PRESIDENT'S MALARIA INITIATIVE

INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

Final Report

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

Contract GHN-I-01-06-00002-00

Prepared for:
United States Agency for International Development

Prepared by:
RTI International
3040 Cornwallis Road
Post Office Box 12194
Research Triangle Park, NC 27709-2194

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Table of Contents

Page

List of Tables iii

Abbreviations iv

1. Introduction 1
   1.1 RTI's Experience with IRS before IRS 1 2
   1.2 Starting up IRS 2
   1.3 Successes 3
   1.4 Challenges and Lessons Learned 6
   1.5 Cost Study Results 8
   1.6 Key Publications 8

2. Review of Core Technical Components of IRS 10
   2.1 Safer IRS Application: History, Successes, Challenges, and Lessons Learned 10
   2.2 Entomology 16
   2.3 Monitoring and Evaluation 21
   2.4 IEC/Community Mobilization 24
   2.5 Training and Capacity Building 27

3. Overview of Country Projects 30
   3.1 Angola (2007–2009) 31
   3.2 Benin (2008–2009) 34
   3.3 Ethiopia (2008–2009) 37
   3.4 Ghana (2008–2009) 40
   3.5 Kenya (2008–2009) 43
   3.6 Liberia (2009) 46
   3.7 Madagascar (2008–2009) 49
   3.8 Malawi (2007–2009) 51
   3.9 Mali (2008–2009) 54
   3.10 Mozambique (2007–2009) 56
   3.11 Rwanda (2007–2009) 59
   3.12 Senegal (2007–2009) 62
   3.13 Uganda (2007–2009) 65
   3.14 Zambia (2007–2009) 69

Appendix 1. An Economic Analysis of the Costs of Indoor Residual Spraying in 12 PMI Countries, 2008–2010 ..... A1-1

List of Tables

Table 1. IRS Results 2007–2009 5
Table 2. Annual Cost per Person Protected by IRS 8
Table 3. IRS 2007 Summary Results 17
Table 4. IRS 2008 Summary Results 17
Table 5. IRS 2009 Summary Results 18
Table 6. Challenges and Responses to Address Data Quality Assurance 22
Table 7. IRS Spray Personnel Trained with PMI Support 28

Abbreviations

CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CHT	community health teams
CHW	community health workers
CREC	Centre de Recherche Entomologique de Cotonou
DDT	diphenyl-trichloroethane
DEEC	Directorate of the Environment (Senegal)
DOMC	Division of Malaria Control (Kenya)
DPS	Provincial Department of Health (Angola)
DPZ	Health Provincial Department (Mozambique)
EPA	Environmental Protection Agency
FMOH	Federal Ministry of Health (Ethiopia)
FY	fiscal year
IEC	information, education, and communication
IQC	indefinite quantity contract
IRS	indoor residual spraying
IVM	Integrated Vector Management
LATH	Liverpool Associates in Tropical Health
M&E	monitoring and evaluation
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MOH	Ministry of Health
MOP	Malaria Operational Plan
MOPHS	Ministry of Public Health and Sanitation (Kenya)
NEMA	National Environment Management Authority (Uganda)
NMCC	National Malaria Control Centre (Zambia)
NMCP	National Malaria Control Program
ORHB	Oromia Regional Health Bureau (Ethiopia)
PEA	Programmatic Environmental Assessment
PMI	United States President's Malaria Initiative
PNLIP	Programme National Intégré de Lutte contre le Paludisme (Rwanda)
PNLP	Programme National de Lutte contre le Paludisme
PPE	personal protective equipment
RBM	Roll Back Malaria
SEA	supplemental environmental assessment
SOP	standard operating procedure
TO	Task Order
TOT	training of trainers
USAID	United States Agency for International Development
USG	United States Government
WHO	World Health Organization
WHOPES	WHO Pesticide Evaluation Scheme

This final report documents the achievements and lessons learned from the United States Agency for International Development (USAID) contract number GHN-I-01-06-00002-00, Task Orders 1 and 2, Indoor Residual Spraying (IRS) under the United States President's Malaria Initiative (PMI). This report is structured to provide an overview of the IRS 1 project (Section 1) and a review of core technical components of IRS (Section 2)—environment; entomology; monitoring and evaluation (M&E); information, education, and communication/community mobilization; and training and capacity building. These sections are complemented by an overview of country projects (Section 3).

1. Introduction

RTI International was awarded the Indoor Residual Spraying (IRS) indefinite quantity contract (IQC) on September 29, 2006. This IQC reflected a new and substantial commitment from USAID to support the use of an effective malaria control intervention in Africa.

Funded by the United States President's Malaria Initiative (PMI) through USAID, RTI provided technical and financial support to countries supported by PMI to expand the use of IRS as an intervention for malaria prevention and control.

The goals of the project were to

- Contribute to the reductions of malaria-related mortality by 50% in 15 target countries.
- Build the capacity of target countries to undertake effective IRS.
- Demonstrate the correct methodologies for IRS.

The main objectives of the project were to

- Introduce the appropriate, effective, and efficient use of IRS in African countries not previously using it as part of systematic control programs.
- Provide technical assistance to improve the targeting and effectiveness of IRS programs in countries that already used the method.
- Provide financial assistance and procurement support to countries that had an established capacity for implementing strong IRS programs, but lacked the resources and mechanisms to fully cover their populations at risk for malaria.
- Develop the capacity of public health institutions, municipal and district governments, and (where appropriate) private sector companies to implement IRS programs by systematically transferring greater responsibility and authority to such institutions with each round of IRS supported under the IRS IQC, and by relying on host country staff to the maximum degree possible in each assisted country.
- Dramatically improve the transparency and quality of current government and industry practices for procurement, technical support, safety, and environmental compliance by setting examples of excellence and establishing clear standards for participation in work under the IRS IQC.

RTI International was the prime contractor for IRS 1. Subcontractors included

- Crown Agents USA, Inc. for procurement services
- Medical Research Council of South Africa for training, technical support in entomology, and quality assurance
- Liverpool Associates in Tropical Health (LATH) for training and for pesticide resistance monitoring and pesticide selection
- Howard-Delafield for information, education, and communication (IEC) training; systems development; and quality assurance.

Resource Organizations included The Malaria Consortium, International Centre of Insect Physiology and Ecology, and International Research Institute for Climate and Society.

1.1 RTI's Experience with IRS before IRS 1

USAID's and RTI's involvement in indoor residual spraying began before the IRS project, under the first Integrated Vector Management (IVM 1) project. Three countries sprayed under IVM 1: Zanzibar, Uganda, and Angola. RTI also supported the Zambian IRS program with procurement and environmental assistance under IVM. When the IRS project began in late 2006, the IVM 1 project ceased direct involvement with IRS.

Countries That Implemented IRS under the IVM 1 Project in 2005–2006

Country	Districts	Dates	Structures Sprayed	Coverage	People Protected
Uganda	Kabale	June–August 2006	103,329	96%	488,502
Angola	Cunene and Huila Provinces	December 2005–March 2006	107,398	90%	590,398
Zanzibar	Pemba and Unguja islands except Stone town	July–September 2006	203,754	93%	1,018,156

Also under the IVM 1 project, RTI produced the *Integrated Vector Management Programs for Malaria Vector Control Programmatic Environmental Assessment* (PEA) in January, 2007. This document served as a guide for environmental compliance during the IRS 1 project, which was awarded shortly before the PEA was published and adopted.

1.2 Starting up IRS

IRS is a large-scale, logistically and technically complex health intervention. RTI worked in 8 countries in 2007, 13 in 2008, and 14 in 2009 (see Start-up Countries table). As aforementioned, 2007 was PMI IRS Year Two, and IRS 1 project Year One. Although the project provided payroll support in 2007 to Kenya, it did not become actively involved with conducting IRS until 2008. Also in Zambia and Ethiopia, the project supported ongoing

government spray programs (see individual country summaries). In the remaining IRS 2007 countries, RTI and its partners were the primary implementers of IRS spray rounds.

Start-up Countries

2007	2008	2009
Angola, Malawi, Mozambique, Rwanda, Senegal, Uganda, and Zambia	Benin, Ethiopia, Ghana, Kenya, Madagascar, and Mali	Liberia

1.3 Successes

PMI, through its contractor RTI, successfully reintroduced IRS as a vector control intervention in 14 countries in Africa during the IRS 1 project. IRS is a logistically and technically challenging undertaking involving hundreds, and at times thousands, of people and many other components. Each specialized component requires its own logistics and expertise to be delivered at a precise time in order to synchronize with the next component.

The biggest accomplishment of the IRS 1 project was exceeding the required 85% spray coverage in the majority of spray rounds (Table 1).

When the project began, few host country governments had entomological baselines or other entomological data to guide vector control generally and IRS specifically. During implementation of the IRS 1 project, country governments began to appreciate the importance of entomological data to inform vector control decision making and began to include entomology activities in their National Malaria Control Programs (NMCPs).

Similarly, community mobilization and IEC/behavior communication change were not perceived as a priority by many countries implementing IRS when the project began. By the end of the project, NMCPs recognized the importance of this activity, included it in their annual planning, and allocated resources to conduct communications and mobilization for IRS. These efforts resulted in higher coverage rates.

The use of insecticides in most PMI countries at the beginning gave minimal consideration to environmental risk mitigation and safety procedures. The IRS 1 project placed a strong emphasis on these, and involved national country institutions and communities in assuring the safety and health of communities participating in IRS.

Other successes included

- Built capacity of NMCP and other authorities. This increased local capacity minimized the need for expensive short-term technical assistance.
- Host country governments recognized IRS and included it in their health policies and strategic plans.
- Some countries used PMI IRS to leverage other resources for malaria prevention.
- Countries learned to gather, analyze, and disseminate their own entomological data.

- Globally, PMI IRS had an impact on malaria leadership, making it possible for other entities to fund IRS—the Global Fund for HIV/AIDS, Tuberculosis and Malaria, the World Bank, and many international nongovernmental organizations (NGOs).
- IRS also advanced a global debate on insecticide resistance consultations and awareness to start in earnest
- RTI developed standard operating procedures, including training curricular, operational manuals, and M&E.
- The project created and coordinated, on behalf of PMI and other local partners, central level technical advisory bodies for IRS.

Table 1. IRS Results 2007–2009

Country	Structures Sprayed				People Protected				Personnel Trained			
	2007	2008	2009	Total	2007	2008	2009	Total	2007	2008	2009	Total
Angola	110,826	189,259	102,731	402,816	612,776	992,856	485,974	2,091,606	582	2,104	585	3,271
Benin		142,814	156,223	299,037		521,738	512,491	1,034,229		335	347	682
Ethiopia[a]		316,829	459,402	776,231		1,000,526	1,539,163	2,539,689		1,198	3,017	4,215
Ghana		254,305	284,856	539,161		601,973	708,103	1,310,076		468	577	1,045
Kenya[a]		364,941	517,051	881,992		1,257,941	1,435,272	2,693,668		1,452	1,719	3,171
Liberia			20,400	20,400			163,149	163,149			340	340
Madagascar		422,132	216,060	638,192		2,561,034	1,274,809	3,835,843		1,673	851	2,524
Malawi	26,950	24,764	74,772	126,486	126,126	106,450	299,744	532,320	300	309	462	1,071
Mali		107,638	126,922	234,560		420,580	497,122	917,702		413	424	837
Mozambique	586,568	412,923	571,194	1,570,685	2,593,949	1,457,142	2,263,409	6,314,500	1,190	1,282	1,343	3,815
Rwanda	159,063	189,756	295,174	643,993	720,764	885,957	1,329,340	2,936,061	655	2,091	2,276	5,022
Senegal	169,743	153,942	176,279	499,964	678,971	645,346	661,814	1,986,131	275	706	570	1,551
Uganda[b]	446,117	575,903	238,332	1,260,352	1,865,956	2,211,388	1,018,924	5,096,268	4,062	4,945	2,114	11,121
Zambia	657,695	762,479	1,189,676	2,609,850	3,600,000	4,200,000	6,500,000	14,300,000	1,300	1,413	1,935	4,648
Total	2,156,962	3,917,685	4,429,072	10,503,719	10,198,542	16,862,931	18,689,769	45,751,242	8,364	18,389	16,560	43,313

[a] Numbers reflect the results achieved under IRS 1 project only. Note that these data differ from PMI's reported results because PMI also included spray results conducted by the Government of Ethiopia and the Government of Kenya.

[b] In 2009, numbers reflect the results of IRS that RTI conducted in the districts of Kitgum and Pader. Note that these data differ from PMI's reported results because PMI also included spray results from other districts.

1.4 Challenges and Lessons Learned

Here, RTI presents overarching challenges and lessons learned that the IRS 1 project experienced. Specific lessons learned are also included in the country summaries and in the technical area sections later in this report.

Challenges

The IRS project faced the following implementation challenges.

- *Reintroducing IRS in Africa*. In most PMI-supported countries in Africa, IRS had not been conducted on a large scale in close to a decade, sometimes more. As a result, RTI was reintroducing a largely unknown, unfamiliar, and complex intervention on a large scale with an ambitious time frame. There were many challenges and complications in reintroducing and establishing IRS.
- *Scaling up*. Rolling out IRS into so many new countries as rapidly as the IRS 1 project did, especially in the first year proved to be difficult. It was challenging to recruit, deploy, and mobilize staff in the compressed start-up time frame. Establishing offices and setting up systems while preparing to conduct spray campaigns strained the available resources both in-country and at the regional office levels. Keeping the management structure aligned with the realities of the project in scope and scale, and in time, was also challenging.
- *Mobilizing seasonal workers*. RTI had to recruit, train, and mobilize large numbers of spray operators and other short-term workers to support IRS operations in a manner that was consistent with local law but did not trigger obligations associated with longer-term employees (e.g., tax withholding, insurance and other benefits, severance procedures, etc.). RTI senior administrators agreed to a hierarchy of options, including subcontracting a local labor contractor to serve as employer of record, reaching written agreement with the Ministry of Health (MOH) to serve as employer of record, and engaging seasonal staff as daily workers where permissible by law.
- *Monitoring and evaluation* (M&E). It was particularly challenging to standardize M&E indicators across countries. Because of its importance in program performance, much effort went into improving project M&E. See the M&E technical section for a more detailed discussion.
- *Lack of local policy or strategic frameworks for IRS implementation.* Some countries had advanced policy frameworks for vector control and environmental regulation (risk mitigation) when IRS started. Others did not, and where such a framework did not exist, it was often difficult to determine what was lawful and authorized and what was not. This ambiguity delayed decisions and slowed project progress.
- *Implementing IRS in post-conflict environments.* The IRS 1 project was implemented in several post-conflict countries (i.e., Angola, Mozambique, Liberia, and to a lesser degree, Madagascar). These environments presented numerous challenges, including logistics, lack of community trust, damaged infrastructure, loss of key staff in institutions, etc.

Lessons Learned

Overarching lessons for the IRS 1 project included

- *Recruiting and hiring senior local staff*. To build in-country capacity and control project costs, RTI hired all long-term staff and most chiefs of party locally in each country. Recruiting efforts attracted very capable and qualified candidates, many with previous experience outside their home country. To provide competitive salaries and benefits, RTI reevaluated its pay scales for cooperating country nationals in several countries and created new personnel categories to accommodate developing country citizens working in their country of citizenship, who also have an established employment record in the international market.
- *Banking and cash management*. Seasonal employees such as spray operators, mobilizers, and others, had to be paid frequently (i.e., weekly), often in remote field locations. Initially, most payments were made in cash. Project staff often handled large amounts of cash to meet payroll and other expenses, which put themselves and the funds at risk. Solutions to this implemented over the three years of the project included establishing bank accounts for field staff and directly depositing funds to them, using third-party payroll service, as well as innovative schemes to use mobile phone money transfers.
- *Using diphenyl-trichloroethane* (DDT). DDT is a useful insecticide available for IRS. However, it is also a persistent organic pollutant. As such, it is also environmentally challenging to use properly, and requires more time and resources to work with than any other insecticide approved by the World Health Organization Pesticide Evaluation Scheme (WHOPES). Therefore, all stakeholders in IRS should have a thorough understanding of the range of issues that accompany DDT use before using it. To that end, RTI prepared environmental monitoring plans for DDT residues associated with the IRS project in Uganda. Similar monitoring programs were later prepared for other countries using DDT, including Zambia, Mozambique, and Ethiopia. These programs had added costs that countries using other pesticides did not.
- *Supplemental environmental assessments* (SEAs). Many of the SEAs that RTI prepared during the first two years of PMI were limited in scope to one or a small number of pesticides, and all were limited to the specific geographic areas (e.g., districts) in which IRS was anticipated at that time. Most of these SEAs needed to be amended soon after to broaden the number of pesticides addressed and geographic coverage. The IRS project, learning from this experience, endeavored to prepare SEAs with a national scope, or for regions within countries, that included all chemicals that might be used in the future.
- *Standardizing best practices*. Because of the number of countries implementing IRS, it was critical to set and achieve standards across multiple countries. Initially, there was considerable variation in operational methods and an absence of commonly accepted standards. However, during project implementation, RTI and its partners acquired considerable experience with what worked and what did not, and used this to build consensus on standards. By standardizing best practices, documenting them in a manual, and ensuring that IRS implementing countries shared their experiences and thoughts, the project was able to move forward with IRS standards as a whole.

- *There is no substitute for evidence*. Having entomological and epidemiological data enable governments to make informed decisions and target interventions.

1.5 Cost Study Results

In RTI's final report on costs of IRS (*An Economic Analysis of the Costs of Indoor Residual Spraying in 12 PMI Countries*, 2008–2010, September 2011; see Appendix 1[1]) costs per person protected by IRS are presented in Figure 3 (page 8 of that report). This figure shows costs from 2008 to 2010 for 12 countries. Countries are categorized as "large IRS program" countries (those where 150,000 or more structures were sprayed in 2010) and "small IRS program" countries (those where fewer than 150,000 structures were sprayed). Details on the methodology used to derive these cost estimates are provided in the report. A summary of ranges in costs per person protected is shown in Table 2.

Table 2. Annual Cost per Person Protected by IRS

Program Year	Large IRS Program Countries	Small IRS Program Countries
2008	$2.26–$7.14	$4.20–$7.19
2009	$2.27–$7.32	$5.90– $7.07
2010	$2.15–$5.79	$4.70–$11.11

1.6 Key Publications

The IRS 1 project produced several valuable publications. Some of these are highlighted below.

- IRS TO1 developed the draft version of the *IRS Standard Operating Procedure Manual* that outlined standard operating procedures based on IRS best practices, USAID requirements, and RTI's internal protocols.
- In 2008, RTI also produced SOPs for all aspects of the IRS cycle from planning to post-spray activities.
- The IRS 1 project organized an *Entomological Monitoring within PMI-Supported Programs* workshop in Nairobi, March 4–6, 2009. Participants came from RTI's IRS and IVM projects, LATH/London School of Tropical Medicine, USAID, Centers for Disease Control and Prevention (CDC), and NMCPs from Uganda, Zambia and Malawi.

[1] The report is also available online at the following url http://www.pmi.gov/technical/irs/IRS_economic_analysis.pdf

- In 2009, the project produced an *IRS Training Guide for Spray Operations* designed to concentrate on essential IRS concepts and applications. It covers
  - General concepts of IRS
    - Practical application sessions, including the use of tanks to spray walls with water
    - Capacity strengthening and program management processes and reporting needs
    - Malaria prevention and control interventions that emphasize IRS methodologies and equipment

2. Review of Core Technical Components of IRS

2.1 Safer IRS Application: History, Successes, Challenges, and Lessons Learned

1. Background

IRS is accomplished through the safe and judicious application of insecticides to the interior walls of homes in the targeted areas. Because IRS uses pesticides, several regulations (e.g., Code of Federal Regulations Section 216 [22 CFR 216]) and environmental protocols must be implemented at each stage of the IRS campaign to ensure the safety of the environment and beneficiary communities.

