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THE PMI AIRS PROJECT SEMI ANNUAL REPORT OCTOBER 1, 2016 – MARCH 31, 2017

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ACRONYMS

AIRS	Africa Indoor Residual Spraying Project
CB-IRS	Community-based indoor residual spraying
CDC	Centers for Disease Control and Prevention
COR	Contracting Officer's Representative
DDT	Dichlorodiphenyltrichloroethane
EC	Environmental Compliance
ECO	Environmental Compliance Officer
HLC	Human Landing Catch
IEC	Information, Education, and Communication
IRS	Indoor Residual Spraying
LLIN	Long-lasting insecticide-treated net
LT	Light Trap
M&E	Monitoring and Evaluation
NEMC	National Environmental Management Council - Zanzibar
NMCP	National Malaria Control Program
NIMR	National Institute for Medical Research - Tanzania
ODK	Open Data Kit
PMI	President's Malaria Initiative
PMT	Performance Management Tracker
PPE	Personal Protective Equipment
PSC	Pyrethrum Spray Catch
PSECA	Pre-Spray Environmental Compliance Assessment
SEA	Supplemental Environmental Assessment
SMS	Short Message Service
SOP	Spray Operator
UCAD	Université Cheikh Anta Diop de Dakar
USAID	United States Agency for International Development
USG	United States Government
WHO	World Health Organization
ZAMEP	Zanzibar Malaria Elimination Programme
ZEMA	Zanzibar Environmental Management Agency

EXECUTIVE SUMMARY

The U.S. President's Malaria Initiative (PMI) Africa Indoor Residual Spraying (AIRS) Project funded by the United States Agency for International Development continued implementation under Task Order 6 to prevent and control malaria in 17 African countries through indoor residual spraying (IRS) and entomological monitoring. During this reporting period (October 1, 2016 to March 31, 2017), the project successfully implemented IRS campaigns in Kenya, Mozambique, Tanzania, Zambia, and Zimbabwe. More than 8 million people were protected from malaria during this period. Details regarding all monitoring and evaluation (M&E) outcomes by country are reported in Annex A.

TOP-LINE RESULTS FROM IRS CAMPAIGNS, OCT 2016-MAR 2017

- 91% average spray coverage
- 1,915,949 structures sprayed
- 8,082,985 people protected from malaria including:
 - 390,465 pregnant women
 - 1,100,394 children under 5 years of age
- 11,345 people trained to deliver Indoor Residual Spraying

HIGHLIGHTS FROM THIS REPORTING PERIOD ARE LISTED BELOW

- Successfully conducted Kenya's first IRS campaign in five years, reaching 97.7% coverage.
- Delivered two capacity building workshops (boot camps) in Mwanza and Zanzibar, Tanzania.
- Completed the destruction of expired insecticides in Zambia and Zimbabwe. Additionally, AIRS Ethiopia eliminated 17,443 kg of expired DDT, which was shipped to Poland for incineration.
- Piloted a community-based IRS approach in Zanzibar.
- Presented eight posters at the ASTMH 65th Annual Conference in Atlanta, Georgia.
- Presented at the Global Digital Health Forum in Washington, D.C. in December 2016.
- Eight manuscripts were submitted to PMI, including *Community-Based Indoor Residual Spraying: An innovative approach to deliver effective, cost-efficient, and sustainable malaria prevention in Ethiopia*, which was published in *Global Health: Science and Practice* in December 2016.

I. COUNTRY HIGHLIGHTS

I.1 ANGOLA

PROGRAM HIGHLIGHTS

- The AIRS Angola program officially concluded activities on October 31, 2016. All equipment and inventory were disposed of according to the approved disposition plan as of December 31, 2016.

I.2 BENIN

PROGRAM HIGHLIGHTS

- Development and approval of the 2017 AIRS Benin work plan.
- In anticipation of the 2017 IRS campaign, several activities were carried out in all three departments (Atacora, Alibori and Donga), including: geographical reconnaissance of the new IRS areas (Alibori and Donga), enumeration of structures, identification of operational site locations, needs assessment, and procurement of local and international equipment and products. AIRS Benin also helped organize an informational visit to the health and politico-administrative authorities, and planning meetings at all levels.
- AIRS Operations Director Allan Were conducted a four-day training (March 13-16) in Cotonou for the new operations team on critical aspects of IRS operations management, planning and implementation.
- Assisted the NMCP in the planning of the withdrawal of IRS in seven communes (Cobly, Materi, Tanguieta, Boukombe, Natitingou, Toucountouna and Kouande) in Atacora; helped develop NMCP's 2017-2021 strategic plan.

I.3 BURKINA FASO

PROGRAM HIGHLIGHTS

- AIRS Burkina Faso, in collaboration with the Institute for Research in Health Sciences (Institut de Recherche en Sciences de la Santé), facilitated a two-day meeting with representatives from USAID, the National Program for the Fight against Malaria (Programme National de Lutte contre le Paludisme), and other local vector control stakeholders. The stakeholder meeting, which provided an opportunity to share malaria-control experience and increased collaboration between PMI AIRS and the government, resulted in a consensus on proposed areas to be sprayed in 2018.

I.4 BURUNDI

PROGRAM HIGHLIGHTS

- Four entomological surveys were conducted at the eight sentinel sites.
- 26,188 mosquitoes were collected by human landing catch (HLC) and included 23 species grouped

in six genera. *An. gambiae* s.l. represented the highest number of mosquitoes captured at 33.05% versus 3.52% for *An. funestus*. Data showed that in the sentinel sites of Mpanda, Nyanza-Lac, and Cankuzo the human biting rate (HBR) was highest, estimated respectively at 47, 30, 30 bites per person per night.

