ 10.49	$ 15.59	$ 13.76	$ 12.68	$ 33.35	$ 15.07	$ 16.12
2009	$ 7.60	$ 11.57	$ 15.68	$ 9.42	$ 32.98	$ 16.46	$ 14.66
2010	$ 6.86	$ 13.19	$ 10.29	$ 11.75	$ 19.93	$ 13.11	$ 22.09

Year	Angola	Mali	Malawi	Liberia	Burkina Faso
2008	$ 21.20	$ 27.04	$ 30.92	na	na
2009	$ 33.44	$ 25.38	$ 27.45	$ 47.18	na
2010	$ 33.66	$ 22.63	na	$ 41.01	$ 38.90

Values for Figure 2: Change in Mean Cost per Structure Sprayed, 2008 to 2010

	2008	2009	2010
Large programs	$ 15.95	$ 14.40	$ 12.25
Small programs	$ 24.44	$ 29.78	$ 31.14
All programs	$ 17.12	$ 16.41	$ 14.25

Note: Minimum/maximum values depicted by the black lines on each column in Figure 2 are provided in the table for Figure 1 above.

Values for Figure 3: Cost per Person Protected, 2008-2010

Year	Ethiopia	Mozambique	Madagascar	Ghana	Rwanda	Senegal	Benin
2008	$ 3.32	$ 4.42	$ 2.26	$ 3.36	$ 7.14	$ 3.60	$ 4.41
2009	$ 2.27	$ 2.92	$ 2.66	$ 3.79	$ 7.32	$ 4.39	$ 4.47
2010	$ 2.15	$ 2.77	$ 2.05	$ 4.74	$ 4.43	$ 3.48	$ 5.79

Year	Angola	Mali	Malawi	Liberia	Burkina Faso
2008	$ 4.20	$ 6.92	$ 7.19	na	na
2009	$ 7.07	$ 7.04	$ 6.85	$ 5.90	na
2010	$ 7.04	$ 6.53	na	$ 4.71	$ 11.11

Values for Figure 4: Change in Mean Cost per Person Protected, 2008–2010

	2008	2009	2010
Large programs	$ 4.19	$ 3.75	$ 3.04
Small programs	$ 5.41	$ 6.88	$ 6.60
All programs	$ 4.38	$ 4.20	$ 3.48

Note: Minimum/maximum values depicted by the black lines on each column in Figure 4 are provided in the table for Figure 3 above.

Figure 5: Distribution of IRS Expenditures across Program Cost Categories (countries with ≥ 150,000 structures sprayed in 2010)

	Ethiopia			Mozambique			Madagascar			Ghana		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Spray operations	59%	57%	53%	54%	41%	51%	45%	53%	38%	49%	50%	47%
Insecticide	10%	11%	21%	16%	26%	19%	13%	8%	27%	13%	10%	7%
Spray equipment	4%	5%	6%	1%	1%	1%	1%	1%	2%	3%	2%	2%
PPE	4%	3%	2%	1%	2%	2%	5%	2%	6%	4%	2%	2%
Shipping	7%	1%	3%	1%	0%	0%	4%	3%	4%	2%	4%	0%
Local labor	2%	5%	4%	6%	4%	6%	11%	10%	4%	8%	10%	14%
Admin-local	2%	3%	4%	12%	9%	8%	17%	14%	13%	11%	16%	22%
STTA & US costs	6%	10%	2%	4%	3%	2%	1%	6%	2%	4%	3%	2%
US/NBO labor	6%	5%	5%	6%	14%	10%	4%	3%	4%	5%	3%	5%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

	Rwanda			Senegal			Benin		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Spray operations	63%	58%	62%	47%	51%	52%	43%	48%	42%
Insecticide	10%	19%	12%	14%	11%	9%	12%	13%	20%
Spray equipment	0%	0%	1%	0%	1%	1%	2%	1%	1%
PPE	1%	1%	3%	2%	2%	4%	3%	2%	1%
Shipping	5%	0%	0%	6%	3%	0%	7%	2%	1%
Local labor	7%	5%	5%	14%	15%	13%	6%	8%	6%
Admin-local	7%	5%	5%	10%	10%	11%	13%	8%	4%
STTA & US costs	2%	5%	2%	4%	2%	3%	4%	3%	3%
US/NBO labor	5%	6%	10%	4%	4%	7%	10%	15%	22%
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 6: Distribution of IRS Expenditures across Program Cost Categories (countries with ≤ 150,000 structures sprayed in 2010)

