INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

Indoor Residual Spraying (IRS) for Malaria Control Indefinite Quantity Contract (IQC) Task Order 1 (TO1)

Analysis of 2008 Expenditures in Five IRS TO1 Countries

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I. Context and Purpose of this Analysis

The President's Malaria Initiative (PMI) began supporting indoor residual spraying (IRS) in 2006 and by 2009; IRS has been implemented in all 15 PMI focus countries. IRS is not a new intervention for vector control and malaria prevention but it is a relatively new intervention for the U.S. Agency for International Development (USAID). It has proven to be highly effective in PMI countries and there is considerable demand—from PMI and non-PMI countries—to scale up its application.

The complexities of planning, preparing, implementing, and concluding IRS operations are well known, requiring numerous time-sensitive material and labor inputs that must be well-synchronized. RTI International has completed spray operations in all of PMI's 15 target countries. Knowing how much IRS costs and the structure of those costs is useful for three reasons:

1. Planning–Some rules of thumb are broadly assumed to apply with respect to IRS costs but not all IRS programs are implemented equally and country-specific context matters. Program structure and scale, population density, and geography and topography may give rise to variability (Worrall et al., 2008). Variability may also arise from differences in settlement patterns, local costs of goods and services, and involvement and experience of host country partners.

   Also, while some analyses of early USAID-funded IRS operations have been conducted, these analyses were complicated by the fact that these were pilot countries and more than just IRS costs (e.g., cost for insectary refurbishment and environmental monitoring for DDT) were embedded in some of these analyses.

2. Sustainability–An important objective of IRS TO1 is to nurture a gradual move toward host country sustainability and self-reliance. As responsibility for specific elements of IRS shifts, it is important to know how much money host countries will need to mobilize. The pace and configuration of handovers will affect these costs.

3. Contribute to economic analyses of IRS–Achieving the maximum impact from the range of available malaria prevention interventions requires an understanding of the relative impacts of each. Cost-effectiveness analyses of IRS have been conducted on a range of IRS program types, using varying approaches to establish costs (Yukich et al., 2008; Conteh et al., 2004; Guyatt, et al., 2002; Goodman et al., 1999). Table 1 summarizes the cost findings of these studies.

Table 1: Literature Review of Reported IRS Costs

	Cost per person	
Location	**Financial costs**	**Economic costs**
Tanzania	$2.45 (Worrell, et.al.)	
Kenya highlands	$0.88 (Guyatt, et.al.) [a]	$0.86 (Guyatt, et.al.) [a]
KwaZulu Natal, South Africa	$4.93 (Worrell, et.al.) $4.15 (Yukich, et.al.)	$4.27 (Worrell, et.al.) $3.27 (Yukich, et.al.) $3.11 (Yukich, et.al.)
Rural LSDI, Mozambique	$4.94 (Worrell, et.al.) $4.96 (Conteh, et.al.) $4.78 (Yukich, et.al.)	$4.82 (Worrell, et.al.) $3.90 (Yukich, et.al.) $4.54 (Conteh, et.al.) $3.90 (Yukich, et.al.)
Peri-urban LSDI, Mozambique	$3.48 (Worrell, et.al.) $2.85 (Conteh, et.al.)	$2.16 (Worrell, et.al.) $2.58 (Conteh, et.al.)
Not specified	$5.76[b] (Goodman, et.al)	

[a] Includes only cost of insecticide.
[b] Cost per child under 5.

In this paper, we provide new cost information from five countries using one common data source in programs managed by a common entity (RTI, together with the National Malaria Control Program [NMCP] in each of the five countries).

II. Approach and Methods

This analysis examines RTI's costs for implementing IRS programs in Benin, Ethiopia, Ghana, Mali and Mozambique from January to December 2008. These countries were selected because they represent a good geographic and programmatic cross-section of countries from among the 14 countries that participated in the USAID IRS Task Order 1 (TO1) project in 2008. Each of these five country IRS programs had been operating for the full, 2008 calendar year, all were one spray round per year programs, and each continued to participate as an IRS TO1 country, allowing potentially for longitudinal analysis of IRS costs. The analysis includes all costs associated with spray operations, management and administration, and technical assistance. Table 2 below shows the cost categories included in this analysis and the types of costs included in those categories.

