



PRESIDENT'S MALARIA INITIATIVE



PMI IRS COUNTRY PROGRAMS: 2016 COMPARATIVE COST ANALYSIS

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ACRONYMS

AIRS	Africa Indoor Residual Spraying
CFV	Control Flow Valve
EC	Environmental Compliance
IEC	Information, Education and Communication
IRS	Indoor Residual Spraying
IT	Information Technology
M&E	Monitoring and Evaluation
MOH	Ministry of Health
NgenIRS	Next Generation IRS
NMCP	National Malaria Control Program
OP	Organophosphate
PMI	President's Malaria Initiative
SOP	Spray Operator
STTA	Short-term Technical Assistance
USAID	United States Agency for International Development
WHO	World Health Organization

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EXECUTIVE SUMMARY

The President's Malaria Initiative (PMI) began implementing indoor residual spraying (IRS) programs in 2006, with a goal of reducing the incidence and prevalence of malaria. The Africa Indoor Residual Spraying (AIRS) Project, implemented from 2011-2014, along with its follow-on project the PMI AIRS Project, currently being implemented from 2014-2017, together constitute PMI's leading pan-African IRS initiative, which has provided program support and implementation of IRS activities since August 2011. This report presents the cost analysis of the expenses incurred during 2016 and compares these costs to IRS costs from 2012, 2013, 2014, and 2015.

The aim of the assessment is to:

1. Evaluate the overall level of IRS spending in each of the PMI AIRS countries, by program activity and by cost category;
2. Calculate and compare the unit costs of IRS in each country, including the cost per person protected, cost per structure sprayed, and cost per area sprayed (per 100 m²);
3. Provide cost comparisons for overall annual expenditure trends within countries over the first five years of the program.

Costing data will support PMI and host countries in the decision-making process of planning and prioritizing future investments. Findings may also help to inform local governments in the planning, funding, management, or implementation of IRS programs.

Through a collaborative process with PMI, project technical, monitoring and evaluation (M&E), financial, and operational staff, the costing team:

1. *Collected project expenditures and output measures.* Financial data were collected from Abt Associates' internal financial tracking systems for the past four years. Information collected was augmented and verified through staff interviews. Program output and operational data were collected from the AIRS M&E systems.
2. *Categorized all financial expenditures according to the methodology framework.* The costing framework used in this analysis includes: (1) capital and recurrent costs, (2) technical program activities, and (3) cost categories. All capital costs are annualized for this report. All costs are reported in 2016 in U.S. dollars; costs from previous years are adjusted for inflation.

Costs in 2016

Project output data, listed in Table CC1, was collected and verified by PMI AIRS M&E staff for the eleven countries with PMI-funded IRS campaigns that were implemented through the PMI AIRS Project in 2016. In total, over 13 million people were protected,

ranging from approximately 496,728 people in Senegal to over 2.6 million people in Zambia. This corresponds to about 3.9 million total structures sprayed, ranging from 124,757 structures in Senegal to 715,541 structures in Ethiopia, a total of over 367 million square meters of structures sprayed, and a total of over 1.7 million sachets or bottles of insecticide used.

The average structure size varied widely across countries, ranging from 42.9 square meters (m²) in Madagascar to 160.6 m² in Rwanda. The average people per structure sprayed ranged from 2.4 people in Zimbabwe and Ethiopia to 4.8 people in Mozambique.

Table CC3 presents the results of the unit cost analysis. The countries have been grouped into two categories (medium and large) based on the size of the program in terms of number of structures sprayed.

The overall unweighted average cost per person protected is \$6.00. The average cost per person protected by program size is \$4.99 for large programs and \$7.75 for medium programs. The unweighted average cost per structure sprayed across countries was \$20.85. The average cost per structure sprayed for large programs is \$19.30 and for medium programs is \$23.55. The unweighted average cost per 100 m² sprayed is \$25.62.

Cost Components in 2016

Country program expenditures were divided into six cost categories: insecticide, spray commodities, spray operations, full-time local labor, local administration, and U.S.-based labor and short-term technical assistance. Details on the types of expenditures included in each cost category can be found in the 2014 report (Johns 2015)¹. The three largest cost categories were insecticide (39.1 percent of all costs), spray operations (29.3 percent of all costs), and local labor (17.2 percent of all costs), constituting an average of 85.6 percent of all costs.

Insecticide

To prevent and manage the increasing challenge of insecticide resistance, the majority of IRS countries switched to the organophosphate Actellic CS in 2016. On average, the portion of insecticide cost per 100 m² sprayed is \$6.67 for countries that used organophosphates with other classes of insecticides, and \$9.63 for organophosphates. These costs reflect the insecticide used (not the insecticide purchased).

Next Generation IRS (NgenIRS) Project

NgenIRS copayments allowed the procurement of additional Actellic CS in three countries (Ethiopia, Mali, and Zambia), while enabling the wider adoption of Actellic CS in Rwanda (in place of carbamates). This allowed IRS to protect an additional 146,676 people with long lasting insecticide, on average, across the five countries. Note that

¹ Available at <http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4>.

costs presented in this report are the prices paid by PMI for the insecticide in NgenIRS-supported countries and do not consider the amount of the NgenIRS subsidy.

Spray Operations

Spray operations include costs associated with temporary labor of spray operators (SOPs), ground transportation, warehousing costs, etc. The three countries that sprayed the most area per day (Ethiopia, Mozambique, and Rwanda) also had the lowest spray operations costs per 100 m² sprayed. However, among countries that sprayed a similar amount of area per day, there is wide variation in the spray operations costs per 100 m² sprayed. Spray operations thus varied as a proportion of the total cost per 100 m² sprayed from 18 percent of costs in Senegal to 44 percent of costs in Zambia.

Full-Time Local Labor

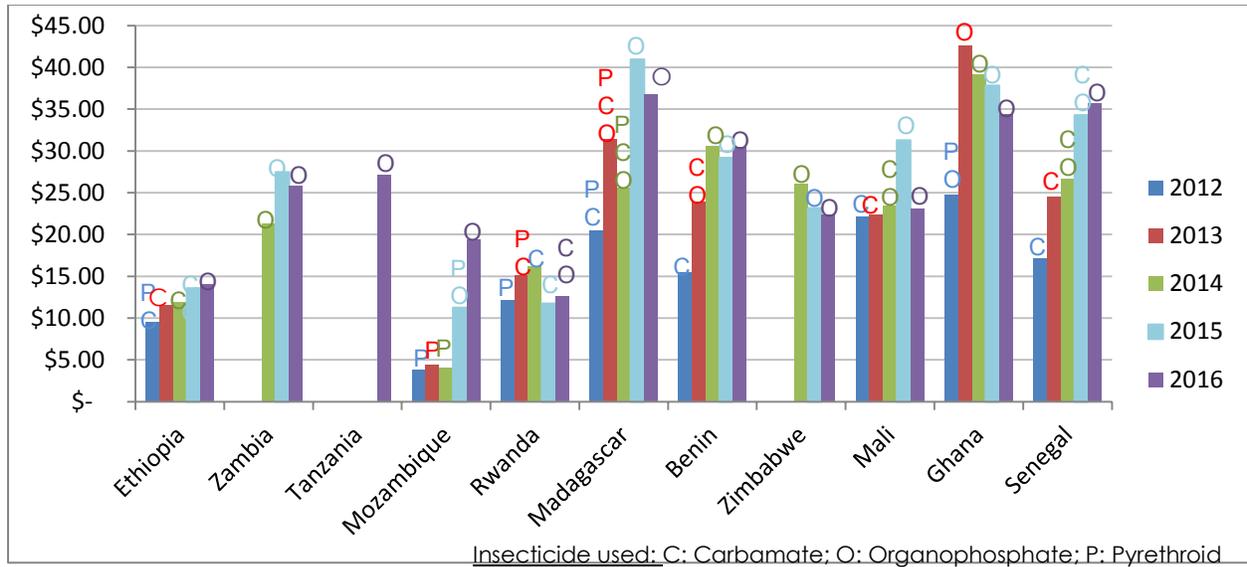
Local labor includes the country site office full-time staff members. The local labor portion of the unit costs per 100 m² sprayed ranged from \$1.09 in Rwanda to \$11.26 in Senegal, with an average of \$4.72. The unit cost of local labor per area sprayed tends to be lower for larger programs and higher for smaller programs.

Year-on-Year Comparison

All countries, with the exception of Senegal, increased the number of structures sprayed in 2016 from 2015: Ethiopia (2 percent), Zambia (8 percent), Mozambique (20 percent), Rwanda (1 percent), Madagascar (25 percent), Benin (7 percent), Zimbabwe (41 percent), Mali (71 percent), and Ghana (3 percent). Senegal (-4 percent) sprayed fewer structures.

Figure ES1 shows the unit costs for the countries included in this analysis for the years 2012 through 2016, as well as the type of insecticide used. It shows that cost per area sprayed in 2016 is generally lower or about the same as in 2015 for Zambia, Madagascar, Zimbabwe, Mali, and Ghana. Cost per 100 m² sprayed increased in Ethiopia, Mozambique, Rwanda, and Senegal in association with the introduction of organophosphate insecticides for some or all of the areas sprayed. Costs per area sprayed increased in Benin. The non-insecticide portion of the cost per 100 m² sprayed was less in 2016 than it was in 2015 in Rwanda, Madagascar, Zimbabwe, Mali, and Ghana. In Ethiopia, Zambia, Mozambique, Benin, and Senegal, the non-insecticide portion of the cost per 100 m² increased, while overall the amount of area sprayed changed by less than 7 percent from 2015 to 2016 in these five countries.

FIGURE ESI: COST PER 100M² SPRAYED 2012 THROUGH 2016



Country Chapters

This report includes a more detailed and specific chapter for each IRS country program covered in this analysis. The country chapters each include a background section with relevant country context, M&E data, total program costs, and unit costs per person protected, per structure sprayed, and per area sprayed. These chapters also include a more detailed analysis of unit costs between 2015 and 2016.

CONCLUSIONS

Limitations

Limitations in available data influence the results. In-kind contributions by host governments may be provided (e.g., supervision or information, education, and communication material), but this is generally unknown and varies by government and spray campaign; therefore, they have not been included in this report.

Comparing unit costs across countries poses limitations in conclusive results as well. It is important to note that variations between countries, unrelated to the IRS program structure or implementation, can account for differences in cost. Country differences include geography and breadth of spray coverage areas, average size of structures, and number malaria transmission seasons. In addition, differences in country input prices may cause variations in unit costs that are not attributable to program efficiency.

As in past reports, we use the area sprayed as the unit for comparing costs across countries. This unit allows for a standardized metric to compare the relative efficiency of country programs that is not influenced by differences in the size of structures or the number of people per structure across countries. However, the true area sprayed is not measured routinely in PMI AIRS country programs. Rather, we estimate the area sprayed

based on the amount of insecticide used. Thus, there still remains the possibility for differences in the efficiency of insecticide use between countries (due to differing spray equipment, etc.) that affect the comparisons. Further, the efficacy of use may change over time; for example, there may be higher efficiency in terms of flow rate when spray pumps are equipped with a control flow valve (CFV), such as those that come standard on Goizper pumps. Thus, some degree of inaccuracy in the comparisons is possible, and should be kept in mind when reading the results.

Program Scale

Broadly speaking, we find, similar to previous years, that unit costs for large programs are lower than for medium programs (although larger programs tend to cost more in total). Using the most standardized comparison unit cost available, there is no 'one-price-fits-all' for IRS across countries. Large-sized programs averaged a cost per 100 m² sprayed of \$23.76, and medium programs averaged \$28.87.

Insecticide

Insecticide makes up the largest cost category across the IRS programs when looking at the cost per 100 m² sprayed and in terms of total expenditures. The insecticide portion of the cost per area sprayed constitutes an average of 37 percent of the total unit cost across country programs. Costs of insecticides in this report reflect the cost of insecticides used (inclusive of the lower amount paid for insecticides through the NGenIRS program).

INTRODUCTION

I.1 BACKGROUND

The President's Malaria Initiative (PMI) aims to reduce the incidence and prevalence of malaria. PMI has provided IRS program support to Ministries of Health (MOHs) and National Malaria Control Programs (NMCPs) in sub-Saharan Africa since 2006. In April 2015, PMI's 2015-2020 strategy was released with specific objectives to: 1) reduce malaria mortality by one-third from 2015 levels in PMI-supported countries, achieving a greater than 80 percent reduction from PMI's original 2000 baseline levels, 2) reduce malaria morbidity in PMI-supported countries by 40 percent from 2015 levels, and 3) assist at least five PMI-supported countries to meet the WHO criteria for national or sub-national pre-elimination. The Africa Indoor Residual Spraying (AIRS) Project, implemented from 2011-2014, along with its follow-on project the PMI AIRS Project, currently being implemented from 2014-2018, together constitute PMI's leading pan-African IRS initiative.

In 2016, the PMI AIRS Project provided 11 PMI-supported countries with full IRS operations and logistics support (Benin, Ethiopia, Ghana, Madagascar, Mali, Mozambique, Rwanda, Senegal, Tanzania, Zambia, and Zimbabwe).

The PMI AIRS Project implements all aspects of the IRS process, including:

- Planning and forecasting IRS programming with government, community leaders, and other key stakeholders;
- Procuring insecticides and spray equipment/materials;
- Managing the supply chain of all IRS equipment and materials;
- Working with local leaders and organizations to ensure community awareness and knowledge of IRS campaign objectives, benefits, and timelines; and working with communities to provide further buy-in and further sensitization regarding malaria control for neighboring communities;
- Implementing IRS campaigns in targeted areas;
- Ensuring environmental compliance (EC) of IRS campaigns, and materials used in the campaigns;
- Monitoring and evaluating all program activities; and
- In most countries, completing entomological surveillance, and testing insecticide effectiveness.

PMI also seeks to ensure sustainability of IRS and other malaria control approaches. It therefore expects the PMI AIRS Project to empower country governments, the private sector, and communities by developing local knowledge and technical capacity needed to lead future IRS efforts. To this end, the project works closely with MOHs and

NMCPs, health centers, and community leaders to encourage and enable their involvement in malaria control planning and implementation. In some countries, the project partners with local organizations that complete entomological surveillance and information, education, and communication (IEC) activities.

PMI requested the Project to provide annual comparative cost analyses on the total and unit costs of the IRS country programs. This report builds upon the 2012, 2013, 2014, and 2015 findings by reporting on 2016 costs and comparing them with those of the previous three years.

1.2 OBJECTIVE

This report presents and compares the findings of a cost analysis of the expenses that were incurred during the last five years of IRS program implementation in eleven PMI countries, using a methodology that can be repeated on an annual basis. The purpose of the assessment is to evaluate the unit costs and the overall level of spending, by program activity and by cost category, in each of these countries.

The analysis separates capital expenditure items (used throughout full project implementation), and recurrent expenditure items (for each year of program implementation). The analysis also includes the cost of items inherited from previous IRS programs, as provided in each country's disposition inventory, as well as the cost of insecticides provided by local governments (where possible) in order to reflect the full cost of program implementation. These categories are defined in detail in the 2014 report (Johns 2015)².

Conducted annually over the course of the project, the analyses will provide cost comparisons for overall annual expenditure trends within and across countries.

1.3 TARGET AUDIENCE

The results and findings of the cost analysis will be used by PMI and host countries to make informed decisions about how and at what funding level to invest in IRS in the future. The findings will also be used by Project staff for program management, and may be shared with PMI's government partners and other key stakeholders to inform them of specific costs of implementing an IRS program in their respective countries. PMI also intends to share findings broadly with global partners and post the analysis on its publicly available website.

² Available at <http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4>.

2. APPROACH

The methodology used for the analyses presented in this report is generally the same as used for the reports from 2012, 2013, 2014, and 2015 (Abbott 2013, Abbott 2014, Johns 2015, Johns 2016). In this report, all insecticide costs reflect the cost of the insecticide used, rather than the expenditures for insecticide procurement (as was done in the 2015 report, but not done in reports prior to 2015). Insecticide costs are estimated based on the unit cost of insecticides procured, with the unit costs incurred in procurement then applied to the amount of insecticide used.

In keeping with the methodology used in the 2014 report, the useful life of capital items reflects a six-year timeframe for implementation. Items with an expected useful life of less than six years (boots, overalls, and other personal protective equipment) were not changed. Further, in the year-to-year comparisons, we did not apply inflation to insecticide costs. Insecticides are internationally available goods; when assessing the price of insecticides across the past four years, price changes do not appear to be correlated with the inflation rates in individual countries. We do adjust all other cost inputs for inflation, as described below and done in previous years' reports.

For a detailed description of the methodology and assumptions used, as well as limitations, please refer to the 2014 report (Johns 2015)³.

This comparative costing analysis covers IRS implementation in 2012, 2013, 2014, 2015, and 2016. However, the dates of each program year (the period of program implementation) vary by country. The specific program dates for each country program can be found in the respective country chapter.

³ Available at <http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4>.

3. CROSS-COUNTRY RESULTS

3.1 BACKGROUND

Output Measures

Table CC1 presents the coverage provided by the PMI AIRS project's spray campaigns in each country. The area sprayed (number of 100 m² sprayed) was calculated by multiplying the total number of sachets/bottles of insecticide used by 250 m², the estimate of coverage provided by each sachet/bottle, and dividing by 100 m² in order to develop a more usable unit of measure. Note that in Rwanda, total number of sachets used in the February spray round was multiplied by 200 m² because the programs use an 8L spray tank (and smaller (100g) sachets), which holds less insecticide than in other countries, and thus covers less surface area. The average size of a structure in each country was calculated by the total area sprayed divided by the number of structures sprayed. The number of people per area sprayed was calculated by dividing the total population protected by the area sprayed in terms of 100 m², and ranged from 2.1 in Zimbabwe to 9.4 in Madagascar. Note that one sachet of carbamate is equivalent to one bottle of organophosphate.

TABLE CC1: PMI AIRS PROJECT SPRAY COVERAGE IN 2016, BY COUNTRY

Country	# of People Protected	# of Structures Sprayed	Area Sprayed (100 m ²)	Avg. Size of Structure (m ²)	# People per Area Sprayed
Benin	858,113	269,179	116,543	43.3	7.4
Ethiopia	1,688,745	715,541	542,392	75.8	2.5
Ghana	570,871	211,283	117,833	55.8	4.8
Madagascar	1,257,036	310,426	133,030	42.9	9.4
Mali	788,922	228,672	211,428	92.5	3.7
Mozambique	1,929,654	405,597	637,380	157.1	3.0
Rwanda*	1,431,410	346,917	634,915	160.6	2.3
Senegal	496,728	124,757	97,973	78.5	5.1
Tanzania	2,042,561	515,217	437,933	85.0	4.7
Zambia	2,626,718	559,550	350,045	62.6	7.5
Zimbabwe	550,475	229,377	263,685	115.0	2.1

* Rwanda had two rounds of spraying in 2016 and there is some overlap in structures sprayed, therefore, some numbers are double counted.

