USAID
FROM THE AMERICAN PEOPLE

PRESIDENT'S MALARIA INITIATIVE

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

PMI | Africa IRS (AIRS) Project

Indoor Residual Spraying (IRS 2) Task Order Four

SEMI-ANNUAL REPORT
OCTOBER 2013–MARCH 2014



Recommended Citation: Africa Indoor Residual Spraying Project (AIRS)

Contract: GHN-I-00-09-00013-00

Task Order: AID-OAA-TO-11-00039

Submitted to: United States Agency for International Development/PMI

Cover Photos: Laura McCarty

Abt Associates Inc. 1 4550 Montgomery Avenue 1 Suite 800 North
1 Bethesda, Maryland 20814 1 T. 301.347.5000 1 F. 301.913.9061
1 www.abtassociates.com

SEMI-ANNUAL REPORT
OCTOBER 2013–MARCH 2014

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AIRS	Africa Indoor Residual Spraying Project
A&P	Anemia and Parasitemia
ASTMH	American Society of Tropical Medicine and Hygiene
BPN	Bites per Person per Night
CAP	Country Capacity Assessment
CDC	Centers for Disease Control and Prevention
COP	Chief of Party
COR	Contracting Officer's Representative
CREC	Entomological Research Center of Cotonou
CTC	Client Technology Center
DfID	Department for International Development
DPS	Provincial Health Directorate/ *Direcção Provincial de Saúde*
DRC	Democratic Republic of Congo
DDT	Dichlorodiphenyltrichloroethane
EC	Environmental Compliance
ECO	Environmental Compliance Officer
ECM	Environmental Compliance Manager
EEM	Enhanced Entomological Monitoring
EIR	Entomological Inoculation Rate
ELISA	Enzyme-Linked Immunosorbent Assays
EOSR	End-of-Spray Report
EP	Enhances Polymer
FMOH	Federal Ministry of Health
HBR	Human Biting Rates
HLC	Human Landing Catches
IEC	Information, Education, and Communication
IQK	Insecticide Quantification Kit
IRS	Indoor Residual Spraying
IVCC	Innovative Vector Control Consortium
LGA	Local Government Area
LLIN	Long-lasting insecticidal nets

LSTM	Liverpool School of Tropical Medicine
LVEP	Vector and Parasite Ecology Lab
M&E	Monitoring and Evaluation
MEP	Monitoring and Evaluation Plan
MIM	Multilateral Initiative on Malaria
MOH	Ministry of Health
MSP	Mobile Soak Pit
N/A	Not Available
NIBR	National Institute of Biomedical Research
NIHR	National Institute of Health Research
NMCC	National Malaria Control Center
NMCP	National Malaria Control Programme
NMEP	National Malaria Elimination Program
NMIMR	Noguchi Memorial Institute of Medical Research
PMI	President's Malaria Initiative
PPE	Personal Protective Equipment
PSC	Pyrethrum Spray Catches
PSDQA	Post-Spray Data Quality Audit
PSECA	Pre-Spray Environmental Compliance Assessment
RDT	Rapid Diagnostic Testing
SC	Suspension Concentration
SMS	Short Message Service
SOP	Spray Operator
TA	Technical Assistance
UCAD	Université Cheikh Anta Diop
USAID	United States Agency for International Development
USG	United States Government
WG	Water Dispersible Granule
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
ZISSP	Zambia Integrated Systems Strengthening Project

EXECUTIVE SUMMARY

During this reporting period (October 1, 2013 through March 31, 2014), the Africa Indoor Residual Spraying (AIRS) project, under the guidance of the United States Agency for International Development (USAID)'s President's Malaria Initiative (PMI), implemented indoor residual spraying (IRS) campaigns in Angola, Madagascar, Mozambique, and Rwanda (in October and February-March). The project covered an average of 94.6 percent of targeted structures, and protected more than 7 million people from malaria. Additionally, AIRS provided technical and operations assistance for IRS campaigns in Zambia completed by the USAID-funded Zambia Integrated System Strengthening Project (ZISSP), and in Zimbabwe completed by the Zimbabwean National Malaria Control Programme (NMCP). Details regarding all monitoring and evaluation (M&E) outcomes by country are reported in Annex C.

TOP-LINE RESULTS FROM IRS CAMPAIGNS, OCTOBER 2013-MARCH 2014

- 1,826,765 structures sprayed
- 94.6 percent average spray coverage
- 7,090,846 people protected from malaria including:
  - 252,320 pregnant women
  - 974,203 children under five years of age
- 6,165 people trained with United States government (USG) funds to deliver IRS

AIRS conducted rigorous entomological monitoring in 16 project countries to identify local malaria vectors and their biting habits, measure mosquitoes' susceptibility to different insecticides, and track residual efficacy of different insecticides. This data helped inform decisions regarding insecticide selection for IRS campaigns in several countries that will spray during the next six months.

In the current reporting period, AIRS work also included the following:

- Technical assistance to Malawi's national IRS program, including improvements to the planning, operations, and technical knowledge of the NMCP;
- Commencement of a comparative combination LLIN study in Mali that looks at the longevity and effectiveness of conventional long-lasting insecticide-treated nets (LLINs) versus LLINs with a synergist; AIRS Mali is focusing on the entomological monitoring aspect of the study.
- Implementation of a study in Mozambique on the residual efficacy of a new polymer-enhanced deltamethrin suspension concentrate (SC) as compared with water dispersible granule formulations of deltamethrin.

AIRS has continued to enhance its innovations to improve IRS programming. The pilot programs that use smart phones for collecting operations and environmental compliance data were continued in Angola, Madagascar, Mozambique, Rwanda, Zambia, and Zimbabwe. The smart phones were used extensively in Zimbabwe to help with the project's monitoring of the NMCP's environmental compliance during the IRS campaign.

Additionally, the mobile soak pit pilot was completed in Madagascar, with mobile soak pits proving to be useful in ensuring environmental compliance when spraying remote areas. Seasonal and full-time staff

using the mobile soak pits were quick to notice that the pits helped reduce the IRS program's environmental footprint, leaving as close to zero impact as possible.

Initial results of these innovations, along with presentations on improving M&E data quality, implementing community-based spraying in Ethiopia, and using entomological data to improve data-based decision-making for IRS planning, were presented by AIRS at the Multilateral Initiative on Malaria (MIM) Pan-Africa Malaria Conference in Durban, South Africa; the 2014 American Society for Tropical Medicine and Hygiene (ASTMH) conference in Washington, DC; and at USAID's Global Health Mini-university.

AIRS also released a new video regarding community-based IRS in Ethiopia and produced two job-aids (the Spray Operator Pocket Guide and the Store Keeper Pocket Guide) to help seasonal staff further understand their roles and responsibilities during IRS programming.

1. Country Highlights

1.1 Angola

TABLE 1: AIRS ANGOLA AT A GLANCE

Number of provinces covered by PMI-supported IRS	Three (Huambo, Huila, Cunene)
Insecticide	Pyrethroid; K-Othrine (Deltamethrin)
Number of structures targeted for spraying by PMI-supported IRS	101,000
Number of structures found by spray operators in 2013	106,515
Number of structures sprayed by PMI-supported IRS	98,136
Spray coverage	92.1%
Total population protected by PMI-supported IRS in 2013	419,353 total; 23,459 pregnant women; 74,542 children
Dates of PMI-supported IRS campaign	October 2-November 19, 2013
Length of IRS campaign	42 operational days (staggered start dates)
Number of people trained with USG funds to deliver IRS*	671

* Based on the PMI indicator definition. It includes only spray personnel such as spray operators, team leaders, supervisors, and clinicians. It excludes data clerks, Information, Education and Communication (IEC) mobilizers, drivers, washers, porters, pump technicians, and security guards.

Entomology

The following entomological activities were conducted in Angola during the reporting period:

- Baseline entomological data collection on vector density and behavior prior to spraying;
- Monthly monitoring data collection post spraying;
- Insecticide resistance testing; and
- IRS quality assurance test and monitoring insecticide decay rates.

The data collection on vector density and behavior was conducted using different collection methods, including Centers for Disease Control (CDC) light traps, pyrethrum spray catches (PSC), and the Prokopack aspirator. The following species of mosquitoes were collected using CDC light traps indoors: *Anopheles gambiae* s.l., *An. coustani*, *Culex* spp, and *Aedes aegypti*. At the baseline, indoor CDC traps collected 0.12 and 0.05 *An. gambiae* s.l. per trap per night in the intervention and control areas, respectively. Post-spray three months (November, December, and January) mean indoor densities were 0.51 and 0.76 mosquitoes per trap per night. An increase in vector density was observed post spraying in both intervention and control areas. This may be attributed to the rainy season. The increase in mosquito density was slightly higher in the control areas than in the intervention sites. This might be due to the impact of IRS.

The Angola AIRS team collected larvae and pupae from the field and reared them to adulthood in the insectary for both cone bioassays and insecticide resistance testing. Larval and pupae collection was conducted in seven villages in the Municipality of Bailundo: Bairro Hospital, Bunju, Candandi, Chitalela, Samora, Val Verde and Velha Chica.

In March 2014, 300 mosquitoes were tested for susceptibility to deltamethrin, fenitrothion, and bendiocarb (100 mosquitoes per insecticide) using the 2013 World Health Organization (WHO) test procedure. The results indicated full susceptibility of the vector to all insecticides.

The standard WHO cone assay was used to evaluate the quality of spraying and subsequently monitor the residual life of the sprayed insecticide. A combination of *An. gambiae* s.l. and *An. coustani* were used for the cone bioassay tests. At time T0, 55 *An. coustani* and 95 *An. gambiae* s.l. were used; at T1, 45 *An. coustani* and 255 *An. gambiae* s.l. were used; and at T2, 15 *An. coustani* and135 *An. gambiae* s.l. were used. Finally, at T3, only 150 *An. gambiae* s.l. were exposed. The test mortality rates for T0 through T3 were, respectively, 97 percent, 85 percent, 54 percent, and 43 percent. The higher survivorship of the exposed mosquitoes at T1, T2, and T3 might be explained by a combination of factors that includes insecticide decay, spray quality, and vector tolerance to the sprayed insecticide. Experience from other AIRS countries has also shown swifter declines in test mortality rates when wild mosquitoes of a certain degree of resistance are used for the cone bioassays, compared to a susceptible colony. Based on these earlier observations, higher test mortality rates might have been observed if a fully susceptible mosquito colony had been used.

Program Highlights

Angola's 2013 IRS campaign took place during this semi-annual report's period of performance. Spray operations start dates were staggered, starting as early as October 2 in Bailundo, Huambo Province, and as late as October 15 in Lubango, Huila Province. The campaign was projected to be completed in 44 operational days but was actually completed in 42.

A total of 101,000 structures were targeted for spray, including 25,000 in Huambo, 60,000 in Huila, and 16,000 in Cunene. Spray operators found a reported 106,515 structures and sprayed 98,136 of them, a 92.1 percent spray coverage rate. The total population protected was 419,353; it included 74,542 children under the age of five years and 23,459 pregnant women.

Other highlights during this period of performance included:

Established the country's first insectary at the end of September 2013. The insectary was developed to strengthen entomological monitoring activities, and provide continued training to build the capacity of the government to make evidence-based decisions to improve malaria control.

Implemented a smart phone pilot with spray operators and team leaders for spray data collection and verification as an alternative to the standard, paper-based data collection tools. Spray operators were trained to collect household spray data with smart phones for real-time access to data and to help guide spray operations. Overall, the AIRS Angola mobile data collection and data verification pilot was successful and provided AIRS staff and Abt's Client Technology Center with a strong foundation to adjust and improve the system for future spray campaigns.

Trained and employed multifunctional seasonal personnel across the three provinces. Historically, mobilizers were trained to carry out advocacy/mobilization, and other seasonal workers were trained to carry out spraying. In 2013, seasonal personnel were trained to handle mobilization and spraying, as well as structure measurement and enumeration; this approach was used for the new spray targets in Bailundo (Huambo Province). In Huila and Cunene sites, returning seasonal workers who had worked only in mobilization or spraying were trained and carried out both functions in 2013.

The Angolan government's promotion of women's involvement in community health programs has led to women's participation in activities that traditionally were reserved for men. Angolan women are breaking barriers by leading the fight against malaria through the implementation of IRS, which is traditionally dominated by men in Angola and most other countries. More and more women find it normal and fulfilling to engage actively in IRS and play a major role in the fight against malaria in their communities. Increasingly, they are filling key roles as trainers, supervisors, and team leaders, and they

continue to fill key IRS positions as spray operators, mobilizers, warehouse support staff, and washers. Approximately 39 percent of women (38.8) were trained for the 2013 campaign.

Challenges and Lessons Learned

- The insectary currently lacks a susceptible mosquito colony. AIRS Angola continues discussions with government authorities to get permission to bring susceptible mosquito colony eggs into the country.
- Limited entomological capability and the distance between the provinces made consistent entomological monitoring impossible.

The 2013 spray campaign in Benin took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (April-September 2013).

Entomology

The Entomological Research Center of Cotonou (CREC) has a direct contract with PMI and is responsible for entomological monitoring and reporting the results to PMI. Hence, it is not part of this report.

Program Highlights

During this reporting period, AIRS Benin finished the 2013 End-of-Spray Report (EOSR); it was submitted to USAID in November and approved in December. A report highlight was the fact that coverage was 95.75 percent. AIRS Benin presented the 2013 EOSR results to the NMCP, USAID, and other malaria stakeholders in February 2014.

In October, AIRS Benin began planning and preparing for the 2014 IRS campaign that occurred in May 2014. On October 29, 2013, the NMCP decided that all nine communes of Atacora Department should be sprayed in 2014. Based on CREC entomological survey results, organophosphates, and specifically pirimiphos-methyl, was recommended as the insecticide to use in the 2014 IRS campaign due to high mosquito resistance to the carbamates used in four communes in 2013.

In accordance with the 2013 Malaria Operational Plan, the AIRS Benin 2014 work plan ensured increased involvement of the NMCP in the 2014 IRS campaign, when the NMCP took on the responsibility of managing the IRS operations in one of the nine communes.

In January 2014, the AIRS Environmental Compliance Officer along with government environmental officers (from the Ministry of Agriculture, Benin Environmental Agency, and NMCP) carried out a pre-IRS campaign inspection in Atacora and visited the 16 operations sites. Except for weed growth and two fences stolen at the operation site in Perma, the operations sites were in good condition. The inspection information was used to write the Letter Report, which was submitted on March 05, 2014. Site refurbishment was carried out March 17-31, 2014.