All costs include applicable overhead expenses. Retrospective financial records from RTI were used as the primary data source. A comprehensive list of all 2008 expenditures recorded by RTI was reviewed. Each item was assigned to an expenditure category per Table 1 and appropriate overhead/indirect cost factors were applied. Observed total program costs were then compared across countries. The countries were also compared in terms of the distribution of costs across IRS cost categories, costs per structure, and costs per person protected. Specific costing issues of importance are:

- Most country IRS programs included non-IRS activities such as insectary refurbishment (Mozambique), entomological monitoring (Ghana), and local subcontracts not related to the IRS mandate (Benin and Ghana). Because the focus

Table 2: Cost Categories for IRS Cost Analysis

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

[a] This category includes non-employee labor engaged to prepare for and conduct spray operations, including spray operators, IEC mobilizers, field supervisors, and data entry clerks.

[b] This category includes salaries of all host country staff employed by IRS TO1.

of this analysis is on costs of IRS itself, costs for these non-IRS activities have not been included.

- Host countries contribute significantly to IRS operations through in-kind contributions, such as Ministry of Health (MOH) and NMCP staff labor, transportation to project events, and warehouse space for IRS commodities (all countries). These costs are not included in this analysis.
- RTI did not finance or purchase insecticide for Ethiopia and Mozambique; other arrangements were made to provide these goods. However, information on these costs was obtained and is included in this analysis to improve cross-country comparison of results.
- The full costs of solid waste management from IRS are not captured in countries where means for final disposal has not yet been defined (Ethiopia, Mali, and Mozambique). Costs for solid waste collection and storage are included.

There are several limitations to this analysis. Most importantly, 2008 is the first full year of IRS TO1 operations for four of the five countries investigated here (Benin, Ghana, Mali, and Ethiopia). In these countries, staffing was augmented by RTI staff based in the U.S. and in Nairobi while recruitment and training of local staff was ongoing. These external labor inputs should decline in subsequent years but total program costs reported here may overstate travel costs and labor costs associated with external support for a more mature program.

Also, capital investments, for instance for soak pit or evaporation tank construction, are useable over several spray cycles. Similarly, spray equipment is useable over several years. The full costs for these inputs have been included in this analysis; they

have not, however, been amortized here because the manner in which these costs were recorded made it difficult to clearly separate out these costs from other spray operations costs.

III. Results

A. Expenditures by Country

Table 3 summarizes 2008 expenditures on IRS in each of the five countries. Total program costs varied from US$2.44 million for Benin to US$5.94 million for Mozambique. Because the scope of operations differs across these countries, expenditure differences are more readily evaluated after standardizing total costs by the number of structures sprayed. This analysis is presented in Section C below.

Table 3: 2008 IRS Program Expenditures

	Expenditures (US$ millions)				
Cost Category	**Ethiopia**	**Ghana**	**Mozambique**	**Benin**	**Mali**
Spray operations	1.61	1.20	3.10	0.88	0.93
Insecticide	0.29[a]	0.36	0.86[b]	0.42	0.30
Spray equipment	0.56	0.30	0.23	0.11	0.14
PPE	0.22	0.14	0.08	0.12	0.08
Shipping	0.20	0.07	0.08	0.13	0.13
Local labor	0.06	0.20	0.32	0.13	0.27
Admin-local	0.07	0.31	0.65	0.34	0.65
STTA & U.S. costs	0.19	0.13	0.27	0.09	0.09
U.S./Nairobi labor	0.18	0.16	0.35	0.21	0.38
TOTAL	**3.26**	**2.94**	**5.94**	**2.44**	**2.98**
People protected [c]	1,000,526	601,973	1,457,142	521,738	420,580

[a] Insecticide used for IRS TO1 operations in Ethiopia were financed by USAID outside the project mechanism and procured from a domestic Ethiopian source.

