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SEMI-ANNUAL REPORT

APRIL 2014–SEPTEMBER 2014

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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
ECSM	Environmental Compliance and Safety Manager
EEM	Enhanced Entomological Monitoring
EIR	Entomological Inoculation Rate
ELISA	Enzyme-Linked Immunosorbent Assays
EOSR	End-of-Spray Report
EP	Enhanced 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 Program
NMEP	National Malaria Elimination Program
NMIMR	Noguchi Memorial Institute for 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 Test
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 the reporting period (April 1, 2014 – September 30, 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 Benin, Ethiopia, Ghana, Mali, Rwanda, and Senegal. The project covered an average of 96.3 percent of targeted structures and protected more than 5.2 million people from malaria. In addition, AIRS provided technical and operational assistance to countries preparing for IRS campaigns in the latter part of 2014 in Angola, Madagascar, Mozambique, Zambia, and Zimbabwe. Details regarding all monitoring and evaluation (M&E) outcomes by country are reported in Annex B.

TOP-LINE RESULTS FROM IRS CAMPAIGNS IN APRIL 2014-SEPTEMBER 2014

- 1,731,906 structures sprayed
- 96.3 percent average spray coverage
- 5,258,169 people protected from malaria including:
  - 112,922 pregnant women
  - 952,156 children under five years of age
- 8,623 people trained with United States Government (USG) funds to deliver IRS

AIRS continued to perform entomological monitoring activities in 14 project countries to identify local malaria vectors and their biting habits, measure mosquito susceptibility to different insecticides, and track residual efficacy of insecticides. AIRS used these data to make insecticide selection decisions for spray campaigns that will begin in the next six months.

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

- Results from the Benin epidemiological data analysis using publicly available Health Management Information System (HMIS) data. The research has led to additional conversations between PMI and AIRS on how best to access health burden data and measure IRS effect in the future.
- Introduction of monthly Tech Talks among home office and field staff to encourage peer-to-peer exchange. The first talk in September focused on using supervisory forms on smartphones.
- Facilitation of a *World Malaria Day Vector Control Brown Bag* at USAID to introduce several AIRS innovations in operations, entomological monitoring and evaluation, and environmental compliance to malaria partners.
- Continued technical assistance to Malawi's national IRS program, including transferring skills to NMCP and district health officers to implement IRS operations in accordance with national and international standards for environmental health and safety.

AIRS expanded its mHealth innovations by developing new mobile approaches in additional project countries with the goal of improving IRS programming. To note, AIRS implemented the practice of sending operational data via SMS every day to supervisory staff in Benin and Senegal for rapid assessment of campaign progress. In the same vein, AIRS digitized the four primary supervisory checklists onto smartphones and tasked government and project staff with completing the mobile tool for close oversight and immediate corrective action of spray operations. Additionally, AIRS investigated mass messaging via SMS and voice to inform and prepare beneficiaries for IRS in Mali.

Finally, AIRS expanded the environmental compliance data collection on mobile phones to more project countries that implement spray programs. These data informed home office and senior management staff of the readiness of each country before approving the start of spray operations.

In addition, AIRS made advancements to the design of the mobile soak pit (MSP), making it lighter, and less expensive, and made of locally-available materials. In the reporting period, the MSP was successfully piloted in Senegal, Mali, and Ethiopia, and will be used again in Madagascar during the eastern spray campaign. The pilots provided valuable feedback to guide design and implementation improvements of the filter footprint, leaving as close to zero impact as possible.

AIRS is committed to knowledge transfer and sharing and participating in global malaria conferences and meetings. The AIRS Technical Director presented on the need for new or improved insecticides for IRS as a critical component for fighting malaria at the Innovative Vector Control Consortium (IVCC) stakeholders' bi-annual meeting. AIRS also released five videos including a speed drawing on entomological monitoring, an animation of IRS operations, mobile soak pit construction training, and two films highlighting building government capacity and increasing women's IRS participation and leadership.

Finally, AIRS produced six success stories, and four Technical Briefs focusing on Environmental Compliance, Operations, M&E, and Entomological Monitoring, and updated the AIRS Project Brief.

1. COUNTRY HIGHLIGHTS

1.1 ANGOLA

ENTOMOLOGY

AIRS Angola established entomological sentinel sites in Bailundo, the only IRS target area in 2014; formerly sprayed areas, including the municipality of Huambo, the municipality of Caála (the control area in Huambo Province); and formerly sprayed and control areas in the municipality of Chibia in Huila Province. During this reporting period, AIRS Angola conducted monthly entomological data collection to determine mosquito species available in the survey areas; vector behavior; and density. Mosquito sampling methods used included Center for Disease Control and Prevention (CDC) light traps, pyrethrum spray catch (PSC), Prokopack aspirator for indoor collections, and the Pit trap for outdoor collections in a total of 10 houses per village sampled in monthly intervals. AIRS Angola conducted morphological identification and preservation of all field-collected vector mosquitoes: a total of 371 specimens were preserved and sent to the National Health Laboratory Service of Witwatersrand Johannesburg, South Africa, for (PCR) analysis; results still pending. Specimens also included mosquitoes collected in larvae and pupae stages, reared to the adult stage in the insectary, and used for susceptibility testing and WHO wall cone bioassay. Of the mosquitoes collected *An. coustani* constituted the highest proportion followed by *An. gambiae* and *An. squamosus*.

Mosquito density was relatively higher in the month of May when the mosquito survey started, compared to subsequent months. Angola has a short rainy season from February to April followed by a dry season. The observed trend in vector density can be explained by this rainfall pattern. The decline in vector density over time was observed in all the intervention and control villages. The highest number of host-seeking and resting *An gambiae* s.l. was collected from the Bailundo intervention area in May using CDC light traps and PSC methods, which were 11.4 mosquitoes per trap per night and 6.1 mosquitoes per hut per day, respectively. The entomological monitoring activities began eight months after spraying when the intervention was believed to have little impact on mosquito population.

The difference in the density of *An. gambiae* s.l. observed between the intervention and control areas in Bailundo reflects the incomparability of the two sentinel sites in terms of their mosquito productivity. Results from CDC light traps collection in the Bailundo intervention area ranged from 0-1.4 *An. gambiae* s.l. per trap per night from June to September. The mean density and man biting rates of *An. gambiae* s.l. was less than one mosquito per hut per day (per trap per night) for all the other sentinel sites and collection types. Susceptibility testing to inform insecticide selection for the 2014 spray campaign was conducted in late March into early April 2014 with sampling from Bailundo Capital, the only IRS target area planned for 2014. The test mortality rates of the *Anopheles gambiae* s.l. tested for insecticide resistance to deltamethrin, bendiocarb, and fenitrothion were all 100 percent. Based on the susceptibility data, pyrethroids, carbamates, or organophosphates could potentially be used for the 2014 spray campaign. Other selection criteria including cost, residual life in relation to the malaria transmission period, operational feasibility, and safety are important factors to determine insecticide selection. Taking these factors into consideration, it was agreed with PMI and the NMCP that pyrethroids would continue to be used for the 2014 spray campaign.

PROGRAM HIGHLIGHTS

In its role as Vice President of the Malaria Partners' Forum in Huambo, AIRS Angola led the World Malaria day activities in partnership with the Provincial Directorate of Health, the Municipal Department of Health of Bailundo, and other PMI partners. AIRS Angola was responsible for

dissemination of key messages about malaria prevention and care, including participation in a radio round table, visits to health facilities and universities, and the Stop Malaria Initiative in key points of Huambo Municipality's City Center.

During this reporting period, AIRS Angola supported the Malaria Operational Plan (MOP) team and PMI Angola with field work, and data gathering for the development of the FY 2015 Angola MOP.

The project continued to implement epidemiologic surveillance within the current and former IRS municipalities in the three provinces to inform PMI on the effectiveness of its ongoing IRS activities, and to establish a surveillance system that will be used to identify outbreaks of malaria in areas where IRS has been withdrawn. It also conducted an assessment of the selected health facilities to identify the current data collection and management system, and to meet with and train the appropriate person(s) responsible for patient data at each of the health facilities with the new data collection tool.

AIRS Angola also supported the Ministry of Health and the Huambo Provincial Government in the development of their Municipal Health Development Plans (PMDS) for 2013-2017 and decentralization of malaria control interventions in accordance with current efforts to decentralize health and other government services to municipal levels. Support was targeted primarily for the municipalities of Bailundo and Huambo.

The pre-spray environmental assessment of the Bailundo operational site was conducted in late July 2014. Given that this site was built in 2013, only minor deficiencies were identified and corrected prior to the onset of the spray campaign. Both the charcoal and saw dust of the soak pit were replaced at the recommendation of the AIRS Environmental Compliance and Safety Manager (ECSM) due to the size of the operational site and the number of spray operators.

The micro-planning meeting was held in early August 2014 with key partners and stakeholders in Bailundo municipality with a focus on spray planning, including quantifications, recruitment, training plans, the spray calendar, roles and responsibilities, implementation timeline, and insecticide selection. Participants at the micro-planning meeting included Provincial and Municipal Health Directorates, civil society representatives, social media, heads of the health facilities, and traditional authorities from within all villages targeted for spraying in 2014.

Seasonal personnel recruitment and training was carried out in August and September 2014. A total of 206 people were trained in preparation for the spray campaign.

CHALLENGES AND LESSONS LEARNED

- The limited participation by the National Malaria Control Program (NMCP) in IRS limits capacity building opportunities and the potential for future IRS in the country.
- There is a lack of a susceptible mosquito colony. Discussions continued with the Minister of Health and the NMCP Director for permission to bring eggs for a susceptible mosquito colony into the country but without any progress; PMI intervention is required.
- A long standing vacancy remains for a Technical Manager/Senior Entomologist with the technical skills, Portuguese and English language skills, and willingness to move to Angola. However, Senior Entomologist Mr. Ranjith de Alwis was hired by Abt as a consultant, and was deployed to Huambo at the end of October 2014.

1.2 BENIN

TABLE 1. AIRS BENIN AT A GLANCE

Number of districts covered by PMI-supported IRS	9
Insecticide	Organophosphates (pirimiphos-methyl EC and CS)
Number of structures sprayed by PMI-supported IRS	254,072
Number of structures targeted by PMI-supported IRS	265,907
Spray coverage	95.5 percent
Total population protected by PMI-supported IRS Pregnant women protected Children under five protected	789,883 25,754 227,530
Dates of PMI-supported IRS campaign	May 5- 27, 2014
Length of campaign	20 days
Number of people trained with US Government funds to deliver IRS*	1,642

Note: *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

In February and April 2014, the Entomological Research Center of Cotonou (CREC) collected baseline data before the IRS campaign began. Baseline data noted that *Anopheles (An.) gambiae* s.l. was the most prevalent vector species (78.8 percent). A high endophagic behavior of *An. gambiae*, (more than 90 percent) was noted. The infectivity of *An. gambiae* was also noted as high (25 percent of *An. gambiae* captured and analyzed via ELISA were found to have the *P. falciparum* circumsporozoitic antigen). In addition, CREC recorded IRS entomological surveillance data from May to September 2014. Cone test bioassays to determine spray quality were performed with a susceptible strain exposed to both pirimiphos-methyl EC and CS sprayed walls (mud and cement walls). CREC noted that the bioassay data showed 100 percent mortality for all mosquitoes exposed to the sprayed walls at all sentinel sites, after 24 hours.

In July 2014, two months after spraying, CREC noted that the pirimiphos-methyl CS continued to be effective on the sprayed cement and mud walls. EC formulation continued to be effective only on the sprayed cement walls and met the minimum criteria for effectiveness (80 percent mortality of exposed mosquitoes). The average density of *An. gambiae* s.l. per structure in the sprayed districts (0.49 per structure) is 8.4 times lower than the average density recorded in the control district of Copargo (4.11 per structure).

The Human Biting Rate (HBR) in the treated districts was 0.27 (74/276) bites per person per night or 8 bites per person per month in June and July. In the control sentinel site, the HBR was 2.18 (148/68) per person per night or 65.4 bites per person per month during the same period. People in the untreated district (Copargo sentinel site) received 8.1 times more *An. gambiae* s.l. bites than people in treated sites. The Entomological Inoculate Rate (EIR) was 18.8 times lower at treated surveillance sites than in the control district in June and July. The EIR in treated districts was 0.018 infective bites per man per night, or 0.54 infective bites per man per month compared to 0.338 infective bites per man per night, or 10.14 infective bites per man per month in the control district in June and July. AIRS Benin supervised the CREC field activities and reviewed the entomological reports before submission to USAID-PMI.

PROGRAM HIGHLIGHTS

The period of this report covers the 2014 IRS campaign, which was implemented in the nine (9) districts of Atakora Region. AIRS Benin started by developing the IRS micro planning during a workshop with IRS stakeholders, including the National Malaria Control Program, the Ministry of

Health (Atakora Region) and the Ministry of Environment (Atakora Region). The workshop took place on April 22, 2014.

Following the "Race to the Starting Line," different activities were completed before the IRS campaign began on May 5, 2014. Activities included: recruitment of IRS campaign seasonal staff, trainings of trainers, and trainings of each category of seasonal staff. The Environment Compliance and Safety Manager (ECSM) completed the review of soak pits and store rooms in accordance with initial inspection (conducted January 2014) recommendations. In 2014, IEC activities were implemented including mass mobilization one day before the spray dates in scheduled villages, while local radios and town criers announced the spray, and IRS leaflets were distributed to each eligible structure. Additionally, the mobilizers worked closely with spray teams during the spraying days to reinforce sensitization and help residents or beneficiaries to put out their belongings.

Over the 20-day spray campaign (May 5- 27, 2014), AIRS Benin used an organophosphate class insecticide (pirimiphos-methyl CS formulation: 25,552; EC formulation: 17,816) to spray 254,072 of the 265,907 structures found by spray operators; covering 95.55 percent of the total number of structures found by spray operators.

The 2014 IRS campaign was successful in spray coverage as well as in implementing the Short Message Service (SMS) as an innovative way for District Coordinators and others in the AIRS Benin management team to communicate daily with spray operators and team leaders. For example, a message was sent through SMS to spray operators and team leaders to remind spray operators and team leaders of proper personal protective equipment (PPE) use in the Natitingou district. SMS was also used to record IRS operational data from each storekeeper in the nine districts of Atakora on a daily basis.

With AIRS Benin's support, the NMCP managed and implemented the IRS campaign in the district of Tanguiéta, one of the nine districts of the Atakora Region during the 2014 IRS campaign.

After the campaign, three methods were used to dispose of the IRS waste: incineration for used respiratory masks and spray operator bags, recycling for insecticide bottles, and burial for used plastic gloves.

The AIRS Benin team completed the post-spray final inspections and drafted the End of Spray Report and submitted to PMI for approval.