In addition to presenting the EOSR results in February 2014, as mentioned above, AIRS Benin presented to the NMCP and USAID the results of the NMCP Capacity Assessment (CAP) to lead and manage the IRS program. The outcomes will be used to develop a sustainability plan for the NMCP to take increasing ownership for implementing the IRS program.

Also in February, AIRS Benin ordered insecticide, equipment, and materials for the May IRS campaign. The NMCP reviewed and validated all management tools, such as the IRS spray card, the Information,

Education and Communication (IEC) card, supervision forms, and the spray operator form, in March 2014. At the same time, AIRS Benin also jointly established an IRS operation plan with the NMCP and the Tanguieta Commune Coordinator; the plan outlines how the NCMP will lead spray operations in Tanguieta in 2014.

1.3 BURUNDI

Program Highlights

With AIRS support, the NMCP established a functional entomology laboratory and an insectary to help with the monitoring of vector control interventions. Six entomological surveillance sites, covering the various malaria epidemiological patterns (fascies), are surveyed monthly to collect data on entomological indicators using PSC and CDC light trap collections. These surveys have identified eight species of *Anopheles* (*An. gambiae* s.l., *An. funestus, An. squamosus, An. coustani, An. maculipalpis, An. brumpti, An. salbaii,* and *An. ziemanni*) and their relative abundance and resting density. Indoor resting density was highest in Gashoho (*An. gambiae* s.l. and *An. funestus* in Novmeber) and Gihofi (*An. gambiae* s.l. and *An. funestus* in Novmeber) sentinel sites. PSC collections revealed that the percentage of gravid malaria vector mosquitoes (*An. gambiae* s.l. and *An. funestus*) inside houses was highest for Kiremba site (55 percent), followed by Cankuzo (48 percent) and Gashoho (45 percent); the smallest percentage was observed in Mpanda (12 percent). Due to seasonal changes, a variation in mosquito density has been observed for all sites, possibly due to climatic and environmental factors. With the recent approval of the use of human landing catches (HLC) by the ethics committee of Burundi, it will be possible to evaluate the biting behavior of malaria vectors. The susceptibility of *An. gambiae* s.l. to deltamethrin and bendiocarb has been assessed in three sites. *An. gambiae* s.l. was resistant to deltamethrin in the sentinel sites of Mpanda and Kiremba (66 percent and 76 percent, respectively) and potentially resistant in Gashoho (92 percent). The vector was susceptible to bendiocarb in the Mpanda and Gashoho sites (99 percent and 100 percent, respectively), and potentially resistant in Kiremba (96 percent). Resistance to DDT (16 percent mortality) was also observed in the Gashoho sentinel site where the test against *An. gambiae* s.l. was carried out, but full susceptibility (100 percent) was observed for malathion.

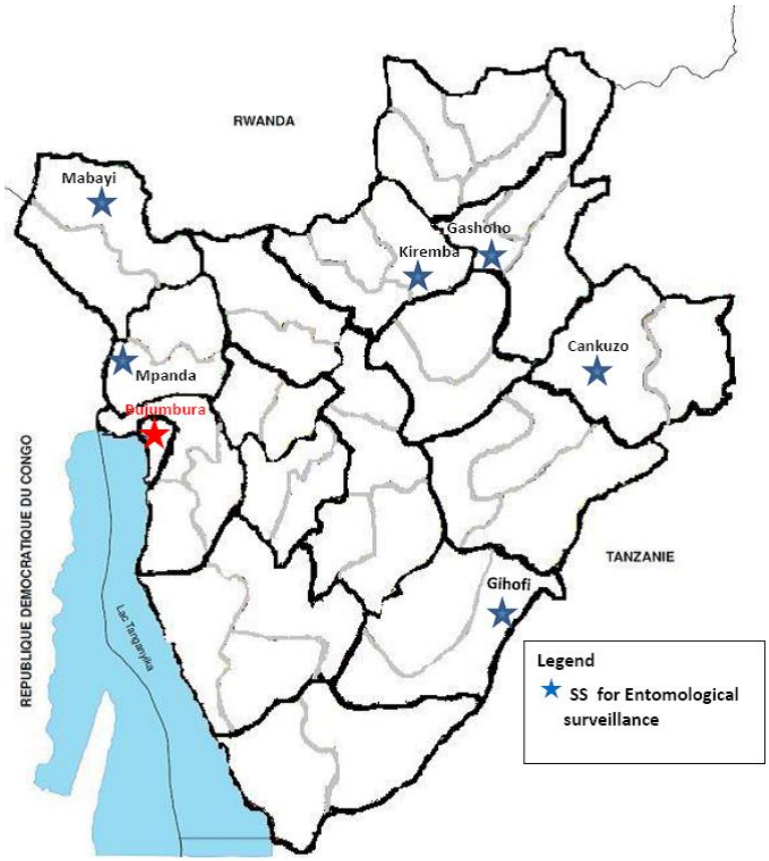
AIRS Burundi is also supporting the purchase of local and international supplies needed to optimize entomological surveillance activities.

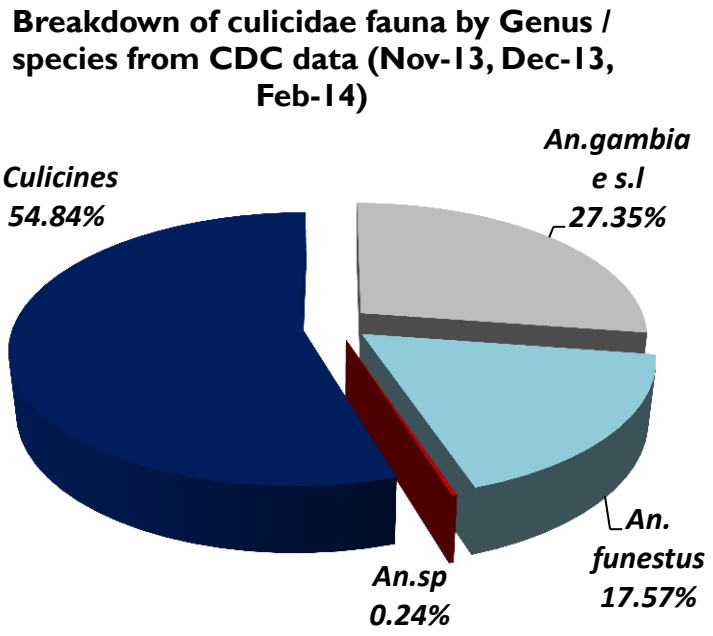
The AIRS Burundi Entomologist assists the NMCP in the coordination of entomological surveillance activities and in the strengthening, training, and monitoring of local technicians. He also manages the budget and represents Abt Associates in meetings of malaria stakeholders.

Challenges and Lessons Learned

- Insufficient number of entomological technicians;
- Inadequate budget to cover all entomological surveillance activities;
- Inadequate equipment and capacity at the entomology laboratory to conduct all lab activities, especially biomolecular investigations (PCR and Enzyme-Linked Immunosorbent Assay (ELISA)); and
- Sentinel sites should be semi-permanent structures with a minimum of their own field technicians and equipment; this will enable them to carry out entomological surveillance activities at the same time in all sites. It also will strengthen the peripheral level of the health system and community involvement in entomological surveillance.

MAP 1: SENTINEL SITES FOR ENTOMOLOGICAL SURVEILLANCE AND THE CULICIDAE FAUNA FROM CDC LIGHT TRAP DATA (NOV-13, DEC-13, FEB-14)





1.4 Democratic Republic of the Congo

Program Highlights

Malaria accounts for about 35 percent of outpatient consultations in health facilities and more than 50 percent of hospitalizations for children under five years old in the Democratic Republic of the Congo (DRC). LLINs are the main method of malaria vector control in DRC.

To assess the impact of LLIN use on malaria vector density, seasonal distribution, behavior, and species composition, PMI is supporting Enhanced Entomological Monitoring (EEM) activities in the DRC. In 2013, AIRS signed a subcontract with the National Institute of Biomedical Research (NIBR) to implement EEM activities in four sentinel sites, but with an increase in the 2014 entomological monitoring budget, this has expanded to seven sentinel sites. Work includes PSC and HLC collections and insecticide susceptibility testing.

PSC and HLC collections were carried out in four sentinel sites (Tshikaji, Lodja, Kabondo, and Kapolowe) in August and November 2013, the dry and wet seasons, respectively. (This report includes the data for both seasons since the data for August 2013 collections were not included in the previous semi-annual report.) A total of 2,426 mosquitoes were captured using the PSC method. *An. gambiae* s.l., *An. funestus*, and *An. paludis* represented 32 percent of the total collection (776/2426 specimens) of PSC. Out of 647 *An. gambiae* s.l. captured, the majority (40.5 percent; 262/647) were caught at Kapolowe, followed by Kabondo (40 percent; 255/647). In Lodja, *An. gambiae* s.l. was less abundant (4 percent; 26 specimens only) than in the other sites; there, *An. paludis* was the most abundant vector (90 percent; 109/121), and it was more abundant there than in any other site.

An. gambiae s.l., *An. paludis*, *An. funestus*, and *An. nili* were collected from indoor and outdoor HLCs. In total, 29.3 percent (431/1473) of mosquitoes captured indoors were *Anopheles* mosquitoes. At the Tshikaji sentinel site, there was a higher human biting rate indoors for *An. gambiae* s.l. in August (dry season) than in the wet season (6.5 and 4 bites per person per night, respectively). This could be due to heavy rains in the area that drained potential breeding habitats in the wet season. However, the indoor biting rate of *An. gambiae* s.l. was higher for other sentinel sites in the wet season (7.0, 16.3, and 32 bites

per person per night for Lodja, Kabondo, and Kapolowe, respectively) as compared to the dry season (2, 13.3, and 9.3 bites per person per night for the respective sentinel sites). For *An. funestus*, a higher indoor biting rate was found during the dry season than during the wet season (2.0 versus 0.3 bites per person per night, respectively in Tshikaji site where the species was found most). *An. funestus* is known to breed mainly in permanent breeding habitats. A higher indoor biting rate during the dry season (8.3) than during the wet season (5.8) was also observed for *An. paludis* in Lodja sentinel site where this species was found in large numbers. Out of all mosquitoes captured outdoors, 23.4 percent (870/3066) were *Anopheles* mosquitoes. The pattern of outdoor biting rates for *An. gambiae* s.l. was the same as described for indoor biting rates, with higher outdoor biting rates during the wet season for most sentinel sites (35.8, 21, and 39.8 bites per person per night for Lodja, Kabondo and Kapolowe sites, respectively) than during the dry season (18.3, 18, and 11.8 bites per person per night in Lodja, Kabondo, and Kapolowe sentinel sites, respectively). In Tshikaji (where a higher biting rate of *An. funestus* was documented), the outdoor biting rate was higher during the dry season (1.3) than during the wet season (0.3). In Lodja, where more than 90 percent of *An. paludis* was collected, the outdoor biting rate was higher during the dry season (50.5) than during the wet season (21.5 bites per person per night). In general, the data showed that irrespective of the season, the human biting rates of the malaria vectors were higher outdoors than indoors in three of four sentinel sites (except for Tshikaji). It has been also observed that biting activities for *An. gambiae* s.l. and *An. paludis* began in the early hours of the night (18:00-19:00). This could be a major challenge to the effectiveness of LLINs.

The susceptibility of *An. gambiae* s.l. to insecticides was tested in all four sites with four insecticides (fenitrothion, bendiocarb, deltamethrin, and permethrin). The results show that *An. gambiae* s.l. was susceptible to fenitrothion and bendiocarb in all the sites, with 100% mortality after a one-hour exposure period, and 24-hour holding period. The vector was also susceptible to deltamethrin in one of the sites (Kabondo) with 100 percent mortality. In other sites, it was potentially resistant to deltamethrin (92 percent, 95 percent, and 96 percent mortality for Tshikaji, Kapolowe, and Lodja sites, respectively). DDT was tested only at Kabondo, and *An. gambiae* s.l. was resistant (40 percent mortality) to this insecticide.

In March, the AIRS DRC Technical Coordinator and the AIRS Senior Technical Advisor traveled to Kinshasa to meet with the NIBR, USAID, and other malaria stakeholders to help plan the activities discussed in the work plan, finalize the international procurement list, visit a sentinel site, and meet with the NMCP. The trip was very productive, and it allowed the AIRS team and the mission to discuss recommendations and suggestions for DRC, and also options for possible expansion of NIBR's scope of work in the future.

1.5 ETHIOPIA

The 2013 spray campaign in Ethiopia took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (April-September 2013).

Entomology

Through the end of January 2014, the project continued entomological monitoring activities that included all PMI primary indicators. Residual efficacy of bendiocarb was monitored monthly after the spray began in mid-August. The monthly decay rate tests were conducted in two districts. Bendiocarb deteriorated significantly after two months of spraying in Siba Kebel (Kersa district) with a mortality rate of only 10-16 percent. In contrast, in Gobu Sayo district, the kill rate was high (more than 80 percent) five months after spraying. Reasons for this variation in the residual life of bendiocarb could be a difference in wall or soil types in the two areas, a difference in residents' interference with sprayed surfaces, or a difference in the amount of insecticide deposited on the surfaces.

During the reporting period, the project assessed susceptibility of the main malaria vector, *An. gambiae* s.l. against 11 WHO-approved IRS insecticide formulations in four fixed sentinel sites (Omonada, Zwai, Chewaka, and Bahrdar). The results showed that, according to the new WHO classification, the vector is susceptible to fenitrothion in all sampling sites (100 percent mortality), except in Omonada, where resistance is suspected (97 percent mortality). The vector is fully susceptible to pirimiphos-methyl in all places tested (98-100 percent mortality). It is also susceptible to propoxur in all sites except Bahrdar, where resistance is suspected (96 percent). *An. gambiae* s.l. was fully susceptible to bendiocarb in Zwai and Chewaka sites. The vector is suspected to be resistant to bendiocarb in Omonada (92 percent) and resistant in Bahrdar (75 percent). The vector is still highly resistant to DDT at all sites. Moreover, the vector was resistant to all the pyrethroids tested, including etofenoprox. In three other testing sites (Abaya, Ameya, and Wonchi), the vector was also highly resistant to DDT and pyrethroids. It was fully susceptible to fenitrothion, pirimiphos-methyl, bendiocarb, and propoxur in Ameya and Wonchi. However, mortality to bendiocarb and propoxur was only 75 percent in Abaya.