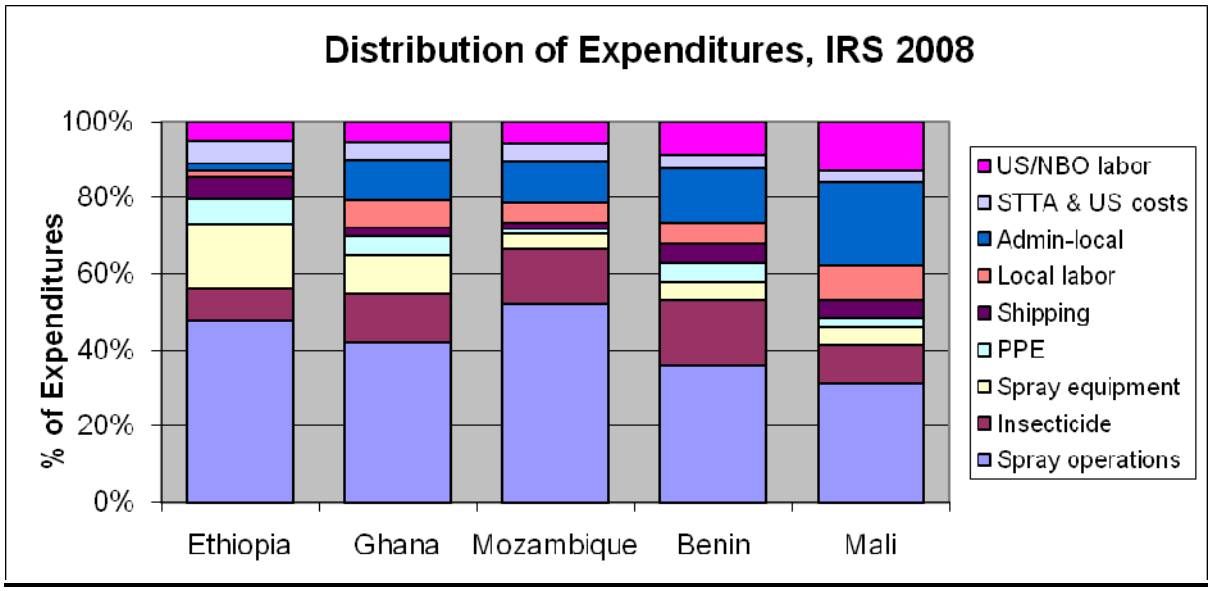
[b] Insecticide used for IRS TO1 operations in Mozambique was financed and procured through a Global Fund grant to the country.

[c] In this analysis, "people protected" is calculated as the total number of people living in structured sprayed during the IRS campaign. People living in structures not sprayed are not counted as "people protected."

B. Distribution of Expenditures across Cost Categories

One way to compare expenditures across countries is to look at their distribution in proportional terms across the major cost categories. This is shown in Figure 1.

Figure 1: Distribution of 2008 IRS Expenditures across Program Cost Categories



Spray operations. In all five countries, spray operations consumed the highest proportion of total expenditures. This ranged from a low of 31 percent in Mali to a high of 52 percent in Mozambique. In Mali, high local administrative costs affected the proportional distribution; had these administrative costs been the average of the other four countries (9.5%), spray operations for Mali would have risen to 36% of total program costs.