AIRS Benin successfully implemented and completed a PSDQA within 90 days after the spray campaign. Audit data show that 91.9 percent (88.96; 94.1) of eligible structures found by spray operators were sprayed during the 2014 campaign compared to the 95.5 percent spray coverage reported during the May 2014 IRS campaign. Based on a 95 percent confidence interval, we are statistically confident that the spray coverage for the May 2014 is beyond the 85 percent coverage rates expected in all nine communes of Atakora.

CHALLENGES AND LESSONS LEARNED

- Mentoring NMCP to successfully conduct a spray campaign in one district for the first time required significant input from the AIRS Benin team. Direct intervention was required at each component of IRS implementation: coordination, IEC/BCC, M&E, logistics and environmental compliance.
- The nine commune coordinators were stretched to handle the IRS operation due to the high number of spray operators and team leaders at each operation base. Closer management is recommended, such as assigning a site coordinator who will run the site area with commune coordinator tasks.
- Until 2014, boots, helmets, face shields, and gloves were not washed on a daily basis, unlike the overalls. AIRS Benin directed that spray operators and team leaders wash their PPE in the rinsing area along a queue. Accordingly, the rinsing area should be redesigned with entry and exit doors to facilitate the washing by each agent or to better equip five or more mobile soak pits.
- AIRS Benin contracted a local micro-credit lending institution named FECECAM (Network

Institution of Funds and Credit for Agriculture) to help with payments of all seasonal staff. The institution has a representative office in each of the nine districts of Atakora which facilitated payments. This also reduced long absences the project previously experienced when workers traveled to process their payment.

- Visibility of IEC Mobilizers: Although IEC mobilizers were dynamic, helpful with mobilization and communicated important messages about the spray with the village, it was difficult to identify them in the village. To help beneficiaries more readily identify IEC mobilizers, mobilizers should wear an armband or a colorful waistcoat to distinguish them from the spray operators.

1.3 BURUNDI

ENTOMOLOGY

National entomology capacity in Burundi remains limited, but significant progress has been made in the past two years with the support of USAID through AIRS. To monitor the efficacy of vector control interventions, the National Malaria Control Program (NMCP) of Burundi now has a functional insectary with a susceptible *Anopheles gambiae* s.s. colony (Kisumu strain) at its eighteenth generation. AIRS Burundi is building the capacity of human and material resources for the management and the maintenance of this infrastructure.

Six entomological surveillance sites, covering the main malaria epidemiological patterns (fascies), are surveyed monthly using PSC and CDC light traps to collect data on species composition, seasonality, and density of the malaria vectors. To date, these surveys have identified eight species of *Anopheles*, their relative importance in the anopheline fauna, their resting density, and their seasonal variations.

Anopheles gambiae s.l. and *Anopheles funestus* s.l. were found as major vectors and represent, respectively, 59.9 percent and 39.0 percent of anophelines collected (N = 11,156) from November 2013 to July 2014. Other *Anopheles* species combined account for about 1.1 percent.

Entomological data from PSC indicated an increase in the indoor resting density of *Anopheles gambiae* s.l. during this reporting period in Mabayi with 4.3 mosquitoes per house per day followed by Mpanda (3.75), Kiremba (3.5), Gashoho (3.2), Cankuzo (2.1) and Gihofi (0.4). *Anopheles funestus* s.l. was more localized in Gihofi, Gashoho, and Mabayi with average indoor resting densities of 7.15, 5.6, and 3.25, respectively. *Anopheles funestus* density was less than one in other sites.

Data from CDC light traps showed that *Anopheles gambiae* s.l. was more active in the sites of Cankuzo and Mpanda with an average of 20.8 and 11.75 mosquitoes, respectively, per CDC light trap per night. In other sites, the density was lower than four mosquitoes per trap per night: Mpanda (3.65), Kiremba (3.2), Gashoho (3.1), and Gihofi (1.25). Data from light traps also showed the endemicity of *Anopheles funestus* s.l. In Gihofi, Mabayi, Cankuzo, and Gashoho *An. funestus* density was 14.25, 5.3, 5.3, and 5.25 mosquitoes per trap per night, respectively.

Tests performed on the insecticide susceptibility of the populations of *Anopheles gambiae* s.l. in six sites showed a good sensitivity to organophosphates (malathion 5%) and carbamates (bendiocarb 0.1%). The pyrethroids (deltamethrin 0.05%) were effective in only one site, Mabayi. *An. gambiae* s.l. have shown a high resistance to organochlorines in most of the sites.

TABLE 2. INSECTICIDE SUSCEPTIBILITY TESTS CONDUCTED ON *AN. GAMBIAE* S.L. IN SIX SITES USING WHO (2013) PROTOCOL

Insecticides / Test Sites	DDT 4% (OC)	Delatmethrin 0.05% (PY)	Permethrin 0.75% (PY)	Malathion 5% (OP)	Bendiocarb 0.1% (C)
Kiremba (Ngozi)	80 % [72-88]	83 % [72-92]	56 % [44-80]	100 %	100 %
Gashoho (Muyinga)	16 % [14-18]	92 % [88-96]	-	100 %	99 % [98-100]
Cankuzo (Cankuzo)	3 % [0-8]	53 % [40-64]	-	100 %	95 % [92-100]
Mpanda (Bubanza)	97 % [92-100]	89 % [76-96]	94 % [92-96]	100%	89 % [84-96]
Mabayi (Cibitoki)	32 % [16-48]	100 %	-	100 %	100 %
Gihofi (Rutana)	85 % [80-92]	85 % [76-92]	-	100 %	100. %

Mosquito samples from each collection method and susceptibility tests were also sent to South Africa for further molecular analysis.

PROGRAM HIGHLIGHTS

AIRS assisted in purchasing local and international supplies needed to optimize entomological surveillance activities. The AIRS Burundi Entomologist assisted the NMCP in the coordination of entomological surveillance activities and in the strengthening of local expertise. He also contributed to the management of the budget and represented Abt Associates in meetings of partners involved in the fight against malaria in Burundi.

With the FY 2014 funds, AIRS Burundi will continue to improve national entomology capacity and support the collection of entomological data to complete a set of data that will establish a clear baseline from which to work in the coming years.

CHALLENGES AND LESSONS LEARNED

- Insufficient number of technicians in relation to the workload: To conduct field activities planned monthly, one must have at least eight technicians (divided in two teams) properly trained in the sampling and the identification of mosquitoes. The number of technicians assigned to field activities in the framework of this project is often lower than the required number. Moreover, the level of skills of the technicians remains variable; some require additional support to reach an acceptable skill level necessary to undertake entomological field activities.
- Inadequate budget compared to the needs of entomological surveillance activities: The needs assessment conducted by the NMCP to strengthen the capacity of entomological surveillance at all levels of the health system exceeds the current commitments of partners.

1.4 DEMOCRATIC REPUBLIC OF THE CONGO

PROGRAM HIGHLIGHTS

Malaria accounts for an estimated 40 percent of outpatient visits by children under five and 19 percent of the overall mortality in children under five. Long Lasting Insecticide-treated Nets (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. With an increase in the 2014 entomological monitoring budget, this expanded to seven sentinel sites. The work includes PSC, human landing catches (HLC), and insecticide susceptibility testing.

This report includes data for the three collection seasons; the February/ March collections are included as a result of the data not being incorporated in the previous semi-annual report. The PSC and HLC collections were carried out in seven sentinel sites (Tshikaji, Mikalayi Lodja, Kapolowe, Fungurume, Kingasani, and Kisangani) in February/March, April/May, and July/August 2014. A total of 5,437 mosquitoes were captured using the PSC method. *An. gambiae* s.l., *An. funestus*, and *An. paludis* were the only *Anopheles* species collected, representing 39.2 percent of the total collection (2,133/5,437) of PSC. Out of the total 2,133 *Anopheles* mosquitoes from PSC, the most abundant species was *An. gambiae* s.l. (92.9%). Out of 1,981 *An. gambiae* s.l. captured, the highest number (41%) were caught from Kabondo, followed by Kapolowe (19.4%), Tshikaji (13.9%), Lodja (10.8%), Kingasani (9.2%), Mikalayi (5.9%), and Fungurume (0.3%). *Anopheles paludis* was the second most abundant (7%; 149/2133) of the total *Anopheles* species. *An. paludis* was collected only from Lodja (96%, 143/149), and Tshikaji (4%, 6/149) sentinel sites. *An. funestus* was the least prevalent (0.1%; 3/ 2133), and was found only in Tshikaji and Mikalayi sites during the July/August collection season.

Out of the total 21,610 mosquitoes collected by the human landing catches (HLC) indoor and outdoor, 5,421 (25.1%) were *Anopheles* mosquitoes. *An. gambiae* s.l., *An. paludis*, and *An. funestus* comprise 51.5, 46.9, and 1.1 percent, respectively, of the total *Anopheles* mosquitoes collected by the HLC in the sentinel sites. Other *Anopheles* collected include *An. nili*, *An. moucheti*, *An. tenebrosus*, *An. zimannie* and *An. rufipes*. Overall, 51.6 percent and 48.4 percent of *An. gambiae* s.l. were collected indoors and outdoors, respectively. Variability in the tendency of *An. gambiae* s.l. to either feed indoors or outdoors was observed with different collection months. Overall, a higher exophagic tendency of *An. gambiae* s.l. was observed for Lodja, Tshikaji, and Kingasani sentinel sites. However, *An. gambiae* s.l. in Kabondo and Mikalayi tends to feed indoors (endophagic). Only three *An. gambiae* were collected from Fungurume, and therefore it was not possible to see any clear trend. *Anopheles paludis* was also collected by the HLC in all sentinel sites except in Kingasani site. 62.5 percent and 28.9 percent were from Lodja and Kapolowe, respectively, with the remainder from the other sites. The vector was primarily feeding outdoors in all the sites. However, *An. paludis* tended to feed indoors in Lodja and Kapolowe sites in April/May and February/March collection seasons, respectively. The peak biting periods of both *An. gambiae* s.l. and *An. paludis* were also varied by sites and collection months. This might be due to climatic and environmental factors. Late peak biting (5 a.m.-6 a.m.) was observed for *An. gambiae* s.l. both indoors and outdoors in the July/August collection season at Mikalayi sentinel site. *Anopheles paludis* showed early peak biting (7 p.m.-8 p.m.) in the same collection season at Lodja sentinel site. This could be a challenge for the effectiveness of LLINs in the areas.

The susceptibility of *Anopheles gambiae* s.l. was determined for pirimiphos-methyl, bendiocarb, deltamethrin and DDT insecticides using the WHO tube tests in all the sentinel sites, except Fungurume site where *An. gambiae* s.l. is very rare. The vector was susceptible (98-100 percent mortality after the 24-hour holding period) to pirimiphos-methyl, bendiocarb, and deltamethrin insecticides, but was resistant (13-45 percent mortality after the 24-hour holding period) to DDT in all the sentinel sites.

1.5 ETHIOPIA

TABLE 3. AIRS ETHIOPIA AT A GLANCE

Number of districts sprayed by PMI-supported IRS in 2014	36 districts in the Oromia region
Insecticides	Carbamates
Number of structures sprayed by PMI-supported IRS	667,236
Number of structures targeted by PMI-supported IRS	670,303
2014 spray coverage	99.5%
Total population protected by PMI-supported IRS Pregnant women protected Children under five years old protected	1,647,099 23,919 230,862
Dates of PMI-supported IRS campaign	August 13 through September 25, 2014
Length of campaign	44 days
Number of people trained with USG funds to deliver IRS*	2,886

Note: *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

Through the end of September 2014, the AIRS project continued entomological monitoring activities for all PMI primary indicators in Ethiopia. During the spray campaign, August and September, the project conducted wall bioassay tests to assess quality of spray operations two to five days after spraying. Entomological surveillance continues to be of significant importance, as AIRS Ethiopia measures the quality of spraying in the conventional district-based (DB) IRS areas, and in the expanded community-based (CB) IRS districts. Forty-eight houses from four districts (two CB IRS and two DB IRS districts) were selected for quality testing. Overall, AIRS Ethiopia noted mosquito mortality was 100 percent in 43 structures out of the 48 structures sampled. There was no difference between the CB and DB IRS spray areas.

AIRS assessed susceptibility of the main malaria vector in Ethiopia, *An. gambiae* s.l., against 11 World Health Organization Pesticide Evaluation Scheme (WHOPES)-approved insecticides for IRS use. Testing in four of the eight fixed sites was completed by September 30, 2014. Test results suggest that there was little or no change in susceptibility levels as compared to last year. The 2014 resistance data from 2 sentinel sites indicated:

- Complete resistance of the vector to DDT (6 percent test mortality)
- Resistance to all pyrethroids tested (11-55 percent test mortality)
- Full susceptibility to propoxur (100 percent test mortality) in both sites (Chewaka and Omonada districts)
- Full susceptibility to bendiocarb (100 percent test mortality) in one site (Chewaka) and resistance to bendiocarb in the second site, Asendabo town) (76 percent test mortality)
- Full susceptibility to pirimiphos-methyl and fenitrothion (100 percent test mortality)
- Test mortality to malathion was 73 percent and 94 percent in Omonada (Asendabo town) and Chewaka, respectively.

PROGRAM HIGHLIGHTS

AIRS successfully carried out IRS in 36 districts during August and September 2014. Additionally, AIRS Ethiopia provided technical and logistical support to 24 PMI-graduated districts in the eastern part of Oromia region. This support included an IRS micro-planning meeting with 55 district, zonal, and regional health staff and providing PPE and spray pump parts. AIRS Ethiopia also supported the IRS operation of these districts with 600 boxes (72,000 sachets) of carbamates procured by PMI.

In 2014, AIRS Ethiopia continued CB IRS in the same six districts as in 2013. The CB spray model continues to rely on health extension workers who are trained to plan and conduct spray operations. AIRS Ethiopia will produce an evaluation report regarding the 2014 CB spray operations in the six districts before the end of 2014.

Per PMI's request, in the spring of 2014 AIRS Ethiopia prepared a work plan on disposal of 80 tons of obsolete and waste DDT accumulated in 60 districts that PMI supported at different points in time since 2008. However, the implementation of the plan was put on hold because the selected incineration facility in South Africa did not meet required EC specifications after the project inspected the plant. During the reporting period, the team reached out to other companies across the globe to identify an alternative incineration partner. Another outstanding issue with implementing the disposal process is to identify a central storing facility near Addis Ababa. PMI Ethiopia and the AIRS Ethiopia team are negotiating with the Federal Ministry of Health on a mutually acceptable option.