The average structure size and number of people per area sprayed both provide additional contextual understanding of a country program's spray campaign. Structure size varied widely between countries, ranging from 42.9 m² in Madagascar to 160.6 m² in Rwanda, over three times as large. The average size of structures sprayed across all 2016 countries was 88.1 m² (not weighting for the different number of structures sprayed between countries). On average each sachet/bottle of insecticide covered about 3.4 structures.

The average size of structures may differ across the five years, even in countries that sprayed the same target areas across the years. The average structure size is calculated based on the number of insecticide sachets/bottles used and the number of structures sprayed. Thus, variations in the average size may be due to changes in spray technique efficiencies, changing the geographic target area for spray operations, or a combination of the two.

Program Size

PMI, project staff and the general IRS community define “program size” using a combination of both the total number of structures sprayed and total number of population protected. For the purpose of this costing report, IRS country programs are separated into three program sizes, using the same cut-off criteria as used in the 2013 report (based on the number of structures sprayed). Note, however, that under this classification, none of the country programs in 2016 were classified as having a ‘small’ program size, and this category is not further included in the analyses. This breakdown is summarized in Table CC2.

TABLE CC2: IRS PROGRAM SIZES

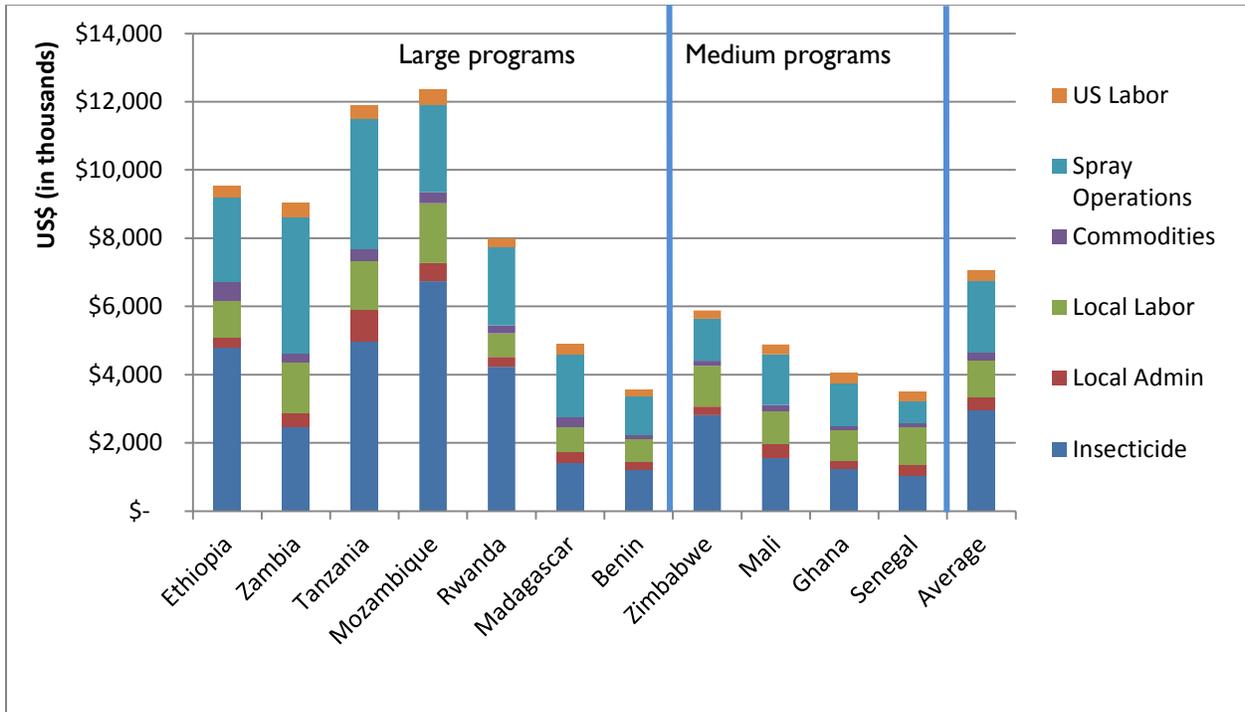
Program Size	# Structures Sprayed	Corresponding ranges within program size for following coverage variables:	
		# Population Protected	# Square Meters Sprayed
Large	230,001 – 705,000	800,001 - 2,600,000	113,401 - 650,000
Medium	100,001 – 230,000	350,000 - 800,000	98,000 - 113,400
Small	10,000 – 100,000	N/A	N/A

For a more detailed analysis, countries will be grouped and presented according to program size, as specified above.

3.2 TOTAL PROGRAM EXPENDITURES

This section presents the IRS country programs' total expenditures for 2016. Figure CC1 below includes all capital and recurrent costs of country IRS programs broken down by cost category. Countries are arranged in order of the number of structures sprayed during 2016 spray campaigns, from largest to smallest.

FIGURE CC1: CAPITAL AND RECURRENT EXPENDITURES, BY COST CATEGORY



Note: Costs of insecticides are reflective of the lower price paid through the NgenIRS project for project countries and include insecticides provided by other donors (such as the Global Fund).

The above figure shows that the U.S.-based labor and STTA cost category remains consistent across all country programs at an annual average of about \$313,000. Local administration, while more variable than the U.S.-based labor cost category, is also considered a fixed cost and averaged about \$386,000 across countries. These fixed costs are discussed in more detail in the cost-drivers analysis section. An average of 75 percent of total project expenditures is spent directly on spray operations, insecticide, and other commodities.

The average total program implementation expenditures for large and medium-sized programs are about \$8.47 million and \$4.58 million respectively.

3.3 UNIT COST ANALYSIS

This section presents country IRS programs' capital and recurrent expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²). The unit costs, shown in Table CC3, are calculated using total program expenditures and the output measures provided in Table CC1.

TABLE CC3: 2016 IRS PROGRAM UNIT COSTS

Program Size	Country	Cost per Person Protected	Cost per Structure Sprayed	Cost per Area Sprayed
Large	Ethiopia	\$ 5.66	\$ 13.35	\$ 14.09
	Zambia	\$ 3.44	\$ 16.16	\$ 25.83
	Tanzania	\$ 5.83	\$ 23.10	\$ 27.18
	Mozambique	\$ 6.41	\$ 30.48	\$ 19.40
	Rwanda	\$ 5.58	\$ 23.03	\$ 12.58
	Madagascar	\$ 3.90	\$ 15.77	\$ 36.81
	Benin	\$ 4.14	\$ 13.19	\$ 30.46
Medium	Zimbabwe	\$ 10.69	\$ 25.66	\$ 22.32
	Mali	\$ 6.19	\$ 21.37	\$ 23.11
	Ghana	\$ 7.10	\$ 19.18	\$ 34.39
	Senegal	\$ 7.04	\$ 28.02	\$ 35.67
Average (unweighted)		\$ 6.00	\$ 20.85	\$ 25.62

The following figures show each of the country IRS programs' unit costs: per person protected, per structure sprayed, and per area sprayed. Countries are ordered by number of structures sprayed, from largest to smallest.

FIGURE CC2: UNIT COSTS PER PERSON PROTECTED, BY COST CATEGORY

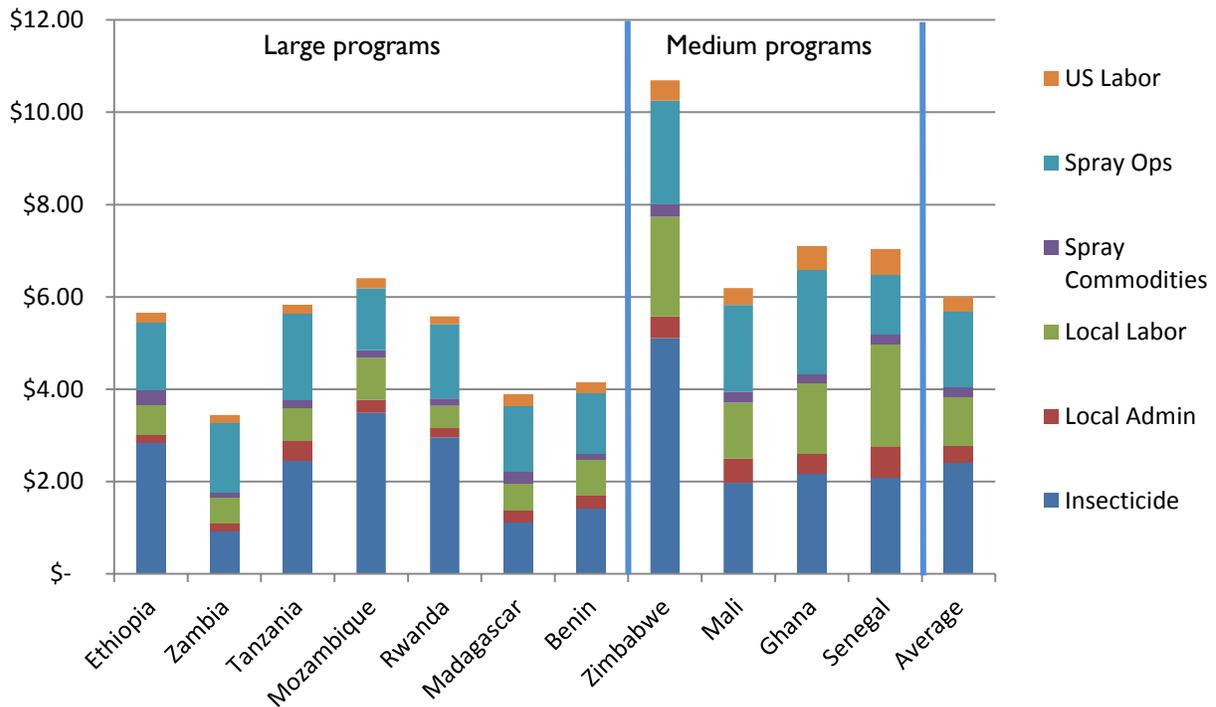


Figure CC2 shows cost per person protected, broken down by cost category. The overall unweighted average is \$6.00. The average cost per person protected by program size is \$4.99 for large programs, and \$7.75 for medium programs. As observed in past studies, the size of the program is correlated with unit costs, with smaller programs tending to have higher unit costs. However, as explored in further sections, other factors in addition to program size also explain differences in unit costs across countries.

FIGURE CC3: UNIT COSTS PER STRUCTURE SPRAYED, BY COST CATEGORY

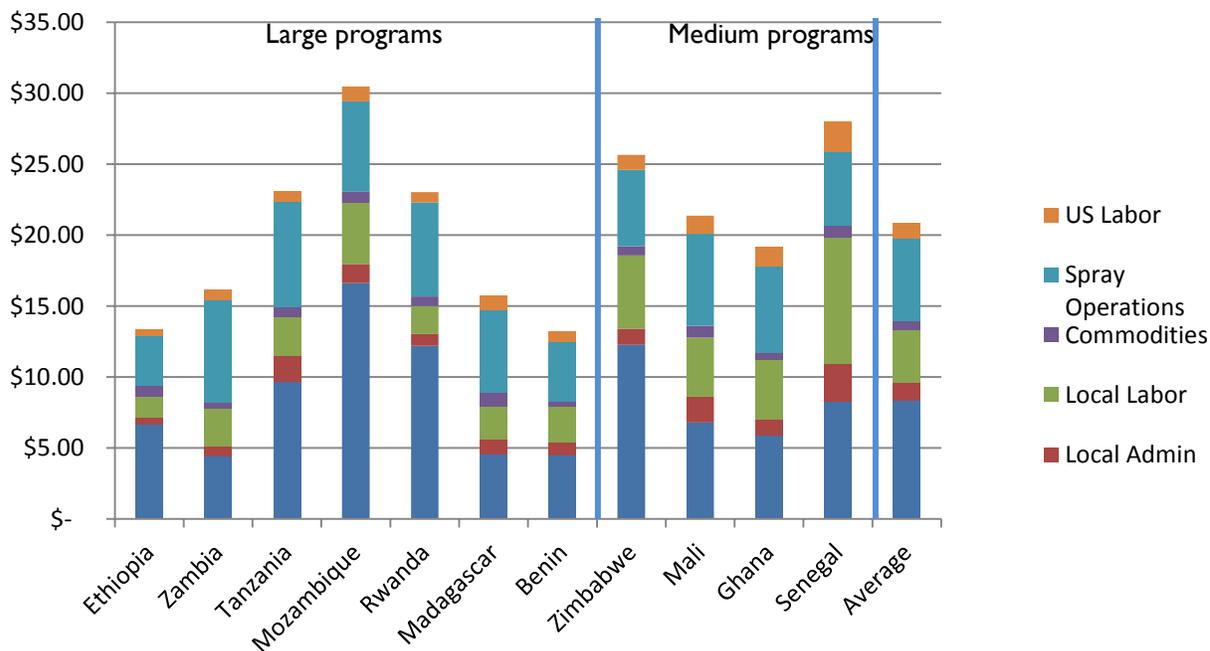


Figure CC3 shows country programs' unit costs per structure sprayed. The average cost across countries (not weighted by the number of structures sprayed in each country) was \$20.85. The average cost per structure sprayed for large programs is \$19.30, and for medium programs is \$23.55.

As stated earlier, the average size of a structure may vary greatly from one country to another, which means that even if fewer structures were sprayed, the same amount of square meters may have been covered. For example, in Figure CC3, the unit costs per structure sprayed for Madagascar is lower than Rwanda. However, in Figure CC4, the unit cost per area sprayed for Madagascar is higher than for Rwanda (Madagascar incurred \$24.23 more per area sprayed than Rwanda). This is because in Rwanda, the average size of a structure is 160.6 m², and in Madagascar the average is 42.9 m². Therefore, presenting the cost per area sprayed (in terms of 100 m²) in comparing costs across countries provides a standardized unit of measure that is not influenced by non-cost variables.

FIGURE CC4: UNIT COST PER AREA SPRAYED, BY COST CATEGORY

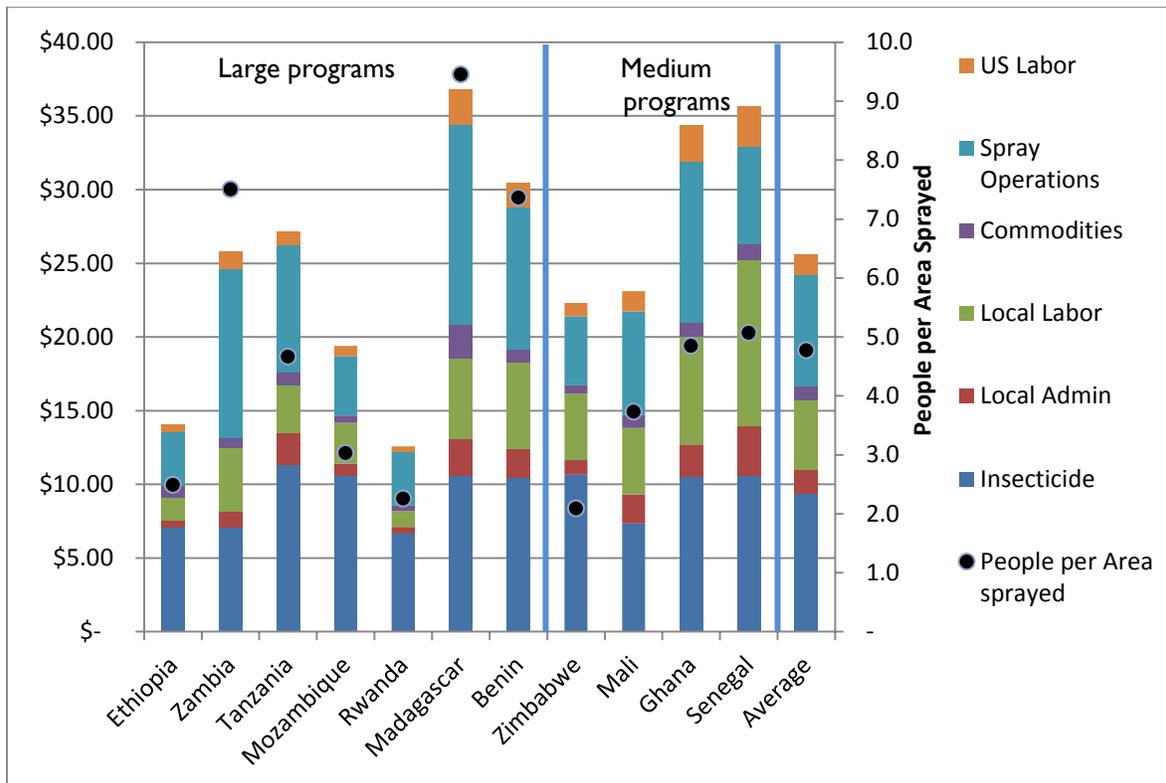


Figure CC4 shows the unit costs per area sprayed (in terms of 100 m²) broken down by cost category, and also includes black dots for the number of people per area sprayed (in terms of 100 m²) to provide context. The countries are in order of number of structures sprayed, from largest to smallest. The unweighted average of all countries is \$25.62 per area. Among the large program countries, Tanzania, Benin, and Madagascar had the highest cost per 100 m² sprayed. Rwanda, which incurred the third highest cost per person protected and per structure sprayed among the large-sized country programs, had the lowest cost per area sprayed of any of the large-sized country programs. Zimbabwe, along with Ethiopia and Rwanda, had the lowest number of people protected per area sprayed among all of the countries, which helps explain the comparatively higher unit costs in other areas relative to the cost per area sprayed.

3.4 COST DRIVERS

This section focuses on the country IRS programs' costs per area (100 m²) sprayed, in order to assess plausible explanations ("cost drivers") for differences in unit cost across the countries. A cost driver is the activity, or unit of an activity, that is responsible for significant differences in costs between one country and another. This section explores selected cost categories separately to assess and explain the variation in unit costs. This section will also continue to categorize countries by program size.

Table CC4 provides the percentage of each cost category out of the total unit cost per area sprayed. This is the first step in determining which cost categories constitute the

largest percentage of costs, and which cost categories show the most variance across countries in terms of their percentage of the total costs.

Table CC4 shows that on average, the largest cost category is insecticide, which accounts for an average of 39 percent of the unit costs. Spray operations and local labor follow as the next largest cost categories, making up an average of 29 percent and 17 percent of costs, respectively. There is variability in the cost categories between countries. For example, local labor accounts for 32 percent of the cost per area sprayed in Senegal, but 8 percent in Rwanda. Insecticides constituted between 27 percent of costs in Zambia to 54 percent of costs in Mozambique. The next step, which will be assessed later in this section, is to determine why these categories are different across countries.