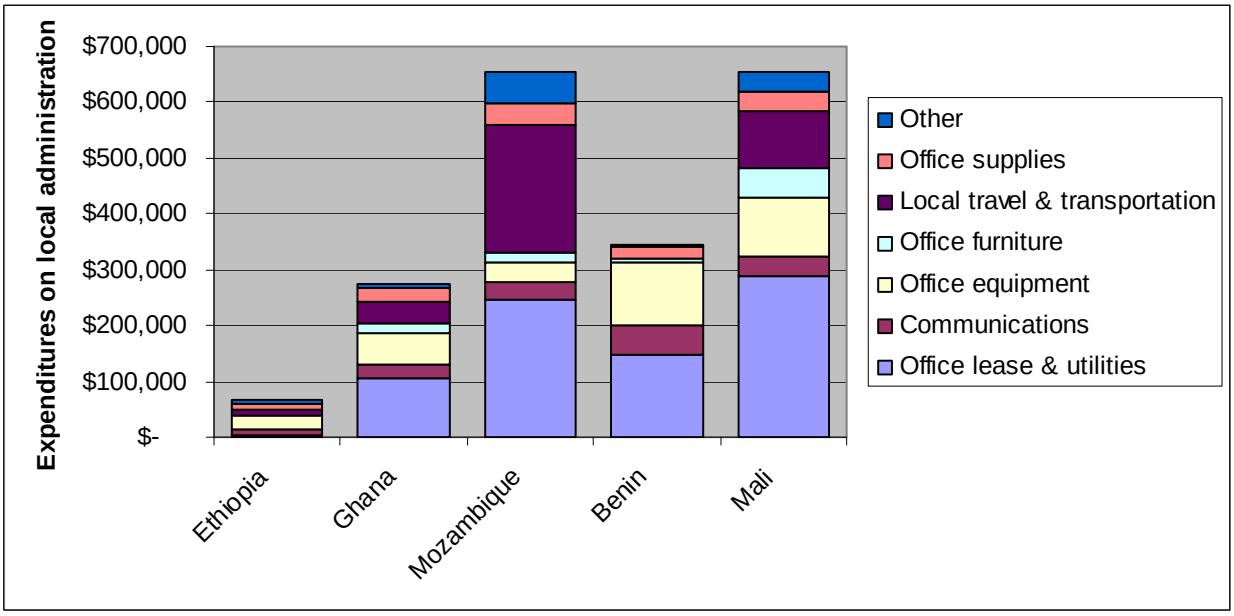
Insecticide, spray equipment, and PPE. The weighted average cost of insecticide across the five countries was 12 percent of total expenditures.[1] This ranged from 9 percent in Ethiopia to 17 percent in Benin. The range was greater for spray equipment. Between 4 and 5 percent of total expenditures in Mozambique, Benin, and Mali were spent on spray equipment, whereas in Ghana and Ethiopia, 10 and 17 percent, respectively, of total spending was for spray equipment. The range in the proportion spent on PPE also varied considerably, from 1 percent in Mozambique to almost 7 percent in Ethiopia. Costs to ship these equipment and supplies to the countries ranged from 1 percent in Mozambique to 6 percent in Ethiopia.

Local labor. This cost category includes salaries of all host country staff employed by IRS TO1. In countries where the Chief of Party (COP) is a third country national (TCN; Mozambique and Benin), these costs are included in the U.S./NBO (Nairobi) labor category (see below). It also does not include short-term, seasonal labor; these costs are included in the spray operations cost category. The range in the proportion of total expenditures used for local labor most likely reflects differences in labor markets. In Ethiopia, where labor costs are low compared to the other countries, only 2 percent was spent on local labor, whereas in Mali, where costs are considerably higher, 9 percent was spent on local labor.

[1] This compares to 14% as reported by Yukich, et. al. (2007) for spray operations in KwaZulu Natal, South Africa.

Local administration. The greatest range in expenditures across these five countries was observed in the local administration cost category. In Ethiopia, local administration comprised only 2 percent of all spending, while in Mali, it was 22 percent, a 10-fold difference. Figure 2 shows a breakdown of local administration expenditures for each country.

Figure 2: Distribution of Local Administrative Expenditures, IRS TO1 2008



Local administrative spending in Ethiopia was very low, in large part because IRS TO1 benefits from co-locating its offices with host country counterparts. These expenditures, in total, were high for Mozambique and Mali but they account for a much lower proportion of total IRS spending in Mozambique because total spending there was about twice as high (US$5.94 million) as in Mali (US$2.98 million). Compared with the other countries, the following contributed to higher local administrative expenditures in Mali: office lease and utilities, office equipment, and office furniture (leasing and purchasing). Spending on local travel and transportation was also higher in Mali compared with other countries of a similar size in this set (Ethiopia and Ghana).

Short-term technical assistance (STTA) and U.S.-based costs. This category includes travel-related costs (airfare, lodging, meals, and incidental expenses) associated with STTA assignments undertaken by U.S. or Nairobi-based technical staff or consultants in support of IRS. It also includes costs of U.S.-based operations directly attributable to the country to support IRS, such as communications, materials, non-spray operations equipment shipping, funds transfer and currency conversion costs. As a proportion of total expenditures, these were relatively more consistent across countries, ranging from a low of 3 percent in Mali to a high of 6 percent in Ethiopia.