- A total of 1,224 ovaries of *An. gambiae* s.l. and *An. funestus* were dissected. The average parous rate was 77.80% for *An. gambiae* s.l., with a probability of 0.88 to survive through one day. For *An. funestus*, the average parous rate was 72.46%, indicating that the majority of the vectors collected are old and may transmit malaria.
- 20,266 mosquitoes were collected by CDC light trap (LT), of which 57.02% were caught in Mpanda. *An. gambiae* s.l. and *An. funestus* represented 30.79% and 5.86%, respectively, of the total collection.
- 3,571 mosquitoes were collected by pyrethrum spray catch (PSC). *An. gambiae* s.l. represented the highest number of mosquitoes captured at 63.03%, and *An. funestus* at 17.83%. An average density of 8.85 *An. gambiae* s.l. and *An. funestus* was observed per house, with a blood feeding rate of 62.32% for *An. gambiae* s.l. and 68.76% for *An. funestus*. These blood feeding rates are high and indicate that post-feeding indoor resting mosquitoes are the most abundant malaria vectors.

1.5 DEMOCRATIC REPUBLIC OF THE CONGO

PROGRAM HIGHLIGHTS

- AIRS Democratic Republic of the Congo (DRC), through the National Institute of Biomedical Research (INRB), implemented entomological monitoring activities in 11 provinces: Kinshasa, Kasai, Sankuru, Tshopo, Haut-Uele, Sud Kivu, Haut Katanga, Tanganyika, Kongo Central, Mai-Ndombe, and Mongala. Activities included PSC and HLC collections and insecticide susceptibility testing.
- Monthly vector monitoring has provided extremely useful insight into the vector dynamics in these two locations. Data through December 2016 showed that biting rates of malaria vectors in both Lodja and Kapolowe were extremely high throughout the year. *An. gambiae* s.l. biting rates remained above 10 bites per person per night every month both indoors and outdoors in Lodja. In Kapolowe, peak biting rates for *An. gambiae* s.l. coincided with the rainy season between October and March, while the biting peak for *An. funestus* s.l. was later in April-May, and considerable biting continued throughout the dry season at between 5-15 bites per person per night between June and September. Although outdoor biting rates of *An. paludis* in Lodja are high, the risk of malaria transmission by this species appears to be nil. Despite LLIN distribution campaigns, biting rates and sporozoite rates in *An. gambiae* s.l. and *An. funestus* s.l. remain high.
- AIRS recruited a medical entomologist to support the INRB team in the implementation of program activities. A final candidate was selected and is scheduled to move to DRC by May 13, 2017.
- AIRS contributed to the development of a National Insecticide Resistance Management Plan for DRC in close collaboration with NMCP, PMI DRC, World Health Organization (WHO) and other country stakeholders.

1.6 ETHIOPIA

PROGRAM HIGHLIGHTS

- Supported the shipment and subsequent destruction by Veolia ES Field Services Limited of 17,443 kg of DDT contaminated cardboard packaging in Poland.
- Hired new staff (eight Zonal IRS Coordinators, one Environmental Compliance Officer (ECO), one Database Manager) and introduced new positions (one Warehouse and Logistics Manager, two

Operations Managers) to enhance implementation and supervision and improve IRS quality in 2017.

- Conducted logistics needs assessments and planning meetings in 10 new IRS districts in Oromia region and eight in Benishangul Gumuz region.
- In collaboration with district health offices conducted pre-spray environmental compliance assessments for 34 graduated districts and mentored Federal Ministry of Health (FMOH) counterparts.
- Conducted microplanning workshops for 18 new PMI-supported districts and 34 graduated districts to review logistics and human resource needs and environmental compliance gaps, and develop district specific operational plans.
- Finalized Ethiopia capacity building assessment and plan for 2017.

ENTOMOLOGY

- Conducted entomological monitoring activities on vector bionomics as a continuation of the second year of the longitudinal study in three sentinel sites (June 2016 – May 2017). The main vector of malaria, *An. gambiae* s.l., reached peak densities at variable times in the three sites between June and September, with densities dropping from October onwards. The peak biting of the malaria vector was variable between sites, with Gobu Sayo and Seka Chekorsa recording pre-midnight biting activity (19.00 – 23.00 hours), and a higher proportion of host-seeking *An. gambiae* s.l. being collected from 23.00 – 4.00 hours in the Ejaji control site.
- Assessed the susceptibility of *An. gambiae* s.l. using the WHO tube test. Results showed the vector was susceptible to propoxur and pirimiphos-methyl in 8/11 and 9/11 sites, respectively. Resistance and possible resistance to pirimiphos-methyl were recorded in one site each (Babile site in Oromia region and Alamata site in Tigray region, respectively). The results will be confirmed through further susceptibility assays to be conducted in 2017. These two sites are outside the current IRS operation sites. In addition, suspected resistance and resistance to bendiocarb were observed in one site each and resistance to DDT and permethrin was recorded in all 11 sites where the test was conducted.

1.7 GHANA

PROGRAM HIGHLIGHTS

- In late October 2016, AIRS Ghana began planning activities for the 2017 spray campaign.
- With the addition of two more districts (Gushegu and Karaga), the team recruited two new District Operations Coordinators. The team carried out key stakeholder engagements in the new districts by December 2016. Following the assessment findings of the pre-spray environmental compliance assessment (PSECA) conducted in mid-December 2016, the country team rehabilitated all 21 operational sites.
- AIRS Ghana successfully completed all recruitment and training, rental of vehicles to transport spray operators and materials, and distribution of materials to the operational sites. AIRS Ghana worked with local governments and communities during the mobilization and sensitization process. The country team shared spray plans and spray progress with NMCP, Regional and Districts Health Directorates, District Assemblies, and community leaders. Community leaders agreed to continue to work with spray teams to reduce refusal and improve coverage.
- In February 2017, the team tracked locked structures identified during the 2016 spray campaign that could not be sprayed. The same structures will be tracked during the 2017 spray campaign to gain a better understanding of the dynamics surrounding locked structures for better implementation of

IRS in the future. This will help with data-driven recommendations on whether these structures should be counted as eligible structures for spray.

- The Country Operations Manager provided south-to-south assistance in Mozambique for about three weeks (mid-September to October) to support AIRS Mozambique’s 2016 spray campaign. AIRS Ghana database manager provided remote support to Mozambique, Tanzania and Kenya.