TABLE CC4: BREAKDOWN OF FIXED AND VARIABLE COSTS, AS PERCENTAGE OF UNIT COST PER AREA SPRAYED

Country	Fixed Costs					Variable Costs				Total Unit Cost
	Local Admin	Capital Items	US Labor	Commodities	Total Fixed Costs	Spray Operations	Insecticide	Local Labor	Total Variable Costs	
Ethiopia	3%	5%	4%	2%	13%	26%	50%	11%	87%	\$ 14.09
Zambia	4%	1%	5%	2%	12%	44%	27%	17%	88%	\$ 25.83
Tanzania	7%	1%	3%	2%	14%	32%	42%	12%	86%	\$ 27.18
Mozambique	3%	3%	4%	1%	11%	21%	54%	14%	89%	\$ 19.40
Rwanda	3%	4%	3%	1%	10%	29%	53%	8%	90%	\$ 12.58
Madagascar	5%	7%	6%	2%	20%	37%	29%	15%	80%	\$ 36.81
Benin	5%	4%	5%	0%	15%	31%	34%	19%	85%	\$ 30.46
Zimbabwe	4%	2%	4%	1%	11%	21%	48%	20%	89%	\$ 22.32
Mali	7%	5%	6%	1%	19%	30%	32%	20%	81%	\$ 23.11
Ghana	5%	3%	7%	1%	17%	31%	31%	22%	83%	\$ 34.39
Senegal	8%	4%	7%	1%	20%	18%	30%	32%	80%	\$ 35.67
Average	5%	4%	5%	1%	15%	29%	39%	17%	85%	\$ 25.62

Madagascar and Senegal spent the largest percentage on fixed costs, and capital items represent a higher percentage of unit costs in Madagascar than in any other country.

The following sub-sections provide a more in-depth cost driver analysis of the following components: fixed costs, insecticides, and spray operations.

3.4.1 FIXED COSTS: U.S.-BASED LABOR AND LOCAL ADMINISTRATION

On average, the fixed costs of country programs are about 15 percent (range: 10 percent to 20 percent) of the total unit cost, while the average of the variable costs is 85 percent (range: 80 percent to 90 percent) of the total unit cost per 100 m² sprayed.

FIGURE CC5: FIXED COSTS PORTION OF COST PER AREA SPRAYED

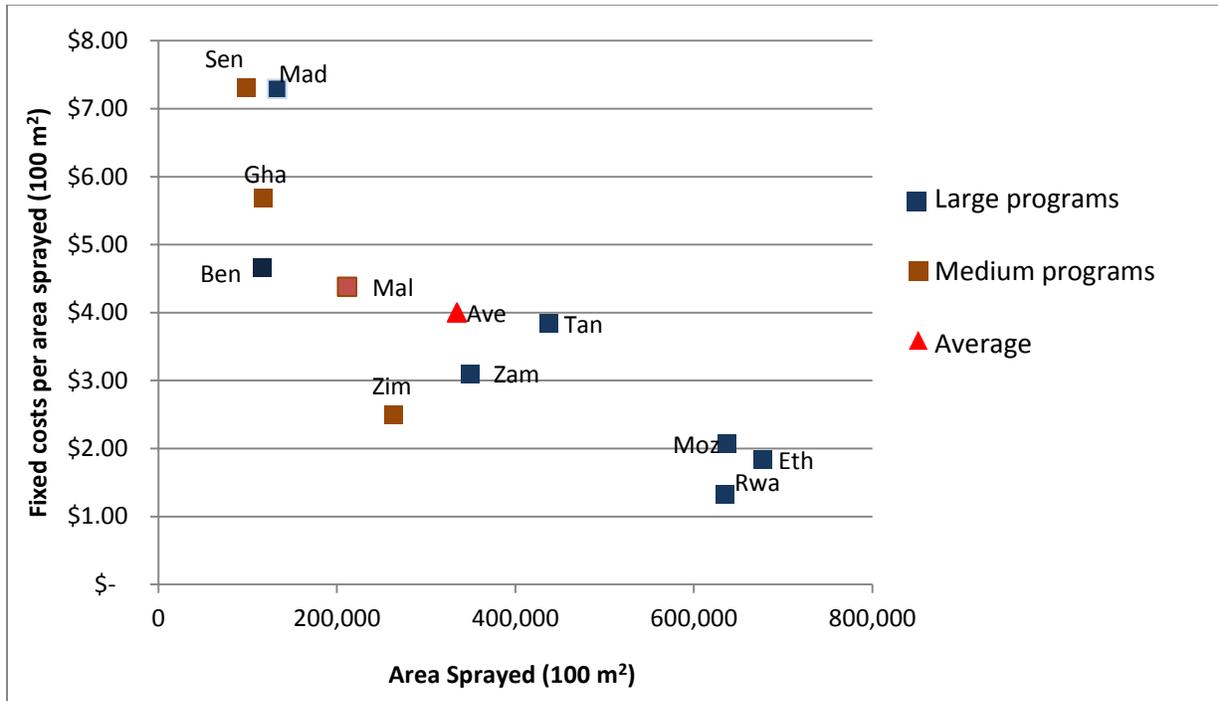


Figure CC5 shows the fixed unit cost per area sprayed (in terms of 100 m²) on the y-axis. This includes capital expenditures, commodities (PPE and other spray equipment), U.S.-based labor and STTA, and local administration costs. The x-axis shows the total area sprayed. As expected, the fixed cost per area sprayed appears to be lower in countries that sprayed more area. The fixed costs per area sprayed ranged from \$1.32 in Rwanda to \$7.31 in Senegal. Madagascar, which had a high percentage of fixed cost, also had the second highest fixed cost per area sprayed. The average fixed cost per 100 m² sprayed of the large programs is \$3.44, and for medium programs is \$4.97.

However, there is still substantial variation in the amount of fixed cost per 100 m² that is not directly correlated with the total area sprayed. For example, Senegal and Benin both sprayed similar amounts of area (98 million m² and 116 million m², respectively), yet Senegal's fixed cost per area sprayed was \$7.31, compared to \$4.66 for Benin. Senegal spent a similar amount as Benin (\$0.25 and \$0.12 per 100 m² sprayed, respectively) for commodities, but about \$1.30 more per area sprayed for local administration, and \$1.02 more for U.S. labor.

The two most expensive countries in terms of fixed costs per area sprayed were Senegal and Madagascar. Senegal had the smallest program size in terms of the number of structures and area sprayed, which help to explain its high fixed cost per area sprayed. Meanwhile, as shown in Table CC4, fixed cost makes up 20 percent of Madagascar's total unit cost. Madagascar's total unit costs is about 39 percent above average, which indicates that the expensive fixed cost per area sprayed is a function of Madagascar's expensive cost per area sprayed overall.

The following two sections will focus on insecticide and spray operations as two major cost drivers.

3.4.2 INSECTICIDE: THE COST OF RESISTANCE

As previously mentioned, the threat of insecticide resistance has forced IRS programs to switch to more expensive classes of insecticide. The impact of using more expensive classes of insecticide is seen clearly in the PMI AIRS Project: given fixed budgets, use of more expensive insecticides results in fewer people being protected by IRS, unless funds can be appropriated from other areas.

The amount and class of insecticide purchased under AIRS country programs does not always reflect the amount and class of insecticide used during the same year's spray campaign. All IRS countries used Actellic, with the exception of Rwanda that used a mix of insecticide classes in 2016. Table CC5 lists the number and class of insecticide sachets/bottles purchased and used in 2016 in the country IRS programs.

TABLE CC5: CLASS AND NUMBER OF INSECTICIDE SACHETS/BOTTLES PURCHASED AND USED IN 2016

Country	Type of insecticide(s) used	Number of sachets/ bottles purchased	Number of sachets/ bottles used	Estimated cost of insecticides used per area sprayed
Benin	Organophosphates	41,213	46,617	\$ 10.49
Ethiopia	Organophosphates	280,000	271,196	\$ 7.07*
Ghana	Organophosphates	38,558	47,133	\$ 10.52
Madagascar	Organophosphates	45,468	53,212	\$ 10.61
Mali	Organophosphates	88,195	84,571	\$ 7.34*
Mozambique	Organophosphates	221,232	254,952	\$ 10.57
Rwanda	Carbamates	121,994	122,986	\$ 6.67 (overall; \$ 5.33 for carbamates, \$ 7.72* for organophosphates)
	Organophosphates (56% of insecticide used)	173,956	155,577	
Senegal	Organophosphates	9,831	39,189	\$ 10.58
Tanzania	Organophosphates	196,450	175,173	\$ 11.38
Zambia	Organophosphates	136,418	140,018	\$ 7.06*
Zimbabwe	Organophosphates	116,519	105,474	\$ 10.66

*NgenIRS countries

In all countries, with the exception of Rwanda, the only class of insecticide purchased and used was organophosphates. In Rwanda, 56 percent of sachets/bottles used were organophosphates, while 44 percent were carbamates. The average cost of insecticides per 100 m² sprayed in organophosphate countries is \$9.63, over 44 percent more than the cost of insecticides per 100 m² sprayed in Rwanda, where both carbamates and organophosphates were used, pointing to a clear correlation between the insecticide class procured and the insecticide portion of the cost per area sprayed.

The average cost per person protected for insecticides used was \$2.36 for countries that used only organophosphates and \$2.96 for Rwanda, which used both organophosphates and carbamates. In mid-2016, Rwanda switched from two spray rounds with carbamates to an annual, one spray round, done in September with Actellic. Year 2016 captures the overlap of two different spray strategies, the end of two spray rounds in the spring of 2016, and the beginning of one spray round with Actellic in the fall of 2016. The cost of insecticides used per person protected is not highly correlated with the type of insecticide used since Benin, Madagascar, and Zambia had the lowest cost per person and the lowest insecticide cost per person protected. The relative size of structures per person protected appears to mask the relationship between the cost of insecticides used and people protected.

Insecticide costs are not included in the following cost driver analyses in order to isolate the additional conclusions drawn in the following section from any consideration of the costs of insecticides.

3.4.3 SPRAY OPERATIONS: PROGRAM SCALE

Spray operations, which includes temporary labor of spray operators (SOPs), ground transportation, and warehousing costs,⁴ accounted for an average of 28 percent of the average cost per 100 m² sprayed across the countries.

The spray operations portion of the cost per 100 m² sprayed is a function of total expenditures, number of campaign days (efficiency), and size of the program (number of structures sprayed), as demonstrated in Figure CC6.

⁴ For a full list of expenditure items included in the spray operations cost category, please refer to the 2014 report (Johns 2015).

FIGURE CC6: SPRAY OPERATIONS COST PER AREA SPRAYED, AREA SPRAYED PER CAMPAIGN DAY, AND TOTAL NUMBER OF STRUCTURES SPRAYED

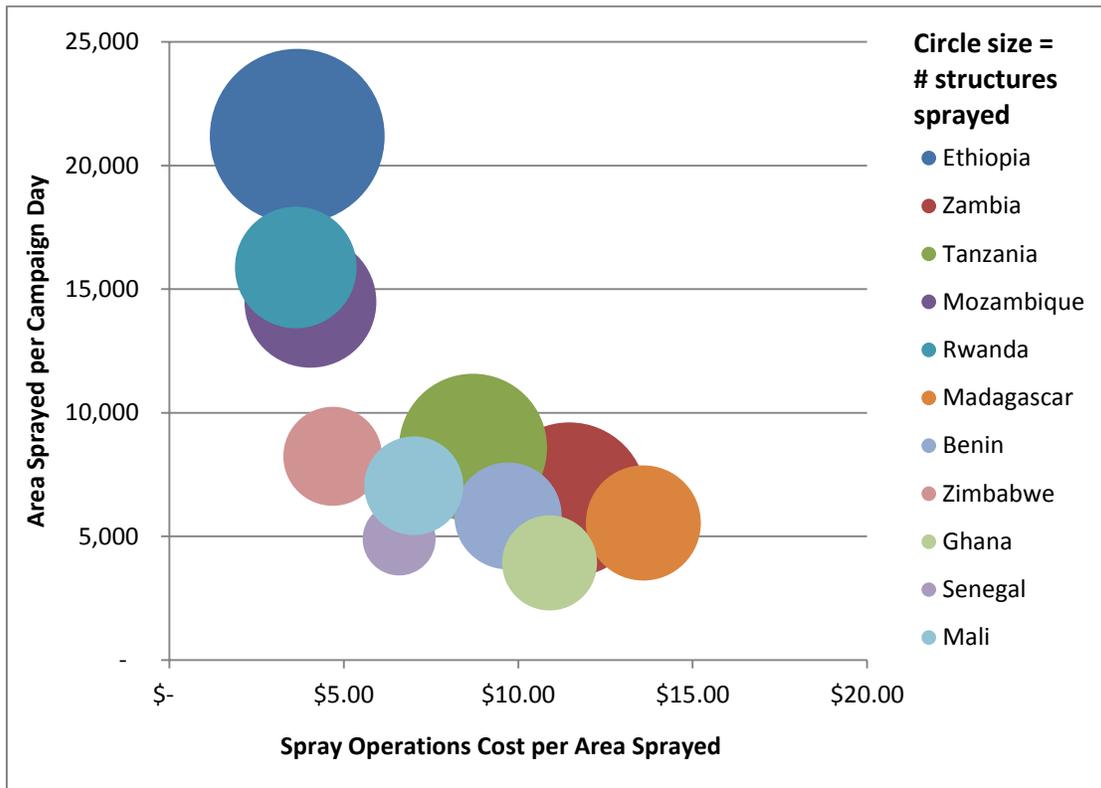


Figure CC6 shows the spread of country program spray operations, including the cost of spray operations per 100 m² sprayed (x-axis), the amount of area sprayed (in terms of 100 m²) per campaign day (y-axis), and the program size in terms of number of structures sprayed (circle size). Ethiopia, Mozambique, and Rwanda sprayed the largest amount of area per campaign day, and consequently had the lowest spray operations cost per 100 m² sprayed. The other country programs sprayed under 9.0 million m² per day. The spray operation cost per 100 m² sprayed in these countries were varied (although separated from Ethiopia, Mozambique, and Rwanda), ranging from \$4.68 in Zimbabwe to \$13.59 in Madagascar, while the spray operation cost per 100 m² sprayed in Ethiopia, Mozambique, and Rwanda were all under \$4.05.

Thus, while being able to spray large amounts each campaign day likely provides cost efficiency, other factors also influence the cost per 100 m² sprayed. For example, while Senegal and Benin sprayed a relatively similar area per day (4.9 million m² and 5.8 million m², respectively, a factor of 1.19), the spray operations cost per area sprayed differed from \$6.58 in Senegal to \$9.71 in Benin (a factor of 1.47). The data presented in Table CC6 helps to explain these differences. Benin used a comparatively larger number of SOPs over a similar period of time than Senegal. Thus, the area sprayed per SOP per day in Benin was 53 percent of that in Senegal, offsetting the greater total area sprayed per day (SOPs in Benin also had higher daily wages than in Senegal). While this explains the differences mathematically, the underlying reasons for the lower area sprayed per SOP per day in Benin than Senegal are not fully clear, but may be related to geography, housing sizes, etc.

TABLE CC6: SEASONAL SPRAY OPERATORS (SOPS) AND CAMPAIGN DAYS

Country	Total # SOPs	Total # SOP Days	Avg. # Days/SOP	Avg. Daily wage of SOP	Total # Campaign days	Total Area Sprayed (# 100 m ²)	Area Sprayed/SOP day	Area Sprayed/Campaign Day
Ethiopia	1,523	41,361	27	\$6.00	32	677,990	16.4	21,187
Zambia	1,365	38,325	28	\$5.32	54	350,045	9.1	6,482
Tanzania	2,517	50,021	20	\$6.63	51	437,933	8.8	8,587
Mozambique	1,157	50,700	44	\$2.09	44	637,380	12.6	14,486
Rwanda	2,211	40,339	18	\$6.70	40	634,915	15.7	15,873
Madagascar	1,112	21,861	20	\$4.68	24	133,030	6.1	5,543
Benin	966	19,365	20	\$7.00	20	116,543	6.0	5,827
Zimbabwe	457	14,336	31	\$15.00	32	263,685	18.4	8,240
Mali	899	17,590	20	\$4.15	30	211,428	12.0	7,048
Ghana	441	12,652	29	\$5.91	30	117,833	9.3	3,928
Senegal	498	8,704	17	\$5.39	20	97,973	11.3	4,899
Average	1,195	28,659	25	6.26	34	334,432	11.4	9,282

*SOPs are not paid; figure represents allowance given to SOPs for meals

Table CC6 provides a detailed breakdown of the number of SOPs that worked in each country spray campaign, as well as the total and average numbers of SOP days, and the average daily wage. Also provided are the total number of campaign days, the total amount of area sprayed (in terms of 100 m²), and the average amount of area sprayed per SOP day and per campaign day (both also in terms of 100 m²). There is no noticeable correlation or trend between the number of SOPs or number of SOP days and the amount of area sprayed per SOP day. For example, two of the three programs spraying the largest area, Mozambique and Ethiopia, used different numbers of SOPs in the program spray campaigns (Mozambique below the average, while Ethiopia was above the average across countries), but utilized an above-average number of SOP-days. However, the amount of area sprayed per SOP per day was relatively close to the average amount sprayed per SOP per day in all countries for Mozambique, but well above the average in Ethiopia (although both are above average).

Figure CC7 provides a comparison of efficiency in SOP productivity (measured by area sprayed per SOP per day) and the spray operations cost per 100 m² sprayed. The graph is sorted by the amount spent for spray operations per 100 m² sprayed, with countries spending less on the right and countries spending relatively more on the left. The red dots in Figure CC7 represent the average area sprayed per SOP per day for each country.

FIGURE CC7: SPRAY OPERATIONS EFFICIENCY AND COST PER AREA SPRAYED

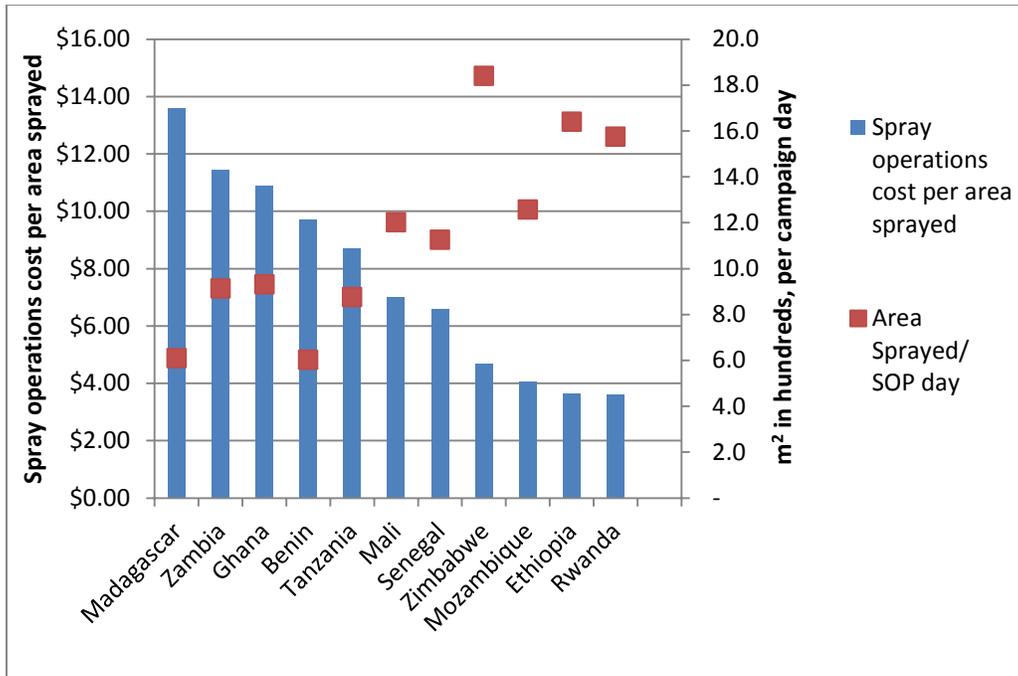


Figure CC7 suggests that countries with higher SOP productivity tend to have lower spray operations cost per 100 m² sprayed, although other factors are also involved. The countries with the lowest spray operations cost per 100 m² sprayed (Rwanda, Ethiopia, Mozambique, and Zimbabwe) had the highest SOP efficiency. Mozambique also had the lowest daily wage for SOPs among the countries. It should be noted that wages for SOPs reflect only, on average, 8% of spray operations costs – thus the decreased spray operations costs associated with greater area sprayed per SOP per day likely reflect overall efficiencies in spray operations.