U.S.- and Nairobi-based labor. The principal components of this category include labor for the U.S.-based Technical Program Managers (TPMs), labor by technical and administrative support staff based in Nairobi, and TCN COPs (in Mozambique and Benin). These costs include labor time applied in the U.S., Nairobi, and in-country during STTA travel. In Ethiopia and Ghana, these expenditures accounted for about 5 percent of total IRS program costs. In Mali, they accounted for 13 percent of total costs. The high proportion of spending in Mali is attributable to the higher than average need for STTA travel in early 2008. During this period, the first spray round was getting under way and concurrently, a COP and local technical team were being recruited and trained. Table 4 shows the breakdown of these expenditures for U.S., TCN, and Nairobi-based support.

Table 4: U.S., TCN, and Nairobi-based Expenditures, 2008 IRS TO1

Labor source	Ethiopia	Ghana	Mozambique	Benin	Mali
U.S.	$84,764	$71,980	$42,769	$94,540	$27,290
TCN	$0	$0	$192,598	$0	$165,896
Nairobi	$93,103	$23,595	$59,132	$75,606	$117,959
Total	**$177,867**	**$95,575**	**$294,499**	**$170,146**	**$311,145**

C. Costs Per Structure Sprayed

Calculating a cost per structure allows for a more relevant comparison of expenditures across countries. Figure 3 shows this comparison, broken out by the major cost categories noted in Table 1 (Section II). Table 5, immediately below Figure 3, shows the number of structures sprayed and the tabulated total cost per structure for each country.

Figure 3: Cost Per Structure Sprayed During 2008 IRS TO1 Operations

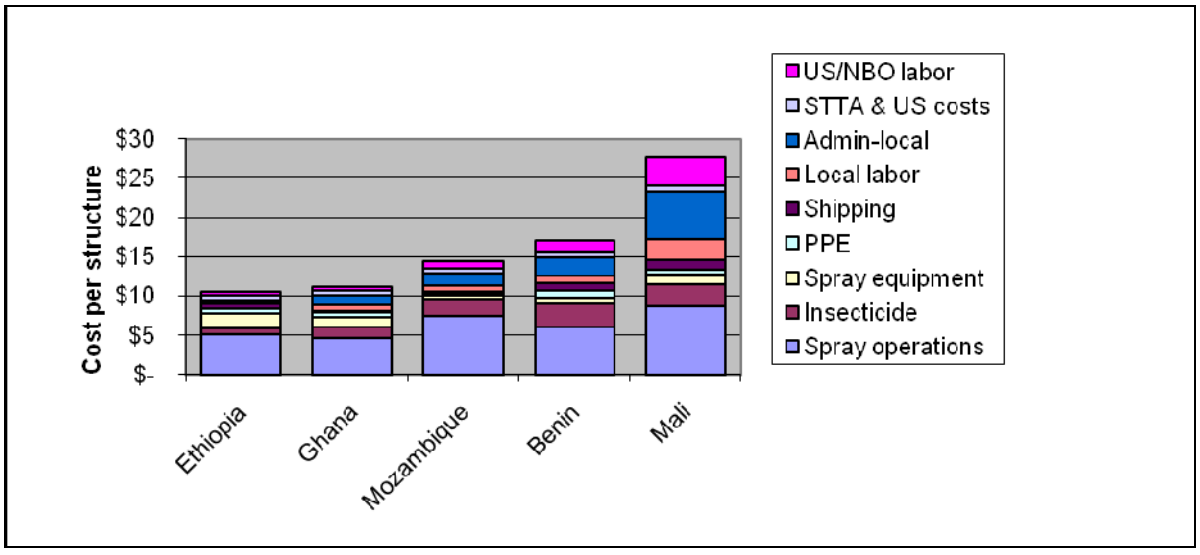


Table 5: Number and Cost per Structure Sprayed, IRS TO1, 2008

	Ethiopia	Ghana	Mozambique	Benin	Mali
Structures sprayed	316,829	254,305	412,923	142,814	107,638
Cost per structure	$10.62	$11.55	$14.38	$17.07	$27.67

Costs per structure were lowest in Ethiopia and Ghana and highest in Mali. The variation from lowest to highest cost per structure is almost three-fold. Some of this variation is explained by factors noted in the previous section on distribution of expenditures. The following factors might also contribute to this variation.