ENTOMOLOGY

- *An. gambiae* s.l. was the most abundant species in all the study sites, comprising 98% of the total *Anopheles* collected. *An. coluzzii* and *An. gambiae* s.s. were the main species identified by polymerase chain reaction (PCR), with *An. coluzzii* dominant in most sites.
- Monthly wall bioassays conducted after the 2016 spray campaign to assess the residual efficacy of the sprayed insecticide showed that pirimiphos-methyl remained effective, killing more than 80% of mosquitoes up to seven months post-IRS. The sprayed insecticide lasted longer on cement and wooden surfaces (doors and windows) than on mud surfaces.
- WHO susceptibility tests indicate that *An. gambiae* s.l. mosquitoes from both IRS and non-IRS districts were susceptible to pirimiphos-methyl and fenitrothion (with mortalities between 98% and 100%) except in Dimabi (non-IRS site), where mosquitoes showed possible resistance to pirimiphos-methyl (97%). *An. gambiae* s.l. was resistant to DDT, deltamethrin, and alpha-cypermethrin across all sites, but was susceptible to bendiocarb in all sites except Gbullung (Kumbungu District) where it was resistant (89% mortality), and Nanton (Savelugu Nanton District), where it was possibly resistant (92% mortality).
- AIRS Ghana supported the National Insecticide Resistance Monitoring Partnership to collect data on insecticide resistance from 10 sentinel sites in all 10 regions of Ghana. Data confirmed high pyrethroid and DDT resistance in *An. gambiae* s.l. across all sites surveyed and was suggestive of a role of monooxygenases in pyrethroid resistance detected. The study also found that *An. gambiae* s.l. was susceptible to pirimiphos-methyl in all sites tested with the exception of Weija in the Greater Accra Region, an area with an irrigation project supporting vegetable farming. The Global Fund supported insecticide resistance data collection in 10 other sites in all 10 regions. The results were similar to PMI-funded results with the exception of reported resistance to pirimiphos-methyl in Greater Accra (Ada site) and Ashanti (Konongo site), similar to Weija site. This joint PMI and Global Fund support is making critical contributions to the national database for IR monitoring and mapping. Discussions are underway to perform confirmatory tests with the papers used for susceptibility testing in this area.
- Preparations were finalized for the study on outdoor biting behavior of *Anopheles*. Data collection will begin in May/June. This study is funded through the country resources.

1.8 KENYA

TABLE 1: AIRS KENYA AT A GLANCE

Number of sub-counties sprayed by PMI-supported IRS in 2017	6 within Migori County (Rongo, Awendo, Uriri, Suna East, Suna West and Nyatike)
Insecticide	Pirimiphos-methyl
Number of structures targeted by PMI-supported IRS	226,827
Number of structures found by SOPs	217,100
Number of structures sprayed by SOPs	212,029
Spray coverage	97.7%

Total population protected by PMI-supported IRS	906,388
Pregnant women	16,932
Children under 5	127,157
Dates of PMI-supported IRS campaign	February 13 – March 18
Length of Campaign	30 days
Number of people trained with USG funds to deliver IRS*	2,270

*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.

PROGRAM HIGHLIGHTS

- AIRS Kenya Chief of Party arrived in country in November 2016.
- Successfully implemented IRS in Kenya for the first time since 2012 in six sub-counties in Migori County from February 13 – March 18, 2017. The spray campaign protected 906,253 people.
- Introduced a number of IRS tools developed by the PMI AIRS Project during this first spray campaign in Kenya, specifically an SMS-based inventory management system (e-Inventory) and other mHealth tools for IRS supervision, spray performance monitoring, seasonal worker job aids and data collection verification. By these measures, AIRS Kenya’s IRS campaign in Migori County was a highly effective vector control intervention and a major success for PMI, NMCP, MOH and the AIRS to reintroduce IRS in Kenya following a five year absence in country.
- Recruited and hired 12 new staff in November and December 2016 to prepare for the campaign.
- Insecticide arrived in Kenya on January 7, 2016. AIRS Kenya experienced some challenges clearing the insecticide due to lapse in product registration with the Kenya Pesticide Control Products Board (PCPB). Arysta renewed its product registration on February 2 resulting in the PCPB issuance of AIRS Kenya’s import license on February 10 to facilitate clearance.
- AIRS Kenya’s annual spray campaign began on time on February 13. AIRS Kenya sprayed 27,780 bottles of Actellic donated by NMCP to begin the campaign while PMI-funded insecticide was cleared and delivered to Kisumu. The spray campaign ended as scheduled on March 18, 2017, spraying 211,995 of 217,995 eligible structures found for a 97.7% coverage rate.
- AIRS Kenya COP participated in NMCP’s Global Fund proposal writing workshop February 27-28 by providing IRS gap analysis and other technical assistance for the 2018-2020 Global Fund proposal.

ENTOMOLOGY

- AIRS Kenya conducted cone bioassay tests February 27 - March 3, 2017, to test spray quality using wild collected *An. funestus* mosquitoes and a laboratory-reared, susceptible colony of *An. gambiae* s.s. Kisumu strain. The exercise was conducted in Rongo, Uriri, Nyatike and Suna West sub-counties in Migori County. High mortality of laboratory-reared susceptible *An. gambiae* was observed in all sites for both mud and cement walls. Similarly, 100% mortality was recorded for wild collected adult *An. funestus*. Mortality was very low in control samples. Results demonstrated a high potency if the insecticide was used, and there was good quality of spray.

1.9 LIBERIA

PROGRAM HIGHLIGHTS

- AIRS Liberia and the Liberian National Malaria Control Program conducted malaria vector monitoring in four sentinel sites: Tomato Camp (Bong County), Jeneta (Margibi County), Frank Town (Montserrado County) and Bokay Town (Grand Bassa County). Monthly collections were

conducted with CDC LTs and PSCs, and HLCs were conducted every two months.