The CDC bottle assay test showed that *An. gambiae* s.l. was fully susceptible to bendiocarb in almost all of the 18 sampled districts except Omonada, where 25 percent resistance to bendiocarb was recorded.

Monthly vector monitoring using PSC showed that *An. gambiae* s.l. density was significantly reduced, from 57.25 mosquitoes per house per night (pre-spray) to less than one in the five months post spray in Gobu Sayo, an intervention village sprayed with bendiocarb. Similarly, the density of *An. gambiae* s.l. in the other intervention site, Seka, decreased from 16.65 per house per night pre-spray to one or less than one mosquito for the five months after spray. In the control site of Ijaji, density increased slightly, from 5.7 to 7.35, in September (post-spray month) compared to the pre-spray month of August. However, the density in the control site also remained low after September. Compared to blood-fed mosquitoes, fewer gravid mosquitoes were collected even before spray, indicating the preference of the vector to rest outdoors after feeding. The pattern was similar after spraying: more blood-fed *An. gambiae* s.l. were collected than gravid mosquitoes.

The proportion of indoor to outdoor collections for the main vector, *An. gambiae s.l.*, was 985 (36.5 percent) indoor vs. 1,711 (63.5 percent) outdoor, indicating a tendency for outdoor (exophagic) feeding. Given that *An. arabiensis* is a member of the *An. gambiae* complex found in Ethiopia, the result is consistent with previous findings. The peak biting time of *An. gambiae* s.l. seems to vary from place to place; the variation is high between the intervention sites of Gobu Sayo (West Oromia) and Seka (South West). The *An. gambiae* s.l. population in Gobu Sayo attempted to feed in higher numbers after midnight and less in the early morning hours. In contrast, more contact occurred in the first half of the night in the other sprayed site, Seka. This variability could be due to ecological/environmental differences between the two sites. In Gobu Sayo, the number of mosquitoes collected through HLC dropped significantly after spraying and remained low throughout the study months. In Seka, biting was reduced significantly one month after spraying but it increased in the second and third months. This is contrary to the indoor resting collections that showed reduction in the vector density for all five months after spray in Seka. This could be due to the vector's increased avoidance to rest indoors after spray or to some unknown factor.

The parity rate was reduced by 35 percent four months after spraying in the bendiocarb-sprayed site, whereas the reduction in parity in the deltamethrin-sprayed site was 12.9 percent. Parity rates increased in the control villages as compared to the baseline.

Results of monthly bioassay tests on four different types of surfaces were evaluated for their effect on the residual efficacy of carbamates. The mortality rate was 100 percent with bendiocarb up to six months post spray on painted surfaces and this was significantly higher than on other surfaces. Bendiocarb works best on smooth, non-porous surfaces.

The project conducted a survey in one site before and after IRS to investigate resting habits of *An. gambiae* s.l. around household structures. The results were finalized in the fall and not included in the

previous semi-annual report. The highest vector density was noted in structures occupied by animals (animal houses) followed by living structures, during both the pre-spray and post-spray collections.

AIRS investigated the role of the water and soil conservation structures dug to retain water in producing adult vectors. The water retention holes were shallow and the soil porous; as a result, they dried up within a week after the rains stopped. These structures may not be big contributors to the mosquito population in areas similar to the study site.

In collaboration with the Innovative Vector Control Consortium (IVCC)/Liverpool School of Tropical Medicine (LSTM), the AIRS Ethiopia team is in the process of introducing a Disease Data Management System for entering and analyzing entomological indicators.

Post-Spray Data Quality Audit

After the 2013 spray campaign, the AIRS team used finalized data and selected a representative probability sample of 800 structures to be used in the Post-Spray Data Quality Audit (PSDQA). Teams of surveyors made up of district malaria focal persons and health extension workers carried out the work in the field with surveying beginning on December 23, 2013, roughly 12 weeks after the end of the campaign.

Spray coverage audit data indicate that 97.5 percent (96.1 lower interval, 98.4 upper interval) of structures were sprayed compared to the 99.6 percent coverage reported in the 2013 EOSR. Spray coverage in five of the 12 sampled districts falls within our post-spray audit's 95 percent confidence interval. While EOSR spray coverage for all sampled districts did not fall within the 95 percent confidence interval of the district-level PSDQA estimates, all PSDQA estimates of coverage - which ranged from 93.0 percent to 100 percent - far exceeded the 85 percent contractually required spray coverage. Additionally, we are statistically confident that the data reported in all 12 sampled districts reflect the true proportion of people protected. However, the overall percentage of people protected as reported in the EOSR (99.5 percent (92.6 lower interval, 99.3 upper interval)) falls slightly outside of the 95 percent confidence interval of the PSDQA.

Overall, these data are very encouraging. We believe the 2013 AIRS M&E system enhancements that strengthened supervision and data verification led to high-quality campaign results.

Program Highlights

During this period, AIRS Ethiopia completed post-spray inventory and environmental compliance inspections for the 2013 spray campaign and conducted a post-spray operations conference. The project incinerated all non-DDT contaminated waste from 36 current project districts and is currently burning waste collected from the 24 PMI-graduated districts.

As part of the enhanced entomological surveillance activities, the team conducted a national training on entomological and insecticide-resistance monitoring with emphasis on the CDC bottle assay. It was done jointly with the CDC Atlanta and the Federal Ministry of Health (FMOH). The FMOH selected 25 high malaria risk districts, from which 22 participants attended the training.

To continue increasing local capacity, the AIRS Ethiopia team co-facilitated some modules in IRS and malaria prevention trainings organized by the FMOH for non-PMI districts. The project also contributed to the development of the national malaria strategic plan by leading discussions on relevant topics at the working group on malaria prevention and IRS. To enhance Jimma University's molecular and biochemical analysis capacity, AIRS Ethiopia donated a large amount of equipment and materials.

The project completed preliminary research and developed a work plan for safe disposal of expired DDT that is currently located in current and graduated project districts.

Challenges and Lessons Learned

- The AIRS team was invited by the FMOH to participate in a number of activities that were not included in the work plan. The AIRS team accommodated this request, participating in two one-week trainings and several meetings on the development of the national strategic plan. Such activities are not easy to plan in advance and yet accommodating the requests enhances the working relationship with government counterparts.
- The delay in FMOH's response to proceed with the DDT disposal plan is affecting the progress of implementing some activities. AIRS and PMI Ethiopia are closely following up the issue.

1.6 GHANA

The 2013 spray campaign in Ghana took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (April-September 2013).

Entomology

Entomological monitoring was conducted in two of the four districts sprayed during the 2013 IRS campaign (Savelugu-Nanton and Bunkpurugu-Yunyoo) and in two unsprayed districts (Tolon-Kumbungu and Tamale metropolis). Results from the entomological monitoring conducted by AIRS Ghana, the Ghana Health Service, and the Noguchi Memorial Institute of Medical Research (NMIMR) showed a reduction in key entomological transmission indicators in the IRS districts. Also, monthly insecticide decay rate bioassays conducted showed that sprayed insecticides remained efficacious in killing local vectors eightmonths post spraying.

An. gambiae s.l. made up 95.4 percent of all *Anopheles* mosquitoes collected, while *An. funestus* made up 1.2 percent of the total *Anopheles* collected. Other *Anopheles* species identified were *An. nili* (2.9 percent), *An. rufipes* (0.1 percent), and *An. pharoensis* (0.3 percent). Results obtained from PSC conducted post IRS showed that the non-IRS districts recorded higher vector densities than the IRS districts. The mean density of malaria vectors (*An. gambiae* and *An. funestus*) per room in the IRS areas was lower than that recorded for the control districts. The average room densities between October 2013 to March 2014 for the two IRS districts, Bunkpurugu-Yunyoo and Savelugu-Nanton, were 0.13 and 0.09 mosquitoes/room/night, respectively, compared to 0.82 and 1.07 for Tolon-Kumbungu and Tamale, the unsprayed districts.

The biting activity of the two main vector species (*An. gambiae* s.l. and *An. funestus*) started at 6:00 pm, with the peak biting period occurring between 11 pm and 4 am. Biting rates of *An. gambiae* s.l. and *An. funestus* were relatively higher in unsprayed districts. During the reporting period (October 2013-March 2014), mean biting rates of 8.15 bites per person per night (bpn) and 5.52 bpn were recorded for the non-IRS districts of Tamale and Tolon-Kumbungu, respectively. These were higher than the mean biting rates of 1.26 bpn recorded for Savelugu-Nanton and 0.35 bpn for Bunkpurugu-Yunyoo, where IRS was conducted between May and June 2013 using Actellic CS.

A comparison of the proportions of parous females obtained from each district showed a significant difference between IRS districts (mean of 24.6 percent for Savelugu-Nanton and 25.2 percent for Bunkpurugu-Yunyoo) and Tamale metropolis with a mean parity rate of 74.5 percent, and Tolon-Kumbungu district with a mean parity rate of 70.5 percent.

WHO wall bioassay tests were used to assess the residual life of the insecticide after spraying. The residual life of the sprayed organophosphate insecticide remained higher than the 80 percent acceptable threshold up to eight months after the walls were sprayed, when tested with the Kisumu strain of *An.*

gambiae. In tests that used a susceptible Kisumu strain of *An. gambiae*, average test mortalities nine months post IRS on cement, mud, and wood surfaces were 75.10 percent, 69.01 percent, and 75.12 percent, respectively. However, in bioassays using field-collected wild *An. gambiae* s.l. of known ages, recorded average mortalities were 64.10 percent, 52.50 percent, and 67.50 percent for cement, mud, and wood surfaces, respectively (nine months post IRS). Control mortalities ranged between 0.0 percent and 20.0 percent. The percentage mortality recorded nine months post IRS suggests a period for retreatment and justifies the April timing of the start of the AIRS program for 2014.

Program Highlights

In November 2013, AIRS Ghana supported an anemia and parasitemia (A&P) survey led by the CDC, which measures A&P levels among children under five years of age and pregnant women. The CDC and NMIMR carried out the study, with AIRS Ghana playing a facilitative role. The results of the survey revealed that the overall Rapid Diagnostic Test (RDT) positivity rate significantly declined from 69.9 percent in November 2010 to 29.2 percent in November 2013. The results also showed that the overall prevalence of asexual parasitemia by microscopy significantly declined from 52.4 percent in November 2010 to 20.6 percent in November 2013.

During the period under review, the Ghana AIRS team developed their work plan for 2014, which was finalized in March. In 2014, Ghana AIRS continued to implement IRS in the same four districts as in 2013. In an effort to reduce costs and make IRS operations more efficient, the number of spray days was reduced from 45 days to 30 days.

To prepare for the 2014 IRS operations, all district temporary staff were recruited and trained well before the start of operations. Insecticides, personal protective equipment (PPE), and other logistics for IRS were procured and organized in time to ensure that the start of the IRS operations in 2014 was smooth. Environmental compliance assessments were also carried out to ensure that the standard operating procedures and best management practices were followed. Stakeholder and partner planning and sensitization meetings were also held in order to create the necessary awareness and effective involvement of all stakeholders for successful spray operations.

A total of 216,876 structures were targeted to be sprayed in the four districts. Spraying was scheduled to begin on April 14 and to end May 17.

Challenges and Lessons Learned

- The A&P survey approval came late and it was difficult for the team to coordinate pre-A&P activities.
- Ghana AIRS was scheduled to conduct a bio-monitoring pilot during the 2014 IRS operations, but this was not approved by NMCP. It will be rescheduled for another AIRS country in 2014.
- The PSDQA, which was conducted in the fall of 2013, highlighted some potential problems with spray operations, so the team conducted focus group discussions with several types of stakeholders. The recommendations resulting from the focus group discussions will be implemented during the 2014 campaign to improve the quality of IRS implementation.

Entomology

The AIRS Madagascar entomological surveillance teams completed baseline data collection one month before the IRS campaign in the central highlands (in October) and in southern Madagascar (in December), noting that *An. gambiae* s.l. continues to be the most prevalent vector species in the spray areas. *An. gambiae* s.l. ranged from 37 percent to 1.4 percent of the total number of mosquitoes collected at sentinel sites in the central highlands. *An. mascarensis* was also captured in the central highlands, representing 8 percent of the mosquitoes collected at one sentinel site. In southern Madagascar, *An. gambiae* s.l. ranged from 16.3 percent to 13.8 percent of the total number of mosquitoes collected at the sentinel sites. Very small numbers of other vector species were collected, representing less than 1 percent of the total number of vector species collected at sentinel sites in southern Madagascar.

During the first week of the IRS campaigns in the central highlands and southern Madagascar, AIRS Madagascar completed wall bioassay tests at three sentinel sites in the central highlands (two sites in districts that sprayed with carbamates and one site that sprayed with pyrethroids), and at one sentinel site in the south sprayed with organophoshate CS. AIRS Madagascar found the quality of spraying was good with test mortality rates of 100 percent, 24 hours after spraying in both spray areas, except for two structures at the sentinel site in southern Madagascar. AIRS Madagascar staff was quick to note non-uniform application of insecticide on the walls in these two structures. AIRS Madagascar identified the spray operators and spray team leaders, who covered these structures, and provided remedial training in spray technique.

As of March 2013, carbamate residual life (measured at Kiangara (Ankazobe district) and Soavina Betafo (Betafo district)) had dropped to, or below, 80 percent mortality four months after spraying during monthly wall bioassays. Mortality rates for carbamates dropped to 69 percent at Kiangara and 80 percent at Soavina-Betafo for mud walls, and 75 percent at Kiangara and 69 percent at Soavina Betafo for wood walls. Pyrethroids continued to have good residual efficacy four months after spraying, with wall bioassay mortality rates measured at Imerina Imady (Ambositra district) at 93 percent for mud walls and 96 percent for wood walls. Organophosphates also continued to note good residual efficacy two months after spraying at Ambovombe (Ambovombe district), with 100 percent mortality for both wood and cement walls.

AIRS completed insecticide-resistance testing at eight sentinel sites using both the WHO tube and the CDC bottle bioassay test methods. AIRS Madagascar found that knock-down time for some of the pyrethroids had significantly increased as compared to previous years, which may indicate emerging resistance to pyrethroids. Additionally, this year's susceptibility testing confirmed that DDT resistance is widespread. Overall, three of the four insecticide classes (pyrethroids, carbamates, and organophosphates), are eligible for insecticide selection in Madagascar, with carbamates and organophosphates noting full susceptibility at all sentinel sites.