CHALLENGES AND LESSONS LEARNED

- Some operation sites were inaccessible at the beginning of the operation due to heavy rains and bad roads. Spray operators in some districts had to work from accessible operation sites until roads improved or were forced to walk long distances.
- Competing priorities of district health offices created delays with the start of operations in some districts. This was particularly relevant in seven districts in West Wellega zone where the start was delayed by nine days from the original schedule.
- Network connectivity was a problem in several districts, and thereby delayed some of the spray data reporting. Data entry clerks had to drive to places with better internet connectivity to send reports to the M&E manager.

Collection and analysis of boot sizes data from the 2013 spray personnel helped significantly to inform the procurement and reduce the boot size issue in the 2014 campaign.

1.6 GHANA

TABLE 4. AIRS GHANA AT A GLANCE

Number of districts sprayed by PMI-supported IRS	4 districts: Bunkpurugu Yunyoo, East Mamprusi, Savelugu Nanton, West Mamprusi
Insecticides	Organophosphate (Actellic 300 CS)
Number of structures sprayed by PMI-supported IRS	205,230
Number of structures targeted by PMI-supported IRS	244,799
Spray coverage	83.8%
Total population protected by PMI-supported IRS Pregnant women protected Children under five years old protected	570,572 12,538 105,983
Dates of PMI-supported IRS campaign in 2014	April 14 to May 31, 2014
Length of campaign	36 days
Number of people trained with USG funds to deliver IRS*	750

Note: *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

Entomological monitoring was conducted in two of the four districts sprayed during the 2014 IRS campaign (Savelugu-Nanton and Bunkpurugu-Yunyoo districts) 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 for Medical Research (NMIMR) showed reduced vector density, biting rates and parity in the IRS districts. Also, monthly insecticide decay rate bioassays conducted so far showed sprayed insecticides remained efficacious in killing local vectors throughout the end of this reporting period. The decay rate will continue to be monitored until mortalities fall and stay below the acceptable threshold (80%).

Anopheles gambiae s.l. made up 96.88 percent and *An. funestus* made up only 1.21 percent of the total *Anopheles* mosquitoes collected during the reporting period. Other *Anopheles* species collected were *An. nili* (1.41%), *An. rufipes* (0.23%), and *An. pharoensis* (0.26%).

Results obtained from the pyrethrum spray catches showed that the unsprayed comparison districts recorded relatively higher vector densities than the aggregate for IRS districts. The mean density of malaria vectors (*An. gambiae* s.l. and *An. funestus*) per room in the IRS areas was relatively lower than in the control districts. The average room densities for the two IRS districts, Bunkpurugu-Yunyoo and Savelugu-Nanton, were 0.65 and 0.14 mosquitoes/room/night, respectively, compared to 0.84 and 2.84 for Tolon-Kumbungu and Tamale, the unsprayed districts.

Biting activity of *Anopheles gambiae* s.l. and *An. funestus* collected remained unchanged as in the previous year. Biting started after 6:00 p.m. and peaked between 11 p.m. and 4 a.m. However, the biting rates of *An. gambiae* s.l. and *An. funestus* were relatively higher for unsprayed districts. The biting rates recorded for Bunkpurugu-Yunyoo district and Savelugu-Nanton district (where IRS was conducted using Actellic CS) were 1.54 bites/man/night (b/m/n) and 3.39 b/m/n, respectively, compared to 12.77 b/m/n and 19.93 b/m/n recorded for Tolon-Kumbungu and Tamale, the unsprayed districts.

A comparison of the proportion of parous females obtained from each district showed a significant difference between IRS districts (the mean parity for the two IRS districts was 26.3 percent) and non IRS districts (Tamale metropolis with a mean parity rate of 71.1 percent and Tolon-Kumbungu district with a mean parity of 65.5 percent). No significant difference existed in the mean parity rates of mosquitoes collected from the two non-intervention areas.

World Health Organization (WHO) wall bioassay tests were used to assess both the quality of spraying during the IRS campaign and the residual life of the insecticide after spraying. Results from the bioassays indicated high-quality spraying and strong performance of the insecticide, with 100 percent mortalities among the three main types of wall surfaces— wood, cement, and mud within two weeks of spraying.

Cone bioassay tests conducted through September 2014, which exposed susceptible mosquito colonies as well as wild mosquitoes of known ages to the organophosphate-sprayed walls, showed high test mortality rates. The residual life of the sprayed organophosphate insecticides remains higher than the 80 percent acceptable threshold five months after the walls were sprayed. In tests that used a susceptible Kisumu strain of *An. gambiae*, average test mortalities five months post-IRS on cement, mud, and wood surfaces were 96.7 percent, 95.8 percent, and 98.9 percent, respectively. Bioassays using field-collected wild *An. gambiae* s.l. of known ages also recorded average mortalities of 90.0 percent, 89.7 percent, and 90.0 percent for cement, mud and wood surfaces, respectively (five months post-IRS). Control mortalities ranged from 0.0 to 20.0 percent.

To test for insecticide resistance, *An. gambiae* s.l. collected from the sprayed areas in Savelugu Nanton and Bunkpurugu Yunyoo were tested against alphacypermethrin (0.5%), etofenprox (0.5%), pirimiphos-methyl (0.25%) and bendiocarb (0.1%) using WHO tube tests. The tests conducted so far show that the *An. gambiae* s.l. from the IRS areas are still susceptible to pirimiphos-methyl (98%-100) but are resistant to permethrin (52%-56%) and etofenprox (33%), and possiblly resistant to alphacypermethrin (92-98%). The mosquitoes were also susceptible to bendiocarb (99%), except in one site where the vectors showed possible resistance (96% mortality).

PROGRAM HIGHLIGHTS

In 2014, AIRS Ghana 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 36 days. The 2014 IRS campaign started on April 14th and ended on May 31st. While the number of seasonal staff, such as spray operators, increased during the shorter spray period, the number of vehicles stayed the same and they were used more efficiently, by making multiple trips per day. Supervision levels for spray operators remained the same to assure high spray quality. This was accomplished by increasing the total number of supervisors to maintain the ratio of one supervisor for every five spray operators. Spray operator coverage reporting was monitored on a daily basis in order to closely track structures that needed additional visits.

Local temporary staff were recruited and trained for the 2014 spray operations well before the start of the campaign. Logistics and environmental compliance assessments were carried out to ensure that the standard operating procedures and Best Management Practices (BMP) were followed. Stakeholder, partner planning, and community 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 244,799 structures were targeted to be sprayed in four districts, Bunkpurugu Yunyoo, East Mamprusi, West Mamprusi, and Savelugu Nanton, which had a targeted total population of 637,370. Spraying began on April 14th in all four districts and ended on May 17th in Bunkpurugu Yunyoo and on May 31st in West Mamprusi, East Mamprusi and Savelugu Nanton. During the spray period, 205,230 (83.8%) of the targeted structures were sprayed, protecting 570,572 people, including 12,538 pregnant women and 105,983 children under 5 years old.

PMI through AIRS Ghana has been supporting the National Insecticide Resistance Monitoring Partnership (NIRMOP). This is a partnership that brings together researchers and partners within Ghana to generate and monitor insecticide resistance data in the country. In 2013, PMI supported training of biologists and technicians in basic entomology in all 10 regions of Ghana. The training, which aimed to train field personnel to assist in the entomological monitoring activities, was part of the strategy by PMI and the NMCP to establish insecticide resistance monitoring across the country.

Between June and August 2014, PMI supported the NIRMOP through the provision of funds to be used by the field workers to conduct larvae collections, rearing of mosquitoes, and resistance testing with all four WHO-approved classes of insecticides for IRS.

CHALLENGES AND LESSONS LEARNED

AIRS experienced low IRS coverage in three districts, especially Savelugu Nanton district, which had a coverage rate of 68%. The spray coverage was 84.9% in West Mamprusi, 87.3% in East Mamprusi, and 92.7% in Bunkpurugu Yunyoo. The team worked hard to ensure that acceptance for IRS and coverage improved in the districts. One of the strategies used was to generate daily reports for communities and compounds with low coverage (coverage less than 90 percent). The reports were used by district teams to revisit plans and follow-up on specific compounds to ensure that revisits were effective. AIRS Ghana also worked with several different stakeholders at different levels to enhance and strengthen IEC activities. AIRS Ghana also engaged more mobilizers and packers and effective collaboration with the regional and district health directorates helped to improve spray coverage.

Ethnic conflicts in some parts of East Mamprusi District affected spray operations; as a result, Shisha community in Sakogu sub-district was not sprayed. At the time of mobilization and spraying, the community was burnt down and residents had fled the community.

During the 2014 IRS campaign, it was observed that having women who were employed in previous spray campaigns in positions that were perceived to be male-dominated (especially as spray operators and team leaders) participate in outreach programs is an effective way of encouraging more women to participate in IRS activities. Also, using men who have been employed in positions that are perceived as female-dominated (washers and water fetchers) for outreach programs will also help demystify the confusion surrounding the roles that males and females can play on IRS activities. IEC/BCC activities should be intensified during the next spray campaign. More women and women's groups should be involved in the dissemination of IEC/BCC messages and men should be encouraged to effectively participate in the preparation of households (i.e. helping with the packing out of household effects) for spray operations.

1.7 LIBERIA

ENTOMOLOGY

Entomological monitoring was carried out in two sentinel sites. One of the sites, Tomato Camp, was sprayed in 2013 but was not sprayed in 2014 and the other site, Frank Town, was last sprayed in October 2012.

PSC, HLC, and CDC light trap collections were carried out during the reporting period in both sentinel sites. Human landing catches were carried out in one house per month (April-June 2014) at both sentinel sites. A total of 147 and 144 *Anopheles* mosquitoes were collected from the human landing catches from the indoor collection and outdoor collection, respectively, at the Frank Town sentinel site. In the Tomato Camp sentinel site, 30 and 12 *Anopheles* mosquitoes were captured indoors and outdoors, respectively.

CDC light trap collections were carried out in five houses, both indoors and outdoors, in May and June 2014 at both sites. A total of 35 and 118 *Anopheles* mosquitoes were collected indoors and outdoors, respectively, at the Frank Town sentinel site. In Tomato Camp, only 28 and 3 *Anopheles* mosquitoes were collected from indoor and outdoor traps, respectively. Pyrethrum spray collections were done each month in 10 houses in May and June 2014 in both sentinel sites. The indoor resting density was 8 and 4 *Anopheles* mosquitoes per room per day for Frank Town and Tomato Camp, respectively.

Insecticide susceptibility tests were conducted against *An. gambiae* s.l. mosquitoes collected from breeding habitats in Nimba Point, Parker's Corner, Bokay and Zwedru villages of Cape Mount, Monrovia, Grand Basa and Grand Gedeh Regions. The tests were conducted between May and July 2014 using the WHO tube test. DDT was tested in all the sentinel sites and *An. gambiae* s.l. was resistant across all sites with mortalities between 16 an 54 percent after the 24-hour holding period. Deltamethrin and fenitrothion were tested in all the sites except Nimba Point. The vector was resistance to deltamethrin in all the sites where the tests were conducted with 46 - 78% mortality. Full susceptibility was documented for fenitrothion in Bokay and Zwedru sentinel sites with possible resistance (95% mortality) at Parker's Corner. Bendiocarb was tested in Parker's Corner and Zwedru sites and *An. gambiae* s.l. was susceptible at both locations with 99% and 98% mortality for the respective locations.

CHALLENGES AND LESSONS LEARNED

There were several challenges during this reporting period. The two main challenges were:

1. The entomology technicians were not able to begin their field work as scheduled at the beginning of the year due to competing priorities.
2. The Ebola virus disease outbreak increased in intensity and the project evacuated our TCN entomologist. Therefore, the main organizer and mentor of the entomology team was no longer in country. Delays in financial and logistical coordination to provide transport to the NMCP technicians impacted their ability to travel to the field to conduct their work.

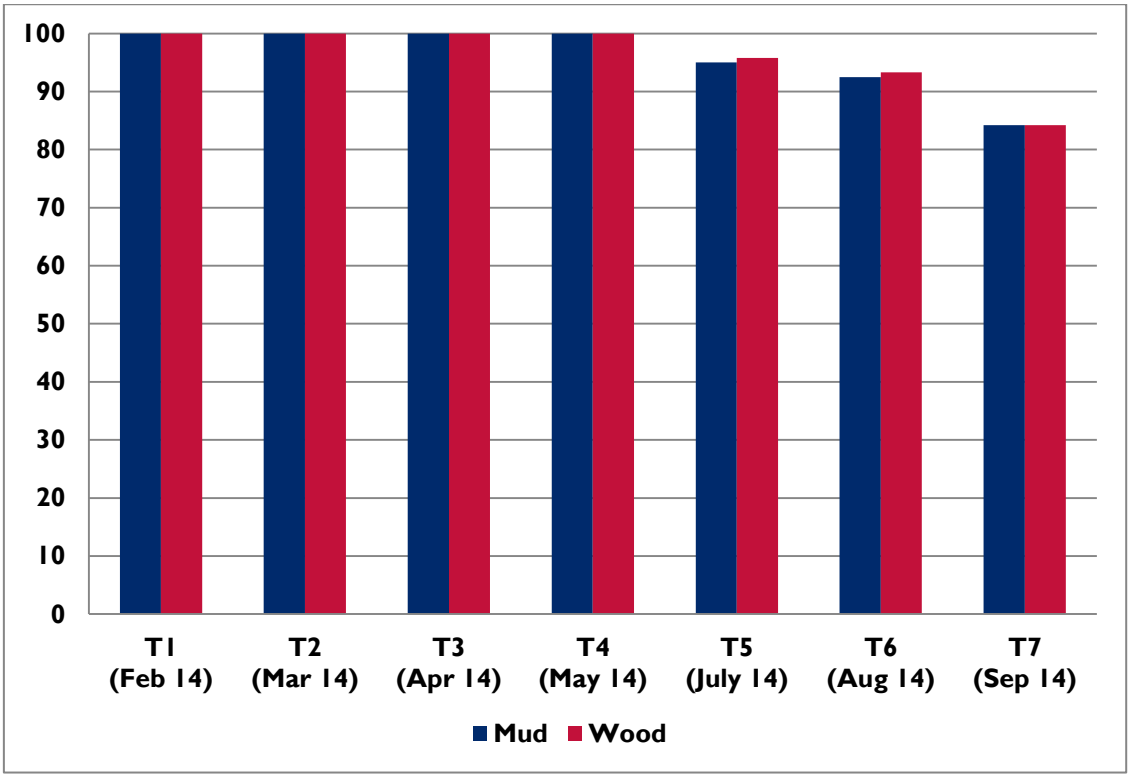
1.8 MADAGASCAR

The 2013-2014 spray campaign in Madagascar took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (October 2013-March 2014).