- *Start-up versus continuing program countries*–2008 was the third implementation year IRS TO1 in Mozambique while it was the start-up year for the other four countries. Little evidence for lower expenditures between the first year and subsequent, non-start-up years is found in the IRS cost literature though sources of such efficiency gains have been conjectured. It would be expected that start-up operations would have higher financing requirements, for instance to construct soak pits (Benin, Ghana, and Mali) or evaporation tanks (Ethiopia) and to purchase the full number of spray pumps to support spray operation.

The empirical record is, however, mixed. Using modeling methods, Conteh et al. (2004) estimated gains from more experienced sprayers being able to cover more structures per day (from 25 for new sprayers to 40 for experienced sprayers) at about 40 percent in Mozambique. Using data from two consecutive spray operation years in western Kenya, Guyatt et al. (2002) found no such efficiencies.

In Mozambique, we did not find clear evidence of efficiency gains. Mozambique's costs per structure are not lower than either Ghana's or Ethiopia's cost per structure, both of which were first-year IRS countries. Such efficiencies may be masked by other differences, as described next.

- *Countries with ongoing IRS programs versus those for which IRS is a new intervention*–Having previous experience with IRS program implementation at the time the IRS TO1 program is introduced might produce efficiencies that lower start-up costs. Ethiopia and Mozambique had previous IRS experience and their costs per structure are considerably lower than for Benin and Mali, where IRS had not recently been implemented. In Ethiopia for instance where the GOE had been spraying for years before PMI support was introduced, some efficiencies may have accrued from shared offices and experienced personnel. Also, the private sector IRS program in Ghana implemented by AngloGoldAshanti provided support to the start-up of the PMI supported IRS program in Ghana which may have produced efficiencies.
- *Magnitude of in-kind contributions from host country program*–We did not undertake a systematic review of in-kind contributions as part of this analysis. One might assume however, countries with prior in-country IRS experience would contribute more alongside external partners than countries with no such experience. Likewise, better resourced countries

and those with better infrastructural capacity might contribute more, lowering the input requirements for programs such as IRS TO1.

- *Settlement patterns in targeted areas*–During the 2008 IRS TO1 spray campaign in Mozambique, wide dispersion of structures was said to have resulted in greater labor and intensity of transportation use. According to the observed costs per structure, this does not seem to have been borne out. Perhaps the very large number of structures reached produced compensatory efficiencies elsewhere in the IRS cost structure. Comparative information on settlement pattern in other countries was not available for this analysis.
- *Definition of a "structure"*–Structure characteristics, especially size, may vary across countries (and within and across regions in a country) and these differences may affect the amount of labor and insecticide required to cover one structure. To examine evidence that structure size has contributed to cross-country variation in cost per structures sprayed, we looked at two measures related to size (see Table 6):
  - Average number of persons living in structures – computed as the reported total number of persons protected divided by the total number of structures sprayed in each spray round.
  - Average surface area sprayed in structures – this proxy for structure size was computed by dividing the number of sachets of insecticide used in each country's IRS campaign by total number of structures sprayed, and multiplying the result by 220 square meters.[2]

We then computed cost per person protected and cost per square meter of sprayed surface area and compared these measures with cost per structure sprayed (see Figure 4 below). Also, to control for structure size in interpreting the cost per person protected, we divided the total surface area sprayed in each country's average structure size by the number of people per structure.

Table 6: Person Protected and Structure Size, IRS TO1, 2008

	Ethiopia	Ghana	Mozambique	Benin	Mali
People protected	1,000,526	601,973	1,457,142	521,738	420,580
People per structure[a]	3.2	2.4	3.5	3.6	3.9
No. sachets used per structure	0.37	0.27	0.64	0.15	0.27
Size of structures sprayed (sq meters)[b]	82	60	142	32	59
Structure surface area per person	25.8	25.2	40.2	8.8	15.0