Indoor man-biting rates (bites per person per night) in the central highlands in the pyrethroid spray area were observed at 0.5941 before the IRS campaign, 0.35 one month after spraying, 0.1 two months after spraying, 0.04 three months after spraying, and 0.0 four months after spraying. In the carbamate spray areas, indoor man-biting rates were noted as 1.39 at baseline, 0.15 one month after spraying, 0.24 two months after spraying, 0.27 three months after spraying, and 0.32 four months after spray. In southern Madagascar in the organophosphate districts, indoor man-biting rates were observed at 2.03 at baseline, 0.14 one month after spraying, and 0.75 two months after spraying.

Program Highlights

AIRS reorganized its IRS program in Madagascar after noting inefficiencies during the 2012-13 IRS campaign, including difficulties supervising and monitoring the work of more than 14,000 seasonal spray staff, 600 soak pits, and 150 store rooms. To remedy these issues, AIRS Madagascar decreased the

number of seasonal staff hired to 2,241, but employed them to work for the entire spray campaign. This led to a manageable number of seasonal staff who could be monitored/supervised. The staff improved their abilities as the IRS campaign continued, and the AIRS Madagascar noted fewer seasonal staff errors, which enabled the project to complete both IRS campaigns on time and cut 50 days from the length of time it took to complete the 2012-13 IRS campaign.

AIRS Madagascar also employed a mobile banking system (via a local cellphone provider) to pay spray operators during the 2013-14 IRS campaign. This system credited SIM cards with the amount AIRS Madagascar owed the seasonal workers for the work they completed during the IRS campaign. The seasonal workers could use the SIM card with their own mobile phones and mobile banking accounts, and/or take the SIM card to "cash points" located throughout Madagascar (at stores, restaurants, mobile phone offices, banks, and micro-credit organizations), to receive cash for the amount credited to their SIM card.

Central Highlands

The IRS campaign was completed on time with minimal issues in the 40 communes (subdistricts) selected for AIRS Madagascar's 2013-14 IRS campaign. Similar to the 2012-13 IRS campaign, spraying in the central highlands was characterized as "focalized" spraying, or only spraying communes with the highest malaria endemicity in a district.

Southern Madagascar

Improvements were made by the AIRS Madagascar team to prepare for the IRS campaign in southern Madagascar, leading to an on-time start on January 20, 2014. Southern Madagascar continued with ""blanket" spraying, with spray teams covering as many eligible structures in the seven targeted districts as possible. AIRS Madagascar finished spraying on March 15, 2014. Better supervision and organization of the IRS campaign enabled AIRS Madagascar to shorten the spray campaign by 45 days compared to the 2012-13 campaign in the region. Mobile soak pits were readily used in the south, with more than 75 percent of spray teams using mobile soak pits while spraying remote areas.

Amboasary district became less stable during the start of the IRS campaign, as the Malagasy army and gendarme conducted campaigns against the "Dahalo" armed bandits in the beginning of 2014. On January 22, 2014, district and gendarme officials asked AIRS Madagascar to reduce its spray area to around Amboasary-ville due to insecurity throughout the district. On January 26, 2014, AIRS Madagascar finished spraying all structures around Amboasary-ville, and began transferring all IRS campaign equipment and insecticide out of Amboasary district to the central warehouse in Ambovombe district. IRS campaign staff in Amboasary district were transferred to nearby districts to help with the IRS campaign. Outside of Amboasary, AIRS Madagascar was also unable to spray some areas in Betroka district due to Dahalo activity.

Challenges and Lessons Learned

- A spray operator passed away on February 17, 2014, due to a health issue unrelated to IRS. After consoling family and community members, AIRS Madagascar worked with community leaders and radio stations to prevent myths and assure beneficiaries of the safety of IRS.
- Insecurity in spray areas continued to be a significant issue, especially in southern Madagascar. Several AIRS Madagascar staff members, including the project's Chief of Party, were stopped at impromptu roadblocks guarded by armed men. AIRS Madagascar worked to develop good relationships with district and gendarme officials, and other NGOs, to gain warnings and understand which areas were too dangerous to spray.
- Staff were confronted by upset spray operators in southern Madagascar (in Ambovombe and

Ampanihy districts), as the spray teams were unsure when they would be paid. Both incidents were diffused after AIRS Madagascar staff pressed for the immediate payment of the seasonal staff via the mobile banking system. However, both incidents could have been prevented if AIRS Madagascar had updated spray teams during the IRS campaign on the exact dates of when they would be paid.

1.9 MALAWI

At PMI's request, the AIRS project provided enhanced technical assistance to the NMCP of Malawi for the 2013-14 IRS campaign. The technical assistance focused on transferring skills and increasing competencies of NMCP and district health officers to program, implement, and monitor IRS operations in accordance with the national and international standards for environmental health and safety. The spray campaign was originally planned to begin in January 2014 in three districts: Chikhwawa, Karonga, and Salima.

Project Highlights

AIRS Regional Operations Manager Dr. Nduka Iwuchukwu conducted four visits and provided remote support to the NMCP during the performance period. He worked closely with the NMCP to share IRS planning tools and calendars developed by the AIRS project, and conducted microplanning meetings that took place in November 2013 in each of the three districts. The Training of Trainers program was held in Salima district in December 2013. Training for various categories of field workers from the three districts was funded by PMI and took place in January 2014. Those trained included: store keepers, pump technicians, drivers, data entry clerks, spray operators, washers, security guards, and clinicians. A total of 1,321 personnel were trained, of which 1,110 were spray operators. During a January-February trip, Dr. Iwuchukwu worked with the district environmental officers to conduct pre-spray environmental assessments using the AIRS project checklists. The planned commencement of the spray operation was preceded by general rehabilitation of the 18 staging sites in all districts as well as community mobilization by health surveillance assistants (HSAs). Due to a shortage of NMCP funds and a significant delay with the Global Fund releasing the government funds to the NMCP, spraying took place only in Salima district. The spray operation began on March 4 and ended on April 24, 2014 (45 operational days). The district had six staging sites and used alpha-cypermethrin (pyrethroid class insecticide) for the operation. Spray data from the district are still being cleaned and compiled. In addition to the technical assistance, PMI funded trainings, fuel, and supervision costs to ensure the progression of the spray campaign.

Challenges and Lessons Learned

- The Malawian government had difficulty in funding IRS in the three districts, leading to the restriction of the spray campaign to Salima district only. The funding challenge also resulted in the following issues: delay in commencing the IRS campaign; non-procurement of vital IRS commodities; inability to fuel supervision and other vehicles as required; and delay in payment of the spray teams.
- Due to funding delays, spray operations occurred during the rainy season, resulting in difficulty in accessing hard-to-reach areas.
- There was a considerable (up to 20 percent in some places) disparity in the number of structures enumerated by the HSAs and found by the spray operators in some cases. Some of the reasons for the disparity could be lack of proper training for the task and inadequate supervision during the enumeration. The HSAs perform several other health activities within the communities at the same time and are therefore extremely busy and poorly motivated.
- There is a need for better planning of IRS and involvement of all stakeholders. These issues were

discussed at the post-spray conference planned for May 2014.

1.10 MALI

The 2013 spray campaign in Mali took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (April-September 2013).

Entomology

The entomological monitoring activities were conducted from July to November 2013. The data was collected from four sentinel sites, two control sites, and two intervention sites. The intervention sites were Tienfala and Touna located in Koulikoro and Bla districts, respectively. The control sites were Baguienda located in Kati and Cinzana in Segou district. Pyrethrum spray catches were used to estimate indoor resting densities of the mosquitoes. *An. gambiae* s.l. was found to be the single most dominate *Anopheles* species collected throughout the survey period from all the sentinel sites.

For the intervention area, the mean indoor resting density of *An. gambiae* s.l. per house/night was 11.9 in July before spraying. Post IRS, the density decreased by 174 percent (4.3 mosquito/house/night) in September, 108 percent (5.95 mosquito/house/night) in October, and 43 percent (8.3 mosquito/house/night) in November as compared to the baseline. In the control area, the average density of *An. gambiae* s.l. per house/night was 28.6 at the baseline before spraying in July. The density increased by 123 percent (63.85 mosquito/house/night) in September, but decreased by 40 percent (17.28 mosquito/house/night) in October and by three times (6.98 mosquito/house/night) in November as compared to the baseline. The significant increase in the density of the vector one month after spraying in the control areas and the decrease in the intervention areas might fully or partially be explained by the impact of IRS. The slight increase in the number of mosquitoes after October in the intervention areas might be due to the short residual life of bendiocarb. The vector population in the control areas showed a decreasing trend after October, possibly due to meteorological factors (Table 3).

TABLE-3: MEAN DENSITY OF *AN. GAMBIAE S.L.*, EXPRESSES AS NUMBER OF MOSQUITOES PER HOUSE PER DAY BY MONTH 2013

Study site	July	September	October	November
Intervention	11.875	4.325	5.95	8.325
Control	28.6	63.85	17.275	6.975

The mean parity rates of *An. gambiae* s.l. were 87 percent and 93 percent in the intervention and control areas, respectively, before spraying in July. The mean rates post spraying were 78.5 percent in the intervention and 92 percent in the control areas. The longevity of the vector decreased in the intervention areas as compared to the control and baseline.

WHO cone bioassay tests were conducted to determine the quality of spraying and insecticide decay rates. The first, T0, test was done 24 hours after spraying. The test mortality rates of mosquitoes exposed to insecticide sprayed surfaces ranged from 99 percent to 100 percent. This is an indication of good quality spraying. But 32 to 42 days (T1) after spraying, the test mortality rates ranged from 47-100 percent. Eighty-four to 92 days after spraying (T3) the test mortality rates ranged from 3-39 percent, which is a clear indication of short residual life of bendiocarb in Mali.

An. gambiae s.l. susceptibility to five insecticides, DDT (4 percent), deltamethrin 0.05 percent, lambda-cyhalothrin 0.05 percent, bendiocarb 0.1 percent, and fenitrothion 1 percent, was tested using the WHO tube test in three IRS districts.

The results of the susceptibility testing completed by AIRS Mali noted the following:

Full Susceptibility:

- Fenitrothion: 100 percent mortality at all the three sentinel sites
- Bendiocarb: 98-100 percent mortality at all sentinel sites
- Deltamethrin: 98 percent in one sentinel site

Resistance:

- Lamda-cyhalothrin at all the three test sites: Koulikoro (13 percent), Baraouli (45 percent) and Bla (77 percent)
- Deltamethrin in two of the three sites: Baraouli (50 percent) and Bla (38 percent)
- DDT at all the three sites: Koulikoro (10 percent), Baraouli (35 percent) and Bla (57 percnt)

LLIN Comparative Study

AIRS Mali initiated a comparative study of a new generation of LLINs and conventional nets. This entailed recruiting a study coordinator and supervisors to oversee all activities. AIRS Mali trained the coordinator, supervisors, and NMCP entomologist to effectively and accurately execute the assessment. *An. gambiae* s.l. from 19 villages in Yanfolila and 22 villages in Bougouni districts were tested for their susceptibility to permethrin and deltamethrin, with and without piperonyl butoxide (PBO). High levels of vector resistance to both insecticides were noted. Sixteen villages with similar levels of resistance and elevated mixed function oxidases were identified. From these 16 villages, four villages were randomly assigned to each study treatment (Permanet 2.0, Permanent 3.0, Olyset, and Olyset plus) as per the study protocol.

The study protocol was updated and submitted to PMI's Operations Research Committee.

The project collected baseline data on resistance intensity, entomological monitoring, and net distribution, which will be used throughout the study. Due to the dry season and environment where the study is being conducted, adequate numbers of mosquitoes were not found from every treatment group. Intensity resistance data, however, were collected from three villages with each one representing a treatment group.

Program Highlights

The EOSR was completed within 40 days of the end of the 2013 spray campaign. The Monitoring and Evaluation Plan was finished prior to the submission of the yearly work plan (i.e., update targets) and after the 2013 spray campaign. Lastly, the 2014 AIRS Mali work plan was also written and submitted in a timely manner.

Throughout the work-planning process, AIRS Mali worked on developing two new program initiatives to increase the efficiency of IRS in Mali. The two new initiatives were the use of mobile technology to increase mass mobilization and communication efforts before and during spray campaigns, and the use of mobile soak pits (as described in the Core Mobile Soak Pit section) to reduce the number of IRS-related soak pit sites in Mali and to reduce the costs of refurbishing a high number of soak pits annually.

Challenges and Lessons Learned

During work planning, it was discovered that the new insecticide to be used in Mali was creating budget constraints. The AIRS Mali team is currently going through the budget to identify ways to accommodate the cost of the insecticide without reducing the number of structures sprayed. The project has noted that the use of mobile soak pits and motorcycle taxis have helped to reduce costs significantly.

1.11 MOZAMBIQUE

TABLE 4: AIRS MOZAMBIQUE AT A GLANCE

Number of provinces/districts covered by PMI-supported IRS in 2013	4 districts in Zambézia province (Milange, Morrumbala, Mocuba, and Quelimane)
Insecticide	Pyrethroid
Number of structures sprayed by PMI-supported IRS in 2013	414,232
Number of structures targeted by PMI-supported IRS in 2013 (found by spray operators)	464,295
2013 spray coverage	89.2%
Population protected by PMI-supported IRS in 2013	2,181,896 (including 139,499 pregnant women and 379,982 children under 5)
Dates of PMI-supported IRS campaign	October 7-December 10, 2013
Length of IRS campaign	47 days in Mocuba, 48 days in Milange and Morrumbala, and 55 days in Quelimane
Number of people trained with USG funds to deliver IRS	1,128

Entomology

Entomological activities conducted from October 2013 through March 2014 included the following:

In October 2013, 24 hours after the spray campaign began, the AIRS Mozambique entomology team performed cone wall bioassays for quality assurance purposes in Samora Machel, October 12, and Coqueiro villages in the districts of Mocuba, Milange, and Morrumbala, respectively. The wall bioassay tests showed high mortality rates (100 percent) of susceptible mosquitoes (*An. arabiensis*) exposed to deltamethrin-sprayed walls in all three sites, indicating the good quality of spraying. The test mortality rates ranged from 98 percent to 100 percent for the months of November (T1), December (T2), January (T3), and February (T4). Cone bioassay data collected five months post spraying in March 2014 indicated the sprayed insecticide remained effective with test mortality of 97 percent and above. AIRS will continue monitoring the decay rate of deltamethrin until it drops below the WHO threshold.