	Angola			Mali			Malawi		
	2008	2009	2010	2008	2009	2010	2008	2009	2010-na
Spray operations	46%	53%	46%	37%	53%	44%	41%	49%	
Insecticide	13%	8%	7%	7%	5%	5%	11%	9%	
Spray equipment	1%	1%	1%	1%	1%	2%	0%	1%	
PPE	2%	3%	3%	1%	3%	4%	1%	1%	
Shipping	5%	3%	0%	5%	1%	0%	3%	1%	
Local labor	11%	10%	12%	10%	7%	8%	6%	5%	
Admin-local	18%	14%	6%	22%	16%	18%	19%	14%	
STTA & US costs	1%	5%	6%	3%	3%	2%	7%	6%	
US/NBO labor	4%	3%	20%	14%	10%	16%	14%	16%	
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	

	Liberia			Burkina Faso		
	2008-na	2009	2010	2008-na	2009-na	2010
Spray operations		36%	45%			21%
Insecticide		6%	8%			14%
Spray equipment		1%	1%			1%
PPE		1%	3%			1%
Shipping		5%	4%			6%
Local labor		7%	6%			7%
Admin-local		12%	8%			9%
STTA & US costs		10%	3%			6%
US/NBO labor		23%	22%			35%
TOTAL		100%	100%			100%

Figure 7: Changes in Program Size Compared with Changes in Amount Spent on Spray Operations

% change: 2008-2010 in:	**Ethiopia**	**Mozambique**	**Madagascar**	**Ghana**	**Rwanda**	**Senegal**	**Benin**	**Angola**	**Mali**	**Malawi**	**Liberia**
Structures sprayed	104.3%	49.7%	165.9%	34.8%	60.0%	65.5%	40.1%	-0.1%	18.2%	201.9%	137.1%
Spray operations costs	19.8%	20.4%	68.1%	19.5%	-6.0%	59.8%	54.9%	57.4%	18.4%	218.1%	159.8%

Figure 8: Changes in Program Size Compared with Changes in Amount Spent on Local Administration

% change: 2008-2010 in:	**Ethiopia**	**Mozambique**	**Madagascar**	**Ghana**	**Rwanda**	**Senegal**	**Benin**	**Angola**	**Mali**	**Malawi**	**Liberia**
Structures sprayed	104.3%	49.7%	165.9%	34.8%	60.0%	65.5%	40.1%	-0.1%	18.2%	201.9%	137.1%
Admin-local costs	165.1%	-12.9%	56.4%	157.3%	-33.1%	62.4%	-45.3%	-49.4%	-13.7%	95.8%	38.2%

Annex 3 – Detailed Country Costs

Table A3-1: 2008–2010 IRS Program Costs, (with capital costs amortized and adjusted for inflation), Large Program Countries

Cost Category	Expenditures (US$ millions)																				
	Ethiopia[a]			Mozambique[b]			Madagascar			Ghana			Rwanda			Senegal			Benin		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operations	1.95	1.98	2.34	3.45	2.73	4.15	1.35	1.81	2.27	1.59	1.34	1.90	3.96	5.64	3.73	1.09	1.47	1.75	0.99	1.10	1.53
Insecticide	0.34	0.38	0.92	1.00	1.70	1.57	0.37	0.27	1.58	0.41	0.28	0.28	0.60	1.84	0.70	0.32	0.32	0.30	0.29	0.30	0.75
Spray equipment	0.12	0.17	0.28	0.05	0.05	0.08	0.02	0.03	0.10	0.10	0.06	0.07	0.03	0.05	0.06	0.00	0.03	0.03	0.05	0.02	0.04
PPE	0.15	0.12	0.09	0.07	0.16	0.19	0.14	0.06	0.34	0.13	0.04	0.06	0.09	0.14	0.20	0.04	0.06	0.13	0.07	0.04	0.03
Shipping	0.23	0.03	0.15	0.09	0.00	0.00	0.13	0.09	0.24	0.08	0.10	0.00	0.35	0.04	0.03	0.15	0.07	0.00	0.15	0.04	0.02
Local labor	0.08	0.17	0.19	0.38	0.24	0.53	0.32	0.35	0.23	0.27	0.28	0.56	0.44	0.49	0.32	0.31	0.44	0.44	0.14	0.19	0.23
Admin-local	0.07	0.12	0.18	0.75	0.60	0.65	0.51	0.48	0.80	0.35	0.42	0.88	0.44	0.44	0.28	0.23	0.30	0.37	0.30	0.19	0.16
STTA & U.S. costs	0.20	0.36	0.07	0.29	0.17	0.19	0.03	0.19	0.13	0.14	0.09	0.08	0.10	0.51	0.13	0.08	0.07	0.10	0.09	0.08	0.12
U.S./Nairobi labor	0.19	0.16	0.22	0.37	0.95	0.79	0.11	0.12	0.26	0.17	0.08	0.20	0.33	0.60	0.60	0.10	0.13	0.23	0.23	0.34	0.81
TOTAL Costs	**3.32**	**3.49**	**4.44**	**6.44**	**6.61**	**8.15**	**2.98**	**3.39**	**5.93**	**3.22**	**2.68**	**4.03**	**6.33**	**9.73**	**6.05**	**2.32**	**2.90**	**3.34**	**2.30**	**2.29**	**3.69**
Structures sprayed ('000)	317	459	647	413	571	618	217	216	576	254	285	343	190	295[c]	304	154	176[d]	255	143	156	167[e]
People protected ('000)[f]	1,000	1,539	2,064	1,457	2,263	2,945	1,320	1,275	2,895	602	708	850	886	1,329	1,366	645	662	960	522	512	636