Efficiency in operations is only partly amenable to changes; as noted above, geography, transportation infrastructure, housing density, etc. also affect the ability of SOPs to spray. For example, spray operations cost per 100 m² sprayed for Madagascar is more than three times greater than Rwanda's, while SOPs spray 90 percent as much area per day in Madagascar as Rwanda. Madagascar's geographical coverage area is more spread out than Rwanda's.

3.5 CONCLUSIONS

Unit of Measure

As in past reports, we use area sprayed as the unit for comparing costs across countries. However, the true area sprayed is not measured routinely in AIRS country programs. Rather, we estimate the area sprayed based on the amount of insecticide used; thus, we are, in actuality, comparing the cost of programs per unit of insecticide used. While this remains, in our opinion, the best metric available for comparing between countries, there still remains the possibility for differences in the efficiency of insecticide use between countries that affect the comparisons. Thus, some degree of inaccuracy in

the comparisons is possible, and should be kept in mind when reading the results. For the country-specific chapters, we use the number of structures sprayed for comparison.

Program Scale

Broadly speaking, we find, similar to previous years, that unit costs for large programs are lower than for medium programs (although larger programs tend to cost more in total). Using the most standardized comparison unit cost available, there is no 'one-price-fits-all' for IRS across countries. Large-sized programs averaged a cost per 100 m² sprayed of \$23.76, and medium programs averaged \$28.87 (Annex II).

There are some fixed costs for IRS programs which are not correlated to program scale, such as local administration and U.S.-based labor, which constitute an average of 5 and 4 percent (\$227,000 to \$918,00 and \$191,000 to \$433,300, respectively) of the total program costs, each.

Two of the important IRS program cost drivers, spray operations and local labor, constitute an average of 30 percent and 18 percent of the cost per area sprayed, respectively. Spray operations and local labor are both correlated with program scale (although there is a minimum level of local labor needed for any program). Programs with outlier costs in these areas are due to specific country context: geography of spray coverage area, number of spray rounds per year, and general cost of living (prices for labor, fuel, etc.).

Insecticide

The insecticide used in spray campaigns is the largest cost category across the IRS programs when looking at the cost per 100 m² sprayed; it is also the largest cost category when assessing total expenditures. The insecticide portion of the cost per area sprayed constitutes an average of 37 percent of the total unit cost across country programs.

4. NGENIRS

In 2016, the AIRS project benefited from the NGenIRS project, a UNITAID-funded partnership between the Innovative Vector Control Consortium, PMI and its IRS implementing partner Abt Associates Inc., Global Fund (GF), PATH/Malaria Control and Elimination Partnership in Africa and National Malaria Control Programs (NMCPs). Its objective is to accelerate and expand access and affordability of new, third generation formulations of IRS insecticides (3GIRS) for malaria vector control to mitigate insecticide resistance. The goal of the NGenIRS project is sustainable and rational deployment of effective malaria vector control tools in insecticide resistance management programs to save lives and improve health. Through the support, four countries on the PMI AIRS project were able to procure Actellic 300CS insecticide at a price of 15 USD per bottle instead of the market price of 23.50 USD per bottle in 2016. The effects of the cost savings are depicted in Table NG1.

The two countries that used exclusively Actellic in both 2015 and 2016 (Mali and Zambia) had lower insecticide costs per structure sprayed in 2016 directly due to NgenIRS. The comparison between 2015 and 2016 are harder to make directly in Ethiopia and Rwanda because of the use of carbamate insecticides in 2015 (for some areas in Ethiopia and in all areas of Rwanda) and 2016 (for the first spray round in Rwanda).

TABLE NGI: EFFECTS OF NGENIRS ON PROGRAM SCALE

Countries Receiving NgenIRS Copayment	Number of Insecticide Bottles Used			Total Cost of Insecticide (to the PMI AIRS project)			Number of Structures Sprayed			Number of People Protected			Insecticide Cost per Structure Sprayed			Comments
	2015	2016	2016 - 2015	2015	2016	2016 - 2015	2015	2016	2016 - 2015	2015	2016	2016 - 2015	2015	2016	2016 - 2015	
Ethiopia	80,836 (plus 240,161 sachets of carbamate)	271,196	190,360	\$4,320,474 (2,122,272 for OP; 2,198,202 for carbamate purchased before 2015)	\$4,793,373	\$472,899	704,945	715,541	10,596	1,655,997	1,688,745	32,748	\$6.13	\$6.70	\$0.57	Ethiopia increased its spray coverage by spraying 10,596 more structures and protecting 32,748 more people in 2016. In addition, it used only OPs in 2016, as opposed to a combination of OPs and carbamates in 2015. Despite the increase in coverage and the use of a better quality insecticide, the insecticide cost per structure sprayed increased by only \$0.57.
Mali	58,472	84,571	26,099	\$1,533,373	\$1,552,889	\$19,516	133,527	228,672	95,145	494,205	788,922	294,717	\$11.48	\$6.79	\$(4.69)	With the insecticide subsidy that Mali received in 2016, it was able to add one more district, spray 95,145 additional structures, and protect 294,717 additional people, while lowering the insecticide cost per structure sprayed by \$4.69.
Rwanda	289,195 (Carbamate)	278,563	(10,632)	\$3,007,913	\$4,232,754	\$1,224,841	343,131	346,917	3,786	1,406,520	1,431,410	24,890	\$8.77	\$12.20	\$3.43	With the insecticide copayment that Rwanda received in 2016, it was able to spray 3,786 additional structures and protect 24,890 additional people. Despite introducing a higher quality insecticide (organophosphates) in 2016, the insecticide cost per structure sprayed increased by only \$3.43.
Zambia	136,652	140,018	3,366	\$3,645,151	\$2,469,973	\$(1,175,178)	519,598	559,550	39,952	2,544,290	2,626,718	82,428	\$7.02	\$4.41	\$(2.60)	The number of structures sprayed and the number of people protected in Zambia respectively increased by 39,952 and 82,428 in 2016, while the insecticide cost per structure sprayed decreased by \$2.60.

5. YEAR-ON-YEAR COMPARISON

5.1 CHANGES IN IRS PROGRAMS FROM 2012 TO 2016

As an IRS program matures, lessons are learned, efficiencies are realized, and needs change. This section provides an overview of the major changes in countries' IRS programs across the years, focusing on changes from 2015 to 2016.

TABLE YR1: YEAR-ON-YEAR COMPARISON OF PROGRAM SIZE⁵

Program Size	2012	2013	2014	2015	2016
Large	Ethiopia Mozambique Rwanda Madagascar Ghana Senegal	Ethiopia Mozambique Rwanda Madagascar	Ethiopia Mozambique Rwanda Zambia Madagascar Benin	Ethiopia Zambia Rwanda Mozambique Benin Madagascar	Ethiopia Zambia Tanzania Mozambique Rwanda Madagascar Benin
Medium	Mali Benin Angola Liberia	Mali Benin Ghana Senegal	Mali Ghana Senegal Zimbabwe	Ghana Zimbabwe Mali Senegal	Zimbabwe Mali Ghana Senegal
Small	Nigeria Burkina Faso	Nigeria Angola Liberia	Angola		

As discussed in Section 3.1, program size is based on the number of structures sprayed by an IRS program. In 2016, PMI-supported IRS through the PMI AIRS Project began in Tanzania.

Table YR2 provides details on the changes in output measures for all country programs between 2015 and 2016. A complete table of output measures for all country programs for the period 2012-2016 is included in Annex I. Table YR3 shows the changes in unit costs between 2015 and 2016. A complete table of unit costs for all country programs for the period 2012-2016 is included in Annex II. For more information, a comprehensive discussion of the changes in each country program is provided at the end of each individual country chapter.

⁵ Listed in the order of program size, from largest to smallest

TABLE YR2: YEAR-ON-YEAR COMPARISON OF OUTPUT MEASURES

Country	People Protected			Structures Sprayed			Area Sprayed (100 m ²)		
	2015	2016	Percent Change 2015-2016	2015	2016	Percent Change 2015-2016	2015	2016	Percent Change 2015-2016
Ethiopia	1,655,997	1,688,745	2%	704,945	715,541	2%	641,994	677,990	6%
Zambia	2,544,290	2,626,718	3%	519,598	559,550	8%	341,630	350,045	2%
Tanzania	n/a	2,042,561	n/a	n/a	515,217	n/a	n/a	437,933	n/a
Mozambique	1,631,058	1,929,654	18%	337,433	405,597	20%	649,370	637,380	-2%
Rwanda	1,406,520	1,431,410	2%	343,131	346,917	1%	578,390	634,915	10%
Madagascar	1,016,841	1,257,036	24%	247,902	310,426	25%	113,493	133,030	17%
Benin	802,597	858,113	7%	252,706	269,179	7%	114,160	116,543	2%
<i>Avg. Large Programs</i>	1,293,900	1,690,605	9%	343,674	446,061	10%	348,434	426,834	6%
Zimbabwe	365,425	550,475	51%	162,127	229,377	41%	183,315	263,685	44%
Mali	494,205	788,922	60%	133,527	228,672	71%	146,180	211,428	45%
Ghana	553,954	570,871	3%	205,935	211,283	3%	113,285	117,833	4%
Senegal	514,833	496,728	-4%	130,170	124,757	-4%	98,010	97,973	0%
<i>Avg. Medium Programs</i>	482,104	601,749	27%	157,940	198,522	28%	135,198	172,729	17%

In Table YR2, all countries, with the exception of Senegal, increased the number of people protected and structures sprayed from 2015 to 2016. Mozambique used almost 4,800 fewer bottles of insecticide (the basis for calculating the area sprayed), while protecting more people and spraying more structures between 2015 and 2016. The project sprayed 1.6 structures/bottle of insecticide in 2016 and 1.3 structures/bottle of insecticide in 2015.

TABLE YR3: YEAR-ON-YEAR COMPARISON OF UNIT COSTS

Country	People Protected			Structures Sprayed			Area Sprayed (100 m ²)		
	2015	2016	Percent Change 2015-2016	2015	2016	Percent Change 2015-2016	2015	2016	Percent Change 2015-2016
Ethiopia	\$5.27	\$5.66	7%	\$12.38	\$13.35	8%	\$13.60	\$14.09	4%
Zambia	\$3.69	\$3.44	-7%	\$18.06	\$16.16	-11%	\$27.47	\$25.83	-6%
Tanzania	n/a	\$5.83	n/a	n/a	\$23.10	n/a		\$27.18	
Mozambique	\$4.48	\$6.41	43%	\$21.63	\$30.48	41%	\$11.24	\$19.40	73%
Rwanda	\$4.83	\$5.58	16%	\$19.79	\$23.03	16%	\$11.74	\$12.58	7%
Madagascar	\$4.57	\$3.90	-15%	\$18.74	\$15.77	-16%	\$40.94	\$36.81	-10%
Benin	\$4.15	\$4.14	0%	\$13.18	\$13.19	0%	\$29.18	\$30.46	4%
<i>Avg. Large Programs</i>	\$4.50	\$4.99	7%	\$17.30	\$19.30	6%	\$22.36	\$23.76	12%
Zimbabwe	\$11.62	\$10.69	-8%	\$26.19	\$25.66	-2%	\$23.16	\$22.32	-4%
Mali	\$9.26	\$6.19	-33%	\$34.26	\$21.37	-38%	\$31.29	\$23.11	-26%
Ghana	\$7.74	\$7.10	-8%	\$20.81	\$19.18	-8%	\$37.82	\$34.39	-9%
Senegal	\$6.53	\$7.04	8%	\$25.81	\$28.02	9%	\$34.28	\$35.67	4%
<i>Avg. Medium Programs</i>	\$8.78	\$7.75	-10%	\$26.77	\$23.55	-4%	\$31.64	\$28.87	-3%

In Table YR3, country unit costs decreased in 2016 compared to 2015 for all three unit costs presented for Zambia, Madagascar, Zimbabwe, Mali, and Ghana. In Benin, the cost per person protected and per structure sprayed remained similar between the two years, while the cost per area sprayed increased from 2015 to 2016. Unit costs in Ethiopia, Mozambique, Rwanda, and Senegal increased across the two years, in association with the introduction (in Rwanda) or switch to the exclusive use of organophosphate insecticides.

A detailed discussion of the changes in each country program is included in the individual country chapters. Figure YR1 below illustrates the cost per 100 m² sprayed in 2012, 2013, 2014, 2015, and 2016, including the type of insecticide used in each year, while Figure YR2 presents the non-insecticide costs per 100 m² sprayed across the years. With the exception of slight increases in Benin, cost per 100 m² sprayed in 2016 were the same or lower than in 2015 for countries that did not change the type of insecticide used (Zambia, Madagascar, Zimbabwe, Mali, and Ghana).

The non-insecticide cost per 100 m² sprayed (Figure YR2) increased in Zambia, Mozambique, Benin, Senegal, and Ethiopia. The reasons for these increases are discussed in the individual country chapters. Of the two NgenIRS countries where non-insecticide costs per 100 m² increased, both Zambia and Ethiopia had additional staff in 2016 (as well as other factors explained in the country chapters and Table YR4). The non-insecticide cost per 100 m² sprayed decreased in Rwanda, Madagascar, Zimbabwe, Mali, and Ghana, with Mali experiencing the greatest percentage decrease in the non-insecticide cost per 100 m² sprayed (\$20.80 in 2015 and \$15.77 in 2016, a decrease of 24%).

FIGURE YR1: YEAR-ON-YEAR COMPARISON OF COST PER AREA SPRAYED

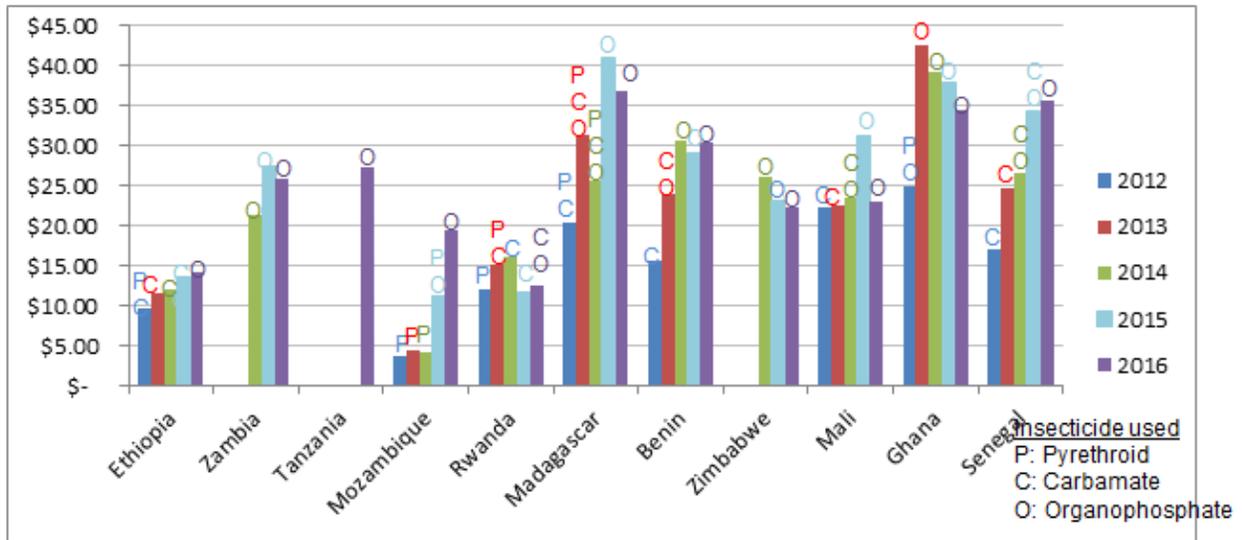


FIGURE YR2: YEAR-ON-YEAR COMPARISON OF NON-INSECTICIDE COST PER AREA SPRAYED

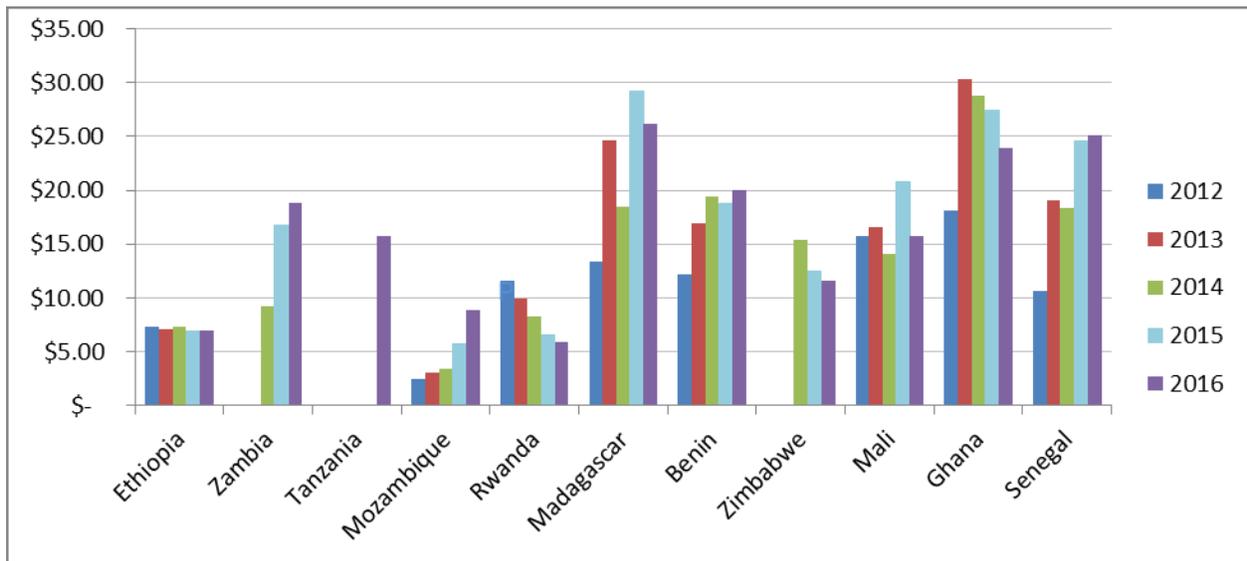


Table YR4 provides the cost per 100 m² sprayed for each country and a summary of average cost per 100 m² sprayed for various groups of country programs for 2015 and 2016, but is separated into two portions: one for insecticide costs and one for non-insecticide costs. For the non-insecticide portion of the cost per area sprayed, countries were grouped by program size, and the average unit cost was calculated (not weighted by the size of the program).