AIRS Mozambique used PSC and HLC to assess mosquito density. Data on vector density were collected from three intervention sites and one control site. Results obtained using PSC before and after spraying showed the non-IRS district recorded higher vector densities than the IRS districts before the IRS operation. The pre-IRS mean density of *An. gambiae* s.l. in the control area was 0, 1.0, and 2.5 mosquitoes per house per day for the months of July, August, and September, respectively. During the same period, no *An. gambiae* s.l. were found resting indoors in any of the intervention areas surveyed. AIRS will assess if this is due to the difference in the availability of breeding sites or the cumulative effect of IRS from the previous years. Pre-IRS density of *An. funestus* in the control site was 7.9, 11.4, and 3.0 mosquitoes per house per day for July, August, and September, respectively, while their mean densities in the intervention area pre-spraying were 2.0, 1.3, and 0.2 mosquitoes per house per day. Again, the density of this vector was lower in the intervention area as compared to the control area even before the IRS operation. Post IRS (October-December), few *An. gambiae* s.l. were collected from either the

control or the intervention areas. The density of *An. gambiae* s.l. in the control area was 4.1, 1.1, and 2.1 mosquitoes per house per day in the respective months, and 0.47, 0.47, and 0.33 mosquitoes per house per day in the intervention area. The density of *An. funestus* was low in both the intervention and control sites post spraying. Due to the sample size, it would be unwise to make conclusions on the impact of IRS on vector density in Mozambique.

Data from HLC collections indicated that post spraying both *An. gambiae* s.l. and *An. funestus* s.l. showed a slight tendency to feed outdoors in the intervention areas, unlike in the control area where both species were found to be more endophagic. Both vectors tended to feed later in the night between 1:00 a.m. and 4:00 a.m. This is good for the efficacy of insecticide-treated nets, as most man-vector contact occurs when people are in bed.

During the entomological short-term technical assistance trip in November by the AIRS Technical Advisor, AIRS Mozambique staff and insectary management staff in Quelimane were given refresher training on morphological identification of malaria vectors, and they attended training on Insecticide Quantification Kits (IQKs) with the Avima team.

In January and February, AIRS Mozambique performed susceptibility tests intended to inform selection of insecticide for the 2015 IRS program. Two insecticides from the pyrethroid class, deltamethrin 0.05 percent and lambda-cyhalothrin 0.05 percent, and one insecticide from each of the other three classes of insecticides recommended for IRS use were included in the study. *An. gambiae* s.l. was tested in Mocuba and *An. funestus* s.l. in the other two districts, Morrumbala and Milange. Due to lack of a sufficient number of mosquitoes, only deltamethrin was tested in Milange. In Morrumbala, *An. funestus* s.l. showed a potential development of resistance to deltamethrin (92.39 percent test mortality rate), while it was fully susceptible to the other four insecticides tested (bendiocarb (99 percent mortality), DDT (100 mortality), and lambda-cyhalothrin and fenitrothion (100 percent mortality)). *An. gambiae* s.l. from Mocuba showed complete susceptibility to all insecticides tested (deltamethrin, bendiocarb, DDT, lambda-cyhalothrin, and fenitrothion) with 100 percent test mortality rates. *An. funestus* s.l. from Milange were fully susceptible to deltamethrin (100 percent test mortality).

Program Highlights

The project conducted the 2013 IRS campaign between October 7 and December 10, 2013. Officials from the NMCP, Ministry of Environmental Affairs (MICOA), Ministry of Agriculture (MINAG), Provincial Health Directorate (DPS), and District Services for Health, Women and Social Welfare (SDSMAS) participated in comprehensive supervision of the campaign. The AIRS Mozambique operations team collaborated with the DPS, SDSMASs, and community leaders in the target districts for community sensitization activities during the campaign. With the help of local leaders, AIRS Mozambique held community meetings to communicate IRS messages in all 34 targeted localities. Additionally, AIRS selected community leaders who did interpersonal communication in their communities to ensure that households received key IRS messages and were aware of the timing of the spray. Following the end of the spray campaign, a site closure process was conducted in the 20 spray sites, which consisted of a material and equipment inventory, soak-pit closure, and transport of all the items to the provincial warehouse.

In February, the NMCP informed PMI and Abt that the districts to be covered during the 2014 IRS campaign in Zambezia Province would be Mocuba, Mopeia, Nicoadala, and Quelimane. The insecticide (pyrethroid) for 2014 IRS in Zambezia Province will be donated by the Ministry of Health, and discussions are presently underway between the NMCP, PMI, and Abt regarding the quantification methodology to be used.

Challenges and Lessons Learned

The following are challenges encountered during the 2013 spray campaign implementation:

- **Improper counting of total population living in sprayed and unsprayed structures:** The data collection verification exercise reflected that Total Populations were not counted correctly for some structures, with the most common mistake being the non-inclusion of children. Solution: This seems to occur because spray operators do not probe for complete numbers, and households tend to omit children when counting. Feedback on this issue was provided to spray operators during the 2013 campaign.
- **Team leaders not using the error eliminator form correctly:** Many team leaders ticked "Yes" on the Error Eliminator form without verifying. This issue was widespread across all bases visited. Solution: Team leader and supervisor training should spend more time on the form, including a practical session on how to complete it.
- **Insecticide stock control at base level:** Sealed boxes of insecticide from the manufacturer should contain 150 sachets, but this number varies based on weight. Many boxes fell short of 150 sachets, which resulted in a discrepancy in the stock cards at the base level. Solution: This will be rectified by having the warehouse assistant at each base open the boxes upon receipt, count each sachet, and record this figure as initial stock on the stock card.
- **Transport safety:** AIRS Mozambique reported a fatal incident on November 18 where a spray operator accidentally fell out of a truck and the spray tank hit his head. Unfortunately, the SOP did not survive the incident. There is a need to take additional precautions to prevent accidents like this one. Solution: AIRS will include a separate training module on safety and security focused on transporting spray operators. The drivers receive a safety and security course prior to them receiving their licenses; however, a refresher course is necessary. The project will also consider a method for fastening the pumps to the benches.

1.12 NIGERIA

Entomology

In November 2013, AIRS Nigeria assessed susceptibility of the main malaria vector, *An. gambiae* s.l., in two sites in Nigeria against seven World Health Organization Pesticide Evaluation Scheme (WHOPES)-approved insecticides. Results of the tests showed that the vector was highly susceptible (100 percent test mortality) to bendiocarb and fenitrothion in both Nasarawa Eggon and Doma local government areas (LGAs) using the WHO tube bioassay. Additional 2013 resistance data from Nasarawa Eggon and Doma are shown below:

- Resistance of the vector to DDT 4 percent (9-25 percent test mortality)
- Resistance to pyrethroids tested (15-44 percent test mortality for deltamethrin; 28-72.5 percent for lambdacyhalothrin; and 68.8-100 percent for alphacypermethrin)

In October, the final month of the six-month monitoring of IRS impact in Nasarawa Eggon and Doma LGAs, more *An. gambiae* s.l. bites were recorded outdoors than indoors. The man-biting rate was 26.1 bpn indoors and 27.4 bpn outdoors in Doma; 8.9 bpn indoors and 10.6 bpn outdoors in Nasarawa Eggon, and 47.3 bpn indoors and 25.3 bpn outdoors in Lafia, a control LGA where there was no IRS.

The project continued collection of longitudinal entomological monitoring data from November 2013 to March 2014 to see if there was any change in vector behavior as the sprayed insecticide decayed further. Man-biting rates averaged for five months (Nov- March) 20.9 bpn indoors and 21.1 bpn outdoors in Doma, 12.1 bpn indoors and 7.1 bpn outdoors in Nasarawa Eggon, and 26.6 bpn indoors and 13.4 bpn outdoors in Lafia.

The PSC method revealed that as the rains ceased, the indoor resting density of mosquitoes fell in both the intervention and control areas. More mosquitoes were caught in the control area than in the intervention area from October through December. However, there were more indoor resting mosquitoes in Doma (144 *An. gambiae* s.l. mosquitoes) than in Lafia (*59 An. gambiae* s.l. mosquitoes) from January through February.

Parity was also determined using WHO-recommended techniques to assess the impact of IRS. In October, the parity rate was 68 percent in Nasarawa Eggon, 71 percent in Doma, and 81 percent in Lafia. Cone bioassay test results from October indicated declined efficacy of the sprayed insecticide with mean test morality rates of 72.7 percent of the susceptible strain and 44.4 percent of the wild mosquitoes. In November, the proportion of parous mosquitoes increased to 73 percent in Nasarawa Eggon, 72 percent in Doma, and 89 percent in Lafia. In March, parity rates have progressively increased with time in the intervention areas and were noted at 84 percent and 81 percent in Nasarawa Eggon and Doma, respectively, which were very close to data from Lafia (86 percent). The data clearly indicated increased longevity of Anopheles mosquitoes as the insecticide decay rate progressed.

Program Highlights

During the reporting period, AIRS Nigeria successfully transitioned from full IRS implementation to entomological surveillance as the main program focus. The transition involved donation of IRS equipment and office furniture to beneficiaries that include the Nasarawa State Ministry of Health; the National Environmental Standards, Regulations and Enforcement Agency; the National Malaria Elimination Program (NMEP); Nasarawa State University Keffi; and the Nasarawa Eggon and Doma LGAs.

AIRS Nigeria is supporting an upgrade of six sentinel sites established by the NMEP across the country. Collaborating with local universities, the project will capture PMI entomology indicators in the six sites and compare the data by type of malaria control intervention and coverage across all geopolitical and most ecological zones of the country. Through various planned activities, it will support the NMEP in using collected information to make evidence-based decisions about vector control activities.

In January, the project organized a principal investigators' and entomology technicians' training in preparation for the 2014 entomology surveillance activities. Participants were drawn from the six sentinel sites. The main objective was to train principal investigators and entomology technicians on basic entomological data collection methods and surveillance.

To strengthen and expand field laboratories/insectary facilities at sentinel sites, AIRS Nigeria procured equipment and materials. Entomology equipment was distributed to the six sentinel sites and surveillance began in all the sites in March. The project developed a supervisory framework for entomologists and university lecturers to supervise the surveillance activities at the six sites.

To capture and share the data with the NMEP and partnering universities, the project modified the AIRS entomological database. The Access database uses a Sugar Sync application, which facilitates the instant syncing of data between individual sentinel sites and the central data collection site in Abuja. The synchronization of the data ensured that information from each sentinel site is properly backed up, stored, and analyzed in real time. Both the NMEP and AIRS have access to the data in real time.

Challenges and Lessons Learned

- AIRS Nigeria had difficulty in harmonizing the Agreement of Performance of Work with the principal investigators in preparation for the surveillance activities.
- There was a delay in obtaining ethical clearance for the surveillance activities, which necessitated the intervention of the FMOH.

These challenges were resolved when the head of the NMEP personally clarified to the parties the timeliness and importance of the monthly surveillance work that needs to be done in order to collect comprehensive vector data for planning and decision-making purposes.

1.13 RWANDA

TABLE 5A: AIRS RWANDA AT A GLANCE: SEPTEMBER-OCTOBER 2013 SPRAY ROUND

Number of districts sprayed by PMI-supported IRS	3 districts (Bugesera, Gisagara, and Nyagatare)
Insecticide	Pyrethroids in Bugesera and Gisagara; carbamates in Nyagatare
Number of structures sprayed by PMI-supported IRS	224,708
Number of structures targeted by PMI-supported IRS	229,039
Spray coverage	98.1%
Total population protected by PMI-supported IRS	957,027 (16,023 pregnant women, 147,531 children under five years old)
Dates of PMI-supported IRS campaign	September 2-October 12
Length of campaign	30 days
Number of people trained with USG funds to deliver IRS*	1,875

TABLE 5B: AIRS RWANDA AT A GLANCE: FEBRUARY-MARCH 2014 SPRAY ROUND

Number of districts covered by PMI-supported IRS	3 districts (Bugesera, Gisagara, and Nyagatare)
Insecticide	Carbamates
Number of structures covered by PMI-supported IRS	123,919
Number of structures targeted by PMI-supported IRS	125,629
Spray coverage	98.6%
Population protected by PMI-supported IRS	512,789 (8,547 pregnant women, 75,753 children under five years old)
Dates of PMI-supported IRS campaign	February 10-March 8
Length of campaign	24 days
Number of people trained with USG funds to deliver IRS*	1,180

* This is based on the PMI indicator definition. It includes only spray staff such as spray operators, team leaders, supervisors, and clinicians. It excludes data clerks, IEC mobilizers, drivers, washers, porters, pump technicians, and security guards.

Entomology

Monthly WHO cone bioassay tests following the September-October 2013 IRS campaign continued until January 2014. At two months post IRS, mortality rates in Gisagara and Bugesera, which both used a pyrethroid, were 60.5 percent and 58.9 percent, respectively. At two months, Nyagatare, which used a carbamate, recorded an average mortality rate of 88.3 percent. At four months post IRS, Gisagara and Bugesera recorded 57.2 percent and 48 percent mortality rates, respectively, and Nyagatare recorded an average mortality rate of 45.9 percent. The team investigated possible reasons for the rapid drop in residual efficacy in Gisagara and Bugesera and ascertained that the structure owners did not repaint their walls; the team also ruled out resistance because it used a susceptible colony. In addition, wall bioassay tests conducted within the first week of spraying showed mortality rates ranging between 96 - 100 percent, indicating that the quality of spraying was satisfactory. Team members decided that other,

unidentifiable factors existed. The drop in Nyagatare at the fourth month could be explained by the residual efficacy period for carbamates. During the February 2014 IRS campaign, the cone bioassays conducted for quality assurance showed mortality rates of 99-100 percent using susceptible *An. gambiae* s.l., indicating a good spray quality. One month post spray (March), the cone bioassay assessments conducted showed average percentage mortalities of 100, 98.3, and 100 for Gisagara, Bugesera, and Nyagatare, respectively.

Further entomological surveillance work completed during the reporting period showed a predominance of *An. gambiae* s.l. (96.14 percent) among all the anophelines collected in the three IRS districts. The densities (number of *An. gambiae* per house) estimated from PSC remained generally high in Gisagara over the period November-January, but they were comparatively low in Bugesera and Nyagatare during the same period.