ENTOMOLOGY

The final entomology report for the 2013-2014 IRS campaign was submitted to PMI in July 2014. All entomological work regarding the 2013-2014 IRS campaign was completed in late May 2014, with the exception of residual efficacy data collection for the southern spray districts, which is still on-going. In September 2014, residual efficacy for the organophosphate used in the spray areas in southern Madagascar was noted as 84.17 percent for 24-hour observed mortality rate, seven months after spraying (Fig. 1). (During the first four months, the tests were performed in Ambovombe. Because of security concerns, the site was replaced with another (Ejeda), which was at T5 in July, 2014).

FIGURE 1. RESIDUAL EFFICACY OF PIRIMIPHOS-METHYL 300 CS, IN SOUTHERN MADAGASCAR FROM 1 MONTH THROUGH SEVEN MONTHS AFTER SPRAYING



Other results from the final entomology report for the 2013-2014 IRS campaign included:

- Of the 5,520 mosquitoes collected before, during, and after the 2013-2014 IRS campaign, 23.3 percent were vector species, primarily, *Anopheles gambiae* s.l., *Anopheles funestus* group, and *Anopheles mascariensis*.
- Distribution of vector species varied considerably between sentinel sites, with sentinel sites in the central highlands containing a higher number of anopheline species than sentinel sites in southern Madagascar, where *Anopheles funestus* and *Anopheles mascariensis* were more prevalent.

- Molecular analysis was completed by the Institut Pasteur-Madagascar, which noted that of the 442 *An. gambiae* s.l. mosquitoes collected and provided to the Institut Pasteur, 435 were identified as *Anopheles arabiensis*. The remaining seven mosquitoes were identified as *Anopheles merus* (all were collected at the Behara sentinel site in southern Madagascar). The ELISA test did not identify any of the 442 mosquitoes as infected by sporozoites.
- Residual efficacy for pyrethroids (sprayed in the central highlands), fell below 80 percent for mud and wood walls five months after spraying. Residual efficacy for carbamates (sprayed in central highlands) fell below 80 percent for mud walls five months after spraying; and fell below 80 percent for wood walls four months after spraying. As noted above, eight months after spraying, organophosphates (sprayed in southern Madagascar) remain effective.
- Susceptibility testing and man biting rates did not differ from the data listed in the previous semi-annual report (October 2013-March 2014).

In August, AIRS Madagascar completed work to set-up three sentinel sites in the east coast spray districts (Ambodifaho in Brickaville District, Mahambo in Fenerive Est District, and Vohitrambato in Toamasina II), and a control site in Vavatenina in Vavatenina District, the non-spray district bordering the three east coast spray districts.

Baseline data collection:

- *An. gambiae* s.l., *An. funestus*, and *An. mascariensis*, the three malaria vectors for Madagascar, were found in Toamasina II (Vohitrambato).
- In the two other sites (Brickaville and Mahambo/Fenerive Est), *An. funestus* was absent during this investigation, while *An. gambiae* s.l. and *An. mascariensis* were found.
- The vectors collected in the three sites have an exophagic tendency.
- Indoor resting density was very low (0 through 0.3mosquitoes per house per day).

Some previously published studies showed that *An. gambiae* s.l. found in the east coast of Madagascar had endophagic and endophilic tendencies. The present results may suggest either a change in resting habit or a change in the species composition of *An. gambiae* s.l.; this could be due to the LLIN mass distribution that was implemented there. All the vectors are preserved for PCR species identification and ELISA for sporozoite detection.

Cone bioassay for IRS quality assessment:

Overall, the bioassay results revealed that the quality of spraying was good (100% test mortality) during the first week of the IRS campaign in Eastern Madagascar and that the insecticide used during the IRS campaign is effectively killing mosquitoes.

PROGRAM HIGHLIGHTS

The EOSR for the 2013-2014 IRS campaign was completed on May 13, 2014, and approved by PMI in August 2014. The 2014 work plan for Madagascar was completed on April 2, 2014, and approved by PMI in July 2014.

During the past six months, AIRS Madagascar focused on preparing for the 2014 IRS campaign. The 2014 IRS campaign covers several new spray areas, including a pilot spray campaign in three districts on the east coast of Madagascar (Brickaville, Fenerive Est, and Tamatave II), where malaria transmission is perennial. The spray campaign in the east coast districts started on September 3, 2014, and ended November 6, 2014, targeting 160,000 structures found during enumeration. Additionally, AIRS Madagascar will continue with targeted spraying in the central highlands during the 2014 IRS campaign (November 3-December 12); however, AIRS Madagascar will spray several new districts, including Fandriana, Faratsiho, Finanaratsoa II, and Manandriana.

Given that AIRS Madagascar will not spray southern Madagascar in 2014, the project closed its office in Fort Dauphin and its warehouse in Ambovombe in July 2014. All equipment and insecticide in the former Ambovombe warehouse was transported to AIRS Madagascar's new warehouse in Tamatave.

AIRS Madagascar completed enumeration of all eligible structures in the new IRS districts in the east coast and central highlands spray areas in June 2014. This provided AIRS Madagascar the exact number of eligible structures targeted for the 2014 IRS campaign and information on the terrain of the spray areas, allowing the team to plan for river crossings, understand the location of communities only accessible via footpaths, and determine which areas would necessitate the use of mobile soak pits.

Since the US government changed its policies in 2014, allowing USAID-funded projects to work with Malagasy government officials, AIRS Madagascar held a regional planning meeting for IRS in the east coast districts with the NMCP and provincial and district government officials in August 2014. The meeting helped gain buy-in from government officials on the IRS campaign, develop a schedule for the IRS campaign, coordinate IRS communication efforts between AIRS Madagascar and government officials, and outline how government officials can contribute to IRS campaign supervision.

Other preparation work for the 2014 IRS campaign completed includes the hiring and training of all seasonal IRS campaign staff, procuring all insecticide and PPE for spraying the east coast and central highlands districts, and completing pre-spray environmental compliance assessments to identify issues with soak pits and store rooms to assure they meet BMP standards before the start of the IRS campaign.

AIRS Madagascar also initiated a pilot operations data collection system with Dimagi, a global IT specialist. Similar to the pilot completed during the 2014 IRS campaign in Senegal, seasonal IRS campaign staff, namely sector coordinators, send in data on the number of structures targeted and sprayed, and the number of bottles of insecticide used in the area they supervise, daily. This data is compiled via a cloud-based database that is shared with all project staff in order to provide a status report of IRS campaign progress and insecticide usage rates. The pilot is currently being implemented in the east coast districts where difficult terrain makes it difficult for the spray data forms to arrive at the data centers on a daily basis. AIRS Madagascar will use the same system, with Dimagi, for the IRS campaign in the central highlands.

In September AIRS Madagascar received approval from PMI for their epidemiological data collection protocols. Under the protocols, AIRS Madagascar will work with the PASSOBA health system strengthening project in the east to collect data from our three treatment districts and two comparison districts, Soanierana-Ivongo and Vavatenina. AIRS Madagascar will collect data from September 2014 through February 2015, in addition to retrospective NMCP data, and use this data to assess the effect of IRS on reported, confirmed malaria cases in the three new districts in the east.

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. NMCP conducted the spray operations in Salima district using a pyrethroid from March 4 to April 24, 2014 (45 operational days).

PROJECT HIGHLIGHTS

During the reporting period, AIRS Regional Operations Manager Dr. Nduka Iwuchukwu conducted two visits. The objective of the first trip in May was to supervise the post-spray EC assessment in Salima district. Dr. Iwuchukwu visited all six operational sites. Only two had cleaned and empty store rooms. None of the soak pits were properly prepared for the off-season. There was no NMCP budget for incineration of solid hazardous wastes despite several discussions and reminders. The general impression was that the NMCP, Ministry of Health, and the environmental authorities did not regard EC as a priority in the planning and implementation of the IRS campaign. Dr. Iwuchukwu provided the following recommendations to the NMCP:

1. Ensure permanent fences are put around the soak pits to prevent access to unauthorized persons and animals.

2. Ensure prompt payment of outstanding rents for the stores to enable the owners to release the IRS items that they were holding.
3. For future IRS campaigns, communities should be requested to donate community stores as part of their contribution/support for IRS activities.

During his final trip to Malawi in July, Dr. Iwuchukwu co-designed and facilitated the post-IRS evaluation conference and supported the NMCP to draft the malaria vector control strategy document.

CHALLENGES AND LESSONS LEARNED

- Significant delays in the release of budgeted funds by the government affected every aspect of the IRS operation and almost terminated the campaign abruptly due to the delay in paying spray teams, who stopped work and protested.
- The lack of a logistician in the NMCP to oversee the logistics of the IRS operations did not allow for prompt delivery of spray equipment to the sites for training and the actual operations.
- Due to the delayed start date, the NMCP conducted IRS during the rains, which slowed the pace of the operations. An inadequate number of data entry clerks (due to limited funds) caused a backlog of data. This, in turn, prevented the district managers from reviewing daily results in a timely manner and from making adjustments required to the spray operations.
- Future IRS campaigns must have budgets for incinerating hazardous solid wastes.
- The inclusion of entomological monitoring in future campaigns is vital for an objective evaluation of the quality of spray and monitoring of residual efficacy.
- The post-spray conference proved to be an effective feedback mechanism for charting the way forward and should be encouraged.

1.10 MALI

TABLE 5. AIRS MALI AT A GLANCE

Number of districts covered by PMI-supported IRS in 2014	3 districts: Bla, Barouéli, and Koulikoro
Insecticide	Carbamates (Bendiocarb) in Koulikoro Organophosphates (Actellic CS) in Bla and Baroueli
Number of structures sprayed by PMI-supported IRS	228,123
Number of structures targeted by PMI-supported IRS	233,706
2014 spray coverage	97.6%
Population protected by PMI-supported IRS Pregnant women protected Children under five years old protected	836,568 22,352 154,764
Dates of PMI-supported IRS campaign	July 15 – August 25, 2014, in Bla and Baroueli August 11 – September 19, 2014, in Koulikoro
Length of campaign	40 days
Number of people trained with USG funds to deliver IRS*	911

Note: *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

AIRS Mali implemented entomology activities as follows:

- Assessed the malaria vector species, density, and parity composition in intervention and selected control areas;
- Established vector feeding times and locations;
- Monitored the quality of insecticide application and insecticide decay rates; and
- Assessed vector susceptibility to insecticides approved for IRS and the mechanism of resistance

VECTOR SPECIES COMPOSITION, DENSITY, FEEDING TIME AND LOCATION

- AIRS Mali collected baseline data from four sentinel sites in August and July in Koulikoro and Kati districts in the Koulikoro region and Bla and Segou districts in the Segou region to assess vector species composition, density, parity, and behavior using HLC and PSC methods. *An. gambiae* s.l. was the most prevalent vector species collected from all of the sites surveyed. Vector density was calculated as the average number of *An. gambiae* s.l. collected per house per day from PSC data. The result indicated 11.2 and 4.3 *An. gambiae* s.l. per house per day for Koulikoro and Bla intervention districts, respectively. The results from the two control villages were 6.25 and 17.45 *An. gambiae* s.l. per house per day for Kati and Segou districts, respectively.
- One month after spraying, AIRS Mali collected monitoring data from four sentinel sites in August and September in Koulikoro and Kati districts in the Koulikoro region and Bla and Segou districts in the Segou region to assess the impact of IRS on vector species composition, density, parity, and behavior using HLC and PSC. *An. gambiae* s.l. was still the most prevalent vector species collected from all of the sites surveyed. Vector density per house per day from PSC data was 1.75 and 11.9 *An. gambiae* s.l. per house per day for Koulikoro and Bla intervention districts, respectively. Data from the two control villages were 5.55 and 70.55 *An. gambiae* s.l. per house per day for Kati and Segou districts, respectively. Vector density per house per day was significantly higher in the control sites as compared to the IRS target sites.
- Data on human-blood-seeking rates or human biting rates of *An. gambiae* s.l. was assessed using HLCs before IRS spraying. The human biting rate before spraying was 33 bites per person per night indoors and 24.7 bites per person per night outdoors in Koulikoro (IRS target area) and 79.2 bites per person per night indoors and 81.7 bites per person per night outdoors in Kati (the control) for *An. gambiae* s.l. Before spraying the vector seemed to be more endophagic in the intervention site compared to the control village. The same results were observed in Segou region. The human biting rate of *An. gambiae* s.l. collected indoors was 3.7 bites per person per night and it was 1.2 outdoors in Bla (IRS target area); 15.2 bites per person per night indoors and 20 bites per person per night outdoors were noted in Segou (the control) at baseline.
- One month after spraying, data from HLC indicated that were 12.7 and 26 bites per person per day of *An. gambiae* s.l. indoors and outdoors in Koulikoro (IRS target area), respectively. At the same time 74.2 bites per person per night indoors and 93.5 bites per person per night outdoors of *An. gambiae* s.l. were noted in Kati (the control site). The vector seemed to exhibit more of an exophagic tendency in both intervention and control sites. In the intervention area one month after spraying, indoor human biting rates of *An. gambiae* s.l. declined significantly compared to the baseline. The number of *An. gambiae* s.l. collected was one bite per person per night indoors and 4.2 bites per person per night outdoors in Bla (IRS target area) one month after IRS was completed. At the same time and compared to baseline a significant increase of indoor and outdoor human biting rates of *An. gambiae* s.l. were noted in Kati (the control site) 45.7 bites per person per night indoors and 49.5 bites per person per night outdoors.

QUALITY CONTROL TESTING AND RESIDUAL EFFICACY MONITORING

In 2014, a carbamate (bendiocarb) was sprayed in Koulikoro district and an organophosphate (Actellic CS) was sprayed in Baraoueli and Bla districts. At the beginning of the IRS campaign, a

quality control assessment was carried out at four sentinel sites (Tienfala and Souban in Koulikoro District, Konobougou and Banido in Baroueli District, and Touna and Tia in Bla District). *Anopheles gambiae* Kisumu strain, which is susceptible to all insecticides, was reared at the AIRS Mali insectary and used for bioassays tests, following WHO procedures. Cone bioassays were conducted in 18 randomly selected sprayed structures in the four sites within 24 hours of spraying to assess the quality of spraying and one month after spraying to determine the insecticide decay rate. The cone bioassay test results showed that 24 hours after spraying, the test mortality rates of susceptible mosquitoes exposed to the insecticide sprayed surfaces was 100 percent. One month after spraying, the average test mortality rates were 95% in Koulikoro, 99% in Baroueli and 88% in Bla.

New Generation of Long-Lasting Insecticide Nets and Piperonyl Butoxide (LLINs +PBO) Study

To determine whether detected resistance to pyrethroids has an impact on the efficacy of LLINs and if the effect can be mitigated using LLINs with synergists, the PMI AIRS Project is implementing an operational research study in Mali. The evaluation is a comparison of the performance of four different LLIN types (treatments), two conventional LLINs (Permanent 2.0 and Olyset) and two LLINs with synergists (Permanent 3.0 and Olyset Plus), using entomological indicators. This study is significant because interpretation of the correlation between frequency of resistance and operational failure is not always straightforward. In 2013, PSI Mali helped with the net distribution activities and the creation of the study database. AIRS Mali is monitoring the LLIN fabric integrity and conducting entomology activities before and after the LLIN distribution.