TABLE YR4: INSECTICIDE VERSUS NON-INSECTICIDE COST PER AREA SPRAYED

Country/ Average	Insecticide cost per 100 m ² sprayed			Non-insecticide cost per 100 m ² sprayed			Comments
	2015	2016	Percent Change 2015- 2016	2015	2016	Percent Change 2015-2016	
Ethiopia	\$6.73	\$7.07	5%	\$6.87	\$7.02	2%	Higher costs in 2016 are explained by additional staff recruitment as well as an increase in the rental cost in the Addis Ababa office to accommodate all staff. In addition, the increase in the insecticide quantity consequently led to an increase in the cost of spray commodities, and transportation to the spray sites.
Zambia	\$10.67	\$7.06	-34%	\$16.80	\$18.77	12%	The project hired 20 full time districts coordinators in August of 2015 so that contributed to the increase in 2016. There was also an increase in the FSN scale in 2016, which led to some staff receiving a significant salary adjustment/increase. Additionally, in 2016, Zambia procured additional insecticide, restarted the campaign and added additional days; therefore, this also had an impact on insecticide and spray operations costs (SOP days and transportation).
Tanzania	n/a	\$11.38	n/a	n/a	15.80	n/a	
Mozambique	\$5.49	\$10.57	93%	\$5.75	\$8.83	53%	Mozambique's higher costs in 2016 are due to several factors, namely: the Maputo and Quelimane Office moves; an increase in the rent of the Maputo office; increase in internet services bandwidth in Maputo and Quelimane; an increased number of staff; an increase in the number of spray campaign days (44 days in 2016 versus 36 days in 2015); an increase in operational site stores space to accommodate new insecticide; the roll out and implementation of mHealth; an increase in seasonal personnel from 1703 in 2015 to 2295 in 2016; and the recruitment of a TCN Operations Manager.
Rwanda	\$5.20	\$6.67	28%	\$6.54	\$5.91	-10%	

Madagascar	\$11.81	\$10.61	-10%	29.14	26.20	-10%	
Benin	\$10.46	\$10.49	0%	\$18.72	19.97	7%	Increase in the number of training days; insertion of training for team leaders; Per the revised Mission Order, the per diem rates in-country increased. In addition, to strengthen IEC activities, there was a higher level of involvement from local leaders compared to 2015 (from 900 in 2015 to 1174 in 2016)
Zimbabwe	\$10.65	\$10.66	0%	\$12.51	11.66	-7%	
Mali	\$10.49	7.34	-30%	\$20.80	15.77	-24%	
Ghana	\$10.40	\$10.52	1%	\$27.42	23.87	-13%	
Senegal	\$9.70	\$10.58	9%	\$24.59	25.09	2%	The local FSN scale increased in 2016 and a warehouse assistant was hired, which caused a spike of 7.4% in local labor costs. Contrary to 2015, when spray operators were trained over a period of three days, in 2016, all spray operators received a five-day training. Also the number of SOPs increased, particularly in Malem Hoddar, as there were fewer days of spraying. Furthermore, in 2015, some sites completed the campaign in 18 or 19 days, compared to 2016 when all 20 days were paid.
Avg. Large Programs				\$13.97	\$14.64	5%	
Avg. Medium Programs				\$21.33	\$19.10	-10%	
Avg. Carbamates	\$5.20	n/a	n/a	\$6.54	n/a	n/a	
Avg. Mixed	\$7.30	\$6.67	-9%	12.40	\$23.87	92%	
Avg. Organophosphates	\$10.75	\$9.63	-10%	\$17.42	15.50	-11%	

Countries that changed insecticides, or that changed the mix of insecticides used, all saw increases in the cost of insecticide used per 100 m² between 2015 and 2016 (Ethiopia, Mozambique, Rwanda, and Senegal). Among these countries, Ethiopia, Mozambique, and Rwanda increased the number of outputs (people protected and structures sprayed). However, non-insecticide costs per 100 m² sprayed also increased in all of these four countries except Rwanda over the period, although the non-insecticide costs increased less, in percentage terms, than the insecticide costs.

Six countries used the same insecticide in 2016 as in 2015. Among these, three countries saw little change in the cost of insecticides per 100 m² sprayed (Benin, Zimbabwe, and Ghana). Zambia, Mali, and Madagascar saw a decrease in the cost of insecticides per 100 m² sprayed, the first two saw a much larger change in association with NgenIRS. Madagascar, Zimbabwe, and Mali also ran IRS programs of larger size in 2016 than in 2015. Thus, the non-insecticide costs per 100 m² sprayed between 2015 and 2016 were lower in Madagascar, Zimbabwe, and Mali. These patterns hold true when assessing the cost per structure sprayed as well.

The insecticide costs per 100 m² sprayed declined by 10 percent for countries using organophosphates, reflecting the lower procurement prices under NgenIRS in three countries. In the case of countries with programs using multiple insecticides (Rwanda), the decreased cost reflects both the NgenIRS subsidy of organophosphates and different proportionate mixes of different insecticide types across the countries (in 2015, Ethiopia, Mozambique, and Senegal used a 'mix' of insecticides, while Rwanda used only carbamates).

Table YR5 provides a summary of the changes in the costs, adjusted for inflation, for spray operations from 2012 to 2013, from 2013 to 2014, from 2014 to 2015, and from 2015 to 2016. Specific numbers are provided in each country chapter below. Additionally, Table YR5 provides the changes in the number of structures sprayed over the three time periods.

TABLE YR5: SUMMARY OF CHANGES IN SPRAY OPERATIONS COSTS AND STRUCTURES SPRAYED

Country	2012 to 2013		2013 to 2014		2014 to 2015		2015 to 2016	
	Change in spray operations cost	Change in number of structures sprayed	Change in spray operations cost	Change in number of structures sprayed	Change in spray operations cost	Change in number of structures sprayed	Change in spray operations cost	Change in number of structures sprayed
Ethiopia	33%	16%	-5%	5%	-3%	6%	6%	2%
Zambia	n/a	n/a	n/a	n/a	124%	27%	30%	8%
Tanzania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Mozambique	-4%	-23%	34%	7%	20%	-24%	52%	20%
Rwanda	56%	46%	-23%	-14%	-3%	16%	5%	1%
Madagascar	708%	-8%	-22%	-20%	-40%	-10%	36%	25%
Benin	4%	11%	-2%	11%	-1%	-1%	13%	7%
Zimbabwe	n/a	n/a	n/a	n/a	-10%	10%	66%	41%
Mali	31%	11%	-18%	0%	-29%	-41%	20%	71%

Ghana	-12%	-44%	4%	4%	-16%	0%	1%	3%
Senegal	0%	-33%	-25%	-1%	-37%	-36%	3%	-4%

From 2015 to 2016, Senegal saw a decrease in the number of structures sprayed and an increase in spray operations costs that was smaller than the decrease in the number of structures sprayed, implying higher spray operations costs per structure sprayed (likely due to reduced economies of scale from spraying fewer structures).

Ethiopia, Rwanda, and Ghana sprayed a similar number of structures between 2015 and 2016, while spray operations costs increased by 6 percent, 5 percent, and 1 percent, respectively. The other six countries (Zambia, Mozambique, Madagascar, Benin, Zimbabwe, and Mali) all sprayed more structures in 2016 than in 2015. For five of these countries, the spray operations costs increased more, in percentage terms, than the number of structures sprayed (see Table YR4 for explanations). In Mali, spray operations costs increased less than the number of structures sprayed.

6. BENIN

6.1 BACKGROUND

TABLE BNI: BENIN QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Jan 10, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	9	9	9	9	9
# Local Staff	13	13	13	14	13
Spray Start Date	May 14, 2012	May 20, 2013	May 4, 2014	April 30, 2015	May 3, 2016
# Spray Rounds	1	1	1	1	1
Insecticides Used	Carbamates	Carbamates Organophosphates	Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	50,842	50,242	44,202	45,664	46,617
# People Protected	762,146	694,729	789,883	802,597	858,113
# Structures Sprayed	206,295	228,951	254,072	252,706	269,179
# 100 Square Meters Sprayed	192,968	125,605	110,505	114,160	116,543

6.2 PROGRAM EXPENDITURES

This section will present an overview of Benin IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE BN2: BENIN IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		227,104	446,263			124,810	\$ 798,177	22.5%
Entomology					28,741		\$ 28,741	0.8%
Environmental Compliance			71,474		59,032	20,994	\$ 151,500	4.3%
Equipment Supplies			79	99,791		9	\$ 99,879	2.8%
IEC			3,021			369	\$ 3,390	0.1%
Insecticide	1,222,450						\$ 1,222,450	34.4%
M&E			53,613		40,860	23,686	\$ 118,159	3.3%
Post Spray			55,638		3,452	11,286	\$ 70,377	2.0%
Spray Campaign			13,813		928,045	2,854	\$ 944,712	26.6%
Spray Planning			34,685		71,146	7,021	\$ 112,853	3.2%
Grand Total	\$ 1,222,450	\$ 227,104	\$ 678,587	\$ 99,791	\$ 1,131,276	\$ 191,303	\$ 3,550,238	100.0%

Table BN2 displays the Benin IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories. The following figure illustrates the cost breakdown in the table.

Insecticide is the most expensive IRS activity (34.4 percent of expenditures), followed by costs for the spray campaign (26.6 percent of expenditures), and local administration activities (22.5 percent of expenditures). PMI AIRS Benin procured 41,213 bottles of insecticide, and used 46,617 (the cost of insecticide used is reflected in the figure above). About 71.5 percent of the total cost for administration consists of labor, both local and U.S.-based. Note that the 'U.S.-based Labor and STTA' expenditures are largely incurred under the administrative and M&E program activities (78 percent of US labor expenditures are in the two categories). Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

6.3 UNIT COST ANALYSIS

This section presents Benin IRS as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE BN3: BENIN UNIT COSTS

		Unit cost	
Cost per	Person protected	\$	4.14
	Structure sprayed	\$	13.19
	100 m ² sprayed	\$	30.46

6.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the PMI AIRS Benin IRS program between 2015 and 2016, as implemented by the PMI AIRS Project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE BN4: BENIN IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide (used)	1,193,573	1,222,450	2%
Local Admin	215,096	227,104	6%
Local Labor	634,911	678,587	7%
Spray Operations	1,000,239	1,131,276	13%
Commodities	117,142	99,791	-15%
U.S. Labor	169,934	191,030	12%
TOTAL	\$ 3,330,896	\$ 3,550,238	6.6%

Table BN4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 6.6 percent from 2015 to 2016, reflecting the increase in the number of people protected and structures sprayed. Costs increased in all categories, with the exception of the cost of commodities, which decreased by 15 percent (roughly \$17,000). Spray operations accounted for the largest increase in costs in both relative and absolute terms (13 percent or about \$131,000).

TABLE BN5: BENIN IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	802,597	858,113	6.9%
Structures Sprayed	252,706	269,179	6.5%
Area Sprayed (100 m ²)	114,160	116,543	2.1%
Unit Costs			
Per Person Protected	\$ 4.15	\$ 4.14	-0.3%
Per Structure Sprayed	\$ 13.18	\$ 13.19	0.1%
Per Area Sprayed	\$ 29.18	\$ 30.46	4.4%

Table BN5, above, compares the year-on-year change in Benin IRS program output measures and unit costs. Overall, in 2016, the program protected more people, sprayed more structures and more area than in previous years. Because the total program costs increased less than the number of people protected, the unit cost per person protected decreased by 0.3 percent. The cost per structure sprayed and cost per area sprayed increased by about 0.1 percent and 4.4 percent, respectively, from 2015 to 2016.

TABLE BN6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	18,353	19,365	6%
Number of structures sprayed	252,706	269,179	7%
Structures sprayed per SOP per day	13.8	13.9	1%
Spray operations cost per SOP Day	54.50	58.42	7%
Spray operations and commodities cost per structure sprayed	9.14	9.11	0%
Spray operations and commodities cost per structure sprayed (without insecticide)	4.42	4.57	3%

Table BN6 displays various measures of implementation efficiency in the last two years. In 2016, the number of SOPs-days increased by about 6 percent compared to 2015,

while the number of structures sprayed increased by about 7 percent, resulting in about 1 percent more structures sprayed per SOP per day than in 2015. As shown in Table BN4, however, the costs for spray operations and insecticides increased, and the cost of commodities decreased between 2015 and 2016. Spray operations and commodities costs decreased by less than 0.1 percent per structure sprayed between 2015 and 2016, but increased by 3 percent when also adding the cost of insecticides.

7. ETHIOPIA

7.1 BACKGROUND

TABLE ETI: ETHIOPIA QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Feb 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	36	36	36	36	36
# Local Staff	19	21	22	21	20
Spray Start Date	June 15, 2012 August 15, 2012	August 15, 2013	August 13, 2014	July 21, 2015 (organophosphates) August 11, 2015 (carbamates)	June 28, 2016
# Spray Rounds	2	1	1	1	1
Insecticides Used	Pyrethroids Carbamates	Carbamates	Carbamates	Carbamates Organophosphates	Organophosphates
# Sachets & Bottles Used	262,167	308,721	312,382	320,997	271,196
# People Protected	1,506,273	1,629,958	1,647,099	1,655,997	1,688,745
# Structures Sprayed	547,421	635,528	667,236	704,945	715,541
# 100 Square Meters Sprayed*	524,334	617,442	624,764	641,994	542,392

* Reverse calculation using number of insecticide sachets/bottles used during campaign multiplied by the average of 200 m² estimated to be sprayed by one sachet and divided by the number of structures sprayed for 2012-2015. In 2016, 250 m² was used.

7.2 PROGRAM EXPENDITURES

This section will present an overview of Ethiopia IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE ET2: ETHIOPIA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		313,300	551,870			220,440	\$ 1,085,609	11.4%
Entomology			143,043		253,213	30,912	\$ 427,168	4.5%
Environmental Compliance			75,266		219,241	34,592	\$ 329,098	3.4%
Equipment Supplies				560,351			\$ 560,351	5.9%
IEC					986		\$ 986*	0.0%
Insecticide**	4,793,373						\$ 4,793,373	50.2%
M&E			66,157		14,664	30,479	\$ 111,300	1.2%
Post Spray			14,995		23,054	1,952	\$ 40,001	0.4%
Spray Campaign			121,417		1,579,340	5,839	\$ 1,706,596	17.9%
Spray Planning			86,683		391,178	19,036	\$ 496,896	5.2%
Grand Total	\$ 4,793,373	\$ 313,300	\$ 1,059,430	\$ 560,351	\$ 2,481,674	\$ 343,251	\$ 9,551,377	100%

* PMI AIRS Ethiopia delegated the mobilization responsibility to the government.

Table ET2 displays the Ethiopia IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories.

Insecticides represented the majority of the total costs at 50.2 percent of costs. The cost of insecticide substantially increased in 2016 due to the use of Actellic CS in all districts. Spray campaign costs and administration were the next two largest categories of costs, representing 17.9 and 11.4 percent of costs, respectively. PMI AIRS procured 280,000 bottles of organophosphate insecticides, and used 271,196 bottles. About 71 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

7.3 UNIT COST ANALYSIS

This section presents Ethiopia IRS as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE ET3: ETHIOPIA UNIT COSTS

	Unit costs	
Person protected	\$	5.66
Cost per Structure sprayed	\$	13.35
100 m ² sprayed	\$	14.09

7.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Ethiopia IRS program between 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ET4: ETHIOPIA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	4,320,474	4,793,373	10.9%
Local Admin	200,830	313,300	56.0%
Local Labor	1,040,842	1,059,430	1.8%
Spray Operations	2,332,850	2,481,674	6.4%
Commodities	460,543	560,351	21.7%
U.S. Labor	373,300	343,251	-8.0%
TOTAL	\$ 8,728,840	\$ 9,551,377	9.4%

Table ET4 compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 9.4 percent from 2015 to 2016, representing an increase in the total annual cost of about \$822,538. In terms of the total increase between 2015 and 2016, insecticides represented the majority of the increase (\$472,899), reflecting the use of organophosphate class insecticides in all districts (and would have increased more without the NgenIRS subsidy).

When the insecticide is excluded from the year-on-year comparison, costs were 7.9 percent greater in 2016 than in 2015. Costs decreased for US labor by about \$30,000 between the years, but this was offset by an increase in the cost of local administration of about \$112,000 and in the other three cost categories (local labor, spray operations, and commodities) of about \$267,000. Higher costs in 2016 are explained by additional staff recruitment as well as an increase in the office rental cost in the Addis Ababa office to accommodate all staff. In addition, the increase in the insecticide quantity consequently led to an increase in the cost of spray commodities, and transportation to the spray sites.

TABLE ET5: ETHIOPIA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	1,655,997	1,688,745	2.0%
Structures Sprayed	704,945	715,541	1.5%
Area Sprayed (100 m ²)	641,994	677,990	5.6%
Unit Costs			
Per Person Protected	\$ 5.27	\$5.66	7.3%
Per Structure Sprayed	\$ 12.38	\$13.35	7.8%
Per Area Sprayed	\$ 13.60	\$14.09	3.6%

Table ET5 compares the year-on-year change in Ethiopia IRS program output measures and unit costs. In 2016, the program achieved higher coverage across the three coverage measures. Between 2015 and 2016, the number of people protected increased 2.0 percent, the number of structures increased 1.5 percent, while the area sprayed increased by 5.6 percent.

Unit costs were higher per person protected, structure sprayed, and area sprayed in 2016 than 2015, reflecting the increase in the costs of insecticides.

TABLE ET6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	39,564	41,361	5%
Number of structures sprayed	704,945	715,541	2%
Structures sprayed per SOP per day	17.8	17.3	-3%
Spray operations cost per SOP Day	58.96	60.00	2%
Spray operations and commodities cost per structure sprayed	10.09	10.95	9%
Spray operations and commodities cost per structure sprayed (without insecticide)	3.96	4.25	7%

Table ET6 displays various measures of implementation efficiency in the last two years. The number of SOP-days increased from 2015 to 2016. In 2016, however, about 2 percent more structures were sprayed than in 2015. Given that spray operations costs increased overall, the cost of spray operations per SOP per day also increased by 2 percent from 2015 to 2016. The increased costs of spray operations resulted in a 7

percent increase of the spray operations and commodity cost per structure sprayed from 2015 to 2016. The cost of spray operations, commodities, and insecticides per structure sprayed increased 9 percent.