Human biting rates were estimated using data from HLC collections. The data trends varied across the study sites. In each of the districts, both indoor and outdoor biting was observed to be almost equivalent with peak biting observed between 11 p.m. to 2:00 a.m. Ovary dissection of the *An. gambiae* s.l. collected by HLC was performed to determine the parity rates. Results did not show any definitive trend across the study sites during the study period.

Program Highlights

The September-October 2013 IRS campaign began implementation on September 2, and was completed on October 12. Pyrethroids were used in Bugesera and Gisagara districts, and carbamates were used in Nyagatare. The overall spray coverage was 98.1 percent. In addition to the targeted structures in the three campaign districts, AIRS Rwanda supported spray activities by special IRS teams in prisons and in police and military camps located throughout the country. These additional IRS campaigns covered 5,865 structures and protected 33,353 people.

AIRS Rwanda validated the September-October 2013 spray coverage through a post-spray audit and found that 97.6 percent of structures were sprayed compared to the 98.6 percent reported from the campaign. Based on a 95 percent confidence interval, we are statistically confident that the spray coverage reported in the September-October 2013 EOSR reflects the true spray coverage across the three IRS districts.

The February-March 2014 IRS spray round targeted 20 of 42 sectors in the same three districts that were sprayed in the September-October spray campaign. Six sectors were targeted in Bugesera, six in Gisagara, and eight in Nyagatare, using a carbamate. The campaign was implemented successfully with no major challenges. A total of 123,919 structures were sprayed out of 125,629 structures found by spray operators, a coverage rate of 98.6 percent. In total, 512,789 residents were protected, including 75,753 (14.8 percent) children under five years old and 8,547 (1.7 percent) pregnant women.

Challenges and Lessons Learned

- Migration/relocation of people within or between sectors/villages resulted in changes in the number of target structures, a challenge for IRS planning and implementation.
- Training of IRS focal persons at the district and sector level is critical in order to strengthen IRS operations, supervision and reporting skills, and knowledge of the local partners for sustainability of the project.
- Recruitment of community health workers with experience as spray operators, as per the Ministry of Health recruitment protocol, was instrumental in ensuring a high level of spray quality and the timely completion of spray activities.
- Regular data collection verification conducted by IRS supervisors through interviewing household

owners was instrumental in validating the accuracy of spray operator data collection in the field, leading to improved data and spray operations integrity.

- After the unfortunate death of a boy in a vehicle accident, AIRS worked with vehicle companies to tighten and improve vehicle safety.

1.14 SENEGAL

The 2013 spray campaign in Senegal took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (April-September 2013).

Entomology

Senegal's entomological monitoring for the IRS program is supported by the Vector and Parasite Ecology Laboratory of University Cheikh Anta Diop (UCAD) of Dakar. UCAD, which received direct funding from PMI, began bioassay tests for the 2013 IRS campaign in August and continued monitoring residual life until January 2014. Results from testing showed that the residual effect of carbamates did not exceed three months in all districts. The recommendation was to find a solution, covering the period from July to September, when vector density is the highest.

Program Highlights

Key activities in this period focused on the following:

During this reporting period, the AIRS Senegal team conducted several activities in preparation for the 2014 spray campaign. For example, the team was tasked with establishing a new site in Sinthiang Koundara in the health district of Velingara. After the Velingara District Coordinator identified possible sites, AIRS Senegal senior staff and local authorities visited the site on February 24-28 to ensure that it fulfilled all environmental compliance standards. AIRS Senegal also conducted an internal review of manuals and tools for the spray campaign. Tools, including supervisory forms, data collection tools, and IEC forms, were then shared with the NMCP for review. All comments made by the NMCP were taken into account before proceeding to printing.

Like in previous years, the NMCP and other local stakeholders have been intimately involved in the planning process for the IRS campaign. On March 17-18, AIRS Senegal met with local stakeholders (both regional and district) to confirm the dates proposed by AIRS and the NMCP for the IRS campaign. Local authorities from Malem Hoddar and Koumpentoum participated in this workshop for the first time as they make important contributions to the campaign, such as providing free site facilities and conducting IEC mobilization.

The AIRS Senegal team is making important contributions to building the NMCP's capacity to plan and implement IRS campaigns independently in the near future. In anticipation of an eventual handover of IRS responsibilities to the government, Abt trained NMCP staff on all components of IRS implementation (environmental compliance, operations, M&E) on March 11-13. The IRS Steering Committee was present at this training workshop. The evaluation survey given at the end of the training showed that trainees were very satisfied with the content and the clarity of the presentations.

Lastly, in the month of March, AIRS hired a videographer to produce a video in Senegal focusing on the project's efforts to work with various local government stakeholders in the implementation, monitoring, and supervision of the IRS campaign. The production of the video was funded with core funds.

Challenges and Lessons Learned

Challenges

The following are challenges that AIRS Senegal faced during the reporting period:

- Supporting the NMCP and districts for a successful handover of the IEC component;
- Preparing the mobile soak pit pilot in two districts as well as an SMS system for mobile daily data collection;
- Establishing a vehicle and driver control system to minimize road accidents; and
- Including IRS activities in districts annual work plans.

Lessons learned

- The development of the work plan and budget distributing responsibilities between the NMCP and AIRS was a thorough process, as it made both parties think in depth about what it would be like to devolve IRS responsibilities in the future. (Note that earlier this year, Koumpentoum was going to be sprayed independently by the NMCP. These plans later changed due to competing priorities within the NMCP. Koumpentoum will therefore again be sprayed by AIRS Senegal in 2014.)
- NMCP capacity building in IRS was crucial for program staff to gain a better understanding of what it takes to run IRS campaigns, and the implications for the NMCP staff's workload if and when responsibilities are fully devolved.
- Following the vehicle incidents recorded during the previous campaign, a checklist was developed by the Environmental Compliance Manager that will lead to more rigorous selection of vehicles and drivers for future campaigns.
- The updated supervision tools will further strengthen supervision of IRS activities.

1.15 ZAMBIA

TABLE 6: AIRS ZAMBIA AT A GLANCE

Number of districts sprayed by PMI-supported IRS in 2013	20 districts (7 in Eastern Province, 5 in Muchinga Province, and 8 in Northern Province)
Insecticides	Actellic 300CS
Number of structures sprayed by PMI-supported IRS in 2013	432,398*
Number of structures targeted by PMI-supported IRS in 2013	530,791 (found 438,334)
2013 spray coverage	81.5% (98.6% from found)
Total population protected by PMI-supported IRS in 2013	1,842,821
Pregnant women protected	N/A
Children under five years old protected	N/A
Dates of PMI-supported IRS campaign	October 1, 2013, to January 25, 2014
Length of campaign	55 days
Number of people trained with USG funds to deliver IRS**	926: Spray supervisors 62 (51 males/11 females) + spray operators 864 (583 males/281 females)

* AIRS provides technical assistance but does not lead IRS operations or collect IRS data in Zambia.

** This is based on the PMI indicator definition. It includes only spray staff such as spray operators, team leaders, supervisors, and clinicians. It excludes data clerks, IEC mobilizers, drivers, washers, porters, pump technicians, and security guards.

Two PMI-funded projects have been assisting the government with implementation of IRS. The Abt Associates-managed ZISSP supports the National Malaria Control Center (NMCC) in all components of IRS operations except environmental compliance and procurement, for which AIRS Zambia is responsible. During the reporting period, the two projects initiated transition of activities and staff from ZISSP to AIRS Zambia. The process is expected to be completed by early summer.

Starting in January 2014, AIRS Zambia began taking on implementation of all IRS components. It also accepted funding, through PMI, from the U.K. Department for International Development (DFID) to expand IRS and entomological surveillance activities to 15 districts in two provinces (Luapula and Central), which had not been sprayed in the past few years. As a separate note, the Government of the Republic of Zambia recently reorganized and subdivided some districts. As a result, the total number of districts for AIRS Zambia to spray in 2014 in both PMI- and DFID-supported areas will be 40, an increase of 11 from the originally planned 29 districts.

Entomology

To establish baseline entomological data, AIRS Zambia conducted a reconnaissance study in February - March in all DFID-supported districts. The project identified locations for three sentinel sites in these project areas. Preliminary results demonstrated that all sampled areas are dominated by *An. funestus* s.l., followed by *An. gambiae,* as the most common indoor-resting mosquito.

Program Highlights

ZISSP and AIRS Zambia supported start-up of the 2013 spray campaign.

In October-December 2013, AIRS Zambia conducted mid-spray environmental compliance inspections using smart phone-based checklists in all three provinces (20 districts) funded by PMI for IRS operations. In February-March 2014, the project, in collaboration with ZISSP, carried out a post-spray inventory audit in the 20 districts to assess the IRS stores, storage practices and inventory management systems, soak pit standards, maintenance issues, and other relevant procedures. The inventory audits also helped to identify areas for improvement in the supply chain and in compliance of environmental and operational activities relevant to the IRS campaign.

AIRS Zambia gave a portfolio review presentation to PMI/USAID on October 9, 2013, on environmental compliance and procurement activities conducted from May 1 to September 30, 2013.

AIRS Zambia supported the NMCC in collecting from the district warehouses approximately 78,000 empty Actellic plastic bottles generated during the 2011 and 2012 IRS campaigns. They were transported to the Lusaka IRS Center, where sorting and cleaning was done in preparation for shredding them into flakes by a local company. Currently, the cleaned bottles are at the Lusaka IRS Center. AIRS Zambia, with support from the Zambian Environmental Management Agency, held a series of discussions with waste management and recycling companies on the management of empty insecticide bottles collected after the 2013 spray season. AIRS is collaborating with Waste Master Zambia Limited and L & M Recycling Company on the recycling of empty plastic bottles. The empty bottles are now being consolidated and squeezed into bales by one of the companies. The bottles then will be transported to South Africa for recycling. Existing recycling companies in Zambia do not have the required equipment to work with the type of plastic used for the Actellic bottles.

AIRS Zambia carried out needs assessments in DFID-funded districts to enable quantification and forecasting of IRS commodities, including insecticides, pumps, and PPE for the 2014 campaign.

In February 2014, AIRS Zambia and ZISSP organized a two-day IRS planning meeting to introduce the IRS program in Luapula and Central provinces to the districts. As part of the meeting, the project team

worked with provincial and district medical officers to define their roles and responsibilities in the 2014 program.

Challenges and Lessons Learned

- Storage space for IRS supplies is a serious issue everywhere in Zambia. There is limited storage space at the central level for IRS commodities. The containers that the NMCC contributes to the IRS materials have become insufficient. The previous consignment was partly stored at the Lusaka IRS depot. After discussing this issue at the IRS technical working group, it was suggested that the project procure a 40-foot container to be based at the NMCC.
- Lack of sufficient storage space in some districts has resulted in store rooms being sometimes crowded with non-IRS items. Some of the newly added districts do not have storage facilities and will have to depend on those in the old districts.
- Using the smart phone-based checklists for environmental compliance inspections in the last campaign was a good lesson. It will be continued in the upcoming spray season to expedite analysis of inspection findings and come up with action plans to prepare operational sites for spraying in a timely manner and to monitor environmental compliance during the campaign.

1.16 ZIMBABWE

TABLE 7: AIRS ZIMBABWE AT A GLANCE

Number of districts covered by PMI-supported IRS in 2013	25 districts
	Manicaland: Makoni, Buhera, Mutare, Mutasa, Nyanga, and Chimanimani **Mashonaland Central:** Guruve, Bindura, Mazowe, and Shamva **Mashonaland West:** Hurungwe, Chegutu, Zvimba, Makonde, Sanyati, and Mhondoro Ngezi **Mashonaland East:** Murehwa, Mutoko, and Goromonzi **Masvingo:** Bikita, Zaka, and Masvingo **Matabeleland North:** Nkay and Bubi **Midlands:** Kwekwe
Insecticide	Pyrethroids
Number of structures covered by NMCP's IRS campaign in PMI-supported districts*	622,300
Number of structures targeted by NMCP's IRS campaign in PMI-supported districts	685,946
2013 spray coverage	90.7%
Estimated population protected by NMCP's IRS campaign in PMI-suported districts**	1,431,643
Dates of PMI-supported IRS campaign	October 1, 2013-January 21, 2014
Number of people trained with USG funds to deliver IRS	477

Note: AIRS provides technical assistance but does not lead IRS operations in Zimbabwe.

* The Zimbabwean NMCP tracks "rooms" as opposed to "structures" as the geographic indicator for the residential space covered by IRS campaigns. However, AIRS Zimbabwe developed an algorithm to convert the number of rooms sprayed to the number of structures sprayed.

** Because AIRS Zimbabwe does not implement IRS and relies on the NMCP for IRS campaign data reporting, the project is not required to report on the number of pregnant women and children under 5 years, protected during the IRS campaign.

Entomology

AIRS entomlogical surveillance completed by AIRS Zimbabwe before the start of the 2013 IRS campaign noted that *An. gambiae* s.l. was the most prevalent vector species in all provinces, except for Manicaland where *An. funestus* was the most prevalent. AIRS Zimbabwe continued to use wild, field caught mosquitoes for its entomological testing, due to the continued difficulties of developing a susceptible colony in Zimbabwe.

Initial bioassays were completed after the NMCP completed spraying around the three sentinel sites used by AIRS Zimbabwe in Mashonaland East, Mashonaland West, and Manicaland provinces. These bioassays all noted that the quality of spraying was good, with 100 percent mortality noted at all sites. Bioassays have continued on a monthly basis to test the residual efficacy of the pyrethroid-class insecticides sprayed during the 2013 IRS campaign. By March 2014, AIRS Zimbabwe noted that residual efficacy varied:

- In Mashonaland East (deltamethrin), at 14 weeks after initial spraying, mortality rates had fallen below 80 percent, 62.5 percent for mud walls and 64.7 percent for cement walls.
- In Mashonaland West (lambdacyhalothrin), at nine weeks after initial spraying, mortality rates remained high at 92.6 percent for mud walls, and 91.6 percent for cement walls.
- In Manicaland (lambdacyhalothrin), mortality rates for mud walls dropped below 80 percent to 63.3 percent, 14 weeks after initial spraying; mortality rates for brick walls dropped below 80 percent to 72.64 percent, 14 weeks after initial spraying; and mortality rates for cement walls dropped below 80 percent to .59 percent, 19 weeks after initial spraying.

Susceptibility testing against *An.* gambiae s.l. was completed in five provinces. Listed below are the susceptibility test results.