- The 16 eligible villages (with evidence of pyrethroid resistance associated with mixed function oxidases) from two districts, Selingue and Bougouni, were combined and randomized to receive one of the four types of study LLINs.
- LLINs were distributed in selected villages based on population enumeration for net distribution. All LLINs were tagged with a unique code provided by the study team and the GPS coordinate of each house was collected and recorded.
- The results of the study are not complete but there are some early indications that show better performance of LLINs with synergists in reducing vector longevity compared to conventional LLINs. Some of the preliminary findings are:

There was a higher survivorship rate and lower attrition rate in the LLINs with synergists. The proportion of holes was:

- Lower in Permanent 3.0 arm than Permanent 2.0 arm;
- Lower in Olyset Plus net arm than Olyset net arm;
- Lower in Permanent 3.0 arm than Olyset Plus net arm;
- Lower in Permanent 2.0 arm than Olyset net arm.

Bioassay test results with and without pre-exposure to PBO indicated a high intensity level of resistance to pyrethroids (permethrin and deltamethrin). The level of resistance observed was directly proportional to the insecticide concentration. Though the sample sizes are not equivalent, the distribution of intensity of resistance doesn't appear to be uniform among the villages where the tests were conducted.

Program Highlights

During this reporting period, AIRS Mali prepared and carried out the 2014 IRS spray campaign in the program's three targeted districts over 40 days. AIRS Mali prepared thoroughly for the IRS campaign and was able to spray 233,706 structures, protecting 836,568 people. The 2014 IRS campaign was the second time that AIRS Mali conducted the pre-campaign environmental compliance inspections using smartphones. AIRS Mali also continued to use an innovative insecticide tracking system, which included adhering an identification number to each sachet of insecticide and cataloging the sachet

identification number in an electronic database. During the IRS campaign, AIRS Mali kept track of when and where each insecticide sachet was given to a spray operator via the identification number and when the empty sachet was returned after spraying. This allowed the team to accurately keep track of where each sachet was used for spraying.

AIRS Mali implemented three pilots in 2014, a mHealth pilot, a mobile soak pit pilot, and a "taxini" pilot. The mHealth mobilization pilot was implemented to test whether mobile technology could successfully reach beneficiaries of the IRS campaigns with critical messages. After the campaign was finished, it was determined that this means of communication is key to develop efficient pre-spray and mid-spray communication methods that may be cheaper than, and just as effective as, mass mobilization efforts. The technology was used to communicate with beneficiaries before, during, and after the spray campaign. SMS and voice messages were sent to cell phone subscribers in three villages in Koulikoro to provide beneficiaries with information on the schedule of the IRS campaign, encourage people to prepare their structures (remove furniture and wall hangings), and remind them of the post-spray practices (such as waiting to enter the structure two hours after spraying). AIRS Mali is currently preparing a report with specific recommendations for sensitization for future IRS campaigns.

AIRS Mali conducted a mobile soak pit pilot project in nine sites (three sites per district) to see whether a mobile soak pit could reduce the travel time for spray operators and reduce the cost of rental vehicles and soak pit maintenance and still meet environmental and safety standards. While additional analysis is ongoing to evaluate whether the pilot saved money, it was deemed a success during the spray campaign because it reduced the spray operators' transportation time.

AIRS Mali used taxinis (motorbikes with connected carts) to reduce both fuel and rental costs in 2014. This means of transportation also facilitates access to areas otherwise inaccessible by larger vehicles. The team is currently analyzing the financial data to see if and how much money was saved using the taxinis.

Challenges And Lessons Learned

- Proper spray progress tracking is essential because if frequent rain interrupts implementation, it may be necessary to increase the duration of the spray campaign by a few days.
- E-management is a powerful tool for effective monitoring of insecticides and other equipment and it can help prevent stock outs.
- The involvement of local administrative authorities is important because it increases the success of sensitization activities and helps fight against refusals.
- The mobile soak pit and "Taxini" pilots were successful, and AIRS Mali would like to expand these activities in 2015 to other areas.

1.11 Mozambique

Entomology

Entomological activities conducted from April through September 2014 included the following:

- April through June 2014, the entomology team continued to conduct cone wall bioassays to assess the level of insecticide on the walls sprayed during the 2013 campaign. This activity was conducted until June when mortality was less than 70 percent in all villages of each intervention district, Mocuba (Samora Machel), Milange (12 de Outubro), and Morrumbala (Coqueiro).
- In June 2014, the Zambézia entomology team received technical assistance from PMI's entomologist. During this visit, two insectary staff, one from Abt and another from the government (DPS), were trained on CDC bottle assays and detection of insecticide resistance intensity and mechanism of resistance. As part of capacity building efforts, AIRS Mozambique supported the presence of technicians from Cabo Delgado and Nampula provinces to also

attend the training.

- During this period, AIRS Mozambique used PSC and HLC to assess mosquito density and biting rates, as well as impact of IRS on vector density, in three intervention sites. The density of malaria vectors was also monitored in one control site. Results obtained using PSC after spraying showed the non-IRS district recorded higher vector densities than the IRS districts from April to June. The pre-IRS indoor densities of *An. gambiae* s.l. in the control area were 0.1, 1.9, and 4 mosquitoes per house per day for the months of July, August, and September, respectively. During the same period in the intervention site the densities varied with no collection in Mocuba and Morrumbala and very low collection in Milange (0, 0.4 and 0.2) when compared with the control. For *An. funestus* s.l. the pre-IRS density in the control site was 2.2, 4 and one mosquitoes per house per day for July, August, and September, respectively. In Milange the densities were 1.7 and 0.6 in July and August and 0.1 in September. In Morrumbala and Mocuba the densities were zero in the same period (no collection). In the intervention sites the densities were low when compared with the control site. During this period the malaria vector density should be lower as there is no rain and the breeding sites are reduced to riverbanks. Entomological monitoring should be continued to understand whether low densities during this period in the intervention sites is a cumulative impact of IRS or a natural tendency of the malaria vector in each area.
- Data from the HLC collections indicated that after the 2013 spray campaign both *An. gambiae* s.l. and *An. funestus* s.l. showed a tendency to feed outdoors in IRS districts. During the same period in the control site, the tendency of both species was to feed indoors. The HLC data from July to September continues to show the tendency of the vector to feed indoors in the control area. The same analysis is difficult to do in the intervention areas (Mocuba and Morrumbala) because of the low number of mosquitoes. Even with a low number of mosquitoes in Milange, where we still find more mosquitoes when compared with other intervention sites, we still see a slight tendency of feeding indoors, *An. gambiae* s.l. peak biting time was from 2:00 a.m. to 3:00 a.m. and *An. funestus* from 8:00 p.m. to 9:00 p.m.
- AIRS Mozambique's entomologist moved to Maputo to increase collaboration with the NMCP entomology staff. To date, the collaboration has been extremely fruitful, resulting in an entomology monitoring plan, including the costs associated with establishing an insectary that will be used by the NMCP as a guide to all provinces where IRS is conducted by the NMCP. AIRS Mozambique's entomologist worked closely with the INS (Instituto Nacional de Saúde/ National Institute of Health) on processing the HLC samples collected on the last IRS round for PCR identification.
- During this period, Abt supported the NMCP entomology activities throughout the country in 17 sentinel sites. The NMCP is conducting susceptibility tests to monitor insecticide resistance, cone wall bioassays to monitor insecticide decay rates, and pyrethrum spray catches to assess the densities and species of the malaria vector. All material, equipment, per diem, and fuel was supported by AIRS Mozambique.

PROGRAM HIGHLIGHTS

During the MOP visit in May/June 2014, it was agreed that the total number of districts to be sprayed with PMI funding in 2014 would increase from four to five and the methodology of partial coverage would not be implemented in 2014. The selected districts for the 2014 spray campaign include Milange, Morrumbala, Mocuba, Mopeia, and Quelimane. Once this decision was made, AIRS Mozambique focused on planning activities for the 2014 IRS campaign, ranging from the organization of the micro-planning meeting at the provincial level to local and international procurements. AIRS Mozambique trained more than 1,500 people, including spray operators, IRS supervisors, data clerks, pump technicians, washers, storekeepers, and guards in preparation for the October 20th launch. In September the project received donated insecticide from the NMCP, as well as insecticide purchased via Abt Headquarters with PMI funding.

Additionally, during this time period, AIRS Mozambique submitted the Enhanced Epidemiological Surveillance Semi-Annual Report covering the period of February 2013 through May 2014. The report included key observations, challenges, and recommendations for improving the epidemiological surveillance activity. AIRS Mozambique is working closely with the DPS to address the challenges faced to date and will report on progress in the next semi-annual report, which will cover June 2014 through November 2014 and will be submitted in January 2015.

Also during this period, AIRS Mozambique conducted a provincial/district level IRS capacity assessment exercise in Quelimane, which resulted in a consensus among the DPS, SDSMAS, and AIRS Mozambique on key areas requiring capacity building efforts in the future.

CHALLENGES

- The amount of insecticide donated by the NMCP for the AIRS Mozambique project was not enough to cover the established 100 percent spray coverage rate and the 20 percent insecticide buffer rate that Abt establishes as best practice for a spray campaign. After several discussions with PMI and the NMCP, it was decided that further insecticide would not be donated from the MOH and therefore Abt initiated insecticide procurement.
- AIRS sent the donated insecticide to the South African Bureau of Standards (SABS) lab for quality testing in August. Initial results indicated that only four out of the 21 batches that were tested passed with respect to WHO specifications. Results from previous testing conducted by Global Fund through the Belgium lab, Walloon Agricultural Research Centre (CRA-W), however, indicated that all batches complied with specifications. Both labs discussed the methods used in their respective testing, and it was concluded that SABS had utilized the wrong testing method for the WG (water dispersible formulation) Deltamethrin in question. SABS re-tested the batches using the correct method and found that in fact all of the samples passed specifications.

1.12 NIGERIA

Between March and September 2014, the project collected a total of 18,677 *Anopheles* mosquitoes at the six sentinel sites using human-baited CDC light trap (indoor and outdoor) and PSC methods. Those collected belong to about 12 anopheline species, which include 15,503 (83.01%) *An. gambiae* s.l., 1,560 (8.35%) *An. funestus*, 1274 (6.82%) *An. coustani*, 27(0.14%) *An. squamosus*, 135(0.72%) *An. nili*, 94(0.50%) *An. pharoensis*, 53 (0.28%) *An maculipalpis*, and 7 (0.04%) *An. rufipes*. The predominant malaria vector in all the areas is *An. gambiae* s.l.

- In Plateau, Jigawa, and Rivers sentinel sites, the project collected a higher number of mosquitoes (per trap per night) indoors as compared to outdoors using the CDC light traps. In contrast, the outdoor collections were higher for Enugu, Lagos, and Nasarawa sentinel sites. The total numbers of *An. gambiae* s.l. (per trap per night) indoors were 95.3, 222.2, 38.2, 26.8, 80.8, and 213 for Enugu, Plateau, Rivers, Jigawa, Lagos, and Nasarawa sentinel sites, respectively. The total numbers of *An. gambiae* s.l. per trap per night outdoors were 103.5, 93.3, 19.3, 6.5, 97.7, and 297.5 for the respective sentinel sites.
- The indoor resting density (total number per room per day) of *An. gambiae* s.l. was the highest at Jigawa (175.9), followed by Plateau (73.3), Enugu (31.3), Nasarawa (30.4), Rivers (17.4), and Lagos (12.6) sentinel sites.

The project also conducted susceptibility tests of *An. gambiae* s.l. to permethrin, deltamethrin, alphacympermethrin, lambdacyhalothrin, propoxur, bendiocarb, DDT, and primiphos-methyl insecticides using the WHO and CDC bioassay methods. *Anopheles gambiae* s.l. was susceptible to carbamates (bendiocarb and propoxur) across all the sentinel sites. Mosquitoes were susceptible to alphacypermethrin in Plateau. They were also susceptible to lambdacyhalothrin using the CDC bottle bioassay in Plateau. Possible resistance or confirmed resistance was observed to the rest of the insecticides, especially DDT. Possible resistance of *An. gambiae* s.l. against deltamethrin was suspected in Plateau and Lagos States. Resistance was also recorded against permethrin and

alphacypermethrin in Plateau and Lagos States, respectively, using WHO tube bioassays. With CDC bottle bioassays, possible resistance was recorded against deltamethrin and permethrin in Plateau and Nasarawa sites, respectively, while the same was recorded against lambdacyhalothrin in Rivers and Nasarawa sites. It is interesting to note that local mosquitoes were found to show high resistance against pirimiphos-methyl, an organophosphate class insecticide, with the exception of Lagos sentinel site. This could be because the formulation is present in the agricultural insecticides, which farmers use in high doses. Further molecular tests might be needed to confirm this trend. The quality of impregnated papers received from the WHO collaboration center and technical grades of primiphos-methyl received from CDC will be assessed soon.

Due to the high level of DDT and deltamethrin resistance previously reported at the Nasarawa and Lagos sentinel sites (unpublished), the project conducted laboratory analyses of knockdown resistance (kdr) and biochemical resistance mechanisms in *An. gambiae* s.s. from sentinel sites of the Guinea Savannah of north central Nigeria (Nasarawa State) and the coastal mangrove of southwestern Nigeria (Epe, Lagos). The analysis identified the kdr mutation as the principal resistance mechanism at Epe and Nassarawa Eggon. Neither *Anopheles* population showed increased levels of metabolic enzymes when compared to the reference susceptible Kisumu strain of *Anopheles gambiae* s.s. Biochemical enzymes were therefore not implicated in deltamethrin and DDT resistance at either site.

PROGRAM HIGHLIGHTS

AIRS Nigeria generated local evidence across the six sentinel sites to guide vector control interventions. The project also collected hospital-based retrospective malaria incident data for the years 2011-2014 to correlate peaks of malaria cases with vector density in Nasarawa State. Additionally, the project held a technical review meeting with all principal investigators leading the monitoring work in PMI-supported areas and representatives from the National Malarial Elimination Program (NMEP) in September. The meeting served as a forum to review results and progress made, share lessons learned and to chart a way forward. Since early fall, the AIRS project has been assisting the NMEP to develop an Integrated Vector Management strategy for the country.