8. GHANA

8.1 BACKGROUND

TABLE GHI: GHANA QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Feb 10, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	9	4	4	5*	5
# Local Staff	25	23	22	23	25
Spray Start Date	April 23, 2012	April 29, 2013	April 14, 2014	April 14, 2015	April 22, 2016
# Spray Rounds	1	1	1	1	1
Insecticides Used	Pyrethroids Organophosphates	Organophosphates	Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	77,288	43,284	44,948	45,314	47,133
# People Protected	941,240	534,060	570,572	553,954	570,871
# Structures Sprayed	355,278	197,655	205,230	205,935	211,283
# 100 Square Meters Sprayed	193,220	108,210	112,370	113,285	117,833

* Although the same areas were sprayed in 2015 as in 2014, the number of districts sprayed increased due to a reorganization of the districts in Ghana.

8.2 PROGRAM EXPENDITURES

This section will present an overview of Ghana IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE GH2: GHANA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		249,763	536,604			175,256	\$ 961,623	23.7%
Entomology			97,305		320,791	21,355	\$ 439,451	10.8%
Environmental Compliance			35,737		37,305	9,817	\$ 82,859	2.0%
Equipment Supplies			197	104,076		125	\$ 104,339	2.6%
IEC			20,049		153,434	6,183	\$ 179,667	4.4%
Insecticide	1,239,766		239			150	\$ 1,240,155	30.6%
M&E			39,788		28,310	42,729	\$ 110,827	2.7%
Post Spray			83,002		18,753	20,101	\$ 121,855	3.0%
Spray Campaign			22,461	7,813	687,291	3,605	\$ 721,170	17.8%
Spray Planning			38,065		37,785	14,114	\$ 89,964	2.2%
Grand Total	\$ 1,239,766	\$ 249,763	\$ 873,447	\$ 111,889	\$ 1,283,669	\$ 293,435	\$ 4,051,969	100.0%

Table GH2 displays the Ghana IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories.

Costs for insecticides, administration, and the spray campaign constitute over 72 percent of costs (23.7, 30.6 and 17.8 percent of total costs, respectively). PMI AIRS procured 38,558 bottles of Actellic CS, and used 47,133 bottles; the cost for the latter is included here. About 74 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

8.3 UNIT COST ANALYSIS

This section presents Ghana IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE GH3: GHANA UNIT COSTS

	Unit costs	
Person protected	\$	7.10
Cost per Structure sprayed	\$	19.18
100 m² sprayed	\$	34.39

8.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Ghana IRS program between 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs. 2015 expenditures, excluding insecticides, have been adjusted to real 2016 U.S. dollars to allow for a more accurate comparison.

TABLE GH4: GHANA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	1,178,488	1,239,766	5.2%
Local Admin	436,932	249,763	-42.8%
Local Labor	888,396	873,447	-1.7%
Spray Operations	1,275,904	1,283,669	0.6%
Commodities	131,826	111,889	-15.1%
U.S. Labor	373,426	293,435	-21.4%
TOTAL	\$ 4,284,972	\$ 4,029,815	-5.4%

Table GH4 compares the year-on-year change in total program capital and recurrent expenditures. It should be noted that Ghana has been experiencing inflation rates over 14 percent per year. This means that costs for 2015 in Table GH4 are higher than the nominal amount spent in that year.

The total program cost decreased by over 5 percent from 2015 to 2016, representing a decrease in the total annual cost of about \$233,003. Costs decreased for (i) administration by over \$187,000, (ii) local labor by almost \$15,000, (iii) spray commodities by almost \$20,000, and (iv) U.S. labor by almost \$80,000. Cost increased for the same period for insecticides (5.2 percent increase of over \$61,000), and spray operations (0.6 percent increase of over \$7,700).

TABLE GH5: GHANA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	553,954	570,871	0.1%
Structures Sprayed	205,935	211,283	2.9%
Area Sprayed (100 m ²)	113,285	117,833	4.9%
Unit Costs			
Per Person Protected	\$ 7.74	\$7.10	-8.2%

Per Structure Sprayed	\$ 20.81	\$19.18	-7.8%
Per Area Sprayed	\$ 37.82	\$34.39	-9.1%

Table GH5 compares the year-on-year change in Ghana IRS program output measures and unit costs. In 2016, the program protected roughly the same number of people as in 2015 (the change is less than 1 percent from 2015 to 2016), sprayed 2.9 percent more structures, and an area that was 4.9 percent larger.

Because the number of people protected increased by 0.1% from 2015 to 2016, while total costs decreased by 5.4%, the cost per person protected decreased from \$7.74 to \$7.10 (8.2 percent) across the two years. The decrease in total costs from 2015 to 2016 and the increase in the number of structures sprayed resulted in lower costs per structure sprayed in 2016 than in 2015. The increase in the area sprayed and the decrease in total costs also resulted in a lower cost per area sprayed in 2016 than in 2015.

TABLE GH6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	11,611	12,652	9%
Number of structures sprayed	205,935	211,283	3%
Structures sprayed per SOP per day	17.7	16.7	-6%
Spray operations cost per SOP Day	109.89	101.46	-8%
Spray operations and commodities cost per structure sprayed	12.56	12.47	-1%
Spray operations and commodities cost per structure sprayed (without insecticide)	6.84	6.61	-3%

Table GH6 displays various measures of implementation efficiency in the last two years. The number of SOP-days used for the campaign in 2016 was higher than in 2015 by 9 percent. While the number of SOP-days increased, the number of structures sprayed increased by only 3 percent from 2015 to 2016, indicating the number of structures sprayed per SOP per day decreased by 6 percent. Further, while the cost of spray operations slightly increased in total from 2015 to 2016, the spray operations cost per SOP per day decreased by 8 percent in 2016. Thus, the spray operations and commodities cost per structure sprayed was 3 percent lower in 2016 than in 2015. When including the costs of spray operations, commodities, and insecticide in the costs per structure sprayed, 2016 again had lower costs than in 2015.

9. MADAGASCAR

9.1 BACKGROUND

TABLE MGI: MADAGASCAR QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Aug 15, 2012 – April 30, 2013	May 1, 2013 – April 30, 2014	May 1, 2014 – April 30, 2015	April 1, 2015 – March 31, 2016	April 1, 2016 – December 31, 2016
Number of Districts	2 ⁶	2 ⁸	5 ⁷	4	5
# Local Staff	15	34	37	33	32
Spray Start Date					
<i>Central Highlands</i>	Nov 26, 2012	Nov 18, 2013	Nov 3, 2014		
<i>Southern Madagascar</i>	February 4, 2013	January 20, 2014			
<i>East Coast</i>			Sept 8, 2014	Aug 31, 2015	Sep 5, 2016
<i>Southeast</i>				Aug 3, 2015	Jul 25, 2016
# Spray Rounds	1	1	1	1	1
Insecticides Used	Carbamates Pyrethroids	Carbamates Pyrethroids Organophosphates	Carbamates Pyrethroids Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	88,567	79,594	91,696	45,397	53,212
# People Protected	1,781,990	1,588,138	1,307,384	1,016,841	1,257,036
# Structures Sprayed	371,391	343,470	274,533	247,902	310,426
# 100 Square Meters Sprayed	221,418	198,985	229,240	113,493	133,030

9.2 PROGRAM EXPENDITURES

This section will present an overview of Madagascar IRS program expenditures in 2016. Costs are organized by activity and cost category.

⁶ Focalized spraying in 40 communes

⁷ Blanket spraying in 3 districts and focalized spraying in 40 communes in the two remaining districts

TABLE MG2: MADAGASCAR IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		326,111	412,287			119,841	\$ 858,238	17.5%
Entomology			126,412		172,756	106,763	\$ 405,931	8.3%
Environmental Compliance			12,528		64,558	13,438	\$ 90,524	1.8%
Equipment Supplies				311,025			\$ 311,025	6.4%
IEC			6,726		69,928	2,195	\$ 78,849	1.6%
Insecticide	1,411,034						\$ 1,411,034	28.8%
M&E			21,077		56,784	34,384	\$ 112,245	2.3%
Post Spray			26,963		41,002	9,686	\$ 77,651	1.6%
Spray Campaign			29,403		1,020,495	8,151	\$ 1,058,049	21.6%
Spray Planning			89,883		381,913	21,429	\$ 493,225	10.1%
Grand Total	\$ 1,411,034	\$ 326,111	\$ 725,278	\$ 311,025	\$ 1,807,437	\$ 315,887	\$ 4,896,772	100.0%

Table MG2 displays the Madagascar IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories.

Insecticides and spray campaign costs were the two most expensive IRS activities (constituting 28.8 percent and 21.6 percent of expenditures, respectively), followed by administration costs (17.5 percent of expenditures). PMI AIRS Madagascar procured 45,468 bottles of Actellic CS, and used 53,212 organophosphate bottles, the costs of the latter are reflected here. About 62 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

9.3 UNIT COST ANALYSIS

This section presents Madagascar IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE MG3: MADAGASCAR UNIT COSTS

	Unit costs
Person protected	\$ 3.90
Cost per Structure sprayed	\$ 15.77
100 m² sprayed	\$ 36.81

9.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the PMI AIRS Madagascar IRS program between 2015 and 2016, as implemented by the project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE MG4: MADAGASCAR IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	1,339,821	1,411,034	5.3%
Local Admin	431,931	326,111	-24.5%
Local Labor	867,096	725,278	-16.4%
Spray Operations	1,327,969	1,807,437	36.1%
Commodities	278,831	311,025	11.5%
U.S. Labor	400,917	315,887	-21.2%
TOTAL	\$ 4,646,565	\$ 4,896,772	5.4%

Table MG4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 5.4 percent from 2015 to 2016. Spray operations costs increased by about \$479,000 (36.1 percent), commodity costs increased by about \$32,000 (11.5 percent), and insecticide costs increased by about \$71,000 (5.3 percent) from 2015 to 2016. Costs decreased in all other categories from 2015 to 2016.

The largest decrease in costs between 2015 and 2016 was for local administration, which declined 24.5 percent (about \$105,821). U.S. labor decreased the second most between 2015 and 2016, in relative terms, with costs decreasing by about \$85,030 (21.2 percent of 2016 costs).

TABLE MG5: MADAGASCAR IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	1,016,841	1,257,036	23.6%
Structures Sprayed	247,902	310,426	25.2%
Area Sprayed (100 m ²)	113,493	133,030	17.2%
Unit Costs			
Per Person Protected	\$ 4.57	\$3.90	-14.8%
Per Structure Sprayed	\$ 18.74	\$15.77	-15.8%

Per Area Sprayed	\$ 40.94	\$36.81	-10.1%
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Table MG5 compares the year-on-year change in Madagascar IRS program output measures and unit costs. Overall, in 2016, the program sprayed the most structures, protected the most people, and sprayed the highest amount of area of the two years presented. The number of structures sprayed increased by 25.2 percent from 2015 to 2016, and the number of people protected increased by 23.6 percent over the same period. Additionally, the area sprayed increased by 17.2 percent. Total program costs increased by 5.4 percent, while the number of structures sprayed increased by 25.2 percent between 2015 and 2016. Thus, the cost per structure sprayed decreased by 15.8 percent between the two years. The increase in the number of people protected (23.6 percent) was larger than the increase in the program costs between 2015 and 2016, indicating that the cost per person protected decreased by 14.8 percent between the two years. The cost per area sprayed decreased from \$40.94 in 2015 to \$36.81 in 2016, a decrease of 10.1 percent.

TABLE MG6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	17,884	21,861	22%
Number of structures sprayed	247,902	310,426	25%
Structures sprayed per SOP per day	13.9	14.2	2%
Spray operations cost per SOP Day	74.25	82.68	11%
Spray operations and commodities cost per structure sprayed	11.89	11.37	-4%
Spray operations and commodities cost per structure sprayed (without insecticide)	6.48	6.82	5%

Table MG6 displays various measures of implementation efficiency in the last two years. In 2016, there was a 22 percent increase in total SOP days employed compared to 2015, which was accompanied by 25 percent more structures sprayed, resulting in about 14.2 structures sprayed per SOP per day (2 percent more than in 2015). However, the spray operation cost per SOP per day increased by about 11 percent from 2015 to 2016, reflecting the fact that total spray operation costs increased over the two years by a larger amount than the increase in the number of SOP-days employed. Spray operations and commodity costs per structure sprayed increased by 5 percent despite the larger number structures sprayed per SOP per day. The increase in operations costs is due to the fact that a new district (Vohipeno) was added in 2015, increasing the number of districts from 4 in 2015 to 5 in 2016; which ultimately required additional resources for seasonal labor, transportation, equipment, washing/cleaning facilities, etc. When including insecticides, commodities, and spray operations cost, the cost per structure sprayed decreased from \$11.89 in 2015 to \$11.37 in 2016, a decrease of about 4 percent.

10. MALI

10.1 BACKGROUND

TABLE MLI: MALI QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Feb 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	3	3	3	2	3
# Local Staff	14	18	18	22	18
Spray Start Date	July 23, 2012	August 1, 2013	July 15, 2014 (Bla and Baroueli); August 11, 2014 (Koulikoro)	July 1, 2015	July 9, 2016
# Spray Rounds	1	1	1	1	1
Insecticides Used	Carbamates	Carbamates	Carbamates Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	77,187	93,435	89,947	58,472	84,571
# People Protected	762,146	850,104	836,568	494,205	788,922
# Structures Sprayed	206,295	228,985	228,123	133,527	228,672
# 100 Square Meters Sprayed	192,968	233,588	224,868	146,180	211,428

10.2 PROGRAM EXPENDITURES

This section will present an overview of Mali IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE ML2: MALI IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		414,729	749,028			185,767	\$ 1,349,524	27.6%
Entomology			88,601		306,903	42,192	\$ 437,697	9.0%
Environmental Compliance			27,305		74,208	42,689	\$ 144,201	3.0%
Equipment Supplies			2,691	187,054		250	\$ 189,995	3.9%
IEC			1,334		85,001	125	\$ 86,460	1.8%
Insecticide	1,552,889		817			75	\$ 1,553,781	31.8%
M&E			66,637		37,838	19,852	\$ 124,328	2.5%
Post Spray					78,551		\$ 78,551	1.6%
Spray Campaign			7,258		898,278	676	\$ 906,212	18.5%
Spray Planning			14,349			1,327	\$ 15,676	0.3%
Grand Total	\$ 1,552,889	\$ 414,729	\$ 958,019	\$ 187,054	\$ 1,480,780	\$ 292,953	\$ 4,886,425	100.0%

Table ML2 displays the Mali IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories.

Insecticide is the most expensive IRS activity (31.8 percent of expenditures), followed by administration (27.6 percent of expenditures) and spray campaign activities (18.5 percent of expenditures). PMI AIRS procured 88,195 bottles of Actellic CS and used 84,571 bottles. About 69 percent of the total cost for administration consists of labor, both local and U.S.-based. Note that the 'U.S.-based Labor and STTA' expenditures are largely incurred under the administrative, entomology, and environmental compliance program activities (92 percent of US labor expenditures are in the three categories). Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

10.3 UNIT COST ANALYSIS

This section presents Mali IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE ML3: MALI UNIT COSTS

		Unit costs	
Cost per	Person protected	\$	6.19
	Structure sprayed	\$	21.37
	100 m ² sprayed	\$	23.11

10.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Mali IRS program between 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs

TABLE ML4: MALI IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	1,533,373	1,552,889	1.3%
Local Admin	431,859	414,729	-4.0%
Local Labor	922,495	958,019	3.9%
Spray Operations	1,232,223	1,480,780	20.2%
Commodities	174,600	187,054	7.1%
U.S. Labor	279,943	292,953	4.6%
TOTAL	\$ 4,574,494	\$ 4,886,425	6.8%

Table ML4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 6.8 percent from 2015 to 2016. Costs declined for local administration by 4 percent (about \$17,000). Costs increased in real and nominal terms for all other categories. Spray operations costs increased by 20.2 percent or about \$249,000. With the UNITAID subsidy, the project added one more district (Fana) which required additional resources for seasonal labor, transportation, equipment, washing/cleaning facilities. The project also increased staff, by hiring an additional district coordinator.

TABLE ML5: MALI IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	494,205	788,922	59.6%
Structures Sprayed	133,527	228,672	71.3%
Area Sprayed (100 m ²)	146,180	211,428	44.6%
Unit Costs			
Per Person Protected	\$ 9.26	\$ 6.19	-33.1%
Per Structure Sprayed	\$ 34.26	\$ 21.37	-37.6%
Per Area Sprayed	\$ 31.29	\$ 23.11	-26.1%

Table ML5 compares the year-on-year change in Mali IRS program output measures and unit costs. Overall, in 2016, the program had higher levels of outputs than in previous year. The difference in the number of people protected and structures sprayed from 2015 to 2016 had an over 55 percent increase, while the area sprayed increased by approximately 45 percent. While the total expenditures increased from 2015 to 2016, there was a greater increase in the three outputs, meaning that the unit costs were lower in 2016 than in 2015. For the cost per person protected and per structure sprayed, unit costs decreased by 33.1 percent and 37.9 percent respectively from 2015 to 2016, while cost per 100 m² sprayed decreased by 26.1 percent.

TABLE ML6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	6,866	17,590	156%
Number of structures sprayed	133,527	228,672	71%
Structures sprayed per SOP per day	19.4	13.0	-33%
Spray operations cost per SOP Day	179.47	84.18	-53%
Spray operations and commodities cost per structure sprayed	22.02	14.08	-36%
Spray operations and commodities cost per structure sprayed (without insecticide)	10.54	7.29	-31%

Table ML6 displays various measures of implementation efficiency in the last two years. The spray campaign was of the same length in 2016 as in 2015, although the area

covered was larger. Thus, the number of SOP-days increased 156 percent from 2015 to 2016. The number of structures sprayed increased by 71 percent over the same period, indicating that SOPs were able to spray 6.45 less structures per day on average in 2016 than in 2015 (a 33 percent decrease). The cost of spray operations increased by 20.2 percent between 2015 and 2016, which was a smaller increase than the increase in the number of SOP days over the same period. Thus, the spray operations cost per SOP per day decreased from about \$179 in 2015 to \$84.18 in 2016, a 53 percent decrease. When spray commodities are included, the cost per structure sprayed decreased 31 percent, and when including insecticides, the cost per structure sprayed decreased by 31 percent.