- Full susceptibility: DDT (organochlorine) at four sentinel sites (Manicaland, Mashonaland Central, Matabeleland North, and Midlands) with 100 percent mortality rates; pirimiphos-methyl (organophosphates) at five sentinel sites (Manicaland, Mashonaland Central, Matabeleland North, Matabeleland South, and Midlands) with 100 percent morality rates; lambdacyhalothrin (pyrethroids) at two sentinel sites (Mashonaland Central and Midlands) with 100 percent mortality rates; deltamethrin (pyrethroids) at two sentinel sites (Mashonaland Central and Midlands) with 100 percent mortality rates; etofenprox (pyrethroids) at one sentinel site (Mashonaland Central) with 100 percent mortality rate; and bendiocarb (carbamates) at four sentinel sites (Mashonaland Central, Matabeleland North, Matabeleland South, and Midlands) with 100 percent mortality rate.
- Possible resistance was noted for DDT at one sentinel site (Matabeleland South) with a 91.3 percent mortality rate.
- Resistance was noted for lambdacyhalothrin at three sentinel sites (Manicaland with a 8.9 percent mortality rate, Matabeleland North with a 80.7 percent mortality rate, and Matabeleland South with a 86.2 percent mortality rate); and for etofenprox at one sentinel site (Manicaland) with a 3 percent mortality rate.

PSC was used to estimate the indoor resting density of the mosquitoes. At the baseline, the density of *An. gambiae* s.l. per room was 0 at the control site, Chabwino Farms. Whereas, the average density of An gambiae s.l in the intervention sites ranged from 0.00 to 0.08 per room per day. PSC collections completed post IRS showed that the control site recorded higher vector densities for *An. gambiae* s.l. than the spray areas. The average room densities for the three sentinel sites in IRS districts were 0.0 at Kasimure, 0.02 at Kawere, and 0.10 at Burma Valley (one to three months after spraying), compared to 0.22 at Chabwino Farms, the control sentinel site during the same time period. For *An. funestus*, at baseline, density was recorded as 1.08 per room at Burma Valley. Density decreased to 0.08 *An. funestus*

per room, one month after spraying, and remained at 0.08 *An. funestus* per room two months after spraying. Three months after spraying, density increased to 1.33 *An. funestus* per room, however, density decreased to 0.66 *An. funestus* per room four months after spraying. By March (five months after spraying), density increased dramatically to 5 *An. funestus* per room. Comparisons were not made with the control site at Chabwino Farms, as *An. funestus* could not be found and collected.

CDC light trap data collected post IRS showed that the non-spray area (Chabwino Farms) recorded a lower number of vectors per trap per night than did the sentinel sites in the spray areas. The number of *An. gambiae* s.l. per trap per night was 0.00 indoors and 0.04 outdoors at Chabwino Farms post-spray, compared to 0.16 indoors and 0.50 outdoors at Kasimure, 0.14 indoors and 0.09 outdoors at Kawere, and 0.5 indoors, and 0.09 outdoors at Burma Valley. The number of *An. funestus* per trap per night was 0.00 indoors and 0.33 outdoors at Chabwino Farms as compared to 4.69 indoors and 2.61 outdoors at Burma Valley.

Program Highlights

The 2013 IRS campaign began on October 1, 2013. Most provinces finished spraying by the end of December. However, vehicle and transport issues in Mashonaland East delayed IRS campaigns in the province, which took place from mid-December to January 21, 2014.

By early October, AIRS Zimbabwe finished building 48 new soak pits in the 25 pyrethroid spray districts. This ensured that all operation sites used by the NMCP in the 25 districts had a soak pit for safely disposing insecticide liquid wastes used during the 2013 IRS campaign.

During the IRS campaign, the AIRS Zimbabwe staff, and three local consultants embedded themselves within the spray teams in all provinces, and closely observed the work of all 37 spray teams in the 25 pyrethroid districts. Overall, AIRS Zimbabwe found the environmental compliance of the IRS campaign implemented by the NMCP to have improved as compared to the 2012 IRS campaign AIRS Zimbabwe was pleased to note that soak pits had become an integral part of IRS. The NMCP and IRS campaign staff were also enforcing the use of helmets, face shields, face masks, and other key PPE in the pyrethroid spray districts. The NMCP had developed a supervision checklist (based on the checklist AIRS Zimbabwe developed and used during the 2012 IRS campaign), for recording data and monitoring their own work. However, AIRS Zimbabwe did note several areas of concern for the NMCP's IRS campaign including:

- Storage conditions in most operation sites are problematic, as PPE and insecticide are usually stored in tents, which are not secure (they cannot be closed and locked). At some operation sites, spray operators or other IRS campaign staff slept in the storage tents (without PPE), to guard against theft.
- About one-third of all spray teams observed did not administer pregnancy tests for female IRS campaign staff. It was noted that many districts lacked pregnancy tests, or arrangements were not made with the local health center to provide pregnancy tests.
- All trucks carrying spray operators to the field lacked seats and railings, and were at risk for persons or IRS campaign equipment falling off the truck.

In February, AIRS Zimbabwe also reviewed the provincial incinerators in the remaining provinces that were not reviewed during the 2012 IRS campaign: Mashonaland Central, Masvingo, Matabeleland North, Matabeleland South, and Midlands. AIRS Zimbabwe found that none of the incinerators were functioning well and were unable to reach high enough temperatures to safely dispose of IRS campaign solid waste. This led to AIRS Zimbabwe working with the pyrethroid districts to dispose of their solid wastes at private incinerators in Harare and Kwekwe.

Challenges and Lessons Learned

- Rearing enough malaria vector mosquitoes for insecticide susceptibility tests continues to be an issue. Wild caught mosquitoes can be difficult to find in some provinces, especially at the end of the dry season. The National Institute of Health Research (NIHR)'s susceptible colony continues to struggle; the colony had only enough adults to test one house in one sentinel site this year. This meant all entomological surveillance was completed with wild-caught mosquitoes.. A new batch of mosquito eggs was provided by the CDC in January, and provided to both NIHR insectaries in Harare and Chiredzi, for developing new susceptible colonies.
- The Zimbabwean government has become reluctant to recognize importation duty waivers for USAID-supported projects. As a result, the new vehicle that AIRS Zimbabwe procured in November 2013, remains unused, as USAID-Zimbabwe, AIRS Zimbabwe, and the Zimbabwean government continue discussions to resolve the duty-waiver issue.

2. Core Sections

2.1 Boot Analysis

In February 2014, AIRS submitted a report on an analysis of the boot sizes used by spray personnel in all the spraying countries. Recommendations from the report will be implemented with a view to reducing incidents of mismatching boot sizes among spray operators during the early days of spray campaigns.

2.2 Spray Operator Pocket Guide

The *Spray Operator Pocket Guide* was finalized in January 2014 and copies were distributed to all countries with spray programs. The job aid, targeted at all field spray personnel, was translated into French, Portuguese, and Malagasy.

2.3 USAID's Global Health Mini-University Presentation

AIRS M&E Specialists Beth Brennan and Jennifer Burnett presented "Innovations to an M&E System Improves Data Quality" and "Speed of Malaria Prevention Program Results" to approximately 70 attendees at USAID's Global Health Mini-University on Friday, March 7, 2014. They provided a brief overview of the AIRS project and its M&E system, and detailed three new M&E measures that have improved the data quality of the IRS program since the three-year project began in 2011. In addition, they highlighted the results of the AIRS Angola e-mobile pilot from October 2013 that tasked spray operators and team leaders with data collection and verification on smart phones and Android tablets. Finally, they outlined the lessons learned, compared the strengths and weaknesses of paper-based and mobile data collection methods, and suggested improvements and next steps for mobile data collection in future IRS campaigns.

2.4 South-to-South Assistance

In October 2013, Ernest Fletcher, the AIRS Ghana M&E Manager, provided short-term technical assistance to the AIRS Mozambique team regarding the implementation of the M&E components of the project. Specifically, he assisted with pre-spray database set-up and the initial supervision of data entry clerks; he worked with database coordinators and M&E assistants and provided feedback on the implementation of data quality assurance protocols. He observed field data collection and provided feedback to AIRS Mozambique staff. After the dismisal of the Mozambique M&E Manager, Mr. Fletcher returned to Mozambique as the acting M&E Manager from November 6 through December 17.

In January and February 2014, Rokhaya Diop, the AIRS Senegal Environmental Compliance Officer, provided short-term technical assistance to the AIRS Madagascar team, to help AIRS Madagascar prepare for the IRS campaign in southern Madagascar. This was necessary because the former AIRS Madagascar Environmental Compliance Officer was dismissed for misconduct in December. Ms. Diop worked with the AIRS Madagascar team to ensure all soak pits and store rooms were ready before the start of the IRS campaign. Given that the project would be without its Environmental Compliance Officer for the spray campaign, Ms. Diop trained AIRS Madagascar's District Coordinators and Operations Coordinator to complete environmental compliance assessments during and after the IRS campaign. She trained several AIRS Madagascar staff members on how to use smart phones to complete environmental compliance assessments. Ms. Diop also worked one-on-one with AIRS Madagascar staff

during the first two weeks of the IRS campaign to ensure they could complete environmental compliance assessments without issue.

2.5 Roll Back Malaria Vector Control Working Group Annual Meeting

In February 2014, Lena Kolyada represented AIRS at the annual Vector Control Working Group meeting of the Roll Back Malaria Initiative. Over the three days of meetings, public and private sector partners and research institutions reported on their progress and set out milestones for the future. Ms. Kolyada met with project partners, including the Liverpool School of Tropical Medicine (LSTM), the Innovative Vector Control Consortium (IVCC), BASF Pest Control Solutions, AVIMA, and the Goizper Group. With LSTM they identified next steps and timelines to improve usability of the LSTM database for entomological monitoring introduced to AIRS Ethiopia. IVCC informed AIRS about its plans and proposed next steps for testing their Insecticide Quantification Kits. BASF described how it would roll out the testing of its new insecticide, chlorfenapyr, in one AIRS country.

2.6 New Employee

Laura McCarty, senior communications manager, provides overall communications support for the AIRS project; she manages the project's website, social media, and web visibility, produces success stories, and manages technical briefs and other deliverables produced by project communications.

2.7 Entomological Database

An Access database on insecticide resistance and cone bioassay data was developed in project year two. However, this entomology database lacked reporting queries that are needed to generate summary reports such as tables and charts directly from the database. Instead, users had to export the data to spreadsheets to produce the reports. This year, AIRS and Abt's Client Technology Center (CTC) added a new function, query, to the database. A generic reporting template and compiler was developed for both the insecticide resistance and cone bioassay databases. The compiler allows the database to directly generate tables and charts by clicking a button rather than having to export the data to MS-Excel. The CTC has already set up this reporting function for the AIRS home office and is currently setting it up for all AIRS country technical managers and entomologists. The reporting function expedites the reporting work of the technical staff, saving time for other technical tasks.

2.8 Deltamethrin Suspension Concentrate (SC)-Enhanced Polymer (EP) Study

A comparative study of the residual life of deltamethrin SC-EP and deltamethrin WG (water dispersible granule) is underway in Mozambique, specifically, in the Mugeba area of Mocuba District in the Central Region, about 200 km from the regional capital, Quelimane. AIRS Mozambique selected and sprayed five houses with deltamethrin SC-EP and five with deltamethrin WG. Cone bioassay data were collected simultaneously from the 10 sprayed houses. The first data were collected 24 hours after spraying and then on a monthly basis from December 2013 to April 2014 (T0 up to T4). By T3, one of the houses sprayed with deltamethrin WG had been demolished; bioassays continued in the remaining four houses.

Cone bioassay tests were regularly carried out using *An. arabiensis* Durban strain from the AIRS Mozambique Quelimane insectary, whose colony is susceptible to deltamethrin. The AIRS Mozambique entomology team members who conducted the tests were not informed of the insecticide formulation used in each structure. The cone bioassays tests used 3–5 day-old female mosquitoes. Standard WHO plastic cones were fixed on the sprayed walls for the assay. Batches of 10 female mosquitoes were

exposed for 30 minutes to the insecticides sprayed at three cone heights (approximately 0.5m, 1.0m, and 1.5m above the ground) in each house. The number of mosquitoes knocked down at the end of the exposure period was recorded. Thereafter, the mosquitoes were fed with 10 percent sugar solution soaked in cotton wool, and the percentage mortality was recorded for each house after a 24-hour holding period. When a percentage mortality of 5 to 20 was observed in the control tests, the mortality was corrected following Abbott's formula.

Both insecticides were also tested against wild *An. gambiae* s.l. (reared from larvae) from Mocuba sentinel area. This was done in March 2014, three months after spraying.

The results on the mean percentage mortality of susceptible *An. arabiensis* insectary colony at the end of the 24-hour holding period are indicated on Table 8 for both insecticides.

TABLE 8. MEAN PERCENTAGE MORTALITY OF *AN. ARABIENSIS* (SUSCEPTIBLE INSECTARY COLONY) AFTER THE 24-HOUR HOLDING PERIOD USING CONE BIOASSAY TESTS

	Mean percentage mortality	
Period	**Deltamethrin SC-PE**	**Deltamethrin WG**
T0 -December 2013	99%	100%
T1 -January 2014	99%	95.00%
T2 -February 2014	100%	94.00%
T3 -March 2014	97%	98.33%
T4 -April 2014)	95%	90.83%

Both deltamethrin SC-PE and deltamethrin WG formulations were highly efficacious against *An. arabiensis* Durban strain in Mozambique four months post spray. At the end of four months 95 percent and 91 percent mean percentage mortalities were observed for SC-PE and WG formulations, respectively. The mean percentage mortality after the 24-hour holding period for the wild *An. arabiensis* mosquitoes were 97 percent and 98 percent for SC-PE and WG formulations, respectively, three months post spray. Monthly monitoring on the residual efficacy of the new formulation (deltamethrin SC-PE) and the conventional WG formulation will continue until the insecticidal decay rate is reduced below the WHO standard 80 percent cut-off point.

2.9 U.S. Global Development Laboratory

At the request of the Contracting Officer's Representative (COR) team, the AIRS project participated in the U.S. Global Developmental Laboratory event. The event, held on March 31 in Washington, DC, celebrated USAID's advances in science, technology, innovations, and partnership through town hall meetings and exhibits. AIRS shared exhibit space with the PMI and TB programs. Staff displayed the AIRS innovation brochure, Goizper spray pump, and mini-soak pits in a jar, played a video showing project IRS innovations, and answered questions about the project. While the number of exhibition hall visitors was not large, the spray pump and the mini-soak pits attracted more people than did the other tables. The most frequently asked questions from visitors, most of whom did not understand the difference between fumigation and IRS, were about the toxicity of IRS insecticides and about mosquito resistance to IRS insecticides.