PMI requested RTI to follow the most stringent measures for environmental compliance in its implementation of IRS. For cases when multiple standards existed such as both U.S. law and local law (usually through the national environmental authority) of the host country government, the more stringent law was followed.

Programmatic Environmental Assessment (PEA)

Part 216 of Title 22 of the Code of Federal Regulations requires that an environmental assessment be conducted before providing assistance for the procurement and/or use of insecticides. As such, USAID asked RTI to develop the Programmatic Environmental Assessment (PEA) for IVM that included IRS, larviciding, and bednets. The PEA, which was finalized in 2007, is an umbrella document from which country-level assessments are derived. It serves as an overall evaluation of environmental and human health issues related to malaria vector control and details the general human health and environmental risks associated with use of insecticides, the pathways of risk associated with IRS through various media (e.g., inhalation, oral, etc.) and activities (e.g., mixing pesticides, spraying, etc.); evaluated human health risks associated with all WHOPES-approved IRS pesticides; and formed a basis for the development and application of standard procedures and best environmental management practices. The PEA can be found at http://www.ehproject.org/PDF/ehkm/ivm-env_assessment.pdf.

Supplemental Environmental Assessment (SEA)

Supplemental Environmental Assessments (SEAs) supplement the umbrella PEA in addressing specific ecological and epidemiological factors of the target areas where IRS activities are implemented to provide USAID and host country decision makers with a full range of potential environmental effects to consider during the decision-making process. The SEA discusses direct and indirect effects of IRS activities, and the mitigation measures and conditions required to avoid, minimize, or offset adverse environmental impacts based on the prevailing ecological and social conditions in the spray area. Between 2005 and 2009, the following SEAs were prepared:

- In 2005, RTI prepared the first IRS *Pesticide Evaluation and Safer Use Action Plan*, later referred to as SEA, for Angola.
- In 2006, RTI prepared four SEAs, approved by PMI, for Madagascar, Uganda Zanzibar, and Zambia.

- In 2007, RTI conducted four new SEAs for Rwanda, Senegal, Malawi, and Mozambique.
- In 2008, six new SEAs (Benin, Ghana, Mali, Kenya, Liberia, and Ethiopia) and three amendments (Angola, Uganda, and Zambia) were conducted.
- In 2009, RTI completed nine amendments (annual amendments for Ethiopia, Mozambique and Zambia that used DDT; and amendments for Ghana, Liberia, Senegal, Madagascar, Malawi, and Rwanda because of the expansion of the IRS project or change in insecticides).

Environmental Monitoring and Inspections:

The IRS environmental team also monitored the implementation of the IRS activities in all project countries to ensure that the IRS activities complied with the environmental management plans as stipulated in countries' SEAs, host country regulations, IRS best practices, and more widely 22 CFR 216 and international treaties. In IRS campaigns, environmental specialists undertook pre-spray and mid-spray inspections in support of the current IRS round, trained local teams, and documented the level of compliance. In countries that used DDT, the team also performed post-spray compliance inspections. The team conducted four inspections in 2007 (Zambia, Angola, Uganda, and Zanzibar), 16 inspections in 2008, and 23 inspections in 2009. Initially, environmental compliance was inconsistent, but steadily improved as the number of inspections increased and ensuing trainings of in-country staff occurred.

2. Successes

During IRS 1, the project achieved several notable successes.

- *The quality of work and the general standards increased*. With technical support from the IRS environmental team along with frequent inspections, training of spray teams, implementation of environmental and human health recommendations and IRS procedures, the overall performance improved every year as can be seen in the photos below.
- *The project recruited environmental specialists who supported the IRS work across the countries on a semi-autonomous basis.* They conducted assessments and provided specific recommendations for the field team to follow up and address all issues identified. Specialists also conducted follow-up visits to gauge and ensure status of compliance. The environmental team had dual reporting lines, within the project and directly to the vice president and head of RTI's Center for International Health. In addition, they had a monthly reporting obligation to the client independent of other reports.

These photos show the improvement in washing facilities and liquid waste management and containment in evaporation tanks in the IRS 1 project over time.

Specific environmental products developed as a result of IRS 1 TO1 included

- *Developed standard operating procedures* (SOPs). In 2008, the environmental team developed the first set of draft SOPs that documented each stage and served as a guide for all aspects of environmental compliance. The SOPs on liquid waste, solid waste, and worker health and safety helped to improve the overall environmental compliance and to make uniform the approaches to compliance on IRS.
- *DDT monitoring protocol*. Within the performance period, RTI also developed protocols for DDT monitoring in Uganda, Ethiopia, and Mozambique. The protocols were very useful for evaluating if the DDT used in the IRS campaign was contaminating people's stored products or was migrating into the environment.
- *Local capacity building*. During implementation, host country governments realized the added value of safe application and created local environmental positions or engaged a local consultant during the entire IRS campaign to help the teams comply with local and international environmental regulations.
- *Waste disposal facilities identified.* On a country-by-country basis, from 2008, the environmental team had identified incinerators to safely dispose of IRS solid wastes in almost all the countries except Ethiopia and Mozambique (two countries using DDT). This was a great achievement because identifying and procuring proper waste disposal facilities had been an ongoing issue since the inception of IRS activities. Some countries had to store the wastes for more than three years before a safe, cost-effective solution was found. Mozambique and Zambia packaged and successfully exported DDT contaminated waste to South Africa for safe disposal following

appropriate international conventions (e.g., Basel and Rotterdam). RTI handed over the IRS program to another contractor in Uganda at the beginning of DDT use there, and was not involved in disposal of the waste. In Ethiopia, DDT waste generated under PMI funding has been consolidated and securely stored pending disposition.

- *Engaging local environmental authorities.* By the end of IRS 1, Ministries of Health (MOHs) in many PMI countries had started to consult and engage local environmental authorities (e.g., Environmental Protection Agencies [EPA] or Ministries of Environment [MOEs]) in IRS and some began to participate as members of national steering or implementation committees at the district level. This was one of the overall goals of IRS to create local capacity for continued implementation of state-of-the-art IRS beyond PMI support.

3. Challenges

The IRS 1 project faced the following implementation challenges.

- *Inadequate local capacity*. In many countries, environmental authorities (EPAs or MOEs) existed only at the national level; consequently, there were inadequate personnel at the local level to support IRS activities. As such, sometimes the responsible institutions did not have human resources to undertake independent local inspections.
- *Delayed campaigns*. When a spray campaign was delayed, late into the rainy season, environmental compliance became more difficult. During the rainy season, personal effects could not be removed from the houses and it became a challenge for community members to observe the two-hour wait before returning back into the houses.
- *Lack of waste disposal facilities*. Lack of appropriate facilities for disposal of IRS wastes, especially DDT wastes, had been a major risk for the government and challenge for the IRS project since its inception. DDT wastes were exported to South Africa for high temperature incineration, which was expensive.
- *Lack of involvement of other key local institutions*. Before IRS, many MOHs operated in relative isolation, vertically implementing initiatives, while skills needed to improve the implementation of the program were often absent in the countries. For example, the Department of Occupational Safety and Health, present in many countries, has seldom been engaged but could make a big difference to the success of the program.
- *Traditional use of insecticides without standards*. In areas (e.g., cotton growing areas) where community members applied insecticides without any personal protective equipment (PPE) and without environmental safeguards, compliance became a challenge. Often there was an added risk of pilferage. In these areas, there should always be strict supervision.
- *Lack of medical supplies to treat exposure in local health facilities*. Although the World Health Organization (WHO) recommends the provision of supplies in health facilities within the spray area, it has often been a challenge because many MOHs do not stock the needed supplies. Because the PMI-supported IRS project did not procure pharmaceuticals, it was difficult to comply with this requirement.

- *Inadequate supervision at the country level*. Inadequate supervision has been a challenge and the cause of noncompliance in some countries. Efforts should be made to improve the supervisory skills by training supervisors.

4. Lessons Learned

- *Facilitating knowledge exchange and stimulating local desire to comply*. RTI learned that once successful IRS countries shared their methodology and experience with other country programs, it created a desire for less-advanced countries to improve their standards. As a result, country teams have allocated and spent more money to construct state-of-the-art disposal facilities to become compliant.

Liquid waste disposal facilities (soak pits) in Angola (under construction) and Ghana (in use)

- *Low human capacity*. In almost all countries, there was a critical deficiency in the physical numbers and types of skills available at country level to oversee quality IRS activities. To address this important challenge, RTI instituted a training of trainers (TOT) scheme to build a critical mass of personnel that not only understood IRS, but could also plan and supervise an IRS campaign. In addition, RTI instituted a learning-by-doing policy, whereby trained and experienced RTI staff were matched with local counterparts. Countries that participated in TOT and successfully implemented the cascade training approach eventually improved the quality of training provided to the spray operators. The project also learned that when more institutions participate in IRS implementation, compliance is often better. The focus should therefore be to equip the relevant institutions with capacity, skills, and resources for them to participate effectively.
- *Cost of compliance*. RTI has learned that it is possible to comply with environmental requirements at a lower cost if the personnel understand the rationale for the environmental interventions undertaken without necessarily prescribing the design or size of the soak pits or evaporation tanks. Although standards are the minimum guides, the project should allow countries to be innovative in implementing the principles of environmental protection. For example, the idea of temporary soak pits in countries such as Madagascar has proven to be very cost effective and efficient in achieving environmental goals.

- *Independent inspections*. During the reporting period, RTI has realized that the more independent external inspections there were in a country, the better the compliance. In fact, it is clear that even if the countries recruited environmental specialists or engaged a local environmental consultant, an independent inspection (either from Environmental Monitoring Capacity Building for Vector Control Interventions Project [EMCAB] or RTI regional office) made a lot of difference in raising the standards for environmental compliance.
- *PMI's support has raised the profile of environmental considerations in IRS*. Even if some of the IRS activities were implemented by host governments (using resources from the Global Fund or Roll Back Malaria [RBM]), these programs have benefitted greatly from the PMI-supported activities when it comes to environmental compliance. Initially, parallel IRS activities were implemented with very little regard for human health and environmental protection. The situation is changing, and now, NMCPs or local environmental authorities are requiring increased environmental compliance for the implementing agencies.
- *Nationalizing or regionalizing the SEAs*. Making the SEAs valid for five years and broadening the insecticide class level at regional or national level has accorded countries with the necessary flexibility to change or expand the program to new target areas without the rigorous process of the SEA amendments. Experience has shown that the local environmental factors do not change significantly unless a completely new ecological area is proposed. When a change of insecticide or slight expansion in area coverage occurred, the IRS project prepared an SEA amendment.
- *Suppliers to provide environmental-friendly packaging*. The IRS project successfully advocated for insecticide suppliers to provide the insecticide in environmentally-friendly packaging. The new packaging has helped to improve health and safety and minimize problems with disposal at the end of the campaign.
- *Difficulties with the polluter-pays principle*. RTI has tried to adopt the principle of "polluter pays" by requiring that the suppliers take back the wastes after the spraying campaign. However, the costs have proven to be much higher than what RTI would normally pay if the disposal were coordinated in-house; moreover, it appeared that waste disposal best practices were not always followed by the supplier, thereby increasing the risk for the U.S. government. Working with the MOH to find local solutions to IRS wastes, leaves capacity in the country for appropriate disposal options that could be used after PMI support ends.

2.2 Entomology

1. Background

The early years of the IRS 1 project saw high variability among countries regarding their capacity to conduct entomological monitoring activities. Some countries such as Ghana, had well-developed entomological infrastructure with skilled entomologists and field technicians, working out of well-equipped facilities. In contrast, other countries had little-to-no infrastructure or capacity to support entomology. For example, Liberia, after 14 years of civil war, had a single entomology field technician at the NMCP. In addition, stakeholders and collaborators in vector control disagreed over who would direct or conduct entomological activities in the early spraying countries. As a result, some early spray rounds were conducted based on solid entomological data and evidence, and some were conducted with less than ideal data.

To address this variability, in 2008, IRS 1 subcontractor LATH seconded an insecticide selection adviser, Ms. Rodaly Muthoni, and an entomological surveillance coordinator, Dr. Josephat Shililu, to the Nairobi IRS office. In 2009, the project organized a workshop in Nairobi to propose a comprehensive, cost-effective set of monitoring tools that could be adopted by all PMI-supported countries to assure IRS quality and to ensure that insecticide resistance did not compromise effectiveness of either the IRS or the long-lasting insecticidal nets. Workshop participants included staff from both the IRS 1 and IVM projects, PMI (representatives from USAID and CDC), and representatives from NMCPs in Malawi, Zambia, and Uganda. Specifically, the objectives of the workshop were to

- Discuss PMI indicators, methodologies, and strategies for entomological surveillance.
- Share and review data in insecticide resistance status and mechanisms for developing a data repository and analysis center.
- Discuss strategies for mitigating insecticide resistance.
- Discuss strategies for building in-country capacity for entomological surveillance and insecticide resistance monitoring.

Entomological monitoring and surveillance within PMI-supported countries have improved over time. For instance, entomological activities were increasingly included in IRS annual work plans and in Malaria Operational Plans (MOPs). The IRS 1 project along with many other stakeholders worked to build the capacities of NMCPs in PMI-supported countries to plan and conduct entomology.

Tables 3–5 summarize the available entomological data during 2007–2009.

Table 3. IRS 2007 Summary Results

Country	2007		
	Baselines	Susceptibility Tests	Efficacy Tests
Madagascar	N/A	In April, tests showed 100% susceptibility to bendiocarb in the Anamalanga region	N/A
Mozambique	Baseline studies conducted from January to September identified *Anopheles funestus* and *Anopheles gambiae*	In five districts, *An. funestus* showed 100% susceptibility to DDT, deltamethrin, lambda-cyhalothrin, and bendiocarb	N/A
Rwanda	Baseline studies identified *An. gambiae, An. ziemani, An. pharoensis, and An. funestus.* Vector behavior studies were conducted in Gasabo, Nyarugenge, Kirehe, Kicukiro, and Nyanza	N/A	N/A
Senegal	Baseline studies were conducted in Velingara, Nioro, and Richard Toll districts in July–September. Collections identified *An.gambiae sl*, *An. funestus*, and *An. pharoensis*. Baseline also studied vector behavior	Susceptibility tests were conducted in Richard Toll and Velingara districts. 100% susceptibility was found in fenitrothion and bendiocarb. Some resistance was found to deltamethrin, lambda-cyhalothrin, permethrin, and DDT	Efficacy tests were conducted in months 3, 4, and 5 after IRS campaign

Table 4. IRS 2008 Summary Results

Country	2008		
	Baselines	Susceptibility Tests	Efficacy Tests
Benin	Collections identified *An gambiae* in Adjohoun, Dangbo, Missérété, and Sèmè	N/A	Efficacy tests identified 89.4% efficacy at 4 months post spray
Ethiopia	Collections identified *An. gambiae* complex over 92%. Collections also identified *An. pharoensis* and *An. coustani*.	N/A	Efficacy tests identified 17% efficacy at 6 months post spray
Ghana	Collections identified *An. gambiae* (87%), *An*. funestus (12%), and other anophelines (1%)	Susceptibility tests identified malathion - 100%; deltamethrin-96%; DDT-63%; propoxur- 90.3%; permethrin- 90%; cyfluthrin- 99%; and lambda-cyhalothrin-99%	Efficacy tests identified 6 months post IRS mud surface-90%, painted mud surface-85%, mud with cement-92%, block with cement painted surface 100%; and wood-87%
Madagascar	Collections identified *An. gambiae* and *An. funestus*	*An. funestus* showed 98% susceptibility to DDT and *An. gambiae* showed 100% susceptibility to alpha-cypermethrin	N/A
Mozambique	Collections identified *An. gambiae* and *An. funestus*	Susceptibility tests in Maganja da Costa, Mocuba, Morrumbala, and Namacurra districts identified 100% susceptibility to DDT, deltamethrin, and lambda-cyhalothrin	N/A

Country	2008		
	Baselines	Susceptibility Tests	Efficacy Tests
Senegal	In August, October, and December, collections identified *An. gambiae s.l., An. pharoensis et*, and *An. funestus* in Velingara, Nioro, and Richard Toll districts	Susceptibility tests in Oussouye, Tambacounda, Kedougou, Ndoffane, Velingara, Dioffior, Thies, Guediawaye, Linguere, R. Toll, and Pdor showed high susceptibility to fenitrothion and bendiocarb and mixed susceptibility to deltamethrin, lambda-cyhalothrin, permethrin, and DDT	Efficacy tests were conducted in Velingara, Nioro, and R. Toll districts at months 1–4 post spraying
Uganda	Collections identified *An. gambiae ss*, *An. arabiensis*, and *An. funestus*	Susceptibility tests identified DDT-36.6%, lambda-cyhalothrin-55%, bendiocarb-100%, and fenitrothion-100%	Efficacy tests were conducted in Apac, Oyam, and Kitgum districts

Table 5. IRS 2009 Summary Results

Country	2009		
	Baselines	Susceptibility Tests	Efficacy Tests
Angola	Collections identified *An. coustani, An. gambiae, An. funestus,* and *An. pharoensis*	Susceptibility tests identified lambda-cyhalothrin-94.44%	Efficacy test showed 89.86% at 1 month after IRS
Ethiopia	Collections identified *An. gambiae s.l., An. pharoensis,* and *An. coustani*	N/A	N/A
Ghana	Collections identified *An gambiae sl, An. funestus*, and *An. pharoensis*	Susceptibility tests identified alphacypermethrin-100%, deltamethrin-95%; permethrin-89.4%; cyfluthrin-98.6%; permethrin- 85.5; propoxur-90.3%; and DDT-62.5%	N/A
Liberia	Collections identified *An gambiae s.l., An. funestus*	Susceptibility tests identified deltamethrin-99%, DDT-99%, and bendiocarb-100%	N/A
Madagascar	Collections identified *An. gambiae* and *An. funestus*	In Anamalanga region susceptibility tests identified *An. gambiae* and deltamethrin at 92.4% in Feb and lambda-cyhalothrin at 90% in March	N/A
Mali	Collections identified *An. gambiae* and *An. arabiensis*	Susceptibility tests identified lambda-cyhalothrin-94.44%	Efficacy test showed 72% at 3 months after IRS, 73.5% at 5 months, and 77.5% at 7 months
Senegal	N/A	Susceptibility tests were conducted in Oussouye, Tambacounda, Kedougou, Ndoffane, Velingara, Dioffior, Thies, Guediawaye, Linguere, R. Toll, Pdor, Dakar center, Malhem Hodar, and Koumpentoum. Results varied. Tests showed high susceptibility to fenitrothion and bendiocarb and mixed for deltamethrin, lambda-cyhalothrin, permethrin, and DDT	N/A

2. Successes

The following list highlights the most noteworthy successes of the entomology component for IRS 1.

- Using a pooling mechanism, RTI procured strategic stocks of mosquito susceptibility kits and stationed them in Kenya. Kenya served as a central repository to deliver stocks to other IRS 1 countries, which greatly increased accessibility
- As a part of capacity development, RTI identified and trained qualified host country staff on how to use specialized entomological techniques such as ELISAs, PCRs, and their accessories and reagents. Also built in-country (MOH/NMCP) entomological monitoring capacity (e.g., Mozambique and Angola).
- RTI also popularized both the use of the WHO and CDC mosquito susceptibility testing methodologies and promoted their use concurrently depending on availability.
- In some countries, RTI employed and seconded entomologist to MOHs and provided the necessary supervision and support to these staff.
- The project facilitated monitoring of entomological aspects by sharing resources through the use of sentinel sites as well as regional facilities to which several districts had access.
- Using entomological data, led country governments to make evidence-based decisions in terms of insecticide selection and for IRS in general.
- NMCPs increasingly understood the importance of entomological monitoring in insecticide-based vector control interventions.
- NMCPs established entomological monitoring databases (e.g., Benin, Ghana, and Liberia).
- The project instituted entomological monitoring in countries where there was none before.
- IRS 1 established protocols (e.g., entomological monitoring timelines and SOPs) to guide entomological monitoring and insecticide selection.