II. MOZAMBIQUE

II.1 BACKGROUND

TABLE MZI: MOZAMBIQUE QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	April 1, 2012 – March 31, 2013	April 1, 2013 – March 31, 2014	April 1, 2014 – March 31, 2015	April 1, 2015 – March 31, 2016	April 1, 2016 – March 31, 2017
Number of Districts	6	4	5	6	7
# Local Staff	28	23	21	25	27
Spray Start Date	October 8, 2012	October 7, 2013	October 20, 2014	October 19, 2015	October 5, 2016
# Spray Rounds	1	1	1	1	1
Insecticides Used	Pyrethroids	Pyrethroids	Pyrethroids	Pyrethroids Organophosphates	Organophosphates
# Sachets & Bottles Used	389,788	329,094	356,807	259,748	254,952
# People Protected	2,716,176	2,181,896	2,327,815	1,631,058	1,929,654
# Structures Sprayed	536,558	414,232	445,118	337,433	405,597
# 100 Square Meters Sprayed	974,470	822,735	914,518	649,370	637,380

II.2 PROGRAM EXPENDITURES

This section presents an overview of Mozambique IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE MZ2: MOZAMBIQUE IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		535,162	574,830			220,014	\$ 1,330,005	10.8%
Entomology			173,523		249,285	16,316	\$ 439,124	3.6%
Environmental Compliance			95,310		70,543	39,665	\$ 205,519	1.7%
Equipment Supplies				324,682			\$ 234,682	2.6%
IEC			63,265		74,398	3,875	\$ 141,538	1.1%
Insecticide	6,737,319*						\$ 6,737,319	54.5%
M&E			120,694		184,539	44,917	\$ 350,150	2.8%
Post Spray			248,490		88,139	19,836	\$ 356,465	2.9%
Spray Campaign			136,408		1,320,082	39,177	\$ 1,495,666	12.1%
Spray Planning			343,488		589,681	49,553	\$ 982,722	7.9%
Grand Total	\$ 6,737,319	\$ 535,162	\$ 1,756,008	\$ 324,682	\$ 2,576,667	\$ 433,352	\$ 12,321,678	100.0%

*Includes estimated cost of organophosphate insecticides based on 2015 unit costs.

Table MZ2 displays the Mozambique IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project's financial systems, and the top row lists IRS program cost categories.

Insecticides and spray campaign are the two most expensive IRS activities (54.5 percent and 12.1 percent of expenditures, respectively), followed by the local administration (10.8 percent of expenditures). PMI AIRS Mozambique received an insecticide donation of 221,232 bottles of organophosphate class insecticides and used 254,952 bottles. About 60 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on local labor and spray operations.

11.3 UNIT COST ANALYSIS

This section presents Mozambique IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE MZ3: MOZAMBIQUE UNIT COSTS

		Unit costs
Cost per	Person protected	\$ 6.41
	Structure sprayed	\$ 30.48
	100 m ² sprayed	\$ 19.40

11.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the PMI AIRS Mozambique IRS program between 2015 and 2016, as implemented by the PMI AIRS Project.

TABLE MZ4: MOZAMBIQUE IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	3,562,669	6,737,319	89.1%
Local Admin	325,872	535,162	64.2%
Local Labor	1,016,940	1,756,008	72.7%
Spray Operations	1,695,652	2,576,667	52.0%
Commodities	443,545	324,682	-26.8%
U.S. Labor	254,731	433,352	70.1%
TOTAL	\$ 7,299,410	\$ 12,363,191	69.4%

Table MZ4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 69.4 percent from 2015 to 2016. The switch to use of organophosphates in all areas resulted in an increase in the costs of insecticide by about 89 percent from 2015 to 2016, which accounts for over 61 percent of the increased cost. The second largest increase in costs in absolute terms was for spray operations, which increased by over \$881,000 (52 percent increase) compared to 2015, while the costs of local labor increased over 72 percent from 2015 to 2016 (about \$739,000). Costs of local administration and U.S. labor also increased by 64.2 percent (about \$209,000) and 70.1 percent (about \$178,000), respectively. Costs decreased between 2015 and 2016 for commodities by over 26 percent, or over \$118,000.

Mozambique's higher costs in 2016 are due to several factors, namely: the Maputo and Quelimane Office moves; an increase in the rent of the Maputo office; increases in internet services bandwidth in Maputo and Quelimane; an increased number of staff; an increase in the number of spray campaign days (44 days in 2016 versus 36 days in 2015); an increase in operational site stores space to accommodate new insecticide; the roll out and implementation of mHealth; an increase in seasonal personnel from 1,703 in 2015 to 2,295 in 2016; and the recruitment of a TCN Operations Manager.

TABLE MZ5: MOZAMBIQUE IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	1,631,058	1,929,654	18.3%

Structures Sprayed	337,433	405,597	20.2%
Area Sprayed (100 m ²)	649,370	637,380	-1.8%
Unit Costs			
Per Person Protected	\$ 4.48	\$ 6.41	43.2%
Per Structure Sprayed	\$ 21.63	\$ 30.48	40.9%
Per Area Sprayed	\$ 11.24	\$ 19.40	72.6%

Table MZ5 compares the year-on-year change in Mozambique IRS program output measures and unit costs. Overall, in 2016, the program sprayed more structures and protected more people, but used almost 4,800 fewer bottles of insecticide (the basis for calculating the area sprayed) than in 2015. (The project sprayed 1.6 structures/ bottle of insecticide in 2016 and 1.3 structures / bottle of insecticide in 2015.) Because the increase in program size was lower than the increase in total expenditures from 2015 to 2016, the unit costs increased across all categories of output measures by 40 percent to 72 percent. This increase demonstrates the effect of using organophosphate on program scale and unit costs. If the costs of insecticide is not included in the unit costs, costs decreased by 10% or more per area sprayed, structured sprayed, and per person protected.

TABLE MZ6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	38,816	50,700	31%
Number of structures sprayed	337,433	405,597	20%
Structures sprayed per SOP per day	8.7	8.0	-8%
Spray operations cost per SOP Day	43.68	50.82	16%
Spray operations and commodities cost per structure sprayed	16.90	23.76	41%
Spray operations and commodities cost per structure sprayed (without insecticide)	6.34	7.15	13%

Table MZ6 displays various measures of implementation efficiency in the last two years. From 2015 to 2016, the number of SOP-days used for the campaign increased by 31 percent while the number of structures sprayed increased by 20 percent, resulting in fewer structures sprayed per operator per day in 2016 than in 2015 (8.7 structures per SOP per day in 2015 vs. 8.0 structures per SOP per day in 2016). Additionally, the cost of spray operations increased between 2015 and 2016, resulting in a 16 percent increase in the spray operations cost per SOP per day between the two years, and an increase in the spray operations and commodities cost per structure sprayed of 13 percent.

When including insecticides, the spray operations and commodities cost per structure sprayed increased by 41 percent.

12. RWANDA

12.1 BACKGROUND

TABLE RW1: RWANDA QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	March 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	3	3	3	4	2
# Local Staff	16	19	17	16	15
Spray Start Date	August 20, 2012	February 11, 2013 September 2, 2013	February 10, 2014 September 8, 2014	February 9, 2015 September 14, 2015	February 15, 2016 September 19, 2016
# Spray Rounds	1	2	2	2	2
Insecticides Used	Pyrethroids	Pyrethroids Carbamates	Carbamates	Carbamates	Carbamates Organophosphates
# Sachets & Bottles Used	172,620	265,189	241,483	289,195	278,563
# People Protected	1,025,181	1,479,342	1,217,837	1,406,520	1,431,410
# Structures Sprayed	236,610	345,862	297,005	343,131	346,917
# 100 Square Meters Sprayed	332,522	529,940	482,958	578,390	557,126

12.2 PROGRAM EXPENDITURES

This section presents an overview of Rwanda IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE RW2: RWANDA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		283,899	415,707			143,207	\$ 842,812	10.6%
Entomology			5,022		585,438	3,657	\$ 594,117	7.4%
Environmental Compliance			40,844		9,862	23,163	\$ 73,870	0.9%
Equipment Supplies			473	233,345		125	\$ 233,943	2.9%
IEC					8,598		\$ 8,598	0.1%
Insecticide	4,232,754						\$ 4,232,754	53.0%
M&E			51,536		3,328	41,502	\$ 96,366	1.2%
Post Spray					22,270		\$ 22,270	0.3%
Spray Campaign					1,355,601		\$ 1,355,601	17.0%
Spray Planning			177,146		313,421	36,944	\$ 527,511	6.6%
Grand Total	\$ 4,232,754	\$ 283,899	\$ 690,728	\$ 233,345	\$ 2,298,518	\$ 248,599	\$ 7,987,842	100.0%

Table RW2 displays the Rwanda IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories.

Insecticides represented 53.0 percent of costs. Spray campaign costs and administration were the next two largest categories of costs, representing 17.0 and 10.6 percent of costs, respectively. The Project procured 121,994 sachets of carbamate and 173,956 bottles of organophosphate, and used 122,986 sachets of carbamate and 155,577 bottles of organophosphate; the costs above reflect the cost of insecticide used. About 66 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

12.3 UNIT COST ANALYSIS

This section presents Rwanda IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE RW3: RWANDA UNIT COSTS

	Unit costs	
Person protected	\$	5.58
Cost per Structure sprayed	\$	23.03
100 m² sprayed	\$	12.58

12.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Rwanda IRS program between 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE RW4: RWANDA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	3,007,913	4,232,754	40.7%
Local Admin	384,215	283,899	-26.1%
Local Labor	676,531	690,728	2.1%
Spray Operations	2,192,944	2,298,518	4.8%
Commodities	294,453	233,345	-20.8%
U.S. Labor	233,375	248,599	6.5%
TOTAL	\$ 6,789,431	\$ 7,987,842	17.7%

Table RW4 compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 17.7 percent from 2015 to 2016, representing an increase in the total annual cost of almost \$1,198,000. Increases in costs from 2015 to 2016 were mainly due to an increase in the cost of insecticide (about \$1,225,000), as a result of the introduction of organophosphates. Costs decreased for local administration by about \$100,000 and for commodities by about \$61,000. Increased insecticide costs, followed by increased transportation costs to transport the new OP insecticide, were the main reason for the cost increase in Rwanda in 2016.

TABLE RW5: RWANDA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	1,406,520	1,431,410	1.8%
Structures Sprayed	343,131	346,917	1.1%
Area Sprayed (100 m ²)	578,390	634,915	9.8%
Unit Costs			
Per Person Protected	\$ 4.83	\$ 5.58	15.6%
Per Structure Sprayed	\$ 19.79	\$ 23.03	16.4%
Per Area Sprayed	\$ 11.74	\$ 12.58	7.2%

Table RW5 compares the year-on-year change in PMI AIRS Rwanda program output measures and unit costs. In 2016, the program achieved higher coverage on all three indicators used in Table RW4 than in 2015. Between 2015 and 2016, the number of people protected increased 1.8 percent, the number of structures increased 1.1 percent, and the area sprayed increased by 9.8 percent. With the total expenditures increasing from 2015 to 2016 in association with the partial introduction of organophosphate insecticide, the unit costs increased by about 16 percent for cost per person protected and per structure sprayed.

TABLE RW6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	32,844	40,339	23%
Number of structures sprayed	343,131	346,917	1%
Structures sprayed per SOP per day	10.4	8.6	-18%
Spray operations cost per SOP Day	66.77	56.98	-15%
Spray operations and commodities cost per structure sprayed	16.02	19.50	22%
Spray operations and commodities cost per structure sprayed (without insecticide)	7.25	7.30	1%

Table RW6 displays various measures of implementation efficiency in the last two years. Between 2015 and 2016, the number of SOP days used for the campaign increased by 23%. At the same time, the number of structures sprayed increased by 1 percent from 2015 to 2016, resulting in fewer structures sprayed per SOP per day. The cost of spray operations decreased per SOP per day by about 15 percent, and costs for spray operations commodities also increased. The spray operations and commodities costs per structure sprayed increased by 1 percent from 2015 to \$7.30, when not including cost of insecticides. As noted above, costs for insecticide also increased between 2015 and 2016.

13. SENEGAL

13.1 BACKGROUND

TABLE SNI: SENEGAL QUICK FACTS

	2012	2013	2014	2015	2016
Program Dates	Jan 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015	Jan 1, 2016 – Dec 31, 2016
Number of Districts	6	4	4	4	4
# Local Staff	14	16	19	18	18
Spray Start Date	June 6, 2012	July 15, 2013	May 15, 2014	May 22, 2015	July 11, 2016
# Spray Rounds	1	1	2	2	1
Insecticides Used	Carbamates	Carbamates	Carbamates Organophosphates	Carbamates Organophosphates	Organophosphates
# Sachets & Bottles Used	106,874	65,049	60,186	39,204	39,189
# People Protected	1,095,093	690,029	708,999	514,833	496,728
# Structures Sprayed	306,916	207,116	204,159	130,170	124,757
# 100 Square Meters Sprayed*	267,185	162,623	150,465	98,010	97,973

* Reverse calculation using number of insecticide sachets/bottles used during campaign multiplied by the average of 250 m² estimated to be sprayed by one sachet and divided by the number of structures sprayed.

13.2 PROGRAM EXPENDITURES

This section presents an overview of Senegal IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE SN2: SENEGAL IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		331,005	613,194			153,144	\$ 1,097,344	31.4%
Entomology			53,526		151,908	23,285	\$ 228,720	6.5%
Environmental Compliance			77,648		12,346	22,217	\$ 112,211	3.2%
Equipment Supplies			294	109,122		3	\$ 109,419	3.1%
IEC			41,479		24,756	5,341	\$ 71,576	2.0%
Insecticide	1,036,482		990			12	\$ 1,037,484	29.7%
M&E			93,142		35,808	21,983	\$ 150,932	4.3%
Post Spray			72,713		22,213	11,494	\$ 106,420	3.0%
Spray Campaign			35,107		251,982	3,910	\$ 290,998	8.3%
Spray Planning			115,002		145,996	28,987	\$ 289,986	8.3%
Grand Total	\$1,036,482	\$331,005	\$1,103,096	\$90,390	\$645,008	\$270,375	\$3,495,089	100.0%

Table SN2 displays the Senegal IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories.

Administration is the most expensive IRS activity (31.4 percent of expenditures), followed by the insecticides (29.7 percent of expenditures), and spray campaign and spray planning activities (8.3 percent of expenditures, each). PMI AIRS procured 9,831 bottles of organophosphate class insecticide, and used about 39,189 bottles (costs reflect the insecticides used). About 70 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

13.3 UNIT COST ANALYSIS

This section presents Senegal IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE SN3: SENEGAL UNIT COSTS

	Unit costs	
Person protected	\$	7.04
Cost per Structure sprayed	\$	28.02
100 m² sprayed	\$	35.67

13.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Senegal IRS program between 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE SN4: SENEGAL IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	950,237	1,036,482	9.1%
Local Admin	404,868	331,005	-18.2%
Local Labor	1,026,743	1,103,096	7.4%
Spray Operations	628,268	645,008	2.7%
Commodities	99,266	109,122	9.9%
U.S. Labor	250,777	270,375	7.8%
TOTAL	\$ 3,360,159	\$ 3,495,089	4.0%

Table SN4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 4.0 percent from 2015 to 2016, representing an increase in the total annual cost of about \$135,000. Reductions in costs from 2015 to 2016 were seen in local administration (18.2 percent).

The costs of insecticides used increased 9.1 percent from 2015 to 2016, reflecting the exclusive use of organophosphates in 2016. Local labor, spray operations, commodities and U.S. labor costs also increased by 7.8 percent, 2.7 percent, 9.9 percent, and 7.8 percent respectively, from 2015 to 2016. The local FSN scale increased in 2016 and a warehouse assistant was hired, which caused a spike of 7.4% in local labor costs. Contrary to 2015, when spray operators were trained over a period of three days, in 2016, all spray operators received a five-day training. Also the number of SOPs increased, particularly in Malem Hoddar, as there were fewer days of spraying. Furthermore, in 2015 some sites completed the campaign in 18 or 19 days, compared to 2016 when all 20 days were paid.

TABLE SN5: SENEGAL IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	514,833	496,728	-3.5%
Structures Sprayed	130,170	124,757	-4.2%
Area Sprayed (100 m ²)	98,010	97,973	0.0%
Unit Costs			
Per Person Protected	\$ 6.53	\$ 7.04	7.8%
Per Structure Sprayed	\$ 25.81	\$ 28.02	8.5%
Per Area Sprayed	\$ 34.28	\$ 35.67	4.1%

Table SN5, above, compares the year-on-year change in Senegal IRS program output measures and unit costs. In 2016, the program had the lowest coverage metrics over the last two years. The number of people protected decreased by 3.5 percent from 2015 to 2016, which was a lesser decline than in the number of structures sprayed (4.2 percent). Area sprayed decreased by less than 0.1 percent over the same period. Because the program size decreased while total expenditures increased, unit costs increased from 2015 to 2016. The cost per person protected increased by about 7.8 percent, while costs per structure sprayed and area sprayed increased on the order of 8.5 percent and 4.1 percent, respectively, from 2015 to 2016.

TABLE SN6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	8,893	8,704	-2%
Number of structures sprayed	130,170	124,757	-4%
Structures sprayed per SOP per day	14.6	14.3	-2%
Spray operations cost per SOP Day	70.65	74.10	5%
Spray operations and commodities cost per structure sprayed	12.89	14.35	11%
Spray operations and commodities cost per structure sprayed (without insecticide)	5.59	6.04	8%

Table SN6 displays various measures of implementation efficiency in the last two years. While there was increase in the cost of spray operations, the number of SOP days used decreased, and the spray operations cost per SOP per day increased by 5 percent

from 2015 to 2016. The decrease in the scale of operations was reflected in the spray operations and commodities cost per structure sprayed (which increased by 8 percent from 2015 to 2016). The use of organophosphate class insecticides in 2016 is also reflected in the increase in spray operations, commodities, and insecticide cost per structure sprayed.

14. TANZANIA

14.1 BACKGROUND

TABLE TZI: TANZANIA QUICK FACTS

	2016
Program Dates	Oct 1, 2015 – Sep 30, 2016
Number of Districts	15
# Local Staff	34
Spray Start Date	February 13, 2016
# Spray Rounds	1
Insecticides Used	Organophosphates
# Sachets & Bottles Used	175,173
# People Protected	2,042,561
# Structures Sprayed	515,217
# 100 Square Meters Sprayed*	437,933

* Reverse calculation using number of insecticide sachets/bottles used during campaign multiplied by the average of 250 m² estimated to be sprayed by one bottle and divided by the number of structures sprayed.

Note that 2016 was the first year of IRS implementation under the PMI AIRS project, and thus a year-on-year comparison is not possible.

14.2 PROGRAM EXPENDITURES

This section presents an overview of Tanzania IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE TZ2: TANZANIA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		917,732	816,096			223,089	\$ 1,956,918	16.4%
Entomology			80,326		293,160	17,591	\$ 391,077	3.3%
Environmental Compliance			73,338		53,277	30,746	\$ 157,361	1.3%
Equipment Supplies			7,827	355,176		3,530	\$ 366,533	3.1%
IEC					286		\$ 286	0.0%
Insecticide	4,982,375						\$ 4,982,375	41.9%
M&E			45,129		23,397	51,861	\$ 120,387	1.0%
Post Spray			87,152		53,142	10,867	\$ 151,161	1.3%
Spray Campaign			76,306		2,535,893	14,637	\$ 2,626,837	22.1%
Spray Planning			250,005		852,390	46,359	\$ 1,148,754	9.7%
Grand Total	\$ 4,982,375	\$ 917,732	\$ 1,436,179	\$ 355,176	\$ 3,811,546	\$ 398,681	\$ 11,901,690	100.0%

Table TZ2 displays the Tanzania IRS program total capital and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories.