- From October 2016 to March 2017, 496 females *An. gambiae* s.l. were collected using PSC (74.60%), CDC LT (14.52%), and HLC (10.89%). In all sites, the main vector was *An. gambiae* s.l. followed by *An. funestus* (less than 1%). Among the other mosquito species, *Culex* spp. were predominant with 946 samples collected mainly with CDC LT (91.01%).
- A subsample of mosquitoes tested using WHO tube tests was sent to South Africa for molecular analysis with the purpose of having additional data on samples collected from 2014 to 2016.
- In October 2016, the team reared the 13th generation of mosquitoes from a Kisumu strain of *An. gambiae* s.s. imported from Mali. Despite an absence of regular power supply, the colony was well established in our 'Insectary-in-a-Box' and will be used as control for susceptibility tests. The data generated was shared during a vector working group meeting including the NMCP, Liberian Institute of Biomedical Research, and agricultural services involved in vector control.

I.10 MADAGASCAR

PROGRAM HIGHLIGHTS

- October 01, 2016 marked the last day of the spray campaign in the East, where a total of 36 communes, located in three districts (Brickaville, Fenerive Est and Tamatave II) were sprayed.
- To build local capacity, AIRS built, out of two separate containers, an insectary-in-the-box as well as a warehouse to store entomological materials for the Malaria Control Directorate (DLP). The insectary and warehouse were inaugurated in the presence of the Minister of Health, Mamy L. Andriamanarivo, the Acting USAID Mission Director, Aaron Bishop, as well as other officials from the Ministry of Health, World Health Organization (WHO) and USAID.
- Entomological data collected indicates that *An. gambiae* s.l., *An. funestus*, and *An. mascarensis* were present at various sentinel sites, with a predominance of *An. gambiae* s.l. (*An.gambiae* s.l. : 33.6%; *An.funestus*: 7.3%; *An. mascarensis*: 4.8%; other *Anopheles* sp: 54.3%).
- The results of the vector susceptibility tests indicated susceptibility of *An. gambiae* s.l. to bendiocarb and pirimiphos-methyl in all spray areas. *An. gambiae* s.l. phenotypic resistance to DDT is widespread followed by resistance to permethrin (a type-I pyrethroid). Resistance to type-II pyrethroids (deltamethrin, lambda-cyhalothrin, and alpha-cypermethrin) was limited. *An. funestus* and *An. mascariensis* were fully susceptible to the insecticides tested: organophosphate (pirimiphos-methyl) and pyrethroids (deltamethrin and permethrin).
- Cone bioassay tests performed in October, one month after structures were sprayed on the East Coast, indicated that the quality of spraying was good with test mortality rates of 100% for all structures sampled and used for the testing. The monthly monitoring of the insecticide decay rate, for the insecticide used (Actellic) showed pirimiphos-methyl lasted seven months on all sprayed surface types in the South East. We are still monitoring the residual life of pirimiphos-methyl on the East Coast. Six months after spraying, 84% to 89% test mortality for falafa-made walls and 85% to 90.5% mortality for wood walls were recorded.

I.11 MALI

PROGRAM HIGHLIGHTS

- AIRS Mali, in collaboration with the NMCP, started transitioning project spray operations to Mopti region, where the project will cover health areas in Bandiagara, Bankass, Djenne and Mopti districts in 2017.
- Completed the geographical reconnaissance and enumeration work in the four new districts (Bandiagara, Djenne, and Mopti) for IRS planning.
- AIRS Mali ECO carried out pre-campaign EC assessments.
- Completed the seasonal epidemiological data collection – the report analyzed the seasonal morbidity and mortality epidemiological trends due to malaria.
- Recruitment is ongoing for a new Database Manager and District Coordinator. A new Operations Manager was hired in March.

ENTOMOLOGY

- The entomological inoculation rate (EIR) was lower in IRS sites (7.03 infected bites/human/5 months) than control sites (45.33 ib/human/5 months), equating to an 84.5% reduction. WHO tube tests revealed full susceptibility to pirimiphos-methyl (0.25%) in all surveyed sites except Niono (a non-IRS site) where further testing is needed to confirm the result. Resistance to DDT (4%), permethrin (0.75%) and deltamethrin (0.05%) was widespread throughout southern and central Mali.
- Conducted residual efficacy monitoring of pirimiphos-methyl (August -December 2016). Cone tests with AIRS insectary-reared *An. gambiae* Kisumu susceptible strain were performed. The residual efficacy of pirimiphos-methyl (Actellic) sprayed on walls in Koulikoro, Fana and Barouéli was two months for mud, cement and painted cement, and three months for mud and Kaolin (according to WHO criteria of > 80% mortality). Despite the relatively short residual duration, mortality remained >60% for five months in 2016.
- Operational research continued in 2016 to assess the durability of combination LLINs. Divergence between Olyset and Permanet brand LLINs began 16 months after distribution and a consistent trend of greater attrition (nets discarded due to decay) for Olyset brand nets continued through 36 months after distribution. There were no consistent trends to indicate any differences in holes or attrition rates for the combination LLINs compared to their respective conventional analogues.
- The 2016 Entomological Monitoring Report was finalized and submitted to PMI.
- Two abstracts were submitted to ASTMH for the November 2017 conference in Baltimore.

I.12 MOZAMBIQUE

TABLE 2: AIRS MOZAMBIQUE AT A GLANCE

Number of districts covered by PMI-supported IRS in 2017	7 districts in Zambézia Province (Derre, Milange, Mocuba, Molumbo, Mopeia, Morrumbala, and Quelimane)
Insecticide	Pirimiphos-methyl
Number of structures targeted for PMI-supported IRS in 2016 (based on structures found by SOPs in 2014)	481,296
Number of structures found by SOPs in 2016	508,295

Number of structures sprayed by PMI-supported IRS	405,597
Spray coverage	80% by District: Derre: 84%, Milange 87%, Mocuba 72%, Molumbo 81%, Mopeia 83%, Morrumbala 88%, Quelimane 71%
Total population protected by PMI-supported IRS	1,929,654
Pregnant women protected	115,639
Children under 5 protected	284,468
Dates of PMI-supported IRS campaign	October 5 - November 26, 2016
Length of Campaign	44 days
Number of people trained with USG funds to deliver IRS*	2,129

*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.