3. Challenges

The IRS 1 project faced the following implementation challenges.

- Insufficient mosquito numbers in-country for appropriate susceptibility tests sample sizes, especially after a round of spraying in an area.
- Susceptible *Anopheles* colonies not available to conduct insecticide decay rates.
- Unavailability of tests kits (e.g., WHO susceptibility tests kits) or late delivery of kits in countries (see the first bullet under Successes for details on how the project addressed this challenge).
- Insufficient in-country capacity and/or skills (human and infrastructure) to conduct entomological monitoring.
- Long distances between the field and nearest entomological facilities for processing and analysis of specimen. Thus, high mortalities occurred while transporting larvae to the rearing sites.

- Insecticide resistance management was difficult with limited data and lack of available insecticide class options.
- As NMCPs acquired capacity in entomology, they then needed to adhere to higher standards of evidence-based decision making for program targeting and procurement. IRS managers had to build this into their procedures.

4. Lessons Learned

Key lessons learned are included in the list below.

- Entomological capability is a prerequisite to conducting IRS and baseline data collection and analysis are key components to making informed decisions on procurement and planning.
- It is important to build NMCPs' capacity to conduct entomological monitoring and assessments as this leads to ownership of the entomological monitoring activity.
- It is easier to reach a consensus with partners when reliable data are used to make key decisions, such as insecticide selection.
- Information sharing among stakeholders involved in insecticide-based vector/pest control interventions was vital in strategizing about insecticide resistance management.
- Use of in-country centers of excellence/research institutions allowed more time for intensive entomological monitoring and thus more data were available. Technical assistance from outside of a country increased costs without significant increase in benefits or capacity building.

2.3 Monitoring and Evaluation[2]

1. Background

- In the first year of IRS 1 (2007), spraying was conducted in six countries (Angola, Uganda, Rwanda, Senegal, Malawi, and Mozambique).
- In the second year (2008), IRS countries increased to 13 (Angola, Uganda, Rwanda, Senegal, Malawi, Mozambique, Benin, Ghana, Mali, Kenya, Madagascar, Zambia, Ethiopia).
- In the third year (2009), the number of countries increased to 14 with the addition of Liberia.

2. Challenges

Although the architecture of RTI's first phase of IRS M&E was generally in place, operationalizing M&E elements was uneven. The M&E functions were hampered by several conceptual and methodological constraints and challenges. The following list highlights the most critical issues:

- Lack of upfront planning to ensure consistent data quality across all countries.
- Work plans did not include a clear M&E plan/strategy across all countries.
- Many data tools were in place, but were not standardized across all countries consistently.
- IRS projects measured slightly different indicators (e.g., household, structure, rooms, etc.) with inconsistent measurement across PMI focus countries.
- Difficulties in establishing a clear, consistent definition of structure (contextualization and interpretation of "structure" was a problem in many countries).
- Lack of baseline data/insufficient time to develop baselines (inadequate or inaccurate geographical reconnaissance), which resulted in incorrect structure counts.
- Lack of uniform understanding of quality assurance principles and processes, including M&E.
- Limited M&E capacity (skills deficit), lack of dedicated resources for M&E, and where M&E staff exist, they lacked the capacity to set up proper M&E system. The M&E training needs were summarized as follows:
  - Overall quality of IRS data (accuracy, validity, reliability, timeliness, integrity)
  - IEC data collected not being used, causing excess, non-beneficial data collection costs
  - Poor coordination between IEC community mobilizers and spray teams
  - Monitoring the performance of IEC teams proved a challenge; process evaluation/quality assurance and quality improvement efforts minimal
  - Field supervision did not include periodic checks on data collection

[2] The material in this section is contained in expanded form in a report from the IRS 2 project titled *Taking Stock of M&E Lessons: Successes, Challenges and Innovations*

- Initially, data quality assurance was not a mandatory requirement in the M&E systems or there was lack of enforcement.
- Monitoring and data audit were perceived as policing function.
- Reporting: programmatic data records were incomplete and often unreliable, leading to late reporting.

3. Actions Taken to Overcome M&E Challenges in IRS 1

To address challenges encountered in IRS 1, RTI instituted several mechanisms to strengthen its M&E component (Table 6).

Table 6. Challenges and Responses to Address Data Quality Assurance

Challenges in IRS 1	Responses
• No internal written M&E plan	Develop a framework for data collection and organization of data flow
• Lack of baseline data in non-conflict and post-conflict countries	Use more intensive field reconnaissance to gather data
• Lack of reliable baseline data (based on either outdated census data or household estimation, whereas IRS requires data on actual structures)	Undertake a detail geographical reconnaissance and door-to-door structure count, serialization of structures, and coding
• Lack of proper documentation and dissemination of relevant IRS data	Introduce appropriate tools and technologies to gather and disseminate information
• Inadequate trained staff for M&E in IRS	Train NMCP officials in M&E skills
• Some countries have a weak MIS (not updated, incomplete data etc.) • Unreliable or nonexistent IRS M&E systems at country level	Set up new IRS M&E systems based in country offices
• Limited NMCP/MOH capabilities in M&E	Train NMCP/MOH counterparts through mentoring and learning by doing
• Lack of coordination between IEC mobilizers and spray operators	Enhance integration (joint coordination, harmonization of activities/synergy)
• Poor data collection tools at the community level	Harmonize and ensure proper use of data collection tools
• Non-use of technology to ensure quality and cost-effective and efficient data management	Use new technology in data collection, collation entry, and safe guards (e.g., cell phones, global positioning satellites, and personal digital assistants)

4. Lessons Learned

Key experiences from which the IRS 1 project learned valuable lessons included

- A comprehensive operational plan, including a fully-developed M&E component, is essential for proper running of the spray operations.
- Reviewing and standardizing activity and output toolkit in IRS countries is critical to ensuring consistency and increasing quality in data capture and reporting**.**
- Enhancing the M&E capacity of staff (including MOH staff) to efficiently address the increased monitoring and data management needs highlighted by project staff.
- Accurate, adequate IRS information must be generated within a limited time frame.
- Efficient supervision of IRS requires for coordination and integration of spray and mobilization activities at the field level to improve quality of the IRS project activities
- Without timely feedback mechanisms, M&E will not optimize its purpose.

5. Conclusion

Effective M&E can be achieved only through a careful, pragmatic approach to addressing limitations and strengthening M&E practices.

- It is imperative that host country governments recognize and prioritize M&E throughout IRS implementation.
- It is important to work with government and local stakeholders to harmonize M&E indicators so that information on project results can be compared, aggregated, and appropriately reported to PMI and other relevant stakeholders.
- Capacity building for project monitoring and evaluation is key to project management.
- It is important to involve the community in project M&E, using social audits or other participatory monitoring methods. To ensure transparency and accountability, it is critical to share M&E results with community members.

2.4 IEC/Community Mobilization

1. Background

Information, education and communication (IEC) and community mobilization are key components of IRS that help to create an enabling environment for a successful spray campaign. The purposes of IEC and community mobilization in IRS are to sensitize communities and stakeholders about the benefits of IRS as a malaria prevention strategy and to inform the beneficiary communities of the necessary preparations required to ensure adequate human and environmental safety for successful spray operations. IEC and community mobilization increase acceptance of IRS activities among target populations through engaging them and encouraging their active participation in project activities. In addition to conducting strong IEC door-to-door sensitization, the IRS project engaged local structures and district leadership to advocate among their communities to minimize refusals, broadcasted IRS sensitization messages through mass media, and distributed IEC materials.

The objectives of IEC and community mobilization were to

- Involve and engage key stakeholders from the start to create program sustainability.
- Provide information on the benefits of IRS in controlling and preventing malaria and malaria-related deaths.
- Inform beneficiaries about their role in IRS before, during, and after spray operations.
- Provide accurate information to the key stakeholders and beneficiaries about safety issues related to environmental and health effects of using the selected insecticides.
- Address community beliefs and misconceptions about IRS.

The implementation of IEC/community mobilization component generally occurred using one of the following three scenarios across the IRS countries:

1. Countries where RTI recruited and hired IEC officers or consultants who spearheaded the IEC/community mobilization component.
2. Countries where the IEC component is implemented by NMCP and other relevant government departments or other stakeholders.
3. Countries that have other organizations contracted by PMI to provide IEC support to the IRS project.

2. Successes

The following list highlights some of the most notable achievements under IRS 1.

- *Programs where RTI conducted IEC and community mobilization were implemented successfully with minimal challenges*. RTI used local structures such as local leaders, women's groups, school clubs, youth groups and community health workers to conduct community mobilization. This strategy proved effective in promoting the project's objectives and creating buy-in, which led to high acceptance of IRS among community members. The strategy was implemented by engaging communities using a participatory approach.

- *Recruiting community mobilizers from their localities*. In so doing, the project increased IRS acceptance among community members since they knew the mobilizer. This strategy also increased coverage as mobilizers knew their geographical areas very well and were able to mobilize all the eligible structures and also guide the spray operators to them. Moreover, this strategy reduced costs, resulting in savings on mobilizer allowances and transportation costs. Typically, IEC mobilizers were engaged for a period of four to five days, and they did not have to be transported from one point to another, as the distances were short.
- *Engaging key stakeholders early*. This is critical to the success of the IRS project, especially to the community mobilization component. The planning and the successful implementation of community mobilization require time and external human resource to coordinate activities. When stakeholders were engaged early, sustainable partnerships were formed, which led to high participation and successful spray campaigns. Therefore, it is recommended to engage stakeholders early to ensure adequate time for IEC preparations.
- *Engaging local leaders.* This yielded active participation in project activities by community members and created a strong sense of local ownership. The IRS project engaged local leaders to identify temporary staff for the community mobilization process. In addition, local leaders assisted in resolving any matters arising between community members and project staff such as refusals for IRS.
- *Using local CHWs to conduct community mobilization*. Community Health Workers are usually the first and most frequent contact community members have with the official health system. Since they are part of the MOH community health education structure, the addition of IRS messages into their workload ensured that IRS messages were disseminated to community members all year long along with other public health messages. This proved to be an effective strategy to build local capacity and sustainability. Because CHWs rarely move from their communities, it reduced the need to train staff annually; instead, the project provided refresher trainings. This ensured continuity of IRS message dissemination.
- *Broadcasting IRS messages on local radio stations*. Where listenership was high, radio was very effective in disseminating IRS messages. All IRS 1 countries used local radio stations to complement the door-to-door mobilization and the community response to these messages was positive.

3. Constraints and Challenges

The IRS 1 project experienced several implementation challenges, which are listed below.

- Contracting the IEC/community mobilization component to other organizations (e.g., Senegal, Rwanda, and Ethiopia) often posed a serious challenge to RTI's ability to implement IRS field activities seamlessly. It was difficult to coordinate IRS field activities that were contracted to different organizations. Where RTI was in charge of IEC and community mobilization, there were fewer challenges and the delivery of the community mobilization component was often more successful. It is possible for the IRS implementer and the IEC/community mobilizer to coordinate and collaborate effectively. However, for this to happen, it will likely require that PMI and the NMCP

mandate coordination and collaboration, at all stages (from work planning to end of spray reporting).

- Initially, employment of consultants and/or RTI staff to oversee community mobilization for IRS limited the engagement of stakeholders because it did not involve them sufficiently. This also led to challenges in gaining community support for the project.
- Initially, many country governments did not prioritize IEC and community mobilization activities, which translated to allocating inadequate resources for IEC. As a result, community members were uninformed about IRS, which often led to delays in startup of activities.
- Using head of health post staff as mobilization supervisors was not an effective strategy because of their existing heavy workload. Supervision of community mobilizers requires daily field visits, which was not feasible. However, since it is important to maintain close working relationships with them, they can be allocated less demanding responsibilities that do not require them to leave the facility (e.g., signing off and storing data forms before they are taken to the data entry centers).

4. Lessons Learned

Experiences of IRS 1 from which the project gained valuable lessons are summarized below.

- *Harmonizing the IEC and community mobilization strategy*. Harmonization across IRS and instituting uniform systems improved the delivery of IRS and made cross-country comparison of activities possible. Moreover, integration of IRS field activities into government plans through joint planning and execution resulted in better coordination and performance.
- *Importance of literacy*. Illiteracy and low literacy can hamper the implementation of projects that rely on local human resources to collect data. The IRS project was implemented in some countries with low literacy levels. This was a major obstacle to collect accurate data. In these countries, it was not easy to recruit people who met the minimum requirement to conduct mobilization.
- *Use of local structures and mechanisms to mobilize communities*. In every country, there were opportunities to link with public health campaigns such as expanded programs for immunization, etc. In some countries (Mali and Benin), these opportunities were utilized, resulting in successful community mobilization campaigns, reducing costs and building local capacity for long-term project sustainability.

2.5 Training and Capacity Building

1. Background

The overall objective of IRS IQC training and capacity building activity was to develop the capacity of public health institutions, municipal and district governments, NGOs, environmental authorities and (where appropriate) private sector companies to implement IRS programs by systematically transferring greater responsibility and authority to such institutions with each round of IRS supported under the IRS IQC, and by relying on host country staff to the maximum degree possible in each supported country. Between 2007 and 2009, RTI laid a strong foundation for in-country implementation of high-quality IRS.

The main capacity building and training activities accomplished under this component included

- Policy level/advocacy workshops carried out in-country to raise awareness of IRS and to ensure country ownership for IRS as key to malaria control interventions.
- Development of training materials, including the *IRS Training Guide for Spray Operations*.
- Supporting countries to carry out IRS national planning and subnational micro-planning for IRS operations.
- Supporting NMCPs to conduct TOT trainings and organize cascade training approaches to strengthen lower cadre IRS seasonal staff in specialized IRS components—environmental safety and compliance, IEC and community mobilization, first aid for insecticide poisoning response (for clinicians), and storekeeping and logistics—as well as training mid-level IRS supervisors/team leaders in the field.
- Capacity building for entomological activities such as refurbishment of insectaries and associated laboratories, and, in collaboration with selected centers of excellence, training entomological technical staff.
- Development of SOPs in all key areas of IRS operations.
- Development of IRS campaign reporting tools.
- Supporting countries to carry out national end-of-spray workshops with various stakeholders to share lessons learned, best practices, and new innovations in IRS.

In all of the IRS 1 countries, capacity building for IRS implementation was conducted at the national and subnational levels. During successive annual trainings, the project adopted a subnational-based training model in IRS target areas to produce a pool of qualified facilitators and trainers to train large cadres of seasonal workers. TOT facilitators were drawn from those staff previously trained in IRS at country partnership in collaboration with NMCPs and other IRS business partners and RTI technical experts from the IRS Nairobi Regional Office. Most of the IRS training conducted in countries consisted of two days of theory sessions for all trainers and three days of practical sessions that included preparation of subdistrict training and site operational plans. Although TOT trainings were residential, the training of spray operators and mobilizers was nonresidential to reduce costs.

Duration of the trainings varied was as follows:

- Spray operators training – 5 days (2 days of theory and 3 days of practical exercises)
- Mobilizers training – 3 days
- Geographic information systems (or mappers training) or geographical reconnaissance training – 2 days (1 day of theory and 1 day of practical exercises)
- Pump technician trainings – 1 day
- Team leaders/supervisors training – 2 days (in addition to spray operators training)

TOT IRS spray operators' training in Kenya

Table 7 summarizes the outcome of training activities conducted between 2007 and 2009.

Table 7. IRS Spray Personnel Trained with PMI Support

Country	2007	2008	2009
Angola	582	2,104	585
Uganda	4,062	4,945	4,412
Malawi	300	309	462
Mozambique	1,190	1,282	1,343
Rwanda	655	2,091	2,276
Senegal	275	706	570
Benin	0	335	347
Ethiopia	0	1,198	3,017

Country	2007	2008	2009
Ghana	0	468	577
Kenya	4,697	1,452	1,719
Liberia	0	0	340
Madagascar	0	1,673	851
Mali	0	413	424
Zambia	1,300	1,413	1,935
Total	**13,795**	**19,077**	**21,664**

2. Successes

Major successes achieved during project implementation are highlighted below.

- Between 2008 and 2009, RTI prepared comprehensive materials for the development of the first IRS training manual and standardized IRS operating procedures.
- RTI supported countries to initiate the refurbishment of insectaries and laboratories in countries such as Rwanda, Mozambique, and Liberia.
- A total of 54,536 IRS spray personnel were trained, thus strengthening in-country capacity to plan, manage, and deliver operational support for IRS campaign activities and offering local solutions to local challenges.

3. Challenges

The IRS 1 project also faced several challenges.

- IRS project aimed to build capacity at different levels, but staff attrition and inadequacy of country systems to absorb technical experts at the NMCP departments resulted in many challenges, such as inadequate staffing.
- Large numbers of seasonal staff trained at operational sites often caused facilitation challenges, as many countries lacked adequate training facilities in rural areas targeted for IRS implementation.
- At the beginning of operations, some countries recruited clinical staff such as nurses and midwives as IRS supervisors but this was not practical because their responsibilities at health facilities required their full attention, which in turn made them unavailable to effectively serve as supervisors for IRS activities.
- During the early stages of IRS implementation (2007–2008), efforts to refurbish insectaries and associated laboratories were delayed in many countries (e.g., Angola, Liberia, and Mozambique); hence, trained staff could not immediately take up roles and handle the associated responsibilities.
- Some countries faced challenges as they had minimal human resources with field technical skills in entomology.

- Some NMCPs had no active vector control units, or weak, under-resourced units. Therefore, IRS activities were given a lower priority than other malaria control activities.
- During the early stages of IRS implementation, many countries lacked malaria and/or vector control policy guidelines and other national malaria strategic documents to guide IRS implementation.
- In some cases, the teams that eventually conducted trainings of the actual spray operators did not have sufficient time to practice and internalize their own training, and in most cases also lacked the skills to conduct adult training and practical skills.
- Capacity building needs to be conducted in context with clear objectives and outcomes of what and how the trainees will be expected to do after training. In most cases, RTI trained people, usually health staff, and created an expectation of promotion considering they had acquired new skills.
- Most NMCPs in PMI countries were not configured or designed to undertake IRS successfully because of limited numbers of staff available for the task, lack of minimum tools to enable staff to function properly, no personnel incentives to specialize in IRS, and lack of government investments in IRS.

4. Lessons Learned

Critical lessons that the project learned included

- Capacity building is an integral aspect of IRS intervention. IRS is a science that requires that all participating groups possess necessary skills that enable them to carry out tasks effectively and in line with standard operating procedures.
- Capacity building activities in collaboration with research institutions and universities strengthened spray operations (e.g., in Kenya, Senegal, and Ghana).
- Decentralized training activities at the subnational levels produced a large pool of staff capable of supporting future IRS activities with minimal support from RTI and other implementing partners.
- Development of seamless partnerships, both at the national and subnational level, was a key strategy to strengthen leadership management for IRS interventions.
- Quality and effective IRS operations require properly trained and committed staff to ensure each piece in the long chain of events is well linked and coordinated.
- Training activities during IRS operations requires standardized materials to enable trainers to deliver the same content to IRS personnel.

3. Overview of Country Projects

This section presents country summaries from the IRS 1 project. Each country summary is intended to be read independently; therefore acronyms are defined on first usage and a brief background is provided for each summary. Moreover, because countries started at different times and with varying levels of capacity and infrastructure, data in the tables may not be included for all indicators in early rounds. The structure of country summaries aligns with Section 1 and provides an overview of the successes, challenges, and lessons learned.