CHALLENGES AND LESSONS LEARNED

- The four technicians deployed per site for the surveillance activity proved to be inadequate. It would be ideal to increase the number to eight during the next phase of the project.
- Local guides were needed in almost all the sites and this may need to be taken into consideration during the next phase of the project.
- Since resistance could be localized, results of susceptibility tests from one site at each of the six sentinel sites might not possess enough representation to justify a policy decision by the NMEP. There is the need (subject to fund limitations) to carry out susceptibility tests at more sites across the various ecological zones. This would provide a more holistic picture of the insecticide resistance pattern across the country and would provide enough representation for the NMEP to make decisions.
- The Kano sentinel site, which was based in Kirikashama in Jigawa, proved to be too remote and had a security risk for visiting supervisors. This site is better relocated to Kano state where the collaborating institution (Bayero University) is located.

1.13 RWANDA

TABLE 6. AIRS RWANDA AT A GLANCE

Number of districts sprayed by PMI-supported IRS	3 districts (Bugesera, Gisagara, and Nyagatare)
Insecticide	Carbamates
Number of structures sprayed by PMI-supported IRS	173,086

Number of structures targeted by PMI-supported IRS	174,411
Spray coverage	99.2%
Total population protected by PMI-supported IRS Pregnant women protected Children under five years old protected	705,048 11,119 103,408
Dates of PMI-supported IRS campaign	September 8 - October 4, 2014
Length of campaign	24 days
Number of people trained with USG funds to deliver IRS*	1,501

Note: *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 continued into April, May, June, and July 2014 following the February 2014 IRS campaign. Percentage mortalities dropped below 80% four months post-spray in Gisagara (78.1%) and Bugesera (64%), and five months in Nyagatare (70%). At five months post IRS (July 2014), monthly wall bioassays showed average percentage mortalities of 66.7, 53.6, and 70 for Gisagara, Bugesera, and Nyagatare, respectively. During the September 2014 IRS campaign cone bioassays were conducted within the first week of spraying for quality assurance. Mortality rates of 100% for susceptible *An. gambiae* s.l. were recorded in all the test sites in the three districts.

Further entomological monitoring showed that *An. gambiae* s.l. generally exhibited more exophagic than endophagic behavior through the reporting period in the three districts. This could be attributed to the *An. arabiensis* population, which constitutes approximately 76 percent of the *An. gambiae* s.l. population in Rwanda (according to *An. gambiae* s.l. molecular identification that was conducted in 2013). *An. arabiensis* have a higher tendency to rest outdoors than indoors.

Indoor resting vector density (average *An. gambiae* s.l./house) remained low (less than one *An. gambiae* s.l./house) in the three districts during the period February to July, which could be accredited to the February 2014 IRS application. A rise in vector density was observed in August 2014 with 2.2, 1.1, and 2.7 average *An. gambiae* s.l./house in Gisagara, Nyagatare and Bugesera, respectively. This rise was observed during the period when insecticide levels on the walls had dropped to levels that might not have been sufficient to keep the vector densities low, in addition to environmental factors that might have favored the proliferation of the vector. Following the September 2014 IRS application a decline in the densities was observed.

In Bugesera, both indoor and outdoor biting remained low (the average was less than 4 bites/person/night) compared to the other districts, but a rise was observed in August 2014 (13.24 for indoor and 18.65 for outdoor bites/person/night) followed by a decline in September 2014. Both Gisagara and Nyagatare districts showed similar trends in biting patterns through the months. In both districts biting rates ranged between 1-9 bites/person/night during the period May–July. In August however, the biting rates rose to 9.9 (indoor) and 20.8 (outdoor) bites/person/night in Gisagara and 55.17 (indoor) and 47.42 (outdoor) in Nyagatare. In September, man biting rates remained high in both districts with values of 9.9(indoor) and 34.4(outdoor) bites/person/night in Gisagara, and 50.38(indoor) and 67.5(outdoor) bites/person/night in Nyagatare. The reduced biting observed in the earlier months of the year could be attributed to the decline in vector densities, which was observed after the IRS application in February 2014. The increase in biting that was observed in August corresponded with a rise in vector density during the same period, which could be explained by the fact that insecticide levels on the walls had plummeted below levels to keep the vector densities low.

PROGRAM HIGHLIGHTS

AIRS Rwanda conducted training to build the capacity of national and district government officials in IRS in the following areas: M&E, logistics and procurement, and IRS planning and implementation. A total of 156 (97 males and 59 females) government staff were trained, including MOPDD staff,

Directors of District Hospitals, District Health Directors, M&E officers, Logistics officers, Sector Social Affairs, and Officers in charge of Community Health Workers in three IRS districts.

The September–October 2014 IRS campaign (the second spray round for the year) began on September 8th and ended on October 4th. A carbamate, bendiocarb (Ficam 80 WP), was used during the September 2014 IRS campaign in the three districts. The final data from the September 2014 spray campaign showed high spray coverage of 99.2 percent.

CHALLENGES AND LESSONS LEARNED

- Engagement of community health workers' supervisors in community mobilization at the sector level in the September 2014 spray round enhanced coordination of IRS activities and acceptability.
- Building the capacity of local leaders by training them on all components of IRS operations enhanced their interest and ownership of project activities. However, their roles and engagement in IRS needs to be re-evaluated to further maximize their involvement.

1.14 SENEGAL

TABLE 7. AIRS SENEGAL AT A GLANCE

Number of provinces/districts covered by PMI-supported IRS in 2014	4
Insecticide	Ficam (Carbamate) in Malem hodar and Kounghel) and Actellic (Organophosphate) in Koumpentoum and Velingara
Number of structures sprayed by PMI-supported IRS	204,159
Number of structures targeted by PMI-supported IRS (found by spray operators)	209,603
2014 spray coverage	97.4%
Population protected by PMI-supported IRS Pregnant women protected Children under five years old protected	708,999 17,240 129,609
Dates of PMI-supported IRS campaign	May 15th (Velingara and Koumpentoum) and July 15th 2014 (Koungheul and Malem Hoddar)
Length of IRS campaign	35 operational days in Koumpentoum and Velingara, and 32 operational days in Koungheul and Malem Hoddar
Number of people trained with USG funds to deliver IRS*	933

Note: *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

In Senegal, UCAD was contracted directly by PMI to provide entomological monitoring in the IRS target districts. For the 2014 campaign, cone bioassays were conducted with susceptible strains of *An. gambiae* s.s. in the four IRS districts. The purpose of the tests was to assess the quality of the spraying and the efficacy of the insecticide after spraying. The residual efficacy of the Actellic was still high four months after spraying with test mortality rates of 98-99% both in Velingara and Koumpentoum. In areas treated with Ficam, bioassay results during the period of spray operations showed good quality of spraying. (See Table 8.)

TABLE 8. AREAS TREATED WITH FICAM

KOUNGHEUL		August	
Sites/spray dates		Mud	Cement
Ida Mouride	No exposed	91	66
16 – 17 August	Dead 24 h	100%	100%
Touba Koungheul	No exposed	97	72
06 August	Dead 24 h	100%	100%
Touba A. Mbenda	No exposed	121	32
04 – 05 August	Dead 24 h	100%	100%
Keur S. Diebel	No exposed	60	92
23 July	Dead 24 h	100%	100%
Pakala	No exposed	26	42
26 July	Dead 24 h	100%	100%
TOTAL	No exposed	395	304
	Dead 24 h	100%	100%

MALEM HODDAR		August	
Sites/spray dates		Mud	Cement
Ndioum Ngainth	No exposed	-	-
14 Aout	Dead 24 h		
Dianké Souf	No exposed	-	-
15 – 17 August	Dead 24 h		
Makka Bella	No exposed	96	62
18 – 19 August	Dead 24 h	69%	100%
Taiba	No exposed		147
16 July	Dead 24 h	-	100%
Niahène	No exposed	90	60
04 - 07 August	Dead 24 h	100%	100%
TOTAL	No exposed	186	269
	Dead 24 h	84%	100%

PROGRAM HIGHLIGHTS

Key activities in this period were focused on the following:

- **Senegal IRS Micro-planning workshops:** Based on the two different phases of the AIRS Senegal campaign, the micro-planning workshop took place April 1-2 in Velingara and Koumpentoum, April 22-23 in Koungheul, and April 27-28 in Malem Hoddar. The workshops were chaired by the district Prefects and attended by all local administrative representatives, community leaders, village chiefs, District Health Management Teams (DHMT), and Health Post Chiefs. During the meetings, spray calendars and communication plans were finalized.
- **Recruitment and pre-IRS medical examination of seasonal personnel:** The Steering Committee at the district level ensured recruitment of seasonal personnel in collaboration with Abt district staff. Pre-IRS medical examination of seasonal personnel was conducted by District medical officers.
- **Training of National Hygiene Service (SNH) staff newly posted in district IRS:** In collaboration with the NMCP, AIRS Senegal organized a training workshop for SNH staff who were new to IRS implementation. This training took place in Kaolack on April 8–12, 2014, to build the capacity of trainers of spray operators. In total, 16 SNH agents were trained, including two NMCP staff.
- **Trainers' Orientation:** The orientation of trainers took place in each IRS region covering the target districts (Koumpentoum, Velingara, Koungheul and Malem Hoddar) on April 29-30th to share and harmonize methodologies to be used by trainers during spray operator and supervisor training workshops.
- **Seasonal workers (spray operators, auxiliary operators, washers, guards, drivers, pump technicians, and storekeepers) training:** This training took place May 6-10 in Koumpentoum and Velingara, and July 7–11, 2014, in Koungheul/Malem. In total, 554 sprayers, 35 site managers, 121 team leaders, and 107 substitutes, 67 washers, 62 guards, 44 pump technicians, and 40 storekeepers were trained.
- **Spray campaign implementation in two phases:** The first phase began on May 15th in Koumpentoum and Velingara districts, using organophosphates, and the second phase began on July 15th in Koungheul and Malem Hoddar districts, using carbamates. Spray operations were completed in 35 operational days in Koumpentoum and Velingara, and in 32 operational days in Koungheul and Malem Hoddar.

- AIRS Senegal used a total of 25,337 sachets of carbamates and a total of 34,849 bottles of organophosphates with an average of 3.3 structures sprayed per sachet/bottle.
- This campaign was conducted with three different pilots. First, AIRS Senegal implemented an SMS platform to collect and disseminate spray campaign data to the client and local stakeholders on a daily basis. Second, the team piloted a smartphone application for delivering standardized supervision throughout the campaign thereby improving overall spray campaign quality. Lastly, AIRS Senegal piloted the use of mobile soak pits in four sites.

- **Smartphone Environmental Compliance Data Collection System:** AIRS Senegal undertook two environmental inspection trips in the four health districts as follows: Velingara and Koumpentoum in April, and Malem Hoddar and Koungheul in July, six and two weeks before the spraying, respectively. AIRS Senegal utilized a smartphone data collection system in 2014 to record site characteristics, capture the GPS location, and take pictures of the sites.
- **IRS evaluation meetings at different sites, district and national levels:** Site and district level evaluation meetings were held shortly after the two phases of the campaign finished. The national IRS evaluation workshop was held on September 17-18, 2014, in the NMCP conference room and attended by UCAD, PMI/USAID, SNH, regional National Health Education and Information Service (SNEIPS) offices, Regional Branch of the Directorate for the Environment and Classified Factories (DREEC) and Directorate for the Environment and Classified Factories (DEEC) offices, district medical officers and mayors of the four target districts, NMCP, and AIRS staff. This year, AIRS Senegal invited prefects of IRS districts in the context of the future handover of IRS responsibilities. The workshop's main topics were 2013 IRS challenges and results of the 2014 spray campaign. District medical officers presented on IRS implementation and results of the campaign. NMCP presented on the country's malaria epidemiological status. Participants and partners appreciated the results achieved and the overall success with respect to innovations launched during the 2014 spray campaign.

Challenges and Lessons Learned

Challenges

- This was the first time using organophosphates for IRS in Senegal. The team had to assess storage space and distribution frequencies based on the large volume of insecticide.
- Introduction of Goizper pumps in Koumpentoum and Velingara required additional training on use of the pumps as well as on the progressive rinsing of the pumps conducted by individual operators.
- To avoid or minimize potential incidents during the campaign the team had to do the following: strengthen vehicle selection by adding criteria for better environment compliance, instruct drivers on the rules and procedures, including speed limits, and ensure high quality oversight for the duration of the operations.
- As in the 2013 campaign, this year the NMCP was fully responsible for IEC/BCC implementation. This sometimes poses some coordination challenges but fortunately they were surmountable and did not cause major problems with the overall spray progress and coverage.

Lessons learned

- Site managers and team leaders were available the day before the start of the campaign to prepare equipment and materials, coding and packaging for each SOP in order to avoid any start-up delays on the first day.
- Availability of a DHMT member as an IRS focal point for the campaign allowed better monitoring of spray operations by the district and consequently performance improvement. For example, in Koumpentoum and Koungheul debriefing meetings were coordinated by the DHMT.
- The presence of AIRS Senegal teams in the field for supervision during the entire campaign greatly improved SOPs' performance.

- Settlement campsites in Fass Thiekene and Ngainth Pathe and MSP pilot sites helped to reduce travel time for spray teams, which consequently led to increasing performance.
- The use of new Goizper pumps helped increase the roles and responsibilities of spray operators in Koumpentoum and Velingara related to progressive rinsing.
- Using smartphones for spray supervision allowed teams to immediately address any shortcomings reported by supervisors. Actors on the ground could receive supervision reports at the same time as managers for anticipating shortcomings.
- Sufficient quantity of activated carbon is needed for mobile soak pit implementation.
- Volunteer IEC teams who supported the beneficiary population for household preparation in Koungheul district were very useful.

1.15 ZAMBIA

ENTOMOLOGY

In early May, the AIRS Regional Entomology Advisor represented AIRS at the Technical Advisory Committee (TAC) and Insecticide Resistance Monitoring Working Group (IRMWG) meetings in Lusaka organized by the National Malaria Control Center. Objectives of the meetings were to review the latest evidence on vector resistance collected by various partners and discuss the national Insecticide Resistance Management (IRM) plan. Key conclusions of the meetings were: a) to use pirimiphos-methyl of the organophosphate class in the 2014 IRS campaign because both *An. gambiae* s.s. and *An. funestus* are susceptible to this insecticide in all the areas; b) to investigate opportunities for using DDT as part of the insecticide rotation in 2016 because *An. funestus* is susceptible to it in all sentinel areas, particularly in the eastern part of the country; and c) to use mosquito collection methods (PSC, HLC, CDC light trap, WHO tube test, and CDC bottle bioassay) as entomological tools to assess the impact of the IRM plan.

The insectary that PMI procured through the Zambia Integrated System Strengthening Project was installed at the NMCC premises and will be able to support AIRS Zambia entomological work during the 2014 spray season.