[a] Insecticide used for IRS TO1 operations in Ethiopia were financed by USAID outside the project mechanism and procured from a domestic Ethiopian source.
[b] Insecticide used for IRS TO1 operations in Mozambique was financed and procured through a Global Fund grant to the country.
[c] In Rwanda, among the total number of structures sprayed, 191,051 of these 295,174 structures were sprayed twice.
[d] In Senegal, among the total number of structures sprayed, 21,589 of these 176,279 structures were sprayed twice.
[e] In Benin in 2010, two spray rounds were conducted to cover each structure twice. In the first round, 166,910 structures were sprayed. During the second round, 200,036 structures were sprayed (due to increased coverage rates and because new structures were found in the target areas.
[f] In this analysis, “people protected” is calculated as the total number of people living in structured sprayed during the IRS campaign. People living in structures not sprayed are not counted as “people protected.”

Table A3-2: 2008–2010 IRS Program Costs, (with capital costs amortized and adjusted for inflation), Small Program Countries

Cost Category	Expenditures (US$ millions)														
	Angola			Mali			Malawi			Liberia			Burkina Faso		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operations	1.33	1.82	2.09	1.08	1.71	1.28	0.31	1.00			0.35	0.90			0.28
Insecticide	0.37	0.27	0.30	0.19	0.15	0.14	0.09	0.18			0.06	0.15			0.18
Spray equipment	0.02	0.02	0.03	0.03	0.04	0.05	0.00	0.01			0.01	0.02			0.01
PPE	0.06	0.12	0.15	0.04	0.10	0.12	0.00	0.01			0.01	0.05			0.02
Shipping	0.13	0.09	0.00	0.15	0.04	0.00	0.02	0.03			0.05	0.08			0.07
Local labor	0.32	0.35	0.54	0.29	0.24	0.24	0.04	0.09			0.06	0.13			0.10
Admin-local	0.52	0.47	0.26	0.63	0.51	0.53	0.14	0.28			0.12	0.16			0.11
STTA & U.S. costs	0.03	0.19	0.28	0.10	0.09	0.06	0.05	0.12			0.09	0.06			0.08
U.S./Nairobi labor	0.11	0.12	0.92	0.41	0.34	0.46	0.10	0.32			0.22	0.44			0.46
TOTAL Costs	**2.88**	**3.44**	**4.57**	**2.91**	**3.22**	**2.88**	**0.77**	**2.05**			**0.96**	**1.98**			**1.32**
Structures sprayed ('000)	136	103	136	108	127	127	25	75			20	48			34
People protected ('000)[e]	686	486	650	420	457	441	106	300			163	421			119

Table A3-3: 2008–2010 IRS Program Expenditures, (actual expenditures, without capital costs amortized and without inflation adjustment), Large Program Countries