3.1 Angola (2007–2009)

1. Background

Angola became one of the first set of countries designated by the United States Agency for International Development (USAID) to receive support from the President's Malaria Initiative (PMI) to implement indoor residual spraying (IRS) activities for malaria control, initially under the Integrated Vector Management 1 project in 2006, and then under the IRS 1 project from 2007. At the time, Angola was recovering from three decades of civil war, which decimated approximately 80% of the country's public health facilities. Before PMI began working in Angola, the National Malaria Control Program (NMCP) had not conducted a large-scale IRS operation.

During the three years of IRS activities in Angola under IRS 1, RTI, in collaboration with NMCP and the Provincial Department of Health (DPS), successfully conducted three rounds of IRS, using pyrethroid-based insecticide in targeted provinces. IRS target provinces were selected by NMCP and PMI based on the level of the malaria burden, population density, accessibility, and rainfall patterns.

An overview of the three rounds is provided in the Table 1.

Table 1: IRS 2007–2009 Summary Results

Year	Round	Provinces	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 2	Huila, Cunene, and Namibe	11/06–3/07	110,826	85%	612,776	N/A	N/A	582
2008	Round 3	Huila and Huambo	12/07–4/08	189,259	91%	992,856	N/A	N/A	2,104
2008	Round 4	Huila and Huambo	10/08–12/08						
2009	Round 5	Huila and Huambo	10/09–12/09	102,731	96%	485,974	27,516	101,145	585
Total				**402,816**		**2,091,606**	27,516	101,145	**3,271**

2. Successes

The IRS project in Angola achieved the successes listed below.

- The communities expressed appreciation for IRS as evidenced by neighborhood support to provide water to reconstitute the insecticide.
- Huila DPS demonstrated keen interest and participation in the IRS planning, implementation, and supervision, proving willingness to take more responsibility for the IRS program.
- The selection of insecticide class occurred through a collaborative effort between NMCP, PMI, and RTI based on entomological monitoring data and rainfall patterns.

- Since inception, environmental compliance has improved each year, and by the 2009 round, high levels of environmental compliance were observed. Only minor corrections had to be made, and these were implemented before the start of the spray round.
- The team found a solution to the disposal of the IRS solid waste, and the contaminated waste from all four previous rounds of IRS was incinerated.
- Monitoring and evaluation progressively improved with each spray round. By the 2008 and 2009 spray rounds, data were highly reliable, and spray teams were reporting on the correct numbers for each indicator and counting structures correctly (number of structures found versus number of structures sprayed).
- Throughout IRS 1 in Angola, more than 1,500 people were trained to carry out IRS.

3. Challenges

Key experiences from which the Angola IRS 1 project learned valuable lessons are included in the list below.

- Supervisors not trained on IRS cannot provide quality supportive supervision and can compromise quality and production because they tend to be too lenient with cases of discipline. To address this, the project required that supervisors, especially from the health department, undergo thorough IRS training before being seconded to the IRS project.
- Spray operations were disrupted by rains. RTI recommends that spray operations commence in August or early September to avoid this issue.
- The high cost of running a program in Angola is a challenge in general. Cost efficiencies need to be sought out and implemented to maximize resources and ensure full coverage of the target area.
- Staff traveling from one province to the other for supervision and troubleshooting were often delayed because of the poor road conditions. Having adequate supervision and leadership in each province through the DPS is critical.
- Higher levels of participation and commitment from DPS would enable the program to be more sustainable. Donations of resources such as warehouses, vehicles, and office space are areas that could help in future rounds to increase provincial-level ownership of IRS.

4. Lessons Learned

The Angola IRS experience provided the following lessons.

- Personal commitment and discipline are key factors to ensure compliance with environmental regulations. In addition, close supportive supervision was essential for ensuring environmental compliance.
- Many spray operators dropped out due to school examinations taking place during the spray round. It is important to ensure the full commitment of spray operator candidates before hiring them.

- Having a memorandum of understanding in place very early in the planning period is important, especially at the provincial level so that roles and responsibilities are clearly defined and agreed upon.
- An six-month (or longer) planning timeframe encourages greater participation, learning, and leadership by DPS. A shorter time frame results in a rushed process.

3.2 Benin (2008–2009)

1. Background

In 2007, the United States Agency for International Development/United States President's Malaria Initiative (USAID/PMI) and the Benin National Malaria Control Program (NMCP), in collaboration with the Entomologic Research Center of Cotonou (Centre de Recherche Entomologique de Cotonou [CREC]) identified different regions in Benin for indoor residual spraying (IRS) interventions. In 2008, the in-country PMI team and the NMCP agreed to focus IRS activities in four communes of Ouémé region: Adjohoun, Akpro-Missérété, Dangbo, and Sèmè-Kpodji. Ouémé, located within the humid zones of southeast Benin, was chosen for spraying primarily because it has one of the highest incidences of malaria in the country.

Under IRS 1, two IRS rounds were conducted in the four targeted communes. The first round, conducted from July to August 2008, sprayed 142,814 structures, had a coverage rate of 94.1%, and protected 521,738 people. The second round, conducted from March to April 2009, sprayed 156,233 structures, had a coverage rate of 99.4%, and protected 512,491 people. Table 1 presents an overview of the results after two IRS rounds.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Communes	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Adjohoun, Akpro-Missérété, Dangbo, and Sèmè-Kpodji	7/08–8/08	142,814	94%	521,738	42,101	82,498	335
2009	Round 2	Adjohoun, Akpro-Missérété, Dangbo, and Sèmè-Kpodji	3/09–4/09	156,223	99%	512,491	30,707	64,236	347
Total				**299,037**		**1,034,229**	**72,808**	**146,734**	**682**

2. Successes

Benin's IRS 1 successes are detailed below.

- Two rounds were successfully conducted, reaching targeted objectives for coverage and population protection.
- All international and local procurements were completed on time.
- No adverse effects were reported during or after the two spray rounds.
- The project achieved full environmental compliance, with all used insecticide sachets collected, no contaminated water spilled, and all IRS waste incinerated after the end of IRS operations.

- Mobilization staff (e.g., community health workers and local authorities) achieved a high level of community mobilization and commitment to IRS activities and a high acceptance rates, with very few refusals.
- The project identified a strong partner in entomology, CREC.[3]
- CREC assessments of the efficiency of IRS operations and monitoring visits (to control the quality and homogeneity of the spraying by spray operators and to monitor entomological activities for vector sensitivity and insecticide durability on different sprayed surfaces) yielded very positive results for the two rounds, indicating good quality and homogeneity of the spraying.
- Vector susceptibility to the insecticide(s) used for IRS was established in a thorough and timely manner.

3. Challenges

The Benin IRS 1 project experienced several implementation challenges, which are listed below.

- Planning of activities, geographic reconnaissance, and all needs assessments to conduct the spray rounds successfully in the narrow timeline available (usually prior to the beginning of the rains) and to achieve expected results in terms of coverage and protection all posed challenges to project staff and counterparts.
- Partnership and collaboration with national, regional, and local authorities for capacity building and integration of IRS as a malaria control strategy were weak or lacking. (The project needs the country to commit resources to IRS specifically and vector control generally at all levels and for government staff to be involved.)
- Numerous U.S. and Benin environmental regulations made achieving environmental compliance difficult throughout the entire set of activities: (1) building logistics sites with rinsing areas and soak pits; (2) training of MOH hygiene agents and representative staff from MOE and MOA on IRS activities, on how to train spray operators, and on how to supervise spray operators in the field; (3) training of spray operators on spraying techniques and on how to mitigate environmental hazards and avoid spillage; (4) tracking insecticide sachets and collecting all IRS waste; (5) safely transporting insecticide and waste; and (6) disposing of waste.
- Developing an information, education, and communication (IEC) strategy and IEC messages was challenging, taking into account and building upon Benin cultural norms.
- Staffing IRS project start up proved difficult because there was limited staff with expertise or knowledge of IRS, which necessitated thorough training and supervision.
- Monitoring and evaluation (M&E) and data quality suffered due to the low education level of data collection staff, who did not necessarily pay attention to the importance

[3] CREC was involved from the beginning of IRS in Benin and also participated in selecting which districts to spray and selecting an appropriate insecticide. CREC successfully conducted all entomological studies, research on vector sensitivity, and research on the rate at which vectors evolve insecticide resistance. CREC is internationally recognized (by USAID, CDC, WHO, and others). In October 2011, CREC published an article in the *American Journal of Tropical Medicine and Hygiene* based on data going back to 2008 about the success of IRS operations in Benin using Bendiocarb insecticide.

of data quality, had a different interpretation of IRS indicator definitions (e.g., structure/ house and people living/sleeping in structures), conducted inadequate data entry, and did not report in a timely manner.

- Recruiting sufficient personnel was difficult; a project of this size has more than 600 people to recruit, train, and supervise during a short but very intense period.
- Ensuring security of seasonal worker payments in the field posed problems initially.

4. Lessons Learned

The Benin IRS 1 project offered important lessons in the following areas.

- Develop an effective insecticide rotation strategy from the earliest possible time in project implementation to mitigate vector resistance.
- When scheduling IRS activities, take into account local activities and events to avoid household absenteeism during spray operations.
- Encourage the involvement of local political authorities and religious leaders at all phases of IRS operations (before, during, and after) to increase community acceptance.
- Include the heads of villages and religious leaders (or their representatives) in IEC activities so that they can participate fully and take ownership of the IEC activities.
- Use a sufficient number of IEC mobilizers (community health workers) during spray operations in collaboration with spray operators to maintain contact with the community, increase acceptance of IRS, and facilitate the work of spray operators.
- Have an adequate amount of rinsing areas, soak pits, and drying areas to avoid congestion when spray operators return to sites.
- Increase the number of secondary logistics sites in spray areas as necessary to reduce time and transport costs.
- Establish systems and protocols to ensure spray operators become fully responsible for their own PPE.
- Provide the cost per person protected by IRS for cost-effectiveness improvement, sustainability, and advocacy for IRS as an effective malaria prevention activity and also to assist MOH with fundraising to scale up IRS activities in other regions.
- Clearly establish the roles and responsibilities of the Government of Benin and PMI in IRS.

Innovations

The Benin project achieved the innovations listed below.

- Developed a system to easily identify each spray operator's individual PPE.
- Included the RTI M&E and environmental consultants as well as other technical staff at the start of IRS operations so that they were part of the preparatory phase.
- Instituted a system to track insecticide sachets checked out by spray operators, with numbering of sachets and daily follow up.

3.3 Ethiopia (2008–2009)

1. Background

RTI International established its indoor residual spraying (IRS) project office in Ethiopia and started IRS activities in June 2008. In Ethiopia, support from the United States President's Malaria Initiative (PMI) has largely focused on Oromia Regional State, Ethiopia's largest regional state, covering approximately a third of the country's land mass as well as representing a third of the country's malaria burden. Ethiopia is unique among African countries in its unstable and epidemic pattern of malaria transmission. Variation in malaria epidemiology, even within the same district and village, based on topography and climate, adds complexity to the malaria control program.

RTI has worked in Ethiopia with its subcontractors and partners—Crown Agents USA for procurement and logistics services and the Medical Research Council of South Africa for geographical information systems development—and collaborated with the C-Change Project for IRS-focused information, education, and communication (IEC) development, review, and dissemination.

RTI has strived to support several activities to strengthen regional as well as national-level planning, implementation, and monitoring of IRS operations:

- Policy technical assistance, including development, review, or modification of in-country guidelines/strategies.
- Training workshops for Federal Ministry of Health (FMOH), Oromia Regional Health Bureau (ORHB), and Zonal Health Bureau staff in IRS microplanning, spray pump maintenance, poison control, and environmental compliance.
- Technical assistance to FMOH/ORHB in procurement of insecticides and operational IRS equipment.
- Rehabilitation of the Adama Malaria Reference Training Center.
- Entomological monitoring of insecticide resistance and vector ecology.
- Quantification and analysis of IRS waste and leftover and expired IRS insecticides.

In 2008, in close partnership with the ORHB, the National Malaria Control Program (NMCP), and PMI, RTI implemented the IRS project in 19 districts of Oromia. The PMI-supported project is rapidly building national capacity and paving the way for further scale up of IRS. A summary of the results of IRS is presented in Table 1.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Region	Dates	Structures Sprayed[a]	Percent Coverage	Population Protected[a]	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Oromia	7/08–9/08	316,829	92%	1,000,526	12,496	161,144	1,198
2009	Round 2	Oromia	5/09–7/09	459,402	92%	1,539,163	28,628	280,813	3,017
Total				**776,231**		**2,539,689**	**41,124**	**441,957**	**4,215**

[a] Numbers reflect the results achieved under the IRS 1 project only. Note that these data differ from PMI's reported results because PMI includes spray results conducted by the Government of Ethiopia also.

IRS field operations have relied heavily on the existing ORHB infrastructure and resources in terms of physical structures for storage and office space, human resources for training and supervision (e.g., through ORHB officers, and zonal and district health office disease control officers), and community mobilization, building on an existing network of community-based surveillance volunteers. Throughout the project, the support of government officials, traditional leaders, and local families has been harnessed to maintain over 90% coverage in all IRS targeted districts in all program implementation campaigns.

In selected project areas, microplanning meetings on gap analysis were held, and after the first year, all essential IRS supplies were procured and distributed to districts on time. Other accomplishments included construction of evaporation tanks and rehabilitation of storage facilities in collaboration with project district health facilities. Capacity-building activities were conducted in the areas of IRS training, pesticide poison management, and spray pump use and management.

Since assuming management of the IRS project in Ethiopia, RTI has conducted regular entomological monitoring of malaria vector densities and behavior in representative project districts. Insecticide susceptibility studies on *Anopheles gambiae s.l.* were carried out in 5 kebeles in 2008 and 11 kebeles in 2009 on five different insecticides.

2. Successes

The Ethiopia IRS 1 project achieved the following major successes.

- In 2008, the Ethiopia IRS project achieved 92% coverage in 16 districts in year one of spraying despite starting late (August rather than June).
- In 2009, RTI Ethiopia expanded from 16 to 23 districts and again achieved more than 92% coverage, starting and ending on time. In terms of logistics, RTI constructed storage facilities in 16 districts and rehabilitated stores as well. RTI also carried out a community IRS Knowledge-Aptitude-Practices (KAP) survey. Comprehensive entomological monitoring was conducted for the first time in Ethiopia, covering vector behaviors, breeding habitats, and resistance and susceptibility.

3. Challenges

Among the barriers faced by the Ethiopia IRS 1 project during 2008–2009 are the following.

- In the beginning coordinating with the Oromia Regional Health Bureau at the district level was difficult, especially with synchronizing activities with their ongoing program.
- In the first round of IRS in Ethiopia, conducted in 2008, RTI faced many challenges starting up IRS. Environmental compliance activities started late, just before spraying. After they started there were problems with coordinating waste disposal and containment, and environmental compliance to safer use protocols for operators.
- Also in 2008, procurement was delayed, causing a late start of spray operations. Procurement delays, both international and local, again persisted in 2009 but did not delay the start of spraying.

- In 2009, the problems of constructing storage facilities and evaporation tanks had been largely resolved, but some facilities still had not yet been built or rehabilitated during the expansion to 23 districts.

4. Lessons Learned

The lessons gained from the PMI-supported IRS 1 operations include the following:

- Ensuring environmental compliance in protecting people (through use of personal protective equipment) and the environment (through construction of evaporation tanks) was a challenge from the beginning of the project, and continued improvements were needed to protect IRS project staff and ensure the safety of the beneficiary communities protected by IRS.
- Along with the IRS IEC campaigns, support and advocacy from both national and local government counterparts and stakeholders are critical factors to successfully achieve the high coverage rates required for malaria prevention.
- Effective communication strategies utilizing the health extension workers in the local areas have proven to be most effective at decreasing re-plastering rates. Homeowners in Ethiopia re-plaster their walls frequently—generally at least once per year, after the Ethiopian New Year. In 2009, an assessment of re-plastering rates found that the IEC messages were not decreasing the rates of re-plastering and a stronger IEC campaign was needed to discourage homeowners from re-plastering their homes after insecticide application.
- Entomological monitoring activities are crucial to ensure the quality and efficacy of IRS operations and to guide the selection of insecticides and the selection of which villages to target with IRS activities.
- Proper selection of districts, evidence-based planning, and timely preparation are necessary to successfully conduct spray campaigns.

3.4 Ghana (2008–2009)

1. Background

In October 2007, Ghana was selected as one of the countries to receive funding under the U.S. President's Malaria Initiative (PMI) indoor residual spraying (IRS) project. The first round of IRS in 2008 targeted five districts: Tolon-Kumbungu, Savelugu-Nanton, Karaga, Gushegu, and West Mamprusi. Total coverage of spray activities across these districts was 93%. In 2009, the number of districts was expanded from five to six (with the addition of East Mamprusi district), and spray activities protected over 708,000 residents, with a coverage rate of 94%.

The IRS project protected the following numbers of people and districts in each project year (Table 1):

- Round 1 (2008) – 601,973 people in five districts
- Round 2 (2009) – 708,103 people in six districts

The Ghana IRS project stands out among other programs because of the high level of enthusiasm displayed by the project staff, the support of District Health Management Teams (DHMTs) and district assemblies, and the high level of involvement by local communities. (For example, area council offices were provided to RTI as warehouse and office space.) There was also strong collaboration between the PMI/IRS project and its partners such as the National Malaria Control Program (NMCP), Environmental Protection Agency, Ghana Health Service, and local traditional authorities.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Tolon-Kumbungu, Savelugu-Nanton, Karaga, Gushegu and West Mamprusi	5/08–7/08	254,305	93%	601,973	13,967	108,124	468
2009	Round 2	East Mamprusi, Gushegu, Karaga, Savelugu-Nanton, Tolon-Kumbungu, and West Mamprusi	5/09–7/09	284,856	94%	708,103	16,881	140,782	577
Total				**539,161**		**1,310,076**	**30,848**	**248,906**	**1,045**

2. Successes

Ghana's numerous successes are provided below.

- In the first two years of IRS operations, the Ghana IRS project consistently exceeded the goal of 90% IRS coverage set by the NMCP and the 85% goal set by PMI. Spray operations were on time and on budget.

- The project met rigorous environmental compliance standards as set by the host country and PMI.
- The project hired local community members and served as a source of livelihood for many households and, in turn, positively changed the lives of community members (especially the youth) across the operational districts.
- Ghana has built a capacity for rapid adoption of IRS, including planning, training procurement, implementation, and supervision.
- Effective collaboration occurs at all levels of the Government of Ghana.
- The Ghana IRS project achieved impressive community acceptance rates and support across the northern region.
- The project identified solid waste incineration equipment in Ghana so that waste did not need to be exported for disposal, which provided substantial cost savings for the project.
- The Ghana IRS project has sufficient capacity to assist other African countries to start up an IRS project.

3. Challenges

Despite the many successes, the Ghana IRS project also experienced some challenges during IRS 1.

- Poor communications network (both Internet and mobile phone) coverage in the districts affected communication flow during operations.
- Operations at the peak of the rainy season were difficult because the community members, who are predominantly farmers, left the villages to work on their farms.
- Buses for spray operators frequently broke down because of poor road conditions, causing delays in travel by spray operators to communities.
- Some community members were reluctant to remove their possessions from their homes for spraying, especially in districts that had already been involved in IRS spray rounds.
- Some households gave inconsistent data at different times.

4. Lessons Learned

The 2008–2009 IRS 1 project experience provided the following lessons.