The project began pre-spray entomological data collections at the end of September 2014 using PSC and CDC light trap collections in six sentinel sites (Serenje, Milenge, Mwense, Kasama, Isoka, and Katete). Each site has both treatment and control villages where collections will also continue on a monthly basis after IRS in all the sites.

PROGRAM HIGHLIGHTS

During the reporting period, the project continued staffing AIRS Zambia with skilled personnel to respond to the requirements of the 2014 work plan, which included direct support and implementation of the full IRS campaign in 40 districts. This is an expansion in geographical area by 15 new districts, and addition of all IRS components to the AIRS scope of work, which previously consisted of EC and procurement components only.

In this period, AIRS Zambia focused on planning and preparing for the 2014 spray campaign that was originally scheduled to start on September 15 but was delayed until October. As recommended by PMI Zambia, the project conducted geographical reconnaissance (mapping) to plan for targeted vs. blanket spraying in order to align with the national strategy for universal net coverage. Akros, a US-based small technology solution firm, produced detailed maps for all 40 districts with the malaria "hot spot" areas based on health facility data layered with the population density information using satellite imagery tools. During the micro-planning meetings with the district authorities, AIRS Zambia discussed the maps to agree on concrete spray targets and coverage areas for each participating district.

The Zambia program upgraded the data collection system to use the AIRS project M&E database and spray data collection form to make the data compatible with other country programs under AIRS. The project also introduced the mSpray tool, for mobile spray data collection developed by Akros. It will be tested in seven districts. AIRS Zambia rolled out an IRS training program to all districts and undertook pre-seasonal EC inspections. As a result, the project rehabilitated infrastructure (soak pits, wash rooms, storage) in most of the operational sites. The team also procured locally and internationally PPE, spray tanks, and other materials for the campaign.

During the reporting period, AIRS Zambia successfully transferred leftover insecticide (7,317 sachets, carbamate class) to AIRS Rwanda for use during the fall 2014 campaign.

AIRS ordered organophosphate class insecticide for the 2014 spray campaign in April-May, but the supplier delayed delivery to Lusaka by approximately seven weeks. This was the main reason for moving the spray start date to October.

AIRS Zambia has been investigating ways of disposing of empty Actellic bottles from the 2012 and 2013 IRS seasons. With the help of the Zambia Environmental Management Agency (ZEMA), the project identified a local company that collects and crushes high density plastic bottles. The company will also ship crushed bottles to South Africa to be recycled into non-consumable products. Six tons have been baled from the 2012 bottles while the 2013 bottles have been collected from the districts and stored at a central place in Lusaka for inspection and onward for baling and subsequent transportation to South Africa.

AIRS Zambia has also supported a meeting of the IRS technical working group, where the group reached an important consensus to reduce the number of days for Spray Operator Training from 18 days to 10 days.

Challenges And Lessons Learned

- The increase in the number of districts that AIRS Zambia is supporting in 2014 has indicated the necessity for additional staff in M&E, entomology, environmental compliance, and procurement. The lengthy recruitment process, particularly in entomology, has delayed the start of a number of preparation activities. The search for candidates is still ongoing.

With the increased resistance of carbamates and pyrethroids across the country, organophosphates are the only insecticides that can confidently be used in the next few years. Should any evidence of resistance be established with organophosphates, there will be extreme pressure on the selection of insecticides.

1.16 Zimbabwe

The 2013-2014 spray campaign in Zimbabwe took place prior to the period covered in this semi-annual report. Results were included in the previous semi-annual report submission (October 2013-March 2014).

Entomology

In preparation for the cone bioassay tests commencing after spraying in November 2014, the susceptibility of *An. gambiae* s.l. from Gokwe South District was tested on pirimiphos-methyl in August 2014. The organophosphate insecticide will be sprayed in the four districts supported by the PMI AIRS Project this year. Results of the tests showed 100 percent susceptibility of the field-collected *Anopheles ga*mbaie s.l. mosquitoes to pirimiphos-methyl. Field-caught *An. gambiae* s.l. from Gokwe South will be used for cone bioassay tests since the susceptible colony at the insectary at NIHR remains inadequate for this exercise.

Susceptibility tests were also completed at two sentinel sites in August 2014: Makakavhule, Beitbridge District, Matabele South Province, and Chilonga, Chiredzi District, Masvingo Province.

Results of susceptibility testing for *An. gambiae* s.l. from Makakavhule, Beitbridge District in August showed that the vector was fully susceptible (100 percent mortality after the 24-hour holding

period) to lambdacyhalothrin and pirimiphos-methyl. However, the vector was resistant to DDT and Bendiocarb with 90 percent and 84 percent mortality after the 24-hour holding period, respectively.

The results from Chilonga suggest that *An. gambiae* s.l. is resistant to DDT but is susceptible to lambdacyhalothrin with 84.6 percent and 100 percent mortality after the 24-hour holding period, respectively. There is a need for caution as the results were based on a small sample size; further tests are recommended. The majority of larvae collected from breeding sites at Chilonga were *An. pretoriensis*, a non-vector species.

Susceptibility tests that were done in April at other sentinel sites were reported on in the previous semi-annual report. Besides the susceptibility tests, AIRS entomologists continued to provide support to NIHR laboratories and to attend meetings, including the Vector Control Sub-committee meeting, the National Annual Malaria Conference, and the IRS Level 1Training.

PROGRAM HIGHLIGHTS

The EOSR for the 2013-2014 IRS campaign was approved by PMI in June 2014 (the report was first submitted in March 2014). The 2014 work plan for Zimbabwe was completed on April 1, 2014, and approved by PMI in July 2014.

Due to a shift in scope of work with AIRS Zimbabwe leading IRS activities in four districts in Manicaland province (Chimanimani, Mutasa, Mutare, and Nyanga districts), instead of providing technical assistance to NMCP-led IRS campaigns, AIRS Zimbabwe has spent most of the last six months focusing on preparing for the 2014 IRS campaign. The 2014 IRS campaign began November 3, and will end around December 10, 2014. The AIRS Zimbabwe-led IRS campaign will target 159,387 structures in the four districts. After further entomological and operations analysis with PMI and the NMCP, it was agreed that the AIRS Zimbabwe-led IRS campaign will mark the first time that organophosphates are used for IRS in Zimbabwe.

Pre-spray IRS campaign work completed by AIRS Zimbabwe over the past six months includes establishing a central warehouse in Mutare in August 2014; training warehouse management staff; recruiting spray operators and other seasonal staff; procuring insecticide and PPE for spraying the four districts; and collaborating with other PMI partners such as Populations Services International (PSI) regarding IRS campaign and malaria prevention communication activities (including the development of written materials, and developing radio and "roadshow" scripts). AIRS Zimbabwe has continued to work to improve environmental compliance regarding IRS in Zimbabwe, and is working with provincial and district officials to develop and improve upon permanent store rooms for storage, instead of using tents for storage. AIRS Zimbabwe has also built four more soak pits in preparation for the 2014 IRS campaign, bringing the total number of soak pits built by AIRS Zimbabwe throughout the country to 118.

AIRS Zimbabwe has worked extensively with the NMCP, provincial, and district officials to plan the 2014 IRS campaign, and thereby AIRS Zimbabwe staff participated in and led sessions on entomology, environmental compliance, and the use of organophosphates during the Level 1 (national IRS) training in July, and the Level 2 (Manicaland-provincial) training in September. AIRS Zimbabwe and the NMCP also signed an Outline of Agreed Activities in September 2014, describing how AIRS Zimbabwe and the NMCP will collaborate during the 2014 IRS campaign.

Other work completed by AIRS Zimbabwe includes the completion of an evaluation of provincial health incinerators used for solid waste disposal in Mashonaland East, Mashonaland West, and Manicaland provinces (completed in May/June 2014). The evaluation, completed by a local engineering firm, Brightell Refractory Solutions, highlighted deficiencies in the ability of the incinerators to reach the correct temperature to properly dispose of IRS campaign solid wastes and provided explanations on specifications and construction work that is needed to bring the incinerators up to standard. The report was submitted to PMI and the NMCP on September 11, 2014. AIRS Zimbabwe also presented on supervision and IRS campaign tracking forms used project-wide during a NMCP-led supervision form conference in April 2014. As a

result of the meeting the NMCP agreed to start using environmental compliance supervision forms during the national 2014 IRS campaign.

CHALLENGES AND LESSONS LEARNED

- Due to changes in importation duty policies, AIRS Zimbabwe and USAID have encountered some difficulties with initial shipments of PPE, entomology supplies, and the importation of a project vehicle. Although the situation has improved and recent equipment has been received with duty payments, after several rounds of negotiation, it was determined that AIRS Zimbabwe could not use its vehicle procured in November 2013 due to import duties that the Zimbabwean government would not absolve.
- Given the sensitivities to data collection and data sharing in Zimbabwe, during discussions with PMI and the NMCP in September, it was decided that AIRS Zimbabwe should not use the project-wide M&E system for the 2014 IRS campaign. Instead, AIRS Zimbabwe will help support the current M&E system used for the NMCP's national IRS programming. AIRS Zimbabwe intends to review and assess the NMCP's system, in order to develop recommendations for improving the system, and incorporating new innovations such as collecting IRS campaign data via mobile phones.

2. CORE SECTIONS

2.1 AUDIT

An independent auditor, Bert Smith & Co., was hired by the United States Agency for International Development's Office of the Inspector General to conduct an audit of the USAID resources managed by Abt under Task Order No. AID-OAA-TO-11-00039. The audit covered the period of August 11, 2011-June 28, 2013. The scope of the audit was to determine whether the costs incurred under the AIRS Task Order were reasonable, allowable, and allocable. Over a nearly 5 month period, $82,777,932 of incurred costs were examined thoroughly against the provisions of the contract agreement, USAID rules and regulations and Abt policies and procedures. No material weaknesses were identified and only seven deficiencies in internal controls were identified. Many of the issues identified have already been remedied through our FCA field visits (e.g. Abt identified missing Excluded Party List Serve/System for Award Management searches prior to the audit and Abt was already in compliance before the audit began) and tightened controls. In addition, there were some findings that Abt felt were already addressed (e.g. Ghana financial misconduct was fully investigated and the allocability of meals and lodging charged to the US government was agreed to by the USAID Contracting Officer). The outstanding comments (e.g. travel concurrences and VAT reporting) will continue to be priorities for the AIRS Team.

Of all the costs examined, only $5,067 were identified as questionable costs.

2.2 BENIN EPIDEMIOLOGY

AIRS M&E Specialist Elana Fiekowsky and Abt Health Economist Ben Johns presented the results of their analysis of Benin epidemiological data using publicly available Health Management Information System (HMIS) data in April 2014 to the COR team. The data proved that Benin HMIS data alone cannot be used to show a statistically significant effect of IRS on the number of confirmed malaria cases. This is due to overwhelming inconsistencies in the data and the number of health facilities reporting data in Benin. Although the Benin HMIS data cannot be used for statistical analysis, this research has furthered conversations between PMI and the AIRS Team on how best to access epidemiological data in the future. AIRS presented this research at the 2014 ASTMH conference in November 2014.

2.3 COMMUNICATIONS

The AIRS website (www.africairs.net) received 49,575 visits from April 1, 2014, to September 30, 2014, an approximate 11-fold increase from the previous six months (April 1 to September 30, 2013). Further analysis of the AIRS website, e-letter, and other communications materials can be found in the quarterly communications analytics reports.

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 three e-letters (in April, June and September) and eight video e-alerts during this reporting period.

AIRS released five videos this reporting period, including a speed drawing on entomological monitoring, an animation video in English and French on IRS operations, a training video on how to build a mobile soak pit, a film on building government capacity in IRS in Senegal and a film on increasing women's participation and leadership capacity in Benin.

AIRS also produced four Technical Briefs focusing on Environmental Compliance, Operations, M&E, and Entomological Monitoring, and updated the AIRS Project Brief.

Clark Abt Prize

AIRS won an Abt Associate corporate award, the 2014 Clark Abt Prize for Outstanding Social Impact. Dereje Dengela, Bradford Lucas, and Allan Were received the award on behalf of the project at Abt's annual meeting on June 27, 2014. The award recognized AIRS for reducing the morbidity and mortality of malaria in Africa.

Conferences

At the Innovative Vector Control Consortium (IVCC) stakeholders' bi-annual meeting in June in Liverpool, England, Dereje Dengela, AIRS Technical Director, presented on the need for new or improved insecticides for IRS as a critical component for fighting malaria. Approximately 120 people from across the globe attended the meeting, including keynote speaker Rear Admiral Tim Ziemer, US Global Malaria Coordinator and leader of PMI.

The AIRS Project held its annual COP retreat in Philadelphia, June 4-8. More than 40 project staff, including 13 COPs, and the PMI COR team, attended the retreat, which addressed cross-cutting issues, such as increasing local government involvement, mHealth, innovations in IRS and supervisory tools. The project retreat allowed for robust south-to-south learning and team building. Following the AIRS retreat, COPs attended Abt's Annual COP Conference, held June 9-12. A key theme of the conference was accountability and execution.

Tech Talks

AIRS introduced monthly Tech Talks in September to encourage peer-to-peer exchange among COPs. The first Tech Talk, led by AIRS Senegal COP Adama Kone, focused on using supervisory forms on smartphones. These discussions promote ideas, accelerate success, promote collaboration, encourage others to leverage ideas from one another, and may help lead to further innovations in IRS.

World Malaria Day

As a part of World Malaria Day (WMD) 2014, AIRS held a brown bag at USAID on April 24th on Vector Control to introduce AIRS innovations in operations, entomological monitoring and evaluation, and environmental compliance. PMI leader Rear Admiral Tim Ziemer attended the event and praised AIRS for its work and role in helping to reduce malaria in Africa in a safe and effective way.

Other WMD activities included Abt's role on the judges' panel with The Against Malaria Foundation, PATH, ONE, and the World Health Organization, for the Peace Corps Malaria Heroes contest to honor individuals who go above and beyond the call of duty in malaria prevention. Nicole de Gier, AIRS Technical Coordinator, represented Abt on the panel.

AIRS released a five-day video campaign the week of WMD, issuing AIRS videos via e-alerts to promote awareness around the event. The event drove substantial traffic to the AIRS website during the week.

2.4 mHEALTH PILOTS

The AIRS team implemented various mHealth projects in four countries in the last six months. Please see Table 9 for the list of pilots by country.