PROGRAM HIGHLIGHTS

- Implemented IRS in seven districts in Zambezia province (Mocuba, Morrumbala, Milange, Molumbo, Quelimane, Mopeia and Derre) in collaboration with Provincial and District Health Directorates.
- The 2016 campaign fell short of the PMI 85% coverage target due to a number of challenges, namely homeowner refusals and closed structures, particularly in urban and peri-urban areas like Mocuba and Quelimane, and poor community mobilization by community leaders to ensure houses were ready when SOPs arrived.
- Completed all EC inspections using smartphones in full collaboration with district level environmental officers of the Ministries of Environment and Agriculture. Nineteen mobile soak pits were piloted in five spray target districts. Solid waste was disposed and/or incinerated under the supervision of the ECO and provincial level environmental officers of the Ministries of Environment and Agriculture. 381,340 bottles and caps of Actellic were washed and prepared for recycling.
- Increased the number of women participating in IRS, including in supervisory roles, from 34% in 2015 to 37% in 2016.
- Implemented mobile phone data collection, messaging, reporting, and supervision tools using the Open Data Kit (ODK) and CommCare platforms. These mHealth tools included: bulk SMS job aids, performance monitoring tracking (PMT), and mobile-based supervisory forms.
- Conducted an internal country capacity assessment (CAP) to assess the Ministry of Health's capability and capacity to carry out IRS.

ENTOMOLOGY

- The standard WHO cone bioassay test used within the first two weeks of the 2016 spray campaign showed high quality of spray in all districts, with a mortality rate of 100% after 24 hours.
- The residual efficacy of the pirimiphos-methyl was measured at T1 (one month after spraying) and results remained acceptable with mortality rates varying from 96.5% to 100%. The residual life of this insecticide will be measured monthly until mortality is below the standard cut-off point of 80% for two consecutive months.
- Between September – October 2016, and January – March 2017, insecticide susceptibility tests were carried out using the WHO tube test on mosquitoes from Mocuba, Morrumbala, Milange and Maganja de Costa. *An. gambiae* s.l. remains susceptible to pirimiphos-methyl at all sites.
- Monthly monitoring activities are in progress in the intervention districts (Mocuba, Morrumbala and

Milange) and the control district (Maganja da Costa) with PSC, HLC and indoor CDC LT collections.

- In Mopeia, HLC, indoor CDC LT, and cone wall bioassay collections are being conducted in both the intervention and control areas of the district as part of the PMI and UNITAID supported cost-effectiveness study of combining IRS and LLINs

1.13 NIGERIA

ENTOMOLOGY

- Provision of vehicles by state ministries significantly reduced the cost of monthly surveillance and other activities carried out by AIRS, accounting for an estimated \$50,000 in savings that can be redirected for other program activities.
- From October 2016 to March 2017, study teams from all six sentinel sites used sampling methods to collect 6,444 *Anopheles* mosquitoes, of which 34.03% were collected using the PSC method; 65.97% were collected using baited CDC LTs. Significantly higher numbers of *An. gambiae* s.l. (40.94%) were collected indoors compared to outdoors (25.03%). Surveys show a predominance of *An. gambiae* s.l. in all sentinel sites with *An. gambiae* s.l. ranging from 86-99% compared to other *Anopheles* species. This is in agreement with previous findings in similar locations. Important minor species such as *An. funestus*, *An. coustani*, and *An. squamosus* were also observed.

1.14 RWANDA

PROGRAM HIGHLIGHTS

- Conducted a Post-Spray Data Quality Audit (PSDQA) of the September 2016 spray campaign. Audit data showed 95.7% (confidence interval, 93.6-97.1) of structures were sprayed compared to 99.3% coverage reported in the September 2016 End-of-Spray Report (EOSR). Based on a 95% confidence interval (CI), spray coverage and the proportion of people protected for the September 2016 EOSR reflected the true spray coverage in Kirehe District but not in Nyagatare District, nor for the campaign overall. Nyagatare's coverage was reported as 99.3% in the EOSR, but the audit estimates Nyagatare's coverage at 93.1% (CI, 89.7-95.4). The population protected according to the EOSR was 99.4% overall, but based on the PSDQA analysis, we are statistically confident that the proportion of people protected is slightly lower than that reported in the EOSR (between 93.7 and 97.5%).
- Recruited Entomological Coordinator in December 2016.
- Provided technical support for MOH-supported IRS campaign (November 11-December 8, 2016)
- Supported the entomology training from February 21-24, 2017. Twenty-seven entomology technicians participated in the training.
- As a member of the national malaria technical working group, AIRS Rwanda participated in the Malaria Strategic Plan mid-term review, the revision of the Malaria Strategic Plan (2013-2020) and concept note preparation for Global Fund.

ENTOMOLOGY

- Cone bioassays were conducted within the first week of spraying. In all test cones, 100% mortality of susceptible *An. gambiae* s.s. was recorded.
- Monthly cone bioassays were conducted. Results showed 94.7% (Nyagatare District) and 96.1% (Kirehe District) average mortalities of susceptible *An. gambiae* s.s. six months post spray (March 2017).