- The involvement of DHMT and district assemblies added to the popularity of the project and increased community acceptance. For example, the involvement of community health nurses in door-to-door sensitization helped boost community acceptance.
- Recruitment of spray operators from the districts being sprayed contributed to high community acceptance of IRS.
- Rigorous and consistent data verification at various operational levels of the program ensures high quality, reliable data.

Innovations

Based on previous experience and with the aim of continuous improvement, a number of innovations were introduced into the Ghana IRS project in 2008–2009.

- After Round 1, recruitment and training for site managers and supervisors were conducted separately from those conducted for spray operators.
- The program introduced the use of Ghana Health Service community-based surveillance volunteers to reach out to community members and increase acceptance of IRS.
- Across the IRS districts in the country, spray operators and other staff (many of whom were earning money for the first time) were introduced to business and investment knowledge to aid them in making judicious use of their wages through investing.

3.5 Kenya (2008–2009)

1. Background

The IRS campaign in Kenya, a joint U.S. Government and Government of Kenya initiative, was part of the U.S. President's Malaria Initiative (PMI) to reduce the impact of malaria in sub-Saharan African countries. Kenya began IRS in 16 seasonal transmission districts in 2007 with support from Global Fund Round 4. In 2007, Kenya was selected as one of the eight new countries to receive funding during the third year of PMI. RTI was tasked to assist with payroll to spray operators for the 2007 IRS round in Kenya. Under the IRS 1 project, Crown Agents USA provided payroll services to spray operators and drivers in 16 districts in 2007. The project became involved in conducting actual IRS activities in 2008.

Under PMI, the U.S. Government agreed to continue supporting IRS activities in 2 of the 16 districts, as well as one endemic district as a strategy of transitioning IRS activities into endemic areas. The USAID/PMI team partnered with the Kenya Ministry of Public Health and Sanitation (MOPHS) through the Division of Malaria Control (DOMC) and District Health Management Teams (DHMTs) in the three PMI-supported districts. The IRS team ensured involvement of all partners in IRS activities during planning, implementation, and supervision phases.

The IRS Kenya project objectives were as follows:

- Provide technical management support in the planning and implementation of effective IRS programs in three districts.
- Develop capacity in DOMC to conduct effective, safe, and well-managed IRS operations in the three IRS districts and for the MOPHS-supported districts.
- Provide safe storage of equipment at the end of the spray period and maintain an inventory of all equipment.

Under this Task Order, USAID/PMI supported IRS activities in three districts—Nandi North and Nandi South (both epidemic) and Rachuonyo (an endemic district) in fiscal year (FY) 2008 and FY 2009. During FY 2008, a total of 364,941 structures were sprayed, protecting an estimated population of 1,257,941, and 3,165 seasonal staff was trained in the same year. In FY 2009, 517,051 structures were sprayed with coverage of 97.6% of the DOMC projected target structures, protecting 1,435,272 people. A total of 2,670 seasonal personnel were trained in the 2009 spray cycle. Table 1 presents a summary of results after two rounds of IRS.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected[a]	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Nandi North, Nandi South, and Rachuonyo	6/08–9/08	364,941	98%	1,257,941	53,424	222,818	1,452
2009	Round 2	Nandi North, and Nandi South, and Rachuonyo	4/09–6/09	517,051[a]	98%	1,435,272	27,675	259,061	1,719
Total				**881,992**		**2,693,213**	**81,099**	**481,879**	**3,171**

[a] Numbers reflect the results achieved under IRS 1 project only. Note that these data differ from PMI's reported results because PMI also includes spray results outside of those conducted by this project (Government of Kenya).

2. Successes

Among the Kenya IRS 1 project's successes are those listed below.

- IRS coverage exceeded 90%.
- The capacity to roll out IRS (planning and implementation) developed at national and district levels.
- High community participation in IRS was achieved because of efficient mobilization strategies.
- A high level of community acceptance of IRS as a malaria preventive measure was achieved.
- To ensure environmental compliance, the project developed an environmental monitoring and mitigation tracking system of environmental indicators and adopted a strict internal routine to guarantee safe pesticide use and environmental protection.
- The project enhanced partnership at the community level by working closely with the provincial administration (e.g., district council, district officers, and chiefs/assistant chiefs).
- A robust system of inventory management and control was put in place and staff were trained on using the tool.
- Best practices in the storage of insecticides and equipment were observed, which helped the district staff and storekeepers minimize risks, damage, and loss.
- A computer-based system was put in place to track the daily issuance and returns of insecticide. Each insecticide sachet was coded, and each spray operator signed the logbook daily for insecticide sachets, reducing losses and increasing accountability.
- Spray pumps and personal protective equipment were tagged by a unique number and assigned to each spray operator; issuance and returns were recorded and registered daily.

3. Challenges

Difficulties encountered by the Kenya IRS 1 project are included below.

- Initial IRS baseline data were not accurate enough for making precise logistics planning and management.
- The lack of clear administrative boundary demarcations in some districts affected IRS planning and implementation with regard to spray coverage.
- Cultural beliefs, myths, and misconceptions in some districts led to refusals.
- High water table in some operational sites led to flooding of soak pits and high construction costs.
- IRS start dates tended to coincide with the long rains, which interfered with operations.
- Some roads in the target districts were inaccessible, leading to loss of vital time for spraying and resources.
- Lack of commitment of supervisors and team leaders hampered supervision and tended to compromise the quality of IRS activities.

4. Lessons Learned

Lessons gained during the IRS 1 experience across 2008 and 2009 include the following.

- *IRS operations*. Integration of mobilization and spray activities is critical for efficient IRS implementation. Having a supervisor(s) coordinating both mobilization and spray operations reduces disharmony and streamlines the coordination process.
- *Stakeholders*. The IRS project benefits from greater involvement of the provincial administration in the IRS exercise for purposes of sustainability.
- *IRS planning*. IRS activities need to be initiated early and with sufficient lead time to ensure adequate preparation of districts for the activity.
- *Training*. IRS project should train a large pool of trainers of trainers at district level to ensure adequate trainee to trainer ratio for quality training.
- *Training curriculum*. Use of a standardized curriculum for training all cadres of staff is important for harmonizing operations.
- *Mobilization strategies*. Diversifying sensitization and communication strategies will empower community members with information on the benefits of IRS to dispel fear and myths.
- *Mass media*. Because local radio is a popular means of disseminating IRS information, priority should be given to this channel of communication to broadcast messages, initiate call-in shows guest hosted by IRS staff, and conduct expert interview sessions.
- *Feedback*. An efficient feedback mechanism on performance improves the quality of data being reported and coverage by the IRS project.
- *For purposes of sustainability*, community leaders should take an active role in IRS campaign activities such as household registration, selection of local seasonal staff, tracking of unsprayed structures, and deterrence of insecticide losses.

3.6 Liberia (2009)

1. Background

Liberia's malaria control program uses several control strategies to fight malaria, including integrated vector control (e.g., indoor residual spraying [IRS] and distribution of insecticide-treated nets); intermittent preventive treatment of malaria in pregnancy; case management; and information, education, and communication. This report summarizes the achievements, lessons learned, and recommendations covering the Liberia IRS project. The Ministry of Health and Social Welfare, through the National Malaria Control Program (NMCP), and the United States Government (USG), through the United States President's Malaria Initiative (PMI), agreed to intensify the control and prevention efforts.

Malaria prevention and control is a major U.S. foreign assistance objective and a core component of the current comprehensive USG Global Health Initiative, announced in May 2009 by President Barack Obama, to reduce the burden of disease and strengthen communities around the world. The objective of the IRS Liberia project is to reduce malaria transmission in the selected counties through the attainment of at least 85% structure and population protection coverage.

The IRS activities in Liberia began with three districts: Mamba Kaba in Margibi County and Owens Grove and District #1 in Grand Bassa County. At the time, the country was recovering from a 14-year civil war (1989–2003). The first post-eradication-era IRS project in Liberia was rolled out on June 4, 2009, marking the beginning of the first large-scale PMI-supported IRS project in Liberia in decades. Activities supported by PMI and managed by RTI in Liberia in collaboration with NMCP in 2009 included spraying of 20,400 structures, which protected a total population of 163,149 in Mamba Kaba, Owens Grove, and District #1. A total of 262 people were employed over a 40-day period.

Results of the 2009 spray round are shown in Table 1.

Table 1: IRS 2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2009	Round 1	Mamba-Kaba, Owen's Grove, and District #1	6/09–8/09	20,400	97%	163,149	7,893	29,709	340
Total				**20,400**		**163,149**	**7,893**	**29,709**	**340**

2. Successes

The IRS 1 project in Liberia achieved the successes listed below.

- In the first round of operation, the IRS project trained 320 people to conduct IRS, representing a significant first step in building a knowledgeable cadre of local IRS staff.

- The project achieved coverage of more than 95% in targeted communities.
- The project has further strengthened the capacity of the NMCP to conduct basic entomological work. To date, four staff from the NMCP can identify the mosquitoes responsible for malaria transmission, conduct pyrethrum spray catches and indoor catches, and perform bioassays. In conjunction with the Integrated Vector Management project, the IRS 1 project has assisted in establishing a functional insectary at the Liberia Institute for Biomedical Research.

3. Challenges

The IRS 1 project has faced a difficult journey starting up and implementing IRS—from crossing the monkey bridges of District #1 to the canoe travel through Worr district, coupled with the long six-hour walks. Conducting IRS in rural Liberia is challenging, but the project reached every community in the targeted districts. The following list identifies some specific challenges that the project faced.

- *Working in a post-conflict environment*. Liberia's context poses many challenges, including lack of infrastructure, security risks, and a dearth of skilled labor.
- *Poor road network*. This has been a major hurdle, resulting in spray operators having to walk for up to six hours to reach certain communities.
- *Relationships between community health teams (CHTs) and district commissioners and superintendents*. These two arms of government do not work well together, with much mistrust between them. IRS, however, needs the active participation of both. The IRS team called for a coordination meeting involving district health officers from the CHT and district commissioners and superintendents from the Ministry of Internal Affairs. At the meeting, participants identified and agreed upon the roles of each partner, including the communities.
- *Involvement of concession companies*. The concessions areas of some private companies are within the areas being sprayed, and omitting these areas from IRS could put the targeted communities at risk for malaria by leaving a reservoir of infection in the spray area. Getting the concessions management to commit resources to IRS was challenging.
- *Lack of infrastructure*. Most government infrastructure was destroyed during the 14-year war, and it has not been possible to either rent or renovate government buildings. As a result, the project had to rent private buildings, which is a practice that does not align well with the principles of building local capacity.

4. Lessons Learned

Lessons learned from the 2009 spray round in Liberia include the following:

- Use of community leaders as chief mobilizers is an effective way of transmitting IRS messages and can minimize reliance on the door-to-door campaigns in successive spray rounds.
- The use of government community health volunteers as spray operators—an approach piloted in Bong—yielded good results; this practice needs to be evaluated further for its potential to reduce annual training costs for IRS operations.

- The response from the private sector partners wanting to conduct IRS has been encouraging. However, to avoid problems in promoting public-private partnership initiatives, it is critical to have a signed memorandum of understanding and contract agreements for casual labor before commencement of any activities.
- Team leaders, supervisors, and IRS coordinators need continued training to equip them with supervisory skills and knowledge.

5. Recommendations

RTI recommends the following:

- NMCP management should play an active role in the implementation of the IRS program.
- NMCP and PMI should establish a forum for the public-private partners to share experiences and to guide each other in proper implementation of malaria prevention activities.
- IRS activities specifically targeting rural districts and communities historically vulnerable to high malaria incidence should be the top priority.
- Based on the current implementation approach, spraying should continue from the Atlantic Ocean and move into the interior as planned until malaria transmission is reduced to insignificant levels.
- Health education and behavior change communication should be used to mobilize communities to participate actively in vector control programs. Partners should focus on development of institutional capacity for IRS expansion and for the intervention to extend to other counties to maximize impact. It takes years to build a successful and sustained IRS program.
- Funding should be sought for the development and promotion of participatory approaches in malaria prevention.
- NMCP and its partners should encourage the participation of the private sector. The private sector will be key to maintaining and expanding the IRS program in Liberia.
- The focus for Liberia should be on continuing to build institutional capacity.

3.7 Madagascar (2008–2009)

1. Background

Since 2007, RTI International has implemented the United States President's Malaria Initiative (PMI)–supported indoor residual spray (IRS) project, offering technical and operational support for IRS activities in the central highlands region of Madagascar. Under the supervision of the PMI country team, and in collaboration with the National Malaria Control Program (NMCP) and other Roll Back Malaria (RBM) partners in health and other related sectors, the primary objectives in Madagascar were to provide technical support for IRS training, monitoring, and quality assurance activities; and support IRS community mobilization activities, including dissemination of information, education, and communication (IEC) materials to promote the success of spray activities in the targeted districts.

Under IRS 1, PMI supported spray activities for two rounds.

- In 2008 (first round of IRS supported by PMI), the IRS project sprayed 422,132 targeted households and protected a population of 2.561 million.
- In 2009 (second round), the IRS project sprayed 216,060 structures and protected a population of 1.275 million.

Table 1 provides an overview of the results during the 2008–2009 IRS campaigns.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Region	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Central Highlands	11/08–1/09	422,132	96%	2,561,034	NA	NA	1,673
2009	Round 2	Central Highlands	11/09–12/09	216,060	96%	1,274,809	25,420	203,664	851
Total				**638,192**		**3,835,843**	**67,479**	**622,334**	**2,524**

2. Successes

In addition to the success of the spraying campaigns, the PMI-supported IRS 1 project in Madagascar achieved many other successes, including the following:

- The project standardized the NMCP technician training, including the development of standardized curricula.
- The team reinforced environmental compliance and built soak pits and washing areas in all communes and temporary soak pits at the village level.
- The Madagascar project successfully expanded IRS activities in the south and northwest areas of Madagascar.
- RTI IRS team worked very closely with *Service de Lutte contre le Paludisme* (i.e., the NMCP in Madagascar) from 2007 to 2009, encouraging the handover of responsibility for various activities throughout the spray rounds.

- The IRS project was able to work well with local nongovernmental organizations in place of the Government of Madagascar in 2009, during a period of national uncertainty.
- All rounds met or exceeded the 85% coverage objectives for optimizing the benefits of IRS.
- Environmental compliance improved greatly after the first round to almost 100% compliance by the end of IRS 1.

3. Challenges

Some challenges faced by the IRS 1 project in Madagascar include the following:

- Long distances and difficult terrain from spray areas to operational sites were very time consuming and difficult for the spray personnel in the first round. Additional operational sites were established in Round 2 to improve efficiency.
- Soak pits were misplaced in some areas where the water table was low in the first round. In the second round, the project considered this before constructing soak pits.
- Spray operators who wore dust masks frightened the community, resulting in refusals. The Madagascar team addressed the issue by replacing the masks with smaller ones.
- Spray operations started too far into the rainy season in the first round. The project planned the second round to begin earlier to complete spraying before the rainy season began.
- There were delays in 2008 with the procurement of insecticide, emphasizing the need to begin as early as possible with procurement for a country where transport of materials and commodities can take additional time.

4. Lessons Learned

Among the lessons learned in Madagascar during the 2008–2009 period were the following.

- Reinforce the participation of the local authorities in each level of IRS for successful mobilization by the population to ensure acceptance of IRS.
- Reinforce the management of solid waste and emphasize warehouse management tools.
- Spray operations should start well before and end at the latest before the beginning of the rainy season.

3.8 Malawi (2007–2009)

1. Background

The United States Agency for International Development (USAID) identified Malawi as one of the second wave of countries to receive funding under the U.S. President's Malaria Initiative (PMI). USAID and the Malawi National Malaria Control Program (NMCP) identified Nkhotakota district as a pilot district to assess the operational feasibility for indoor residual spraying (IRS) activities. Under the IRS 1 project, PMI asked RTI to cover 40% of Nkhotakota district in 2007 and 2008. In 2009, PMI asked RTI to support the NMCP to implement IRS in the entire district.

Prior to PMI's involvement in IRS in Malawi, two activities in a small-scale pilot of IRS funded by the African Development Bank focused on the operational costs and feasibility of IRS in rural areas. Spraying was conducted in about 30 villages in areas south of the Vwaza Marsh and near Maloma, consisting of approximately 1,700 households and 400 households, respectively.

Later, the Illovo sugar plantation in Nkhotakota district began spraying the housing of their employees. Initially, they sprayed only within the plantation boundaries, and then later expanded spraying beyond the boundaries to try to reduce infections coming in from nearby settlements. The Malawi NMCP and PMI decided that building upon the Illovo program in the surrounding district would serve two purposes: (1) to establish a strong public-private partnership fighting malaria and (2) to reach a wider area easily by building on an existing program.

The IRS 1 project in Malawi supported various components related to the IRS campaigns, including those listed below.

- *Partnership development.* The IRS project worked to develop close partnerships among the NMCP, the District Health Management Team (DHMT), and Illovo Sugar Estates to facilitate scale up of the program's activities to the entire district.
- *Environmental compliance.* The IRS project ensured continued compliance with international and local environmental laws and regulations, in addition to implementing an environmental monitoring and compliance program.
- *Capacity building.* The IRS project worked with the NMCP and the DHMT to build capacity in IRS program implementation and management. The IRS project also supported training of community members in malaria prevention and IRS.
- *Implementation of IRS campaigns.* In collaboration with NMCP, the IRS project provided operational and management support for the implementation of IRS activities, including microplanning, daily supervision, inventory management, monitoring and evaluation, and quality assurance.
- *Community mobilization*. The IRS project, in partnership with the DHMTs, identified community information, education, and communication (IEC) mobilizers to carry out IEC campaigns before and during the spray round.

Table 1: IRS 2007–2009 Summary Results

Year	Round	District	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 1	Nkhotakota	11/07–12/07	26,950	93%	126,126	N/A[a]	25,677	300
2008	Round 2	Nkhotakota	10/08–11/08	24,764	93%	106,450	4,258	21,290	309
2009	Round 3	Nkhotakota	9/09–11/09	74,772	91%	299,744	7,815	66,136	462
Total				**126,486**		**532,320**	**12,073**	**113,103**	**1,071**

[a] The number of pregnant women protected was not recorded in 2007 in Malawi.

2. Successes

The IRS 1 project in Malawi counts the following among its successes.

- From 2007 to 2009, three spray rounds were conducted in Nkhotakota (see Table 1). Coverage for each round was near or above 90%.
- The IRS project trained a total of 1,071 spray personnel.
- The IRS project protected a total of 532,320 people.
- Conducted vector susceptibility tests before each round and performed a full range of entomological monitoring over the three years.
- Completed Supplemental Environmental Assessments for the Malawi IRS program.
- RTI Environmental Compliance Inspectors performed timely pre-spray and mid-spray environmental compliance inspections.
- The project successfully convened a meeting entitled "Extraordinary Meeting of the Environmental Council" and responded to specific questions from the council regarding environmental safety aspects of the IRS spray program in Malawi. As a result, the Director of Environmental Affairs issued a certificate of approval for the IRS project in Malawi.
- After each spray round, DHMT and RTI organized a series of community open meetings, led by DHMT. After the first round, 16 locations in Nkhotakota district held meetings. This extensive and inclusive exercise was designed to allow community members to freely discuss their perceptions and ideas about IRS and to contribute to planning future rounds. In addition, a national-level workshop on lessons learned was held in Lilongwe after each spray round.

3. Challenges

The following were the challenges experienced in conducting the IRS 1 project in Malawi.

- Scaling up IRS in a new country can be daunting. The project was faced with high turnover at the chief of party level, which the project addressed by sending in temporary replacements from outside the country.