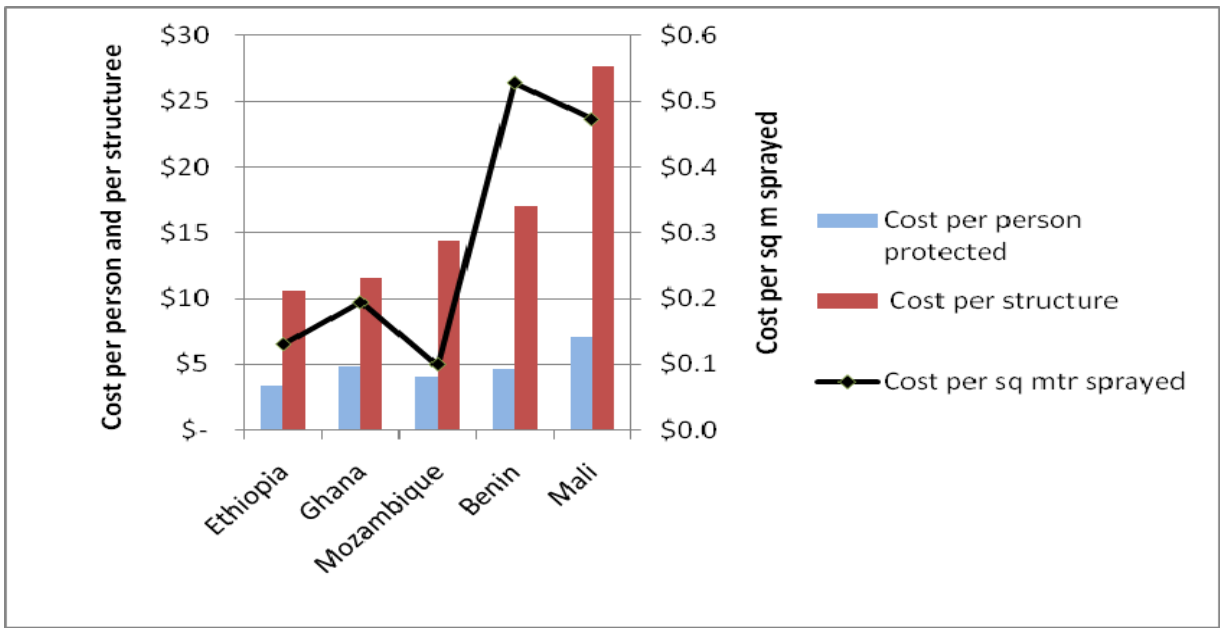
[a] People per structure is computed as the reported total number of people protected during the IRS campaign and the total number of structures sprayed.

[b] Size of structure sprayed is imputed here as the average surface area sprayed, which is equal to the number of sachets used per structure multiplied by 220 square meters (the average assumed surface area covered by one sachet).

[2] One sachet of insecticide can reportedly cover 250 square meters of wall space. This assumes optimal conditions and experienced spray operators. We used a lower figure of 220 square meters to adjust for assumed less than optimal field conditions.

The number of people per structure ranged from a low of 2.4 in Ghana to a high or 3.9 in Mali. There was more than a four-fold difference in structure size. Structures in Benin were the smallest with 32 square meters of surface area sprayed. Structures in Mozambique were the largest with 142 square meters of surface area sprayed. Figure 4 shows average costs per structure, per person and per square meter sprayed.

Figure 4: Cost per Person Protected, per Structure and per square meter sprayed, IRS TO1, 2008



On costs per person protected, except for Mali findings for IRS TO1 countries are comparable to those found by other researchers (see Table 1). Ethiopia, Ghana and Mozambique have reasonably comparable costs on each of the three measures. Mozambique's higher cost per structure appears to be driven by the larger average size of structures in that country. Efficiencies in spraying larger structures (e.g., lower travel time and costs relative to total area sprayed) may in part explain Mozambique's lower cost per square meter sprayed.

While Benin is comparable to these three countries on cost per person, its costs per structure is higher and its cost per square meter sprayed is considerably higher. Benin is the most expensive country, topping even high-cost Mali on this latter measure. The very small average size of structures in Benin may be driving the higher cost, requiring more costs for set up at structures and more movement (labor and transport) time between structures relative to time spent in structures for spraying.