Insecticide is the most expensive IRS activity (41.9 percent of expenditures), followed by the spray campaign activities (22.1 percent of expenditures) and administration (16.4 percent of expenditures). PMI AIRS procured 196,450 bottles of organophosphate insecticide, and used about 175,173 bottles (costs reflect the insecticides used). About 53 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

14.3 UNIT COST ANALYSIS

This section presents Tanzania IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE TZ3: TANZANIA UNIT COSTS

	Unit costs	
Person protected	\$	5.83
Cost per Structure sprayed	\$	23.10
100 m ² sprayed	\$	27.18

15. ZAMBIA

15.1 BACKGROUND

TABLE ZAI: ZAMBIA QUICK FACTS

	2014	2015	2016
Program Dates	March 1, 2014 – Feb 28, 2015	March 1, 2015 – Feb 28, 2016	March 1, 2016 – Feb 28, 2017
Number of Districts	40	39	35
# Local Staff	27	48	46
Spray Start Date	October 13, 2014	September 28, 2015	September 26, 2016
# Spray Rounds	1	1	1
Insecticides Used	Organophosphates	Organophosphates	Organophosphates
# Bottles Used	112,603	136,652	140,018
# People Protected	2,000,824	2,544,290	2,626,718
# Structures Sprayed	409,544	519,598	559,550
# 100 Square Meters Sprayed	281,508	341,630	350,045

15.2 PROGRAM EXPENDITURES

This section presents an overview of Zambia IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE ZA2: ZAMBIA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		356,927	764,032			217,963	\$ 1,338,921	14.8%
Entomology		32,165	165,430		353,255	27,802	\$ 578,651	6.4%
Environmental Compliance			35,890		338,968	24,817	\$ 399,675	4.4%
Equipment Supplies				249,554			\$ 249,554	2.8%
IEC					199,634		\$ 199,634	2.2%
Insecticide	2,469,973						\$ 2,469,973	27.3%
M&E			56,605		193,013	66,344	\$ 315,963	3.5%
Post Spray			48,824		128,444	15,035	\$ 192,303	2.1%
Spray Campaign			116,485		1,952,429		\$ 2,068,914	22.9%
Spray Planning			313,931		846,494	67,450	\$ 1,227,875	13.6%
Grand Total	\$ 2,469,973	\$ 389,092	\$ 1,501,196	\$ 249,554	\$ 4,012,237	\$ 419,410	\$ 9,041,462	100.0%

Table ZA2 displays the Zambia IRS program total capital (including disposition) and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories.

Insecticides and spray campaign costs are the two most expensive IRS activities (27.3 percent and 22.9 percent of expenditures, respectively), followed by the administration (14.8 percent of expenditures). PMI AIRS Zambia procured 136,418 bottles of organophosphate insecticide; 140,018 bottles were used. About 73.3 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs were less than expenditures on insecticide, local labor, and spray operations.

15.3 UNIT COST ANALYSIS

This section presents Zambia IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE ZA3: ZAMBIA UNIT COSTS

Unit costs	
Person protected	\$ 3.44
Cost per Structure sprayed	\$ 16.16
100 m ² sprayed	\$ 25.83

15.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Zambia IRS program for 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ZA4: ZAMBIA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	3,645,151	2,469,973	-32.2%
Local Admin	636,198	389,092	-38.8%
Local Labor	1,274,085	1,501,196	17.8%
Spray Operations	3,086,005	\$4,012,237	30.0%
Commodities	250,061	249,554	-0.2%
U.S. Labor	494,326	419,410	-15.2%
TOTAL	\$ 9,385,827	\$ 8,842,563	-3.7%

Table ZA4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 3.7 percent from 2015 to 2016, representing an decrease in the total annual cost of about \$344,000.

The largest cost decrease in absolute terms was for insecticide, which decreased by about \$1.18 million from 2015 to 2016 (a 32.2 percent decrease), accounting for over 78 percent of the decreased cost between the two years. Local administration costs decreased by 38.8 percent (about \$247,000) from 2015 to 2016. Spray operations costs increased by \$926,232 (30.0 percent) from 2015 to 2016, with over half of the increase related to additional costs for hire of seasonal day labor, IEC, and ground transportation. Local labor also increased by 17.8 percent (\$227,112). The project hired 20 full time districts coordinators in August 2015, which contributed to the increase in local labor costs in 2016 (because the costs for the coordinators were incurred for the full year in 2016). There was also an increase in the FSN scale in 2016, and some staff received a 30% increase. In addition, the project had to procure additional insecticide, restart the campaign and add extra days, which had an impact on insecticide and spray operations costs (SOP days and transportation).

TABLE ZA5: ZAMBIA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	2,544,290	2,626,718	3.2%
Structures Sprayed	519,598	559,550	7.7%
Area Sprayed (100 m ²)	341,630	35,045	2.5%
Unit Costs			
Per Person Protected	\$ 3.69	\$ 3.44	-6.7%
Per Structure Sprayed	\$ 18.06	\$ 16.16	-10.5%
Per Area Sprayed	\$ 27.47	\$ 25.83	-6.0%

Table ZA5, above, compares the year-on-year change in Zambia IRS program output measures and unit costs. In 2016, the program had higher output metrics across the three categories considered, with increases in program outputs of over 3 percent and 7 percent compared to 2015 for the number of people protected and structures sprayed, respectively, and over 2 percent greater area sprayed. While the program size increased between 2 percent and 8 percent across the different outputs, total expenditures decreased by over 3%. Thus, unit costs decreased from 2015 to 2016 by 6 percent to over 10 percent across the three output metrics.

TABLE ZA6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	33,597	38,325	14%
Number of structures sprayed	519,598	559,550	8%
Structures sprayed per SOP per day	15.5	14.6	-6%
Spray operations cost per SOP Day	91.85	104.69	14%
Spray operations and commodities cost per structure sprayed	13.44	12.03	-10%
Spray operations and commodities cost per structure sprayed (without insecticide)	6.42	7.62	19%

Table ZA6 displays various measures of implementation efficiency in the last two years. From 2015 to 2016, SOP productivity decreased from spraying 15.5 structures per day to spraying 14.6 structures per day (representing a 6 percent decrease). Further, while the

number of SOP-days employed in the campaign increased by 14 percent between the two years, costs for spray operations increased by 30.0 percent, indicating that the spray operations cost per SOP per day increased by 14 percent between the two years. With lower productivity and increased spray operations costs, the spray operations and commodities cost per structure sprayed increased by 19 percent from 2015 to 2016, rising from \$6.42 to \$7.62. The costs for insecticides decreased by 32.2 percent between the two years, which is a decrease greater than the increase in the number of SOP days employed. The increased efficiency in use of insecticide indicate that when including costs for spray operations, commodities, and insecticides per structure sprayed, costs decreased from \$13.44 to \$12.03, a decrease of 10 percent (compared to the 19 percent increase when insecticide costs are not included).

16. ZIMBABWE

16.1 BACKGROUND

TABLE ZWI: ZIMBABWE QUICK FACTS

	2014	2015	2016
Program Dates	March 1, 2014 – Feb 28, 2015	March 1, 2015 – Feb 28, 2016	March 1, 2016 – Feb 28, 2017
Number of Districts	4	4	4
# Local Staff	10	12	15
Spray Start Date	November 1, 2014	October 11, 2015	October 24, 2016
# Spray Rounds	1	1	1
Insecticides Used	Organophosphates	Organophosphates	Organophosphates
# Bottles Used	67,040	73,326	105,474
# People Protected	334,746	365,425	550,475
# Structures Sprayed	147,949	162,127	229,377
# 100 Square Meters Sprayed	167,600	183,315	263,685

16.2 PROGRAM EXPENDITURES

This section presents an overview of Zimbabwe IRS program expenditures in 2016. Costs are organized by activity and cost category.

TABLE ZW2: ZIMBABWE IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		253,338	713,306			172,389	\$ 1,139,032	19.4%
Entomology		2,151	310,085		220,818	22,532	\$ 555,586	9.4%
Environmental Compliance		1,817	121,506		29,647	23,690	\$ 176,660	3.0%
Equipment Supplies				150,503			\$ 150,503	2.6%
IEC						913	\$ 913	0.0%
Insecticide	2,811,510						\$ 2,811,510	47.8%
M&E					116	17,380	\$ 17,495	0.3%
Post Spray			606		19,928	25	\$ 20,558	0.3%
Spray Campaign			44,303		780,570	4,981	\$ 829,854	14.1%
Spray Planning					183,212		\$ 183,212	3.1%
Grand Total	\$ 2,811,510	\$ 257,306	\$ 1,189,806	\$ 150,503	\$ 1,234,289	\$ 241,910	\$ 5,885,325	100.0%

Table ZW2 displays the Zimbabwe IRS program total capital (including requisition) and recurrent expenditures from 2016. The first column lists the program activities as tracked by the PMI AIRS project's financial systems, and the top row lists IRS program cost categories.

Insecticides and administration are the two most expensive IRS activities (47.8 percent and 19.4 percent of expenditures, respectively), followed by spray campaign (14.1 percent of expenditures). PMI AIRS Zimbabwe procured 116,519 bottles of organophosphate insecticide; 105,474 bottles were used (reflected in figure above). About 77.8 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

16.3 UNIT COST ANALYSIS

This section presents Zimbabwe IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m²).

TABLE ZW3: ZIMBABWE UNIT COSTS

	Unit costs
Person protected	\$ 10.69
Cost per Structure sprayed	\$ 25.66
100 m² sprayed	\$ 22.32

16.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Zimbabwe IRS program for 2015 and 2016, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ZW4: ZIMBABWE IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2015 (Adjusted)	2016	Percentage Change (2015 to 2016)
Insecticide	1,952,140	2,811,510	44.0%
Local Admin	313,078	257,306	-17.8%
Local Labor	874,963	1,189,806	36.0%
Spray Operations	743,734	1,234,289	66.0%
Commodities	158,480	150,503	-5.0%
U.S. Labor	203,030	241,910	19.1%
TOTAL	\$ 4,245,426	\$ 5,885,325	38.6%

Table ZW4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 38.6 percent from 2015 to 2016, representing an increase in the total annual cost of almost \$1.64 million. Reductions in costs were seen in local administration (17.8 percent) and commodities (5 percent) from 2015 to 2016.

The costs of insecticides used increased 44 percent from 2015 to 2016, approximately reflecting the increased structures and area sprayed. Spray operations costs increased 66 percent (about \$490,000) between the two years. Costs of local labor and U.S. labor also increased by 36 percent (about \$315,000, mostly due to hiring a third-country national as a seconded entomologist for the National Malaria Control Program) and 19.1 percent (roughly \$39,000) respectively.

TABLE ZW5: ZIMBABWE IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2015	2016	Percentage Change (2015 to 2016)
Output Measures			
People Protected	365,425	550,475	50.6%
Structures Sprayed	162,127	229,377	41.5%
Area Sprayed (100 m ²)	183,315	263,685	43.8%
Unit Costs			
Per Person Protected	\$ 11.62	\$ 10.69	-8.0%
Per Structure Sprayed	\$ 26.19	\$ 25.66	-2.0%
Per Area Sprayed	\$ 23.16	\$ 22.32	-3.6%

Table ZW5, above, compares the year-on-year change in Zimbabwe IRS program output measures and unit costs. In 2016, the program had higher output metrics across the three categories considered, with increases in program outputs of over 40 percent compared to 2015. Because the increase in program size was larger than the increase in total expenditures, unit costs decreased from 2015 to 2016 by between 2 percent and 8 percent across the three output metrics.

TABLE ZW6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2015	2016	% Change from 2015 to 2016
Number of SOP days	8,657	14,336	66%
Number of structures sprayed	162,127	229,377	41%
Structures sprayed per SOP per day	18.7	16.0	-15%
Spray operations cost per SOP Day	85.91	86.10	0%
Spray operations and commodities cost per structure sprayed	17.61	18.29	4%
Spray operations and commodities cost per structure sprayed (without insecticide)	5.56	6.04	8%

Table ZW6 displays various measures of implementation efficiency in the last two years. From 2015 to 2016, SOP productivity decreased and 66 percent more SOP days were used for the spray campaign in 2016 than in 2015, while the number of structures sprayed increased by 41 percent over the same period. Thus, the number of structures sprayed per SOP per day decreased from 18.7 to 16.0, a decrease of 15 percent. Given that the number of SOP-days employed increased by approximately the same rate as the increase in the cost of spray operations between 2015 and 2016, the spray

operations cost per SOP per day increased by less than 0.1 percent. The spray operations and commodities cost per structure sprayed increased from \$5.56 in 2015 to \$6.0 in 2016 (8 percent); when including the costs of insecticides in the calculation, the cost of spray operations, commodities, and insecticides increased by 4 percent across the two years.

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ANNEX I: YEAR-ON-YEAR COMPARISON OF OUTPUT MEASURES

Country	People Protected						Structures Sprayed						Area Sprayed (100 m ²)					
	2012	2013	2014	2015	2016	Percent Change 2015-2016	2012	2013	2014	2015	2016	Percent Change 2015-2016	2012	2013	2014	2015	2016	Percent Change 2015-2016
Ethiopia	1,506,273	1,629,958	1,647,099	1,655,997	1,688,745	2%	547,421	635,528	667,236	704,945	715,541	2%	524,334	617,442	624,764	641,994	677,990	6%
Zambia			2,000,824	2,544,290	2,626,718	3%			409,544	519,598	559,550	8%			281,508	341,630	350,045	2%
Tanzania					2,042,561						515,217						437,933	
Mozambique	2,716,176	2,181,896	2,327,815	1,631,058	1,929,654	18%	536,558	414,232	445,118	337,433	405,597	20%	974,470	822,735	914,518	649,370	637,380	-2%
Rwanda	1,025,181	1,479,342	1,217,837	1,406,520	1,431,410	2%	236,610	345,862	297,005	343,131	346,917	1%	332,522	529,940	482,958	578,390	634,915	10%
Madagascar	1,781,990	1,588,138	1,307,384	1,016,841	1,257,036	24%	371,391	343,470	274,533	247,902	310,426	25%	221,418	198,985	229,240	113,493	133,030	17%
Benin	762,146	694,729	789,883	802,597	858,113	7%	206,295	228,951	254,072	252,706	269,179	7%	192,968	125,605	110,505	114,160	116,543	2%
<i>Avg. Large Programs</i>	1,558,353	1,514,813	1,548,474	1,509,551	1,690,605	9%	379,655	393,609	391,251	400,953	446,061	10%	449,142	458,941	440,582	406,506	426,834	6%
Zimbabwe			334,746	365,425	550,475	51%			147,949	162,127	229,377	41%			167,600	183,315	263,685	44%
Mali	762,146	850,104	836,568	494,205	788,922	60%	206,295	228,985	228,123	133,527	228,672	71%	192,968	233,588	224,868	146,180	211,428	45%
Ghana	941,240	534,060	570,572	553,954	570,871	3%	355,278	197,655	205,230	205,935	211,283	3%	193,220	108,210	112,370	113,285	117,833	4%
Senegal	1,095,093	690,029	708,999	514,833	496,728	-4%	306,916	207,116	204,159	130,170	124,757	-4%	267,185	162,623	150,465	98,010	97,973	0%
<i>Avg. Medium Programs</i>	932,826	691,398	612,721	482,104	601,749	27%	289,496	211,252	196,365	157,940	198,522	28%	217,791	168,140	163,826	135,198	172,729	23%

ANNEX II: YEAR-ON-YEAR COMPARISON OF UNIT COSTS

Country	People Protected						Structures Sprayed						Area Sprayed (100 m ²)					
	2012	2013	2014	2015	2016	Percent Change 2015-2016	2012	2013	2014	2015	2016	Percent Change 2015-2016	2012	2013	2014	2015	2016	Percent Change 2015-2016
Ethiopia	\$3.33	\$4.39	\$4.53	\$5.27	\$5.66	7%	\$9.16	\$11.26	\$11.19	\$12.38	\$13.35	8%	\$9.56	\$11.59	\$11.95	\$13.60	\$14.09	4%
Zambia			\$3.00	\$3.69	\$3.44	-7%			\$14.65	\$18.06	\$16.16	-11%			\$21.31	\$27.47	\$25.83	-6%
Tanzania					\$5.83					\$23.10							\$27.18	
Mozambique	\$1.36	\$1.68	\$1.61	\$4.48	\$6.41	43%	\$6.89	\$8.83	\$8.42	\$21.63	\$30.48	41%	\$3.80	\$4.45	\$4.10	\$11.24	\$19.40	73%
Rwanda	\$3.94	\$5.43	\$6.41	\$4.83	\$5.58	16%	\$17.08	\$23.22	\$26.27	\$19.79	\$23.03	16%	\$12.15	\$15.16	\$16.15	\$11.74	\$12.58	7%
Madagascar	\$2.54	\$3.93	\$4.49	\$4.57	\$3.90	-15%	\$12.18	\$18.19	\$21.37	\$18.74	\$15.77	-16%	\$20.44	\$31.40	\$25.60	\$40.94	\$36.81	-10%
Benin	\$3.93	\$4.32	\$4.29	\$4.15	\$4.14	0%	\$14.51	\$13.11	\$13.33	\$13.18	\$13.19	0%	\$15.51	\$23.90	\$30.66	\$29.18	\$30.46	4%
<i>Avg. Large Programs</i>	\$3.02	\$3.95	\$4.05	\$4.50	\$4.99	7%	\$11.96	\$14.92	\$15.87	\$17.30	\$19.30	6%	\$12.29	\$17.30	\$18.30	\$22.36	\$23.76	12%
Zimbabwe			\$13.02	\$11.62	\$10.69	-8%			\$29.47	\$26.19	\$25.66	-2%			\$26.01	\$23.16	\$22.32	-4%
Mali	\$5.61	\$6.16	\$6.30	\$9.26	\$6.19	-33%	\$20.74	\$22.88	\$23.09	\$34.26	\$21.37	-38%	\$22.17	\$22.43	\$23.43	\$31.29	\$23.11	-26%
Ghana	\$5.09	\$8.63	\$7.71	\$7.74	\$7.10	-8%	\$13.50	\$23.32	\$21.43	\$20.81	\$19.18	-8%	\$24.82	\$42.60	\$39.13	\$37.82	\$34.39	-9%
Senegal	\$4.18	\$5.78	\$5.66	\$6.53	\$7.04	8%	\$14.90	\$19.27	\$19.66	\$25.81	\$28.02	9%	\$17.12	\$24.54	\$26.68	\$34.28	\$35.67	4%
<i>Avg. Medium Programs</i>	\$4.96	\$6.86	\$8.17	\$8.78	\$7.75	-10%	\$16.38	\$21.82	\$23.41	\$26.77	\$23.55	-10%	\$21.37	\$29.86	\$28.81	\$31.64	\$28.87	-3%