- The first spray round was delayed and consequently took place just before and during the annual rainy season. To help address the issue, the project borrowed spray equipment and personal protective equipment from another country to increase the number of spray operators and shorten the number of spray days.
- Although the *Anopheles* mosquito vectors were susceptible to the pyrethroid insecticides first used in Malawi, the local *culex* species were not. When the *culex* population thrived after the first round of spraying, communities within the spray area doubted that the spray round had worked.
- Some insecticide stored in the Illovo storage facility was stolen. Although the theft was addressed by local police and courts under Malawian law, it nonetheless reflected poorly on an otherwise effective program.
- The project faced difficulties in the early rounds in obtaining an accurate count of structures/households sprayed.
- Labor unrest over remuneration disrupted one spray round.

4. Lessons Learned

The 2007–2009 IRS experience culminated in the following lessons learned.

- A clear understanding among the implementing stakeholders on how structures/ households are to be defined and counted is essential to successful project monitoring and evaluation.
- Accurate, agreed-upon denominator data on structure count will prevent disputes over monitoring of results. In Malawi, there are different sources for population and dwelling data, with different totals.
- Local ownership and leadership of the program is necessary to avoid and mitigate misunderstandings about compensation.

3.9 Mali (2008–2009)

1. Background

Mali was identified by USAID as one of the third wave of countries to receive funding under the U.S. President's Malaria Initiative (PMI). USAID and the National Malaria Control Program (Programme National de Lutte Contre le Paludisme [PNLP]) identified two endemic districts (Koulikoro and Bla) for indoor residual spraying (IRS) activities. Bla district has a population of approximately 259,000 people, and Koulikoro district has approximately 172,000 people. In 2007, USAID and the PNLP agreed to focus IRS activities in both districts with the intention of expanding coverage to others areas in future spray campaigns.

Under IRS 1, Task Order 1, RTI conducted two spray rounds: one in 2008 and one in 2009, covering the districts of Bla and Koulikoro in both rounds. The results of the two spray rounds are presented in Table 1.

Table 1: IRS 2008 and 2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2008	Round 1	Bla and Koulikoro	7/08–8/08	107,638	90%	420,580	13,488	84,286	413
2009	Round 2	Bla and Koulikoro	5/09–7/09	126,922	94%	497,122	24,659	88,030	424
Total				**234,560**		**917,702**	**38,147**	**172,316**	**837**

2. Successes

The IRS 1 project in Mali counts the following among its successes.

- Through capacity building and the participation of PNLP in spray operations, PNLP is well placed to progressively take on more IRS tasks.
- The IRS project in Mali successfully met and exceeded the 85% IRS coverage objective, providing optimal protection for the community.
- Local steering committees functioned well and helped to resolve issues as they arose during implementation.
- The IRS project protected more than 900,000 people through the two spray rounds.

3. Challenges

The challenges experienced by the IRS 1 project are listed below.

- Rains, which made roads impassable and hampered household preparation for IRS, caused some delays in spray operations.
- Ensuring adequate supervision of warehouses and soak pits was challenging because of the numerous spray sites.

- Lack of motivation among spray operators and information, education, and communication mobilizers was detrimental to the quality and timeliness of spray operations.

4. Lessons Learned

The 2008–2009 IRS experience culminated in the following lessons learned.

- The effective participation in microplanning and supervision of the structures within the Ministry of Health (e.g., PNLP, regional level health centers, and community health centers) is essential to transfer skills and facilitate sustainability.
- The strong involvement of the Ministry of Environment (through the National Directorate and other branches at regional and district levels) during the training session and their subsequent supervision strengthened the partnership between the MOE and MOH and boosted the activities conducted by the environmental specialists.
- Developing a cadre of mechanics who can maintain and repair pumps not only strengthens capacity but also saved time and reduced costs.
- Having local authorities identify spray operator candidates contributes to community buy in and the success of the spray round.
- In the future, it is advised to consolidate staging sites (e.g., warehouses and soak pits), and provide closer supervision to each one, to ensure adequate supervision.
- Increasing incentives and providing certificates for acknowledging good work can boost morale.

3.10 Mozambique (2007–2009)

1. Background

In 2007, Mozambique was identified as one of the second wave of countries to be added to the list of the President's Malaria Initiative (PMI)-supported Indoor Residual Spraying 1, Task Order 1 countries. Since then, RTI has managed the Mozambique IRS project in collaboration with PMI, the National Malaria Control Program (NMCP), Ministry of the Environment (MOE), and other key national stakeholders. The primary objectives of the program are as follows:

- Support training and capacity building at various levels of government and among partners as a means of achieving sustainability of IRS and its positive impact on malaria.
- Achieve over 85% spray coverage of structures found in the targeted area.
- Hire and train staff and ensure supervision for IRS activities.
- Demonstrate best practices for responsible and quality application of IRS, including implementation of a secure insecticide chain of custody.
- Purchase pumps, spare parts, and personal protective equipment for spray operations in the targeted districts.
- Provide technical assistance and capacity building in entomology to the Government of Mozambique through support to NMCP.

Through IRS 1, RTI, in collaboration with PMI, NMCP, and the Provincial Department of Health (DPS), implemented three successful spray rounds, achieving over 85% coverage each year. Table 1 provides an overview of the 2007–2009 IRS spray rounds.

Table 1: IRS Summary Results, 2007–2009

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 1	Quelimane, Nicoadala Namacurra, Mocuba, Milange, and Morrumbala	10/07–2/08	586,568	97%	2,593,949	N/A	574,654	1,190
2008	Round 2	Quelimane, Nicoadala Namacurra, Mocuba, Milange, and Morrumbala	8/08–11/08	412,923	96%	1,457,142	N/A	264,263	1,282
2009	Round 3	Quelimane, Nicoadala Namacurra, Mocuba, Milange, and Morrumbala	7/09–10/09	571,194	97%	2,263,409	116,457	429,529	1,343
Total				**1,570,685**		**6,314,500**	**359,735**	**1,616,187**	**3,815**

2. Successes

Among the successes counted in the Mozambique IRS 1 project are the following.

- IRS management and leadership capacity were developed at central and provincial levels through annual training-of-trainers workshops and close collaboration with the RTI IRS Mozambique program team throughout all planning and implementation activities.
- Spray results showed over 90% coverage (houses and population protected) in all districts.
- IRS materials and commodities were purchased and delivered to districts on time.
- Environmental impact of IRS was minimized through careful environmental compliance review and inspections. The IRS and IEC supervisors were trained on malaria, IRS, entomology, and IEC. The Zambezia Health Provincial Department (DPSZ) and RTI conducted the training, using the training manuals developed by the Ministry of Health and RTI. These supervisors were able to supervise IEC and IRS operations on their own.
- The project established good working relationships with other nongovernmental organizations (e.g., Adventist Development and Relief Agency, Inter-religious Program Against Malaria, and Population Services International), governments (DPSZ, the Ministry of Environmental Affairs, Provincial Directorate of Agriculture of Zambezia, and municipalities), and communities (provincial, district, and local governments). Entomological monitoring capacity was built through supporting a full-time IRS entomologist and providing her with technical support and guidance in IRS monitoring in the districts.
- The project developed an insectary with the aim of supporting IRS with evidence-based results.

3. Challenges

The Mozambique IRS 1 project faced the following challenges in implementing IRS.

- Initial poor recruitment processes did not strictly adhere to recommended criteria for spray operators, IEC mobilization agents, or storekeepers, causing challenges for spray operations.
- Coverage was reduced from optimal levels because spray operators were not able to spray the planned number of households per day when they were sent to peripheral communities with lower population densities.
- A lack of management-specific orientation and training led to weak management capacity of supervisors at base operations. Field storekeepers exhibited weak management capacity due to poor qualifications and lack of training.
- The use of DDT requires additional inspections, residue sampling, and mitigation measures that have cost implications for the project.

4. Lessons Learned

Lessons learned during IRS implementation in Mozambique include the following.

- Support for inventory of insecticide stocks in Mozambique will help the government to procure stock based on actual need.
- Entomological monitoring evaluation data should guide the insecticide selection decision.

3.11 Rwanda (2007–2009)

1. Background

Rwanda is one of the second wave of countries to receive indoor residual spraying (IRS) funding under the United States President's Malaria Initiative (PMI). PMI, the Rwanda Ministry of Health (MOH), Rwanda's National Malaria Control Program (Programme National Intégré de Lutte contre le Paludisme [PNLIP]), and the national Malaria Unit under the Centre for Treatment and Research on AIDS, Malaria, Tuberculosis and Other Epidemics (TRAC Plus) identified IRS as a malaria intervention to be supported with PMI funds in Rwanda through IRS 1. Starting in 2007, four IRS 1 spray rounds have been carried out. Table 1 provides a summary of results obtained during the four rounds,

Table 1: IRS 2007–2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 1	Kicukiro, Nyarugenge, and Gasabo	8/07–10/07	159,063	97%	720,764	N/A	123,955	655
2008	Round 2	Nyanza, Gasabo, Kicukiro, Nyarugenge, and Kirehe	8/08–10/08	189,756	94%	885,957	15,748	146,214	2,091
2009	Round 3	Nyanza, Gasabo, Kicukiro, Nyarugenge, and Kirehe	1/09–3/09	295,174	99%	1,329,340	19,210	228,127	2,276
	Round 4	Gasabo, Kicukiro, Nyarugenge, Kirehe, Nyanza, Bugesera, and Nyagatare	8/09–10/09						
Total				**643,993**		**2,936,061**	**46,490**	**498,296**	**5,022**

In addition to achieving the IRS coverage targets, the IRS project has focused on building capacity for key national-, district-, and community-level stakeholders. Beyond implementing IRS operations, the IRS 1 project conducted other Malaria Operational Plan activities, including carrying out national and district evaluation meetings, conducting logistics and warehouse assessments, supporting an entomology field technician training course (developed by RTI and the TRAC Plus Malaria Unit), rehabilitating an insectary for strengthening entomological capacity of the MOH, and conducting environmental assessments before and during spray operations.

2. Successes

The Rwanda IRS 1 project's achievements include the following.

- By intensifying collaboration and communication at all levels with local authorities both before and during the spray campaign, RTI increased ownership of the program at lower levels.
- The IRS Rwanda project maintained high environmental compliance in each round.
- All rounds met and exceeded the 85% IRS coverage objective to ensure maximum community protection.
- Responsibility for coordinating national IRS stakeholders was gradually transferred to the TRAC Plus Malaria Unit, showing increased ownership by the PNLIP.
- The IRS project rehabilitated the insectary and built capacity of the MOH to conduct entomological surveillance.
- The strong involvement of participants from the national and district level in the training of trainers provided stakeholders with a deeper insight and broader knowledge about IRS, which was beneficial for monitoring visits.

3. Challenges

Conducting IRS in Rwanda posed the following challenges.

- Payment delays for spray operators and information, education, and communication (IEC) mobilizers caused challenges for spray operations.
- Motivation of IECs at the village level was low, and local leadership was lacking.
- Religious beliefs and superstitions led to refusals in some villages.
- In urban districts, people were less available to accept IRS during the work day.
- Elections caused some delays for spray operations in the 2008 round.

4. Lessons Learned

The Rwanda IRS 1 project gained the following lessons during the 2007–2009 period.

- Involvement of all stakeholders at the national level facilitates successful IRS operations at the district level.
- To ensure proper efficiency of IRS in Rwanda, the PNLIP established a regular communication network to provide updates on operational activities, which included RTI, Population Services International, and the PMI country office.
- Immediate sharing of problems and issues among partners during spray operations will ensure better results.
- Ensuring payments of IEC agents and spray operators on time will facilitate a smooth spray round.
- IRS key messages can be combined with other messages on malaria control (e.g., prevention and appropriate treatment).
- The inspection of all personal protective equipment at the end of daily operations helped in the early identification of items that required replacement, repair, or additional washing.

- Reinforcement of district IRS oversight committees led by the district health teams boosted district-level ownership of the program.
- The involvement of district environmental health and hygiene officers in environmental monitoring and compliance inspections contributed to a high level of environmental compliance.
- On-the-spot monitoring and training to reinforce standard operating procedures ensured compliance with environmental standards.

3.12 Senegal (2007–2009)

1. Background

Since 2007, RTI, through funding from the United States President's Malaria Initiative (PMI), has been supporting the Senegal National Malaria Control Program (Programme National de Lutte contre le Paludisme [PNLP]) in planning and implementation of the indoor residual spraying (IRS) program. From 2007 to 2009, the IRS project covered three epidemic-prone districts selected by PNLP—Nioro, Vélingara, and Richard Toll—and conducted five rounds of IRS, with three rounds spraying all three districts, and two rounds of spraying only Richard Toll. The additional rounds in Richard Toll were carried out as a strategic decision to prevent the second peak in malaria transmission in April and May, which occurs in that district.

Throughout the three-year period, RTI worked closely with PNLP, National Hygiene Service, the Ministry of the Environment (MOE), the Directorate of the Environment (DEEC), and PMI to ensure full participation of all stakeholders in planning and operations. The IRS 1 project in Senegal successfully achieved the IRS coverage goals in each spray round, built capacity in all districts, and maintained strong environmental compliance. The table below provides an overview of the results from each round.

Table 1: IRS 2007–2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 1	Nioro, Velingara, and Richard Toll	5/07–8/07	169,743	98%	678,971	N/A	143,486	275
2008	Round 2	Richard Toll	3/08–4/08	153,942	95%	645,346	21,715	144,825	706
	Round 3	Nioro, Velingara, and Richard Toll	6/08–8/08						
2009	Round 4	Richard Toll	2/09–4/09	176,279	96%	661,814	21,499	145,835	570
	Round 5	Nioro, Velingara, and Richard Toll	5/09–8/09						
Total				**499,964**		**1,986,131**	**64,941**	**434,146**	**1,551**

2. Successes

Successes achieved in the Senegal IRS 1 project include the following.

- The significant emphasis placed on increasing participation of government staff (district and central Ministry of Health [MOH]) for various components of program implementation in each round was quite successful at building capacity and creating ownership of the IRS program at all levels. The RTI Senegal IRS team worked in excellent collaboration and consultation with PNLP at the central and district levels and with the MOE throughout operations, particularly in supervision conducted by the Hygiene Service and MOE. Continuing to involve MOH and MOE in all aspects of IRS will be critical for scaling up IRS and the eventual turnover of IRS to the Government of Senegal.
- By hiring pump technicians to be in charge of the progressive rinse and maintenance of the spray cans, the Senegal IRS project effectively reduced the amount of damaged spray equipment during the 2008 spray rounds by 6% when compared with the previous year.
- The Senegal IRS project exceeded the IRS coverage objective of 85% for maximizing protection of the community against malaria.
- Because of the IRS project's strict adherence to stock management standards, no major cases of pilferage of insecticides occurred throughout IRS 1 in Senegal.
- The IRS project identified a solution to the IRS-contaminated waste disposal and was able to incinerate the solid waste from all rounds.
- RTI worked extremely closely with the National Hygiene Service, PNLP, DEEC, and PMI to ensure high participation and national ownership of the program. Regular meetings took place each year during the spray rounds to ensure that the program encouraged integration of various national departments.

3. Challenges

During the period from 2007 to 2009, the Senegal IRS 1 project faced the challenges listed below.

- Information, education, and communication (IEC) was managed by the ChildFund consortium, which posed some challenges for IRS operations since integration and coordination of IEC activities with IRS operations was not optimal.
- Rains caused some delays in spray operations because household members did not want to place their property and belongings outside in the rain and spray operators moved more slowly in the rain.
- The low emphasis placed on IEC activities at the community level by IEC partners resulted in unsensitized communities. Therefore, spray operators had to accomplish IEC activities by conducting community education, mobilization, and assistance in the removal of property and household items prior to spraying in some villages. RTI highly recommends that IEC be strengthened at the community level in subsequent rounds.
- Procurement issues in 2008 delayed startup of spray operations. The delay in starting operations created difficulty during the spray round and led to lost efficiency because many areas were not accessible during the rainy season.

- Partners relied heavily on RTI for vehicle usage for supervision and monitoring, and integration for the supervision visits was poor. All parties wanted their own vehicle to travel to the field sites. This can be avoided in the future with clear communication at the beginning and with facilitation of early planning regarding integration for field visits.
- Agreement on the definition of a "structure" in Senegal was difficult because there are some large apartment buildings and places where multiple families live together. Ultimately, the Senegal project included "batiments" as a "structure" for the sake of IRS. Spray operators were trained to identify "batiments" as freestanding structures where people sleep.
- Because some parts of spray operators' bodies (e.g., the neck), were not covered by personal protective equipment, many exposure cases resulted. Additional equipment should be procured in the future to protect the necks of the spray operators.

4. Lessons Learned

IRS project staff learned the following lessons from the IRS 1 experience in Senegal.

- In the future, it would be better to implement IRS activities earlier, prior to the start of the rainy season, which can be accomplished through better planning and earlier procurements.
- Involving the community in the selection process of spray operators and IEC mobilizers is a best practice that needs to be implemented in the future.
- In some districts, selection of spray operators and IEC mobilizers was carried out by the District Health Management Team (DHMT) without enough involvement at the community level. However, during the Richard Toll 2009 IRS round, the DHMT engaged community representatives in the selection process. This was shown to have a positive impact on IRS ownership by the community, thereby reducing possible community reluctance or refusal of IRS.

3.13 Uganda (2007–2009)

1. Background

RTI began IRS in Uganda under the Integrated Vector Management (IVM) 1 project in 2006 in Kabale district in southeastern Uganda. The first indoor residual spraying (IRS) 1 project spray round was undertaken during the period of January–March 2007. Community compliance was excellent, with political leaders calling for 100% coverage of the whole district.

Kanungu district was the second beneficiary of the IRS project. The project targeted 75% of the district and, as in Kabale, achieved the target. Community compliance, again, was very high, with clear evidence of declining numbers of malaria cases reported from health centers after the spray exercise.

In 2008, the project expanded to the northern Uganda districts of Oyam, Apac, Kitgum, and Pader, based on the criteria of high transmission indices of malaria in these districts. The activities ranged from social mobilization and information, education and communication (IEC) efforts among people in target communities to training of spray personnel, procurement and distribution of logistics, management and safe disposal of waste, as well as coordination, monitoring, and reporting on progress of IRS implementation.

IEC was undertaken by an independent partner, Health Communication Partnership (HCP) but RTI implemented a well-coordinated, effective community mobilization program promoting spraying activities in the IRS target districts.

Table 1: IRS 2007–2009 Summary Results

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 2[a]	Kabale	2/07–3/07	446,117	98%	1,865,956	65,639	428,449	4,062
	Round 1	Kanungu	3/07–4/07		99%				
	Round 1	Kitgum	4/07–5/07		95%				
	Round 1	Pader	7/07–8/07		98%				
	Round 1	Amuru	10/07–11/07		99%				
2008	Round 1	Gulu	1/08–3/08	575,903	91%	2,211,388	110,967	507,299	5,008
	Round 1	Oyam	3/08–4/08		93%				
	Round 1	Apac	4/08–5/08		92%				
	Round 2	Kitgum	8/08–9/08		89%				
	Round 2	Pader	8/08–9/08		95%				

Year	Round	Districts	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2009[a]	Round 3[b]	Kitgum	1/09–2/09	238,332	91%	1,018,924	52,567	242,046	2,114
	Round 3[b]	Pader	1/09–2/09		95%				
Total				**1,260,352**		**5,096,268**	**229,173**	**1,177,794**	**11,184**

[a] Round 1 of IRS for Kabale was conducted in 2006 under the IVM 1 project, before IRS 1 began.

[b] In 2009, numbers reflect the results of IRS that RTI conducted in the districts of Kitgum and Pader. Note that these data differ from PMI's reported results because PMI also included spray results from other districts.

2. Successes

Successful endeavors during the Uganda IRS project include the following.