2.10 Smart Phone Pilot

In 2013–14, the environmental compliance smart phone data collection system was rolled out to the AIRS countries based on the spray operations calendar, starting with Liberia, Nigeria, and Ghana. These early countries achieved a lesser degree of system integration than later users, as their use revealed problems that were fixed which facilitated adoption by later users. By March 2014, Version 3 of all eight

environmental compliance inspection checklists had been installed on phones in the field, and more than 1,200 reports had been uploaded to the database, including reports from every country in which AIRS conducts spray operations.

The original goal for 2013–14 was the successful adoption of the smart phone inspection system for the pre-spray environmental compliance assessments (PSECAs) conducted by the country Environmental Compliance Officers. The utility of the system, however, quickly led to its use by other senior in-country staff and visiting home office staff. In addition, AIRS staff in the home office quickly realized that the data generated offered a convenient way to track the progress of preparations for the spray campaign, and they pushed for the earlier development of a supervisor-level reporting system. This reporting system proved difficult to produce, but in the interim, an automated email system was instituted that provides responsible parties with actionable status notifications from each inspection submission. By March 2014, a rudimentary report system was in place and accessible by in-country and home office staff.

The technical assistance plan to address field problems with the smart phone inspection system was somewhat slow to evolve, but in January 2014, training was provided by Abt home office staff via conference call to the IT coordinators in each country. These coordinators are expected to provide frontline support in the field. AIRS also designated a regional resource in Zambia to provide secondary support.

In February–March 2014, AIRS consolidated and refined environmental compliance and operations mid-season inspection checklists into Version 4, translated them into French and Portuguese, and produced a printable version for use by project and government staff who do not have access to the smart phone system.

The smart phone data collection system is a significant work-saver that avoids the generation of large volumes of paper checklists and delays in the distribution of information. By providing a thorough inspection report, as well as critical site photographs, it maximizes the efficiency of pre-spray preparations and reduces the necessity of trips to remote sites, which can consume hours or days of senior staff time. The use of time, date, and GPS stamping produces permanent, auditable records of environmental compliance.

2.11 Mobile Soak Pit Pilot Test

In Madagascar, the distance between targeted villages is great, and roads are poor. Spray teams often camp for days at a time, as it is difficult or impossible for them to return to a central operational site for end-of-the-day clean-up. Due to these operational conditions, the central highlands of Madagascar was chosen for the first pilot test of the mobile soak pit (MSP) concept that had been developed earlier in 2013. Although for this pilot, containers for the filter were purchased in the United States and sent to Madagascar, it was discovered early in the pilot that appropriate containers were available in local markets, adding to the simplicity of MSP implementation at a local level. An initial challenge was to locate a source at a reasonable cost for the granulated activated carbon, which is the key feature of the MSP. In the end, a company in South Africa was identified and used. Despite the high cost of transport of material from the United States and South Africa, the total cost of each MSP was estimated at $100.00. The MSPs were built by the district coordinators and sector managers as a training exercise during the Training of Trainers, which was overseen by Allan Were, the AIRS Operations Director who was in Madagascar in early November doing short-term technical assistance.

For the pilot, 20 MSPs were distributed to appropriate locations in the central highlands, with the team leaders providing primary supervision, and sector managers, district coordinators, and AIRS staff providing additional oversight when possible. Before spraying activities began, the Environmental Compliance Manager attended the training and demonstration of soak pit installation, which involved hands-on participation and built team confidence in their ability to properly implement the pilot.

Both a Global Environmental Management Specialist (GEMS) consultant and the Environmental Compliance Manager visited several other sites to observe use of the MSPs, and, in general, were satisfied with their observations. Where some teams were not following the proper protocols, a refresher training was given on-site, and performance improved.

In January 2014, the MSP pilot was extended to southern Madagascar, and south-south technical assistance was provided by one of AIRS's most experienced Environmental Compliance Officers, Rokhaya Diop from Senegal. As in the central highlands, the pilot test was deemed a success and credited with helping to increase spray coverage and improve environmental compliance.

For the 2014–15 spray season, AIRS will extend the use of the MSP to Mali, Senegal, and Ethiopia, and possibly to other countries as the opportunity arises. Although the pilot was a success, improvements and refinements are needed.

2.12 Multilateral Initiative on Malaria 2013 Conference

In October 2013, the AIRS project and PMI convened two symposiums at the MIM Pan-Africa Malaria Conference held in Durban, South Africa. The first symposium was entitled "Data-driven Decision-making in the Context of IRS Scale-up and Increased Insecticide Resistance." Panelists were Dr. Martin Akogbeto from CREC in Benin; Dr. Mike Coleman from LSTM; Dr. Lassana Konate from UCAD in Senegal; Moussa Cisse from AIRS-Mali; and Dr. Christen Fornadel from PMI. The second symposium was entitled "Indoor Residual Spraying; Maximizing Innovation, Impact, and Sustainability." Panelists were Christopher Helm, IVCC; Dr. Yemane Yihdego, AIRS Ethiopia; Peter Chandonait, AIRS Environmental Compliance and Safety Director; and Dereje Dengela, AIRS Technical Director. The PMI COR team of Allison Belemvire, Kristen George, and Christen Fornadel along with AIRS Project Director Bradford Lucas were co-chairs for the symposiums.

2.13 American Society of Tropical Medicine and Hygiene 2013 Conference

In November 2013, the AIRS project and PMI convened a symposium entitled "Indoor Residual Spraying: Maximizing Innovation, Impact and Sustainability" at the ASTMH conference held in Washington, DC. The panelists were Tom McLean, IVCC; Dereje Dengela, AIRS Technical Director; and Josh Rosenfeld, AIRS Technical Coordinator.

2.14 Communications

The AIRS website (www.africairs.net) received 4,576 website visits from October 1, 2013 to March 31, 2014, an approximate 5 percent increase from the previous six months (April 1 to Sept 30, 2013). During this period, six success stories were written, posted on the website, shared on Abt Associates' Facebook and Twitter pages, and distributed via the AIRS quarterly e-letter. AIRS distributed one e-letter (in December) and one video e-alert on Ghana to more than 4,200 global health professionals. Further analysis of the AIRS website, e-letter, and other communications materials can be found in the quarterly communications analytics reports.

In March, we sent out a communications packet to each of the AIRS country offices that included the AIRS innovations brochure, the AIRS one-page project brief, and a flash drive with the completed AIRS videos. AIRS Chiefs of Party were encouraged to share these materials with USAID missions, government partners, and other stakeholders.

During this reporting period, we established an AIRS Twitter account, expanding our reach through social media. Currently, we have 22 followers, including PMI, USAID Rwanda, Bayer Malaria, Cherri Africa, Plan International, Stomp Out Malaria, and Reducing the Fever.

ANNEX A: INSECTICIDE AND EQUIPMENT PROCUREMENT

Commodity	Country	Description	Total Cost	Order/PO Date	Delivery Date
Entomology Supplies	Angola	Impregnated Papers	$530.00	Nov, 2013	Dec, 2013
Insecticides	Benin	Organophosphates	$699,578.37	Jan, 2014	Apr, 2014
Insecticides	Benin	Organophosphates	$169,330.62	Mar, 2014	Pending
Personal Protective Equipment	Benin	Mask, Gloves, Hard hats, Faceshields, coveralls, Gumboots, First Aid Kits	$74,352,01	Feb, 2014	May, 2014
Goizper Sprayers	Benin	IK 12 VC Sprayers	$26,430.00	Feb, 2014	Apr, 2014
Entomology Supplies	Burundi	Impregnated Papers	$2,884.00	Oct, 2013	Nov, 2013
Entomology Supplies	Burundi	Impregnated Papers	$3,710.00	Mar, 2014	Apr, 2014
Entomology Supplies	Ethiopia	Impregnated Papers	$2,870.00	Sept, 2013	Oct, 2013
Insecticides	Ghana	Organophosphates	$974,609.28	Jan, 2014	Mar, 2014
Personal Protective Equipment	Ghana	Masks, Hard hats, Faceshields	$15,822.00	Feb, 2014	Apr, 2014
Goizper Pumps	Ghana	Pumps, Spare Parts	$ 3,089.00	Mar, 2014	Apr, 2014
Hudson Sprayers & Parts	Ghana	Spare Parts	$ 3,296.00	Feb, 2014	Apr, 2014
Goizper Sprayers	Ghana	IK 12 VC Sprayers	$7,539.00	Feb, 2014	Mar, 2014
Entomology Supplies	Liberia	Impregnated Papers	$ 890.00	Jan, 2014	Feb, 2014
Entomology Supplies	Liberia	Impregnated Papers	$ 400.00	Jan, 2014	Feb, 2014
Insecticides	Madagascar	Organophosphates	$1,511,654.40	Oct, 2013	Dec, 2013
Entomology Supplies	Madagascar	Entomology Monitoring Supplies	$ 426.71	Oct, 2013	Nov, 2013
Entomology Supplies	Mali	Entomology Monitoring Supplies	$13,484.94	Dec, 2013	Mar, 2014
Entomology Supplies	Mali	Entomology Monitoring Supplies	$4,938.88	Jan, 2014	Mar, 2014
Entomology Supplies	Mali	Impregnated Papers	$4,200.00	Feb, 2013	Feb, 2013
Entomology Supplies	Mali	Impregnated Papers	$640.00	Feb, 2014	Feb, 2013
Etnomology Supplies	Mali	Impregnated Papers	$360.00	Mar, 2014	Mar, 2014
Insecticides	Mali	Organophosphates	$1,753,064.56	Jan, 2014	Pending
Insecticides	Mali	Organophosphates	$83,474,64	Mar, 2014	Pending
Insecticides	Mali	Bendiocarb – Fiacam VC	$71,061.45	Mar, 2014	Apr, 2014
Personal Protective Equipment	Mali	Mask, Glove, First Aid kits, Faceshields, head lamps, Batteries	$42,989.60	Feb, 2014	Apr, 2014
Hudson Spare Parts	Mozambique	Spare Parts	$3,808.00	Mar, 2014	*Pending

Commodity	Country	Description	Total Cost	Order/PO Date	Delivery Date
Entomology Supplies	Mozambique	Entomology Monitoring Supplies	$4,027.17	Mar, 2014	*Pending
Entomology Supplies	Nigeria	Entomology Monitoring Supplies, Lab supplies	$601.04	Oct, 2013	Dec, 2013
Entomology Supplies	Nigeria	Entomology Monitoring Supplies	$26,047.65	Jan, 2014	Feb, 2014
Entomology Supplies	Nigeria	Impregnated Papers	$584.00	Oct, 2013	Oct, 2013
Entomology Supplies	Nigeria	Impregnated Papers	$330.00	Oct, 2012	Nov, 2013
Entomology Supplies	Nigeria	Impregnated Papers	$420.00	Feb, 2014	Feb, 2014
Entomology Supplies	Nigeria	Entomology Monitoring Supplies	$3,163.31	Dec, 2013	Feb, 2014
Entomology Supplies	Nigeria	Entomology Monitoring Supplies	$9,777.40	Jan, 2014	Feb, 2014
Insecticides	Rwanda	Bendiocarb – Fiacam VC	$1,006.110.00	Dec, 2013	Jan, 2014
Personal Protective Equipment	Rwanda	First Aid Kits	$2,469.15	Nov, 2013	Jan, 2014
Personal Protective Equipment	Rwanda	Mask, gloves, Aprons	$64,711.92	Nov, 2013	Jan, 2014
Hudson Spare Parts	Rwanda	Nozzles, Spare Parts	$16,692.01	Nov, 2013	Jan, 2014
Entomology Supplies	Rwanda	Impregnated Papers	$1,760.00	Feb, 2014	Feb, 2014
Entomology Supplies	Rwanda	Impregnated Papers	$1,610.00	Feb, 2014	Feb, 2014
Insecticides	Senegal	Organophosphates	$1,164,662.01	Jan, 2014	April, 2014
Insecticides	Senegal	Bendiocarb – Fiacam VC	$121,936.41	Jan, 2014	
Personal Protective Equipment	Senegal	Masks, Faceshields	$21,358.50	Dec, 2013	Feb, 2014
Goizper Sprayers	Senegal	IK 12 VC Sprayers	$40,058.56	Dec, 2013	Mar, 2014
Entomology Supplies	Zambia	Entomology Monitoring Supplies	$7,808.71	Feb, 2014	Feb, 2014
Entomology Supplies	Zambia	Impregnated Papers	$1,400.00	Feb, 2014	Feb, 2014
Entomology Supplies	ZImbabwe	Entomology Monitoring Reagents	$ 4,032.86	Feb, 2014	Pending
Entomology Supplies	Zimbabwe	Ento Monitoring, Lab supplies	$ 2,172.00	Feb, 2014	Pending
Entomology Supplies	Zimbabwe	Ent Monitoring Lab supplies	$2,569.19	Feb, 2014	Pending

ANNEX B: M&E RESULTS SUMMARY

IRS RESULTS OCTOBER 2013–MARCH 2014

Country	# Structures Sprayed	Spray Coverage	Total Population Protected	Children Under Five Protected	Pregnant Women Protected	# People Trained**
Angola	98,136	92.1%	419,353	74,542	23,459	671
Madagascar	343,470	98.8%	1,588,138	296,395	64,792	834
Mozambique	414,232	89.2%	2,181,896	379,982	139,499	1128
Rwanda (Sept- Oct 2013)	224,708	98.1%	957,027	147,531	16,023	1,875
Rwanda (Feb-March 2014)	123,919	98.6%	512,789	75,753	8,547	1,180
Zambia***	N/A	N/A	N/A	N/A	N/A	N/A
Zimbabwe*	622,300	91.4%	1,431,643	N/A	N/A	477
AIRS TOTAL	1,826,765	94.6%	7,090,846	974,203	252,320	6,165

* Data are included in AIRS total. However, AIRS is providing technical assistance, not leading IRS operations or collecting data.

**Includes spray staff (e.g., spray operators, team leaders, supervisors, clinicians) only. Excludes data clerks, IEC mobilizers, drivers, washers, porters, pump technicians, and security guards

***AIRS does not directly support efforts directly leading to these indicators.

.