TABLE 9. MHEALTH PILOTS BY COUNTRY

Country	Month	Project	Implementing Partner
Benin	May	SMS platform for operational data and SMS reminders to SOPs	Client Technology Center (CTC)
Senegal	June/July	SMS platform for operational data and mobile-based Supervisory Forms	Dimagi
Mali	August	Mobile phone-based mobilization	CTC

Madagascar	September	SMS platform for operational data	Dimagi

In year 3, the AIRS team has sought to implement mHealth projects to aid various aspects of the IRS project. Piloting these diverse projects has allowed the team to learn which projects are most scalable project-wide. To better understand this work and the lessons learned, AIRS M&E Specialist Elana Fiekowsky completed trips to both Senegal and Mali to assist in the mHealth project implementation. A final mHealth report has been submitted on the Benin mHealth project, while the Senegal and Mali teams are completing their reports now that the teams have completed the spray season. AIRS Technical Coordinator Mariandrea Chamorro and Elana Fiekowsky presented the Senegal mobile-based Supervisory Forms tools and pilot outcomes to the COR team in September 2014.

2.5 Deltamethrin Suspension Concentrate (SC) - Polymer Enhanced (PE) Residual Life Study

The comparative residual life study of the two WHOPES-approved deltamethrin products, Deltamethrin SC-PE and Deltamethrin WG, started in December 2013 in Mozambique and continued to the end of this reporting period. The study results indicated that both Deltamethrin SC-PE and Deltamethrin WG formulations were highly efficacious against *Anopheles arabiensis* Durban strain consistently for four months. At the end of the fourth month the mean test mortality was 95 percent and 91 percent for SC-PE and WG formulations, respectively. At T5 (five months after spraying), 100 percent mortality was observed for SC-PE formulation, whereas it was 84.4 percent for WG formulation. Exposure mortality dropped to less than 70 percent for both types of formulations at T6 and T7. The unusual sudden test morality drop noted at T6 as compared to T5 and a uniform increase observed at T7 as compared to T6 necessitated further data collection to verify the results. At T8 both formulations showed over 90 percent mortality against the same mosquito species. Collection of residual life data is currently ongoing. The study will be stopped and the final report submitted when mosquito test mortality consistently drops below the WHO threshold.

2.6 Draft Manuscripts On The Residual Life Of Insecticides

Two manuscripts have been drafted and circulated. Comments and inputs have been received from the COR and other PMI teams. We are currently working to address those comments and resubmit the revised version.

2.7 IRS Team Leader Guide

The IRS Team Leader Guide was finalized and released in June 2014. The job-aid, which comes in four languages, English, French, Portuguese, and Malagasy, details the roles and responsibilities of IRS Team Leaders. Copies of the guides were printed and distributed to all AIRS countries that conduct spraying. A copy is also available on the AIRS website. The primary audiences for the guides are Team Leaders and all individuals engaged in supervision of field spray activities.

2.8 Gender

Using the trained and hired data, in addition to the Cultural Practices gender assessments, the AIRS team analyzed and wrote a corresponding report. Based on this report, the PMI AIRS team will implement various initiatives under TO6 to make the project more gender inclusive and increase the number of women hired. Furthermore, results of the assessment will be shared at ASTMH in November.

2.9 Cost Study

The 2013 cost study was submitted to PMI on August 6, 2014, and the PMI COR team provided their feedback and comments. AIRS will re-submit a revised version of the cost study taking these

comments into consideration. The 2013 cost study used the same methodology as the 2012 cost study but it also includes a comparison of Year 1 and Year 2 costs.

2.10 Roll Back Malaria Annual Meeting On Malaria In Pregnancy

Peter Mumba, the COP for Ghana AIRS, attended the Roll Back Malaria meeting, which was held in Accra July 15-17, 2014. The theme of the meeting was "Commitment to strengthening, accelerating, and supporting MIP programming". His attendance was paid for by Abt corporate funds.

2.11 Mobile Soak Pit

In environmental compliance, AIRS continued to develop the Mobile Soak Pit (MSP), resulting in a new design with lighter, less expensive, and more locally-available materials. The ECSM performed STTA in Madagascar and demonstrated the construction of the new model of MSP that uses lighter and more locally available materials. The MSP was piloted in Senegal, Mali, and Ethiopia, and these pilots provided valuable feedback in efforts to improve the design and implementation of the filter. Additionally, a testing plan was developed, and a qualified laboratory was identified to perform the chemical analysis required for efficacy testing of the MSP.

2.12 Water Transport Of Pesticides

This year AIRS Madagascar was tasked with spraying in a new area, eastern Madagascar, which posed significant challenges because of the low, wet terrain, resulting in several areas that are accessible only by boat. The AIRS ECSM provided short-term technical assistance to train the new Environmental Compliance Officer, and to develop protocols for water transport of pesticide. Those protocols were used in this campaign, and will also be submitted as a new PMI BMP.

2.13 Smart Phone Environmental Compliance System

The smartphone environmental compliance system continued to evolve, including the provision of better access to the cloud-based database, and the initiation of automatic emails providing results of mid-spray inspections to designated project staff. In all, there were 1,616 report submissions from inspections performed in the field between March and September. These inspections and automatic emails allowed for immediate correction of non-compliant conditions.

2.14 Incinerator Evaluation

AIRS continued searching for qualified incinerators for expired/obsolete DDT disposal. The ECSM Peter Chandonait performed an inspection at the South African company A-Thermal, but due to an unfavorable regulatory status and Mr. Chandonait's recommendation, the facility cannot be used. AIRS continues to investigate means of disposal, and has identified, Veolia, based in Poland, as a probable vendor.

2.15 Capacity Building: Assessment And Action Plans

The AIRS project completed assessments of the capabilities of local stakeholders to take greater ownership of IRS programming. Out of 13 countries active in Year Three of the project, 12 completed the assessments with the exception of Madagascar, where the project has limitations on engaging with the government to implement the IRS. Seven out of 12 countries produced capacity assessment summaries and capacity-building action plans that are currently being implemented. Two countries (Mozambique and Zambia) are getting ready to submit the assessment summaries for review to PMI. As part of the capacity-building action plan, AIRS Senegal conducted a workshop for approximately 25 NMCP staff where they shared tools, and trained NMCP staff on every aspect of IRS early in the year. The program used country funding for this event. The Ethiopia program will add "Feedback and Lessons Learned" sessions on various IRS tools developed under AIRS to the 2014 post-spray evaluation conference scheduled at the end of

October 2014. Ghana, Benin, and Rwanda programs are planning to complete hand-over workshops in October-November 2014. Other countries will plan for skill transfer opportunities in the upcoming year. See Table 10 for the status of the CAPs in each AIRS project country.

TABLE 10: AIRS COUNTRY CAPACITY ASSESSMENT PROGRESS

No	Country	Status as of September 30, 2014
1	Angola	AIRS presented CAP to PMI Washington and the Mission; CAP process will likely not move forward under TO4 although the team is interested in investing in more ento capacity building before the end of TO4.
2	Benin	Assessment Summary and Action Plan are approved and completed for the year.
3	Ethiopia	Assessment Summary and Action Plan are approved. Implementation is in progress.
4	Ghana	Assessment Summary was approved. Action Plan is approved by PMI Washington and waiting for feedback from PMI Ghana.
5	Liberia	n/a
6	Madagascar	n/a
7	Mali	Assessment Summary and Action Plan are approved. Implementation is in progress.
8	Mozambique	The Zambezia provincial health directorate conducted their own capacity assessment in September. The team wrote a CAP summary and now it is ready to be submitted to PMI this week for review/approval.
9	Nigeria	n/a
10	Rwanda	Assessment Summary and Action Plan are approved. Implementation is in progress.
11	Senegal	Assessment Summary and Action Plan are approved. Implementation is in progress.
12	Zambia	Results of the assessment are finalized and agreed upon with the NMCP. Team is working on the summary.
13	Zimbabwe	n/a

2.16 SOUTH-TO-SOUTH ASSISTANCE

Dr. Nduka Iwuchukwu, AIRS Nigeria COP, continued technical assistance (TA) to the Malawi NMCP through the end of July 2014. AIRS TA to Malawi began in November 2013 with an overall objective to support the NMCP with planning, preparing, and executing a spray campaign. During the spray operation, March 4 - April 24, 2014, the NMCP reached 77.3 percent coverage, protecting 302,938 persons in 78,965 structures sprayed in the Salima district selected for the IRS campaign.

During the reporting period, Dr. Nduka travelled to the country twice. The objective of the first trip in May was to supervise the post-spray EC assessment in all six operational sites of Salima district. As a result, he provided recommendations to the NMCP and PMI Malawi on improving environmental safety of soak pit areas and emphasized financial challenges the district administration had with renting temporary stores and supplying cleaning materials for spray operators.

The objective of the July trip was to participate in the post-spray conference and contribute to the development of the malaria vector control strategy document. For the post-spray conference, Dr. Nduka shared his observations from the campaign on effective and efficient IRS. He also worked with the NMCP to prepare a presentation for key officials of the Ministry of Finance to justify the importance of and request for timely budgetary disbursement for IRS activities. As a contributor to the strategy document, Dr. Nduka consulted the working group on the IRS section, specifically target areas and insecticide options to consider in the near future.

2.17 CHLORFENAPYR INSECTICIDE TESTING

Upon request from PMI, AIRS in collaboration with BASF Pest Control Solutions, Public Health, is evaluating the impact of chlorfenapyr, an insecticide which could be used for IRS, on important entomological parameters. The evaluation requires standard experimental huts with mosquito exit and entry windows. The Nigeria Institute of Medical Research (NIMR) is one of the research institutions in Africa with the expertise and proper experimental huts required to sufficiently support the successful implementation of the study. AIRS has entered into an agreement with the institute to test this product using resources available at NIMR.

The main objective of this evaluation is to determine the persistence of chlorfenapyr. Specifically, objectives of study are the following:

- Assess the intrinsic insecticidal bioefficacy on key disease vectors (susceptible and insecticide resistant strains) to chlorfenapyr, alpha-cypermethrin, and bendiocarb.
- Determine the best bioassay techniques to estimate chlorfenapyr efficacy and residual activity on relevant wall substrates.
- Compare the efficacy and residual activities of chlorfenapyr applied as an indoor residual spray on relevant substrates with that of bendiocarb and alpha-cypermethrin at WHO recommended doses.

The testing began on August 11, 2014, with the spraying of six experimental huts. Data collection will last for six months and the final report will be produced in February-March 2015.

ANNEX A: INSECTICIDE AND EQUIPMENT PROCUREMENT

Commodity	Country	Description	Total Cost	Delivery Date
Entomology Supplies	Angola	Light traps	$6,659.33	April 2014
Insecticides	Benin	Organophosphates	$699,578.37	April 2014
Insecticides	Benin	Organophosphates	$169,330.62	June 2014
Goizper Sprayers	Benin	IK 12 VC Sprayers	$26,430	May 2014
Entomology Supplies	Burundi	Entomology Monitoring Supplies	$3,866	July 2014
Entomology Supplies	Burundi	Entomology Monitoring Supplies	$1,610	July 2014
Entomology Supplies	Burundi	Entomology Monitoring Supplies	$4,991	July 2014
Entomology Supplies	Burundi	Entomology Monitoring Supplies	$3,608	Aug 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$834.26	June 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$56.98	Sep 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$2,816	May 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$1,297	June 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$466	July 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$6,024	June 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$251	July 2014
Entomology Supplies	DRC	Entomology Monitoring Supplies	$554	June 2014
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	$883	July 2014
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	$238.04	June 2014
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	$11,437	Aug 2014
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	$12,922	Sep 2014
Personal Protective Equipment	Ethiopia	Coveralls	$55,214	Sep 2014
Hudson Pumps	Ethiopia	Spare Parts	$82,250.48	April 2014
Personal Protective Equipment	Ethiopia	Boots, Gloves, Masks, Face shields	$293,573.30	June 2014
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	$3,815.32	May 2014
Entomology Supplies	Liberia	Entomology Monitoring Supplies	$456.62	May 2014

Commodity	Country	Description	Total Cost	Delivery Date
Insecticides	Madagascar	Organophosphates	$29,725.80	Sep 2014
Entomology Supplies	Madagascar	Entomology Monitoring Supplies	$1,012	Aug 2014
Personal Protective Equipment	Madagascar	Gloves, Faceshields, Masks	$34,618	July 2014
Entomology Supplies	Mali	Entomology Monitoring Supplies	$299	June 2014
Entomology Supplies	Mali	Entomology Monitoring Supplies	$265	July 2014
Entomology Supplies	Mali	Entomology Monitoring Supplies	$937	Sep 2014
Insecticides	Mali	Organophosphates	$1,753,064.56	June 2014
Insecticides	Mali	Organophosphates	$83,474.64	June 2014
Insecticides	Mali	Bendiocarb – Ficam VC	$71,061.45	May 2014
Entomology Supplies	Mozambique	Entomology Monitoring Supplies	$14,251.40	June 2014
Entomology Supplies	Mozambique	Entomology Monitoring Supplies	$362	July 2014
Personal Protective Equipment	Mozambique	Masks	$10,512	April 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$2,340	July 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$12,018	May 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$6,970	June 2014
Entomology Monitoring Supplies	Rwanda	Entomology Monitoring Supplies	$1,542	July 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$3,007	Aug 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$1,149	Sep 2014
Entomology Supplies	Rwanda	Carbamates	$1,234,820.16	Sep 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$78,078.50	June 2014
Entomology Supplies	Rwanda	Entomology Monitoring Supplies	$8,134	June 2014
Insecticides	Senegal	Organophosphates	$1,164,662.01	Apr 2014
Insecticides	Senegal	Carbamates	$121,936.41	Sep 2014
Goizper Pumps	Zambia	Pumps	$9,143.25	Sep 2014
Personal Protective Equipment	Zambia	Gumboots	$30,074.11	Sep 2014
Personal Protective Equipment	Zambia	Hard hats, face shields, brackets	$30,884.40	Aug 2014
Entomology Supplies	Zimbabwe	Entomology Monitoring Supplies	$302.83	July 2014
Entomology Supplies	Zimbabwe	Entomology Monitoring Supplies	$309	May 2014
Entomology Supplies	Zimbabwe	Light traps	$18,432.80	Sep 2014
Personal Protective Equipment	Zimbabwe	Hard hats, respirators, face shields	$12,083.20	Sep 2014

ANNEX B:
M&E RESULTS SUMMARY

IRS RESULTS APRIL 2014 – SEPTEMBER 2014

Country	Structures Found	Structures Sprayed	% Spray Coverage	Total Population Protected	Pregnant Women Protected	Children <5 Protected	People Trained*
Benin	265,907	254,072	95.5%	789,883	25,754	227,530	1,642
Ethiopia	670,303	667,236	99.5%	1,647,099	23,919	230,862	2,886
Ghana	244,799	205,230	83.8%	570,572	12,538	105,983	750
Mali	233,706	228,123	97.6%	836,568	22,352	154,764	911
Rwanda	174,411	173,086	99.2%	705,048	11,119	103,408	1,501
Senegal	209,603	204,159	97.4%	708,999	17,240	129,609	933
TOTAL	1,798,729	1,731,906	96.3%	5,258,169	112,922	952,156	8,623

Note: *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.