- In 2007 and 2008, the project achieved tremendous results in terms of targeted coverage and population protected against malaria.
- A major achievement in all the participating districts was a well-trained team of spray operators, in excess of 2,500 people, supported by 120 supervisors and 300 team leaders and a government district health team that was conversant with IRS and malaria control.
- Community awareness was high, with acceptance at more than 98% of targeted households.
- The project maintained best practices in environmental compliance and occupational health, ensuring that spray teams were well protected and stores were secured and well managed. The project also ensured minimization of possible insecticide side effects through proper conduct of pre-spray preparedness of target eligible structures and adherence to post-spray entry by residents of sprayed eligible structures, as well as through quality spray delivery.
- The project produced a DDT Supplemental Environmental Assessment and performed diligent sampling of the environment and tracking of project staff for possible contamination.
- The project carried out pre-, mid-, and post-spray inspections in all districts. Post-spray inspections were only conducted in DDT districts of Apach and Oyam.
- The project trained personnel at both the ministry and district levels.
- In building institutional capacity, an important element contributed by the project was the involvement of District Directorate for Health Services (DDHS) in microplanning.
- The project fenced off wash areas to restrict access to such sites.
- The project engaged district environment officers in all districts to participate in environmental compliance inspections. As a result, the project was able to successfully hand over the activity to the National Environment Management Authority (NEMA) after two rounds of spraying, without the involvement of RTI in the activity other than oversight responsibilities.

- The project conducted orientation of program staff and training on environmental compliance indicators and potential political and media issues regarding environmental issues.
- The project performed timely renovation of storage facilities for compliance.

3. Challenges

The challenges confronted by the project include those listed below.

- Changes in insecticide selected for use in 2008 resulted in stocks being unused. The disposition of these stocks became an issue, and some of the insecticide expired. USAID/PMI asked RTI to move some of the stock out of Uganda because it was no longer going to be used in the country. While RTI was beginning to collect the chemical from the regional stores to Kampala to begin this process, RTI staff were arrested for attempting to move the insecticide. After this became a police case, RTI could no longer move the insecticide.
- DDT use became contentious at times. Arguments were taken to the courts and to the streets, absorbing much project energy and attention.

4. Lessons Learned

Experiences during the Uganda IRS provided these lessons.

- Pesticide selection must be based on scientific evidence and part of a vector control strategy that includes resistance management. Switching pesticides after or during a procurement is impractical and problematic.
- Education and engagement of additional environmental and agricultural stakeholders is necessary to identify and resolve issues, which require extra resources and time.
- DDT use brings with it a range of issues: environmental, political, community perception, waste disposal, and vector control. Careful management of all aspects of DDT use is necessary for a successful program.
- An IRS program must work through existing health systems if it is to succeed. Parallel or substitute systems or groups will disappear as soon as support is withdrawn.
- Ugandan national and district-level health staff want to have ownership of, and authority over, IRS. Building their capacity to run the program therefore should be an early priority, not an end goal.
- Consensus building should be a high priority. Different ministries and line agencies in Uganda (Ministry of Environment, NEMA, Ministry of Agriculture, and National Malaria Control Program) sometimes had differing priorities and agendas.
- The project should increase IEC activities at the community level. The lower emphasis of IEC activities at the community level during a later spray round forced supervisors in some villages to conduct additional education/mobilization of communities before deploying spray teams. Therefore, for future efforts, it is recommended that resources allocated for district-level sensitization meetings be redirected toward mobilization on the community level.

- Focus should be given to minimizing pilferage. Minimization of pilferage of spray materials (especially insecticides) requires vigilance and collaboration from all partners, including the police, intelligence officials, local leaders, and community members. By continuing to use monitoring mechanisms and data management procedures like those used during this spray exercise, future programs will be able to minimize this problem.
- Equipment maintenance training is necessary before spray operations begin. The project experienced a higher-than-expected amount of damage and malfunctioning of personal protective equipment and spray equipment. The problem was corrected through continuous technical support supervision and emphasis on maintaining personal responsibility by all spray operators. In the future, it is recommended that training programs emphasize this issue before initiating spray activities.

3.14 Zambia (2007–2009)

1. Background

Zambia, through the support of the U.S. President's Malaria Initiative (PMI), is implementing indoor residual spraying (IRS) for malaria control as part of an Integrated Vector Management (IVM) strategy. Zambia's current IRS program began in 2003, following the success of IRS by the private sector at the Konkola Copper Mines. IRS is implemented by the National Malaria Control Centre (NMCC) of the Ministry of Health (MOH).

RTI International first supported Zambia's IRS program under the IVM 1 project in 2005 and 2006. Since 2007, RTI has been working with Zambia's MOH and the NMCC to provide technical support to IRS in Zambia in the areas of environmental compliance and IRS commodities procurement. This support has contributed to the timely implementation of IRS activities and improvement of environmental compliance in the Zambia IRS program. Unlike other IRS 1 countries in Africa, in Zambia RTI does not directly implement spray operations in the field. Training of operators, logistics, storage in the districts, spraying, and other activities are conducted by the districts themselves with assistance from NMCC, PMI (through other assistance mechanisms), and other donors.

Malaria transmission in Zambia occurs throughout the year, with the peak during the rainy season, which occurs between November and April. *Plasmodium falciparum* accounts for more than 90% of all infections. *Anopheles gambiae* is the major malaria vector. All nine provinces of Zambia are endemic for malaria, with 90%–100% of the population at risk.

In 2007 and 2008, IRS in Zambia was conducted in 15 districts situated in five provinces. In 2009, IRS coverage was expanded to 36 districts. For these years, the IRS project supported environmental compliance technical assistance to all IRS districts and provided insecticide procurement support for 15 districts. Results from these spray rounds are presented in Table 1.

Table 1: IRS 2007–2009 Summary Results

Year	Round	Dates	Structures Sprayed	Percent Coverage	Population Protected	Pregnant Women	Children <5 yrs	Spray Personnel Trained
2007	Round 1	9/07–12/07	657,695	93%	3,600,000	N/A	N/A	1,300
2008	Round 2	9/08–12/08	762,479	92%	4,200,000	N/A	N/A	1,413
2009	Round 3	9/09–12/09	1,189,676	90%	6,500,000	N/A	N/A	1,935
Total			**2,609,850**		**14,300,000**			**4,648**

2. Successes

Successes achieved from 2007 to 2009 include the following:

- Three spray rounds (2007–2009) successfully conducted under IRS 1.
- Timely procurement of IRS commodities for the Zambia IRS project.

- Construction of wash bays, evaporation tanks, and soak pits required for environmental compliance and safe disposal of liquid pesticide wastes in the 15 PMI-supported districts.
- Completion of the annual Supplemental Environmental Assessments.
- Assistance to the Environmental Council of Zambia (since renamed the Zambia Environmental Management Agency) in conducting Zambia Strategic Environmental Assessments.
- Timely pre-spray, mid-spray, and post-spray environmental compliance inspections in 15 PMI-supported districts.
- In Kisumu, Nairobi, three Zambian specialists received training in environmental best management practices for IRS.
- Environmental monitoring and analysis of soil and food for possible dichloro-diphenyl-trichloroethane (DDT) contamination.
- Repatriation of DDT solid waste to country of origin for high-temperature, controlled incineration and safe disposal.

3. Challenges

The IRS 1 project in Zambia experienced several challenges during the period:

- The project began in 2007 with no in-country staff and no office presence, at the request of PMI. Absence of in-country staff greatly hindered the project's ability to function. In January 2009, RTI hired a program manager, but the task of project management proved to be too much for one person. Because of the difficulty of supervising construction of wash facilities, soak pits, and evaporation tanks with no in-country staff, the project had to hire consultants and conduct short-term technical assistance visits to accomplish the tasks, impeding efficiency and causing delays.
- Poor stock management resulted in excess DDT, which was nearing its expiration date. This stock was used in a special, supplemental spray round.
- Delays in receiving annual quantifications for IRS commodities forced a rushed, last-minute procurement.
- Delays occurred in soil and food sample analysis for DDT because of regulatory restrictions on export of samples for analysis outside of Zambia and limited capacity of in-country facilities to successfully analyze samples.
- Hygiene facilities (toilets and showers) for spray operators were inadequate, as were storage facilities for IRS activities in the districts.
- Insufficient funding and lack of timely provision sometimes hindered IRS operations at the district level.
- Coordination among stakeholders in IRS was insufficient for Zambia's IRS program, which is large and complex and involves many stakeholders, both national and international. Coordination and collaboration improved over time.

4. Lessons Learned

The 2007–2009 IRS 1 project in Zambia offered the following lessons:

- Spraying should be completed on time. Spraying in 2009 lasted until the end of December 2009, extending into the rainy season, when people are reluctant to remove their household effects from their houses and do not like to remain outside for the required time to let insecticide dry on the walls inside houses. In addition, spraying was frequently postponed because of rains, lowering spray effectiveness.
- Evaporation tanks should be constructed near storage and washing facilities. In Chililabombwe and Mufulira, most of the evaporation tanks were not being used because of their distance from bathing and toilet facilities and the storeroom.
- Timely provision of procurement requirements by the districts and NMCC will guarantee enough time to procure necessary items in an efficient manner.

Appendix 1. An Economic Analysis of the Costs of Indoor Residual Spraying in 12 PMI Countries, 2008–2010

USAID
FROM THE AMERICAN PEOPLE

PRESIDENT'S MALARIA INITIATIVE

INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL

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

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

Prepared for
United States Agency for International Development

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

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Table of Contents

Page

Acknowledgements iii

Abbreviations v

I. Background 1

II. Approach and Methods 2

III. Results 5

IV. Summary and Conclusions 14

Annex 1 – Inflation, GDP Deflator (annual %) 16

Annex 2 – Detailed Country Costs 17

Abbreviations

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

I. Background

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

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

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

In this report, we present an analysis of the costs associated with PMI-supported indoor residual spraying (IRS) in 12 countries from 2008 to 2010.[3] Results are intended to help guide decision-makers in allocating resources for IRS; analyze trends in costs within a country and across cost categories over time; and determine if economies of scale apply.

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

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

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

This analysis takes our previous expenditures analyses one step further in that we have amortized capital costs and applied deflators to improve comparability across time. Still, caution must be applied when attempting to make comparisons among countries and within countries over time based on costs alone.

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

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

II. Approach and Methods

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

Table 1: Countries Included in this Analysis, by year

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

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

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

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

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

Table 2: Cost Categories for IRS Cost Analysis

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

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

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

Table 3: IRS Cost Items Amortized

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

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

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

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

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

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

III. Results

A. Spray Operations Performance Indicators

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

Table 4: IRS Performance Indicators

Country	Year	Structures sprayed	People protected	People per structure[a]	No. sachets used per structure	Size of structures sprayed (sq meters)[b]	Number of Spray Rounds	Insecticide Used
Ethiopia	2008	316,829	1,000,526	3.2	0.37	81.5	1	DDT
	2009	459,402	1,539,163	3.4	0.43	95.5	1	DDT
	2010	646,870	2,064,389	3.2	0.46	101.1	1	Pyrethroid
Mozambique	2008	412,923	1,457,142	6.3	0.66	144.7	1	DDT/Pyrethroid
	2009	571,194	2,263,409	4.0	0.72	159.3	1	DDT/Pyrethroid
	2010	618,290	2,945,721	4.8	0.84	183.9	1	DDT/Pyrethroid
Madagascar	2008	216,749	1,319,690	6.1	0.58	126.9	1	Pyrethroid
	2009	216,060	1,274,809	5.9	0.57	125.1	1	Pyrethroid
	2010	576,320	2,895,058	5.0	0.34	74.6	1	Pyrethroid/Carbamate
Ghana	2008	254,305	601,973	2.4	0.27	59.5	1	Pyrethroid
	2009	284,856	708,103	2.5	0.25	55.5	1	Pyrethroid
	2010	342,876	849,620	2.5	0.21	46.6	1	Pyrethroid
Rwanda	2008	189,756	885,957	4.7	0.55	120.3	1	Pyrethroid
	2009	191,051	866,002	4.5	0.61	133.2	Round 1	Pyrethroid
	2009	295,174	1,329,340				Round 2	Pyrethroid
	2010	63,395	280,832	4.5	0.69	151.2	Round 1	Pyrethroid
	2010	303,659	1,365,949				Round 2	Pyrethroid
Senegal	2008	153,942	645,346	4.2	0.31	67.7	1	Pyrethroid
	2009	21,589	113,544	3.8	0.33	72.1	Round 1	Pyrethroid
	2009	176,279	661,814				Round 2	Pyrethroid
	2010	254,559	959,727	3.8	0.35	76.2	1	Pyrethroid
Benin	2008	142,814	521,738	3.7	0.15	32.3	1	Carbamate
	2009	156,233	512,491	3.3	0.14	31.0	1	Carbamate
	2010	166,910[c]	636,448	3.1	0.16	35.4	Round 1	Carbamate
	2010	200,036	623,904				Round 2	Carbamate

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

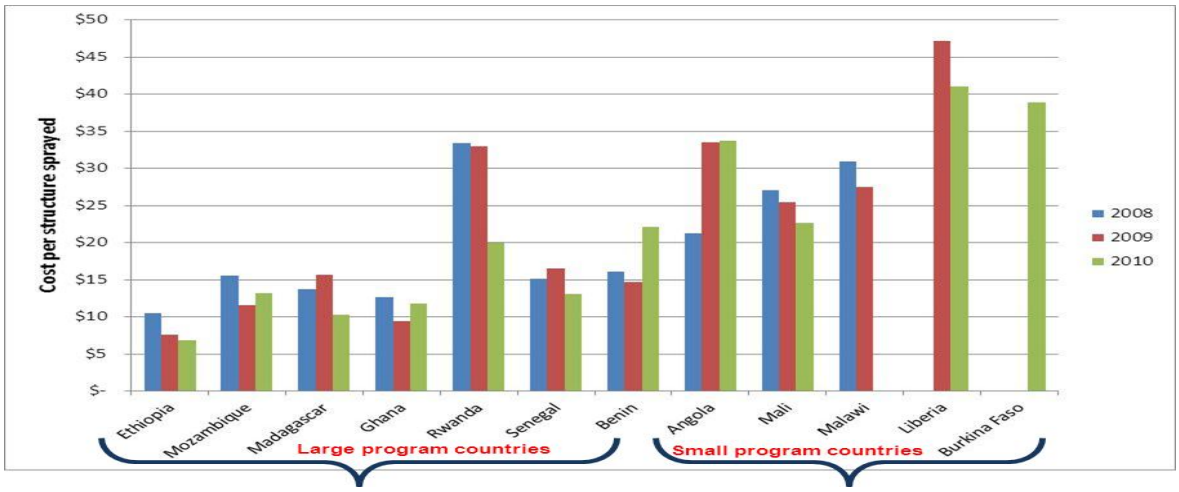
Country	Year	Structures sprayed	People protected	People per structure[a]	No. sachets used per structure	Size of structures sprayed (sq meters)[b]	Number of Spray Rounds	Insecticide Used
Angola	2008	136,051	685,908	5.0	0.47	104.3	1	Pyrethroid
	2009	102,731	485,974	4.7	0.53	115.7	1	Pyrethroid
	2010	135,856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

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

B. Costs per Structure Sprayed and per Person Protected

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

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



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

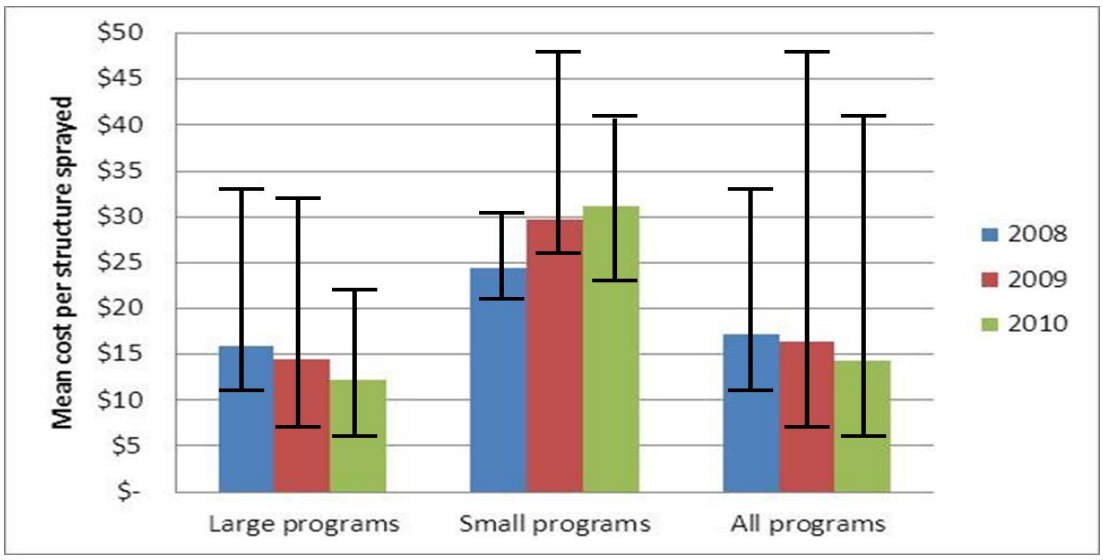
The seven leftmost countries on this figure are the large program countries where more than 150,000 structures were sprayed in each of the three years from 2008 to 2010. (Benin in 2008 is the exception where 143,000 were sprayed.) The five rightmost countries are the small program countries where fewer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

- Costs appear to be higher for small program countries. With the exception of Rwanda (especially for 2008 and 2009), costs per structure sprayed were lower in the large program countries compared with the small program countries. The cost was close to or less than $15 per structure for all countries where more than 150,000 structures were sprayed, with the exception of Rwanda in all three years and Benin in 2010. The cost leaps to an average of more than $20 for all countries in each year where fewer than 150,000 structures were sprayed. The cost differences observed by program size are statistically significant at the $p<0.01$ level for both 2009 and 2010; they are less significant for 2008 ($p<.08$).[9]
- In six of the seven large program countries, costs per structure in 2010 were lower than in 2008. Benin, the smallest of this group is the exception. The increased costs in Benin in 2010 were driven in part by the switch from spraying each structure once each year in 2008 and 2009 to twice in 2010. Additionally, the CCN country program director was replaced by a more expensive third country national (TCN).
- In three of the four small program countries (Burkina Faso which sprayed only in 2010 was excluded), costs declined from the first year of operations. Angola was the exception.
- The high cost per structure sprayed observed for Liberia was in part a consequence of the very large average size of structures in that country (see Table 4).
- The high cost in Burkina Faso is not attributable to structure size; structures in that country are comparable in size to other PMI IRS countries. As noted earlier, the high cost here appears to be a consequence of the high costs of external support that was required in this start-up country. These costs accounted for more than 40 percent of total costs and they were spread across relatively few structures.