Mali is a high-cost country for IRS on all three measures. Mali is the country with the highest local administrative and labor costs (discussed in Section III B), and the greatest labor inputs from U.S.- and Nairobi-based staff. These cost categories account for 36 percent of the difference in per structure costs when compared to Ghana, also an IRS TO1 start-up country in 2008. Were

Mali's costs for these three cost categories to be similar to Ghana's in proportional terms to total expenditures, the cost per structure in Mali would have decreased to US$21.90, still high but closer to the costs for the other countries.

IV. Summary and Conclusions

Across the five countries examined here, this analysis finds noteworthy variation in the cost of IRS programs implemented as part of the USAID IRS TO1 project. Variation was found in the distribution of expenditures and costs per structure, per person protected, and per square meter of surface area sprayed. Sources of this variation were discussed above. As this analysis was limited to five countries, adding additional countries to the analysis would help to confirm the patterns observed here and the conclusions, below, we draw from those patterns.

There is some evidence of cost efficiencies from experience. 2008 was a start-up year in four of the five IRS TO1 countries examined here; it was the third year for IRS TO1. Based on costs per square meter of sprayed surface area, Mozambique was the lowest cost of the five countries, suggesting that some cost efficiencies may have accrued to that program. Ethiopia was the lowest cost country on two of the three measures and second lowest on the third measure. Ethiopia's NMCP had many years of ongoing IRS operations experience prior to IRS TO1's introduction and it is possible that efficiencies accrued to ISR TO1 from that prior country-level experience. In Ghana, IRS has been recently implemented by private firms and here too, some of this experience and use of existing infrastructure (for instance trainers and training centers) may have contributed to the lower costs observed here compared to other countries examined. Benin and Mali were truly start-up IRS countries and Benin's costs were higher on two of the three cost measures. Mali's costs were higher on all three measures, considerably so on two of the three measures.

Tracking IRS costs for individual countries across program years would provide a better measure of such efficiencies. Still, savings in years subsequent to IRS start up are not likely to be substantial because 80 to 90 percent of IRS program costs are recurrent. Saving would come from either reductions in costs for spray equipment that can be used across several spray rounds, from logistics planning (if spray operations are conducted in the same areas and there has been little change in population and settlement patterns), and from operational efficiencies gained from experience.

Input differences contribute to cost variation. Differences in inputs required of IRS TO1 accounted for some of variation in costs observed. Local administrative costs for instance were considerably lower in Ethiopia due to savings accrued by co-location of project offices in government facilities. Also, as noted above labor and material input requirements may vary with the type and size of the predominant structure sprayed and we found some evidence for this. Further investigation of how this factor affected costs would be useful.

Perhaps the most noteworthy finding is the high costs observed for Mali. Some of this could be expected because Mali was a start-up country in 2008, requiring substantial

STTA inputs to simultaneously prepare for a spray campaign and recruit and train local staff. With a fully-trained local team having been put in place, these costs should come down in subsequent years. The high cost of local administration in Mali has been noted for other health sector programs as well, These costs should, however, be relatively fixed and should coverage scale up in future years, some reduction in costs per structure and per person protected should be observed.

A note about programming for sustainability and its impact on IRS costs. All IRS TO1 country work plans include activities designed to promote capacity building among host country counterparts and partners. As these stakeholders acquire skills and mobilize resources to implement IRS, the need for external assistance (and thus IRS program costs) should decline. For instance, IRS TO1 costs in Ethiopia and Mozambique were an average of 13 percent lower because insecticide purchases were financed through sources other than the project. Some countries may soon be able to provide spray equipment and PPE and others may take on more responsibility for logistical planning and operations. As these transitions occur, costs may decline because local costs, especially for labor, are likely to be lower than costs international organizations obtain. The pace of progress towards sustainability will thus affect IRS costs.

As a final note, it is important to distinguish between an analysis of the type presented in this report and a full cost analysis. The purpose here was to determine the costs to IRS TO1 for its contributions to the spray campaigns it supports. None of the country results presented here include the costs of the labor and material inputs from government counterparts, and other stakeholders that contributed to planning, implementation, and follow-up of spray operations. Such an analysis would be a useful tool for sustainability planning.

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