- PSC and HLC were conducted during the reporting period in three IRS districts (Bugesera¹, Nyagatare, and Kirehe) and one non-IRS (control) district, Ngoma. *An. gambiae* s.l. was the major vector collected in all sites.
- Kirehe District showed the highest average vector density (0.89 *An. gambiae* s.l./house/day) among the IRS districts (Bugesera was 0.68 *An. gambiae* s.l./house/day and Nyagatare 0.4 *An. gambiae* s.l./house/day). The control (non-IRS) district showed the highest density at 4.31 *An. gambiae* s.l./house/day.
- *An. gambiae* s.l. generally showed slightly more exophagic than endophagic tendency in the four districts, including the control district: Bugesera 48.6% endophagic vs 51.4% exophagic; Kirehe 28.7% endophagic vs 71.3% exophagic; Nyagatare 41.7% endophagic vs 58.3% exophagic; and Ngoma 48.8% endophagic vs 51.2% exophagic.
- High biting tendency was observed as early as 7 p.m. - 8 p.m. in Kirehe and Nyagatare. In Nyagatare, approximately 4.5 bites per person per hour were recorded from 6 p.m. to 7 p.m. outdoors and 3.6 indoors. An increase in indoor biting was observed at around 10 p.m. (4.25 bites/person/hour), peaked to 4.87 bites/person/hour at 1 a.m. and remained high until 3 a.m. Outdoor biting in Nyagatare dropped from 4.5 bites/person/hour at 7 p.m. to 2.5 bites/person/hour at 10 p.m. An increase was observed during the period 2-3 a.m. (5.5 bites/person/hour) after which there was a drop to 1.2 (bites/person/hour) at 6 a.m. In Kirehe, both outdoor and indoor biting was 1.3 bites/person/hour at 6 p.m., rising to 2.42 bites/person/hour outdoors at 10 p.m., and peaking at 1 a.m. (4.5 bites/person/hour). Indoor biting in Kirehe was highest between 10 p.m. to 2 a.m. (1.45-2 bites/person/hour). In Bugesera, hourly biting was generally low (0.2 bites/person/hour) at 7 p.m. both indoors and outdoors. It peaked around 9 p.m. at 0.8 bites/person/hour (indoors) and 1.42 bites/person/hour (outdoors), dropped in the next hour, and remained relatively constant through the rest of the night.

I.15 SENEGAL

PROGRAM HIGHLIGHTS

- Conducted advocacy trips to increase local community participation for the upcoming spray campaign, resulting in free office space and operational sites, transportation, community mobilization, and refusal management from local authorities. Local authorities in all districts provided three out of four offices and 25 out of 30 operational sites free of charge to the project. The IRS Working group (AIRS, NMCP, National Hygiene Department and Directorate of Environment and Classified Institutions) discussed plans for the upcoming spray campaign.
- AIRS, in collaboration with the NMCP, developed an alternative IRS protocol to be piloted in one health post (Touba Ngueyenne, District Malem Hoddar), building on the results achieved in the first phase of community-based IRS (CB-IRS).

ENTOMOLOGY

- PMI through AIRS Senegal worked with Université Cheikh Anta Diop de Dakar (UCAD) to conduct entomological monitoring in the IRS target districts and ensured sentinel sites are relevant to the focal IRS technical approach being implemented in Senegal. In each IRS district (Niuro, Koungheul, Koumpentoum and Malem Hoddar), four sentinel villages were selected: two from malaria hot spot villages (health posts that received IRS in 2016) and two from low transmission non-hot spots (health posts that did not receive IRS in 2016). Two additional 'external' malaria hot spot sites were

¹ Bugesera was sprayed with GOR resources but AIRS Rwanda continues entomological monitoring (PSC & HLC).

selected from a neighboring control district that did not receive IRS in 2016 (Ndofane, Kaffrine and Tambacounda). The sentinel sites included two sprayed hot spots, two internal controls and two external controls for each of the four spray districts for a total of 24 sites.

- UCAD conducted cone bioassay tests two weeks after spraying using the susceptible *An. gambiae* Yaounde strain. Residual performance was shortest in Malem Hoddar where mortality was greater than 80% for only one month after spraying, although mortality remained above 70% after three months on mud and cement walls. Elsewhere, mortality was higher than 80% on cement walls for four to five months. Strictly following WHO criteria, residual performance was two to four months on mud walls; however, in most sites, mortality remained higher than 70% for five months. WHO cylinder tests indicated full susceptibility of wild *An. gambiae* s.l. to pirimiphos-methyl (0.25%) in all 15 sites tested, including all four IRS districts. Resistance to bendiocarb (0.1%) was recorded only in the Dakar suburbs of Pikine and UCAD campus, with possible resistance in Kedougou and Diourbel and full susceptibility recorded in IRS districts.

1.16 TANZANIA

TABLE 3: AIRS TANZANIA AT A GLANCE

	Zanzibar	Tanzania Mainland	Total
Number of districts sprayed by PMI-supported IRS in 2017	9 (Central, Chakechake, Micheweni, Mkoani, North A, North B, South, West, Wete)	9 (Bukoba Rural, Missenyi, Ngara, Chato, Nyang'hwale, Butiama, Musoma Rural, Kwimba, Sengerema)	18
Insecticide	Pirimiphos-methyl	Pirimiphos-methyl	---
Number of structures targeted by PMI-supported IRS	40,488	574,905*	615,393
Number of structures found by SOPs**	42,147	657,938	700,085
Number of structures sprayed by PMI-supported IRS***	38,884	625,738	664,622
Spray coverage	92.3%	95.1%	94.9%
Total population protected by PMI-supported IRS	191,119	2,377,403	2,568,522
Pregnant women	5,746	88,376	94,122
Children under 5	32,946	457,103	490,049
Dates of PMI-supported IRS campaign	Feb 14 – March 1, 2017	Jan 25 – Feb 21, 2017 March 8– April 4, 2017	
Length of Campaign (in days)	14	48	55****
Number of people trained with USG funds to deliver IRS*****	429	3,201	3,630

Note: *This includes 20,000 structures to be sprayed through a Public Private Partnership with Geita Gold Mine (GGM) that is yet to happen. **Data cleaning is ongoing and figures will change upon final submission. ***This excludes the GGM campaign which is yet to occur. ****The first 7 days of the Zanzibar campaign overlapped with the January 25 campaign in mainland. ***** 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.

PROGRAM HIGHLIGHTS

- AIRS Tanzania collaborated with the NMCP and the Zanzibar Malaria Elimination Programme (ZAMEP) to conduct IRS in three phases from January 25 - April 4, 2017. The Project exceeded its target of spraying 615,393 structures in Tanzania and Zanzibar. Overall, the Project sprayed 664,622

structures out of 700,085 structures that spray operators found in the targeted districts in mainland and Zanzibar, accounting for a coverage rate of 94.9%. The Project protected 2,568,522 residents, including 490,049 children under five years of age and 94,122 pregnant women.