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

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

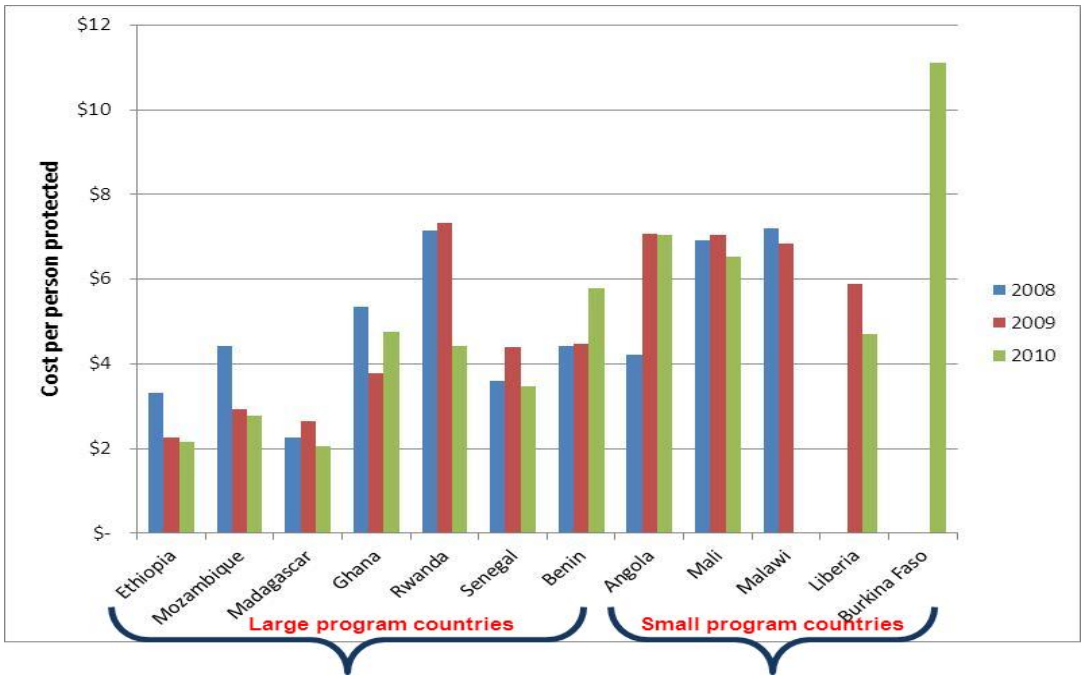
Figure 2: Change in Mean Cost per Structure Sprayed, 2008 to 2010 [a]



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

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

Figure 3: Cost per Person Protected, 2008-2010



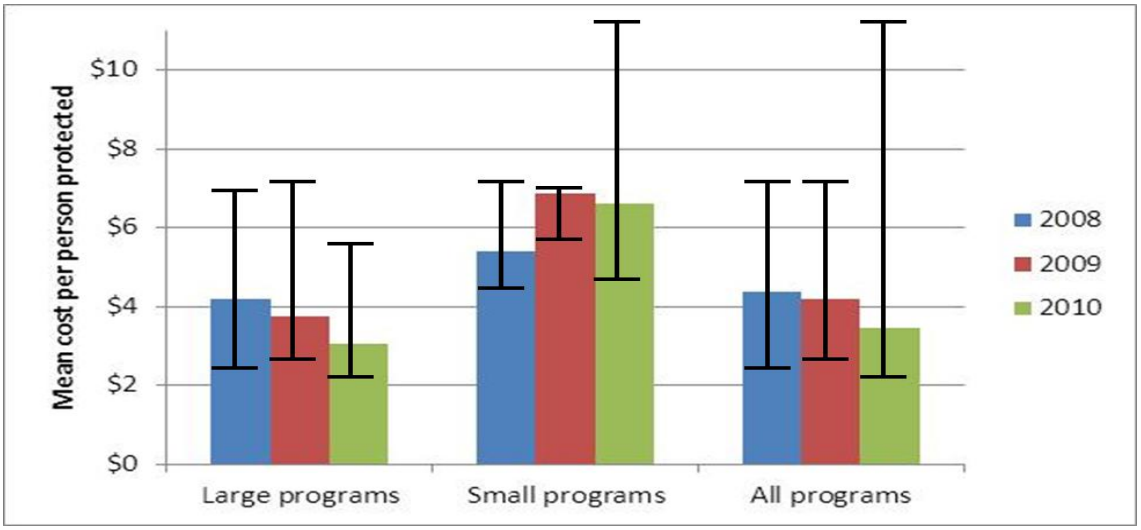
A bi-modal pattern similar to that observed on costs per structure sprayed is observed here. Costs were generally lower in the large program countries than in the small program countries. Differences in cost per person between small and large programs are also significant (at the $p<.01$ level) for 2009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

- Costs per person declined from 2008 to 2010 in six out of the seven large program countries. Benin was again an exception. Costs per person also declined in three of four small country programs, Angola being the exception.

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

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

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



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

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

C. Distribution of Expenditures across Cost Categories

Table 3 shows aggregate changes in the use of resources across major cost categories for large and small country programs. Among the large programs, there was remarkable stability from 2008 to 2010 in how resources were used. Spray operations as a proportion of total costs show a small decline over time, but insecticide shows a small

increase. There also appears to be a downward trend among large programs in their need for external support as reflected by the 50 percent decline in the "STTA and U.S. costs" category. It may be too early to draw such a conclusion as 2008 and 2009 were similar and only in 2010, one year, do we see an apparent change.

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

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

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

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

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

Notable country-specific findings include

- Ethiopia, Mozambique, and Madagascar. As noted earlier, these countries sprayed similarly high numbers of structures in 2010, and their total costs did not reflect this similarity. On inspection of allocations across cost categories, we begin to see some possible explanations. Local administration and local labor

costs are uniformly lower in Ethiopia, as are insecticide costs since structures are on average half as large in Ethiopia compared with Mozambique. Spray operations in Mozambique were on average 40 percent more costly than in Ethiopia and nearly 50 percent more costly than in Madagascar, also most likely reflecting the larger structure size there (requiring more spray operator time per structure) and the relatively higher cost of temporary labor.

- Benin. The disproportionate increase in cost noted earlier in 2010, is due to the shift in that year to two spray rounds per structure and due to the higher cost of shifting country program leadership from a CCN to a TCN. As program size increases, the impact on cost of this two spray round requirement compounds. Also of note is the increasing cost for labor sourced outside the country (the U.S./Nairobi-based office [NBO in the figures] labor category) which was a consequence of shifting from a CCN chief of party (COP) to a third country national (TCN).
- Angola. The consistently increasing costs in Angola, despite a program size that remained the same in 2010 as it was in 2008, is attributable to a shift in program leadership from a CCN to a TCN, increased STTA from outside the country, increased local labor (i.e., full-time, year-round program staff) and spray operations costs.

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

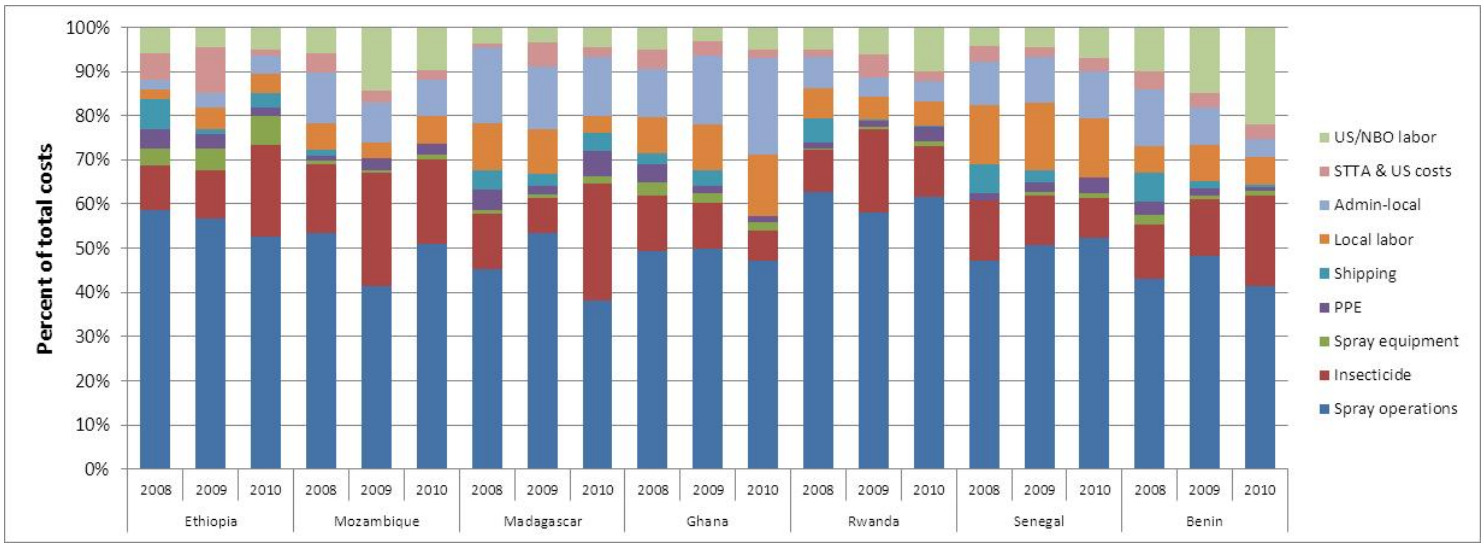
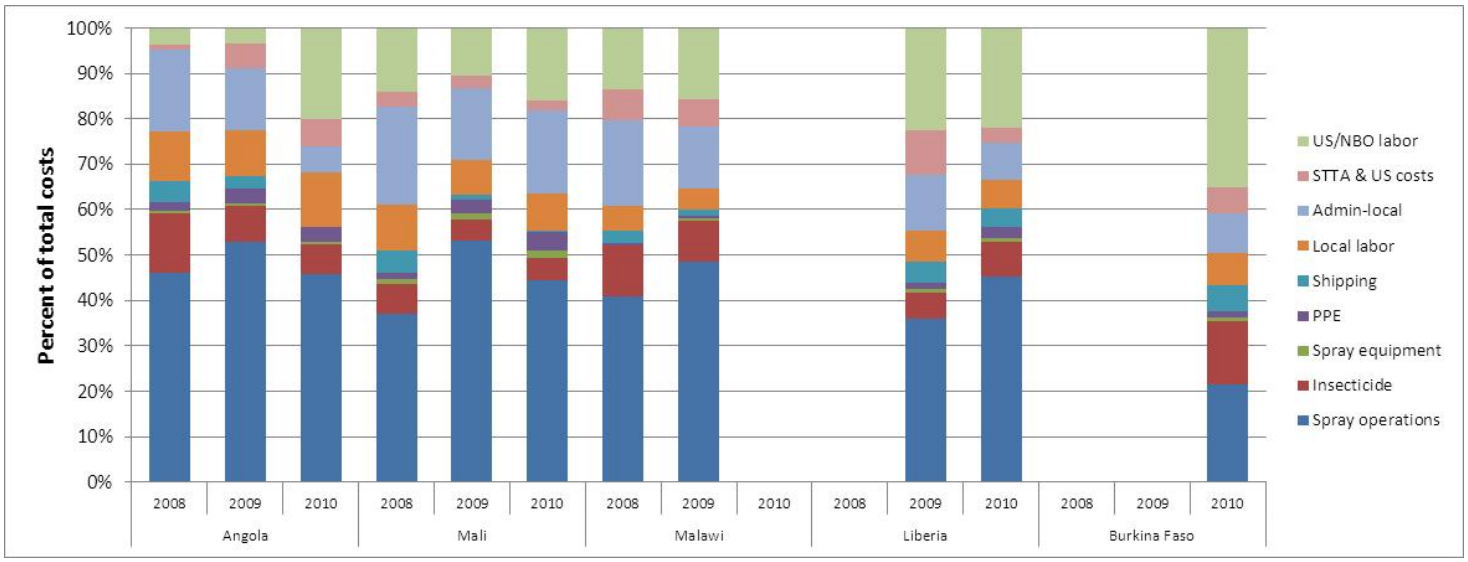


Figure 6: Distribution of IRS Expenditures across Program Cost Categories (countries with ≤ 150,000 structures sprayed in 2010)



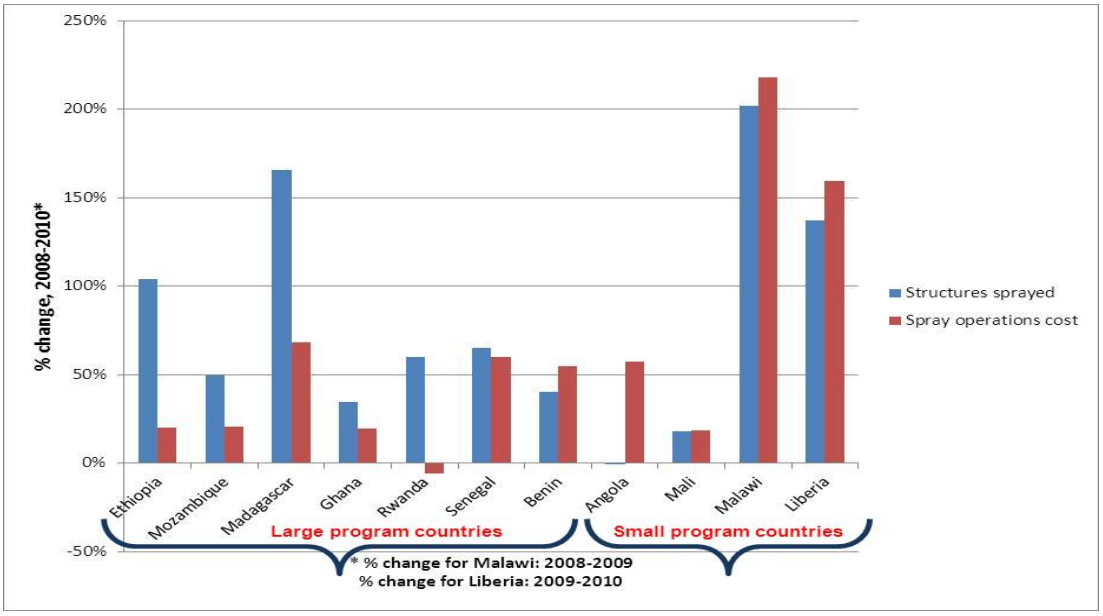
D. Changes in Costs Compared with Changes in Program Size

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

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

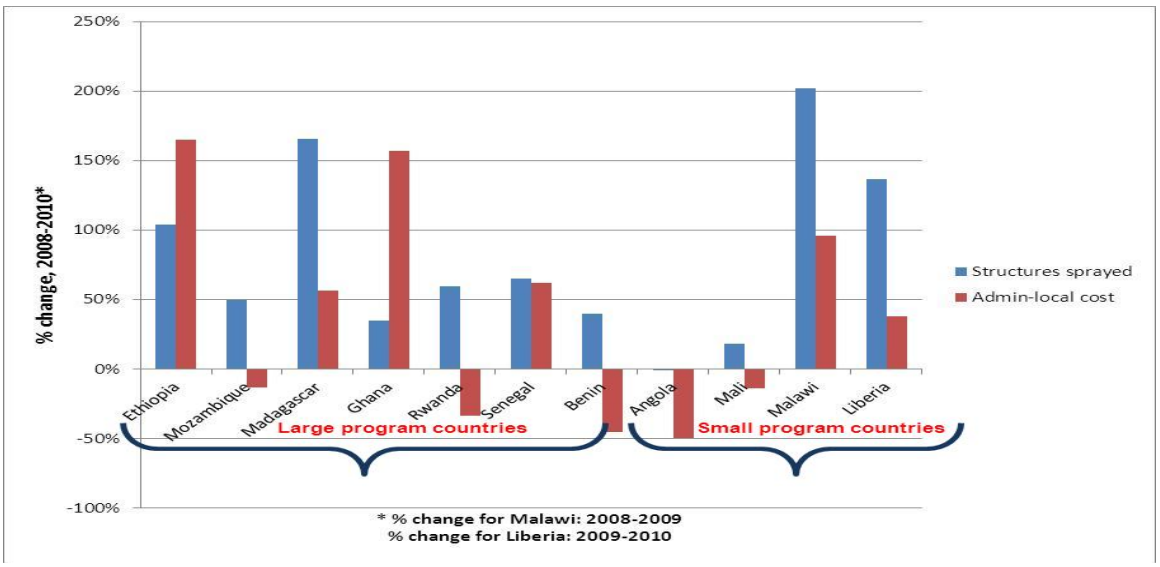
For small program countries, three of the four countries (Burkina Faso is omitted because IRS was applied only in 2010) showed a tendency towards lower efficiency, with growth in the cost of spray operations outstripping growth in the program size. This tendency was greatest in Angola where there was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

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



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

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



IV. Summary and Conclusions

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

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

IRS Program Costs Are Declining over Time. Measured by mean costs per structure sprayed and per person protected, costs have declined steadily in these countries by about 25 percent from 2008 to 2010. Costs in small programs have on the other hand increased over time, though the rate of increase appears to have slowed substantially from 2009 to 2010.

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

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

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

For small programs, the distribution of costs across cost categories was less stable over time, largely because of the increase in the average proportion allocated to local

administration and to external assistance (i.e., STTA and in-country leadership from TCNs).

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

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

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

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

Annex 2 – Detailed Country Costs

Table A2-1: 2008–2010 IRS Program Costs, (with capital costs amortized and adjusted for inflation), Large Program Countries

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

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

Table A2-2: 2008–2010 IRS Program Costs, (with capital costs amortized and adjusted for inflation), Small Program Countries

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

Table A2-3: 2008–2010 IRS Program Expenditures, (actual expenditures, without capital costs amortized and without inflation adjustment), Large Program Countries

Cost Category	Expenditures (US$ millions)																				
	Ethiopia[a]			Mozambique[b]			Madagascar			Ghana			Rwanda			Senegal			Benin		
	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10	'08	'09	'10
Spray operations	1.61	1.66	2.25	3.10	2.09	4.03	1.15	1.43	2.27	1.20	1.05	1.89	3.50	4.46	3.72	1.09	1.16	1.75	0.96	0.87	1.53
Insecticide	0.29	0.35	0.92	0.86	1.57	1.57	0.32	0.25	1.58	0.35	0.26	0.28	0.52	1.70	0.70	0.27	0.30	0.30	0.25	0.28	0.75
Spray equipment	0.56	0.26	0.56	0.23	0.00	0.18	0.09	0.02	0.31	0.30	0.04	0.06	0.11	0.10	0.08	0.01	0.07	0.09	0.11	0.00	0.06
PPE	0.22	0.06	0.10	0.08	0.20	0.15	0.18	0.00	0.46	0.14	0.03	0.10	0.23	0.07	0.21	0.09	0.07	0.13	0.12	0.00	0.04
Shipping	0.20	0.03	0.15	0.08	0.00	0.00	0.11	0.09	0.24	0.07	0.09	0.00	0.31	0.03	0.03	0.13	0.07	0.00	0.13	0.03	0.02
Local labor	0.06	0.14	0.19	0.32	0.19	0.53	0.27	0.27	0.23	0.20	0.22	0.56	0.38	0.39	0.32	0.31	0.35	0.44	0.13	0.15	0.23
Admin-local	0.07	0.10	0.27	0.65	0.48	0.66	0.45	0.37	0.79	0.31	0.38	0.89	0.42	0.38	0.26	0.23	0.28	0.38	0.34	0.13	0.16
STTA & U.S. costs	0.19	0.35	0.07	0.27	0.17	0.19	0.03	0.18	0.13	0.13	0.09	0.08	0.10	0.49	0.13	0.08	0.06	0.10	0.09	0.08	0.12
U.S./Nairobi labor	0.18	0.16	0.22	0.35	0.93	0.79	0.10	0.11	0.26	0.16	0.08	0.20	0.31	0.58	0.60	0.09	0.13	0.23	0.21	0.33	0.81
TOTAL Costs	**3.38**	**3.12**	**4.72**	**5.94**	**5.63**	**8.11**	**2.71**	**2.72**	**6.26**	**2.86**	**2.25**	**4.06**	**5.88**	**8.21**	**6.05**	**2.33**	**2.49**	**3.42**	**2.36**	**1.87**	**3.72**
Structures sprayed ('000)	317	459	647	413	571	618	217	216	576	254	285	343	190	295[c]	304	154	176[d]	255	143	156	167[e]
People protected ('000)[f]	1,000	1,539	2,064	1,457	2,263	2,945	1,320	1,275	2,895	602	708	850	886	1,329	1,366	645	662	960	522	512	636

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

Table A2-4: 2008–2010 IRS Program Expenditures, (actual expenditures, without capital costs amortized and without inflation adjustment), Small Program Countries

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