Cost Category	Expenditures (US$ millions)																				
	Ethiopia[a]			Mozambique[b]			Madagascar			Ghana			Rwanda			Senegal			Benin		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operations	1.61	1.66	2.25	3.10	2.09	4.03	1.15	1.43	2.27	1.20	1.05	1.89	3.50	4.46	3.72	1.09	1.16	1.75	0.96	0.87	1.53
Insecticide	0.29	0.35	0.92	0.86	1.57	1.57	0.32	0.25	1.58	0.35	0.26	0.28	0.52	1.70	0.70	0.27	0.30	0.30	0.25	0.28	0.75
Spray equipment	0.56	0.26	0.56	0.23	0.00	0.18	0.09	0.02	0.31	0.30	0.04	0.06	0.11	0.10	0.08	0.01	0.07	0.09	0.11	0.00	0.06
PPE	0.22	0.06	0.10	0.08	0.20	0.15	0.18	0.00	0.46	0.14	0.03	0.10	0.23	0.07	0.21	0.09	0.07	0.13	0.12	0.00	0.04
Shipping	0.20	0.03	0.15	0.08	0.00	0.00	0.11	0.09	0.24	0.07	0.09	0.00	0.31	0.03	0.03	0.13	0.07	0.00	0.13	0.03	0.02
Local labor	0.06	0.14	0.19	0.32	0.19	0.53	0.27	0.27	0.23	0.20	0.22	0.56	0.38	0.39	0.32	0.31	0.35	0.44	0.13	0.15	0.23
Admin-local	0.07	0.10	0.27	0.65	0.48	0.66	0.45	0.37	0.79	0.31	0.38	0.89	0.42	0.38	0.26	0.23	0.28	0.38	0.34	0.13	0.16
STTA & U.S. costs	0.19	0.35	0.07	0.27	0.17	0.19	0.03	0.18	0.13	0.13	0.09	0.08	0.10	0.49	0.13	0.08	0.06	0.10	0.09	0.08	0.12
U.S./Nairobi labor	0.18	0.16	0.22	0.35	0.93	0.79	0.10	0.11	0.26	0.16	0.08	0.20	0.31	0.58	0.60	0.09	0.13	0.23	0.21	0.33	0.81
TOTAL Costs	**3.38**	**3.12**	**4.72**	**5.94**	**5.63**	**8.11**	**2.71**	**2.72**	**6.26**	**2.86**	**2.25**	**4.06**	**5.88**	**8.21**	**6.05**	**2.33**	**2.49**	**3.42**	**2.36**	**1.87**	**3.72**

Structures sprayed ('000)	317	459	647	413	571	618	217	216	576	254	285	343	190	295[c]	304	154	176[d]	255	143	156	167[e]
People protected ('000)[f]	1,000	1,539	2,064	1,457	2,263	2,945	1,320	1,275	2,895	602	708	850	886	1,329	1,366	645	662	960	522	512	636

[a] Insecticide used for IRS TO1 operations in Ethiopia were financed by USAID outside the project mechanism and procured from a domestic Ethiopian source.
[b] Insecticide used for IRS TO1 operations in Mozambique was financed and procured through a Global Fund grant to the country.
[c] In Rwanda, among the total number of structures sprayed, 191,051 of these 295,174 structures were sprayed twice.
[d] In Senegal, among the total number of structures sprayed, 21,589 of these 176,279 structures were sprayed twice.
[e] In Benin in 2010, two spray rounds were conducted to cover each structure twice. In the first round, 166,910 structures were sprayed. During the second round, 200,036 structures were sprayed (due to increased coverage rates and because new structures were found in the target areas.
[f] In this analysis, "people protected" is calculated as the total number of people living in structured sprayed during the IRS campaign. People living in structures not sprayed are not counted as "people protected."

Table A3-4: 2008–2010 IRS Program Expenditures, (actual expenditures, without capital costs amortized and without inflation adjustment), Small Program Countries

Cost Category	Expenditures (US$ millions)														
	Angola			Mali			Malawi			Liberia			Burkina Faso		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operations	1.15	2.72	2.08	1.02	1.36	1.28	0.27	0.79			0.27	0.90			0.28
Insecticide	0.32	2.72	0.30	0.16	0.14	0.14	0.07	0.17			0.05	0.15			0.18
Spray equipment	0.09	2.72	0.04	0.14	0.01	0.09	0.00	0.04			0.04	0.05			0.04
PPE	0.18	2.72	0.04	0.08	0.03	0.12	0.00	0.03			0.03	0.09			0.04
Shipping	0.11	2.72	0.00	0.13	0.04	0.00	0.02	0.03			0.04	0.08			0.07
Local labor	0.27	2.72	0.54	0.27	0.19	0.24	0.04	0.07			0.05	0.13			0.10
Admin-local	0.45	2.72	0.31	0.65	0.41	0.53	0.13	0.22			0.11	0.17			0.12
STTA & U.S. costs	0.03	2.72	0.28	0.09	0.09	0.06	0.05	0.12			0.09	0.06			0.08
U.S./Nairobi labor	0.10	2.72	0.92	0.38	0.33	0.46	0.10	0.31			0.21	0.44			0.46
TOTAL Costs	**2.71**	**2.72**	**4.51**	**2.93**	**2.58**	**2.92**	**0.68**	**1.79**			**0.90**	**2.06**			**1.38**
Structures sprayed ('000)	136	103	136	108	127	127	25	75			20	48			34
People protected ('000)[e]	686	486	650	420	457	441	106	300			163	421			119