- The project held stakeholder advocacy, planning and sensitization meetings to facilitate awareness and encourage a participatory approach with relevant stakeholders in the spray campaign. The mobilization approach was modified in 2017 to rely on hamlet leaders to sensitize and mobilize their communities under the close monitoring of trained site mobilizers.
- Environmental compliance assessments were conducted by the project, pre-, during and post-spray to ensure compliance with United States Government and Government of Tanzania environmental regulations. Prior approvals were obtained from the National Environmental Management Council (NEMC) and the Zanzibar Environmental Management Agency (ZEMA) before commencement of IRS operations.
- Three IRS approaches continued to be used in 2017. The centralized approach was used in two districts of the mainland and all nine districts in Zanzibar, except in the Junguni Shehia of Wete District where a community-based approach was piloted. CB-IRS was implemented in one district on the mainland, while the quasi CB-IRS approach was implemented in six districts on the mainland. This entails conducting two-thirds of the campaign using the traditional IRS model and renting vehicles for SOP transportation. For the remaining one-third of the campaign, the SOPs rely on bicycles for transportation, reducing operational costs for the overall campaign. During the final third of the campaign, the spray teams will not travel more than 10km from the operational site, as they spray from the farthest point away and progressively move closer to the operational site each day. The 2016 structures definition document, approved by NMCP, ZAMEP and PMI, continued to be used in 2017 to determine eligible structures.
- Empty insecticide bottles will be recycled into products that will be used for non-consumptive services by a recycling company certified by the NEMC. The recycling company is a partnership of two organizations – Sobest limited (based in Mwanza) and Mbope Investment (based in Dar es Salaam).
- Operations Director Allan Were and Deputy Project Director Paula Wood facilitated capacity building workshops (boot camps) for national and district IRS leaders in Mwanza and Zanzibar, Tanzania. The workshop in Mwanza took place December 5-9, 2016, and was attended by 56 participants. The participants included representatives from NMCP, PMI spray districts, the regional offices of the Lake Zone, NEMC, and AIRS Tanzania. The workshop in Zanzibar took place December 12-16, and had 34 participants coming from ZAMEP, the nine IRS districts; three non-IRS districts; ZEMA; Zanzibar Food and Drug Board; and AIRS. Naomi Kaspar from PMI Tanzania participated for one day at the Zanzibar workshop.

ENTOMOLOGY

- Entomological surveillance for AIRS Tanzania was subcontracted to the Mwanza and Amani Centers of the National Institute for Medical Research.
- NIMR Mwanza Centre conducted IRS quality assays in a random sample of one village in each intervention district on mainland Tanzania. ZAMEP conducted the assays in Zanzibar, under AIRS supervision. The assays were conducted within the first 14 days after spray start date. The 24-hour mortality observed following a half-hour exposure to sprayed surfaces ranged from 88% to 100%.
- Baseline results from the wall cone bioassays to monitor the decay rate of the insecticide showed high efficacy in all sentinel sites. Monitoring will continue every month until the observed 24-hour mortality falls below 80% for two consecutive months.

I.17 ZAMBIA

TABLE 4: AIRS ZAMBIA AT A GLANCE

Number of districts covered by PMI-supported IRS	35
Insecticide	Pirimiphos-methyl
Number of structures targeted by PMI-supported IRS	542,184
Number of structures found by SOPs	612,929
Number of structures sprayed by SOPs	559,550
Spray coverage	91%
Population protected by PMI-supported IRS	2,626,718
Pregnant women	69,118
Children under 5	399,367
Dates of PMI-supported IRS campaign	September 26 - December 10, 2016
Length of Campaign (in days)	54
Number of people trained with USG funds to deliver IRS*	1,982

*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.

PROGRAM HIGHLIGHTS

- AIRS Zambia implemented IRS in four provinces: Eastern (9 districts), Luapula (10 districts), Muchinga (7 districts) and Northern (9 districts).
- The start dates for the 2016 IRS campaign in Zambia were staggered to allow the AIRS team to be in the field and supervise the logistic activities for the start of the campaign.
- AIRS trained 147 supervisors from 35 districts to enhance the supervision of SOPs and assure high spray quality. Local temporary staff were recruited and trained well before the start of the campaign. Logistics and environmental compliance assessments were carried out to ensure standard operating procedures and Best Management Practices (BMP) were followed. Stakeholder, partner planning, and community sensitization meetings created awareness and effective involvement of all stakeholders for successful spray operations.
- 542,184 structures were targeted to be sprayed in the four provinces and the targeted population was 2,475,741. By the end of IRS operations, day 54 of the campaign, SOPs found 612,929 structures. AIRS Zambia procured more bottles to finish spraying, resulting in a short break in the campaign. Spraying resumed once the 4,008 additional bottles arrived in country.
- In some of the districts, quality of supervision was below par. AIRS has worked with MOH and NMEP to ensure districts are proactive in planning, implementing, and supervising IRS and that the supervisors are well-trained.

ENTOMOLOGY

- Entomological surveillance was conducted in 12 sentinel sites in six districts in Zambia from October 2016 through the end of the reporting period, March 2017.
- The WHO cone bioassay was performed 24 hours after spraying and showed 100% mortality in five out of six sprayed sites. Mortality for mud sprayed walls was 88% in Isoka. Remedial measures were taken to control the quality in the district. Pirimiphos-methyl was effective on cement in three sites (Kasama, Isoka, and Milenge) in March five months after the spraying. The test mortality rate was

less than the 80% WHO threshold on the mud and cement sprayed walls in Mwense and Katete and on mud in Isoka and Kasama. The mortality was above 80% for both mud and cement in Milenge District five months after spraying.

- The most abundant vector collected at our entomological sites was *Anopheles funestus* s.l. The mean indoor resting density of *Anopheles funestus* s.l. dropped from 1.6 *Anopheles funestus* s.l. per room per day in September to 0.9 in the intervention sites in January three months after IRS. In the control sites, the indoor resting density per room per day was 3.3 *Anopheles funestus* s.l. per room in September and 5.0 in January. The mean density of *Anopheles funestus* s.l. in the intervention sites (2 *Anopheles funestus* s.l./trap/night) was 6.5 times lower than the density in the control sites (13/trap/night) in January using the CDC light trap collection method.
- The human biting rate of *Anopheles funestus* s.l. (indoors) was reduced from 13.3 bites per person per night during the pre-spray period to 8.3 bites per person per night in January three months after spraying in the intervention sites.

1.18 ZIMBABWE

TABLE 5: AIRS ZIMBABWE AT A GLANCE

Number of districts covered by PMI-supported IRS in 2016	4 (Chimanimani, Mutare, Mutasa, Nyanga)
Insecticide	Pirimiphos-methyl
Number of structures targeted by PMI-supported IRS	256,527
Number of structures found by SOPs	240,044
Number of structures sprayed by PMI-supported IRS	229,377
Spray coverage	95.6%
Population protected by PMI-supported IRS	550,475
Pregnant women	17,325
Children under 5 years old	95,787
Dates of PMI-supported IRS campaign	October 24 to December 21, 2016**
Length of campaign (in days)	32
Number of people trained with U.S. Government funds to deliver IRS*	687 (600 men, 87 women)

*Based on the PMI indicator definition, this number includes only spray personnel such as SOPs, TLs, supervisors, and clinicians. It excludes DECAs, drivers, washers, porters, pump technicians, and security guards.

**Late delivery of the second batch of insecticide caused a delay in completion of the spray campaign.

PROGRAM HIGHLIGHTS

- Following the adoption of the blanket spraying approach, an additional 22 wards were added in Chimanimani, Mutare, and Nyanga districts; and 23 villages were added in Mutasa District.
- The team carried out a PSDQA to validate reported spray coverage and people protected during the October- December 2016 spray campaign. Overall, PSDQA results showed coverage above 90%, slightly lower than spray results reported by spray operators during the IRS campaign.
- AIRS Zimbabwe provided technical contributions to NMCP during the writing of the Global Fund Concept Note to help access funds for malaria prevention and control in Zimbabwe (2018-2020).
- The project successfully used for the first time 15 mobile soak pits. The project provided 22 latrines (separated for females and males) at IRS campsites to improve sanitation and promote gender inclusion at these sites.

- The project incinerated 2,200 kg of IRS contaminated waste generated during 2016 IRS campaign. Waste included used disposable respirators, used mutton cloth, and contaminated empty cardboard boxes. The incineration process took place at Hwange Colliery incinerator in February 2017.
- In January 2017, AIRS Zimbabwe completed the incineration of 12,543 bottles of Actellic expired in 2014 at Hwange Colliery incinerator. The incineration of the expired insecticide complied with WHO standards and was approved by the Environmental Management Agency of Zimbabwe.

ENTOMOLOGY

- The country team completed monthly cone bioassay tests to determine the decay rate of the pirimiphos-methyl from November to March at Burma Valley (Mutare District) and at Chakohwa (Chimanimani District). At Chakohwa, residual efficacy was above 88% at four months for mud, cement and brick wall surfaces. In Burma Valley, mortality remained at 100% for mud surfaces but decreased to 97.3, 90.0, and 71.1% for cement, brick, and painted surfaces, respectively, in the fourth month, and to 98, 93, and 80%, respectively, in the fifth month. Cone bioassay tests will continue at the two sentinel sites until mosquito mortality is below 80% for two consecutive months.
- In Manicaland, the *An. funestus* s.l. was the predominant vector species at Burma Valley and Vumba in contrast to *An. gambiae* s.l. at Chakohwa. *An. gambiae* s.l. is re-emerging at Burma Valley after apparently disappearing after the introduction of organophosphates in 2014.
- The project team did not test insecticide resistance in 2016 due to unavailability of breeding sites as a result of the severe drought, but conducted susceptibility tests on DDT (4%) for *An. gambiae* s.l. from Chakari site (the area where NMCP conducts IRS with DDT) in March 2017. The results showed 100% susceptibility to the insecticide.
- In February, the Technical Manager/Entomologist worked with the CDC team from Atlanta to help set up the equipment in a new entomological laboratory and co-facilitated training of staff at Africa University (AU).
- The team began setting up an insectary-in-a box at AU. Estimated completion date is October 2017.

2. CORE

2.1 OPERATIONS RESEARCH

ZAMBIA OPERATIONAL RESEARCH STUDY

In November 2016, the operational research protocol “Correlating resistance intensity of pyrethroid insecticides with the performance of LLINs in an experimental hut setting and the use of organophosphate IRS to mitigate pyrethroid resistance” was approved by PMI’s Operational Research Committee. The study was expected to provide information on the association of pyrethroid resistance intensity and LLIN efficacy when tested in experimental huts in two different locations of high and low intensity resistance as obtained through baseline studies, primarily via entomological indicators.

The team conducted insecticide resistance intensity assays using the newly developed Resistance Intensity Rapid Diagnostic Test in March/ May, 2016 (first round) and November/ December 2016 (second round) in Luapula Province in Northern Zambia. The results from the second round of tests indicated that the intensity of pyrethroid resistance in the two villages selected earlier as low and high resistance intensity showed different patterns from the first round of tests. Based on the results from the second round of tests, there seems to be no differences in resistance intensity for pyrethroids in two villages six months after the first round of tests. This lack of difference may be due to the unstable condition of insecticide resistance intensity in the area. The variations in pyrethroid resistance intensity observed between results from the two data points casted doubts on the ability to answer the main question of interest. It was therefore decided not to continue the experimental hut study; however, monitoring on the changes in the intensity of insecticide resistance as part of the routine entomological monitoring in the country will continue.

GHANA OPERATIONAL RESEARCH STUDY

The protocol for the operational research “Evaluation of pirimiphos-methyl efficacy in experimental huts when sprayed on half the usual surface area against natural populations of *Anopheles gambiae* in Ghana” was recently approved by the Institutional Review Board of the Noguchi Memorial Institute in Ghana and Abt Associates Inc. The study, which aims to determine if the amount of insecticide sprayed and its operational cost can be reduced without compromising the efficacy of IRS, will evaluate different spraying scenarios by spraying only the top or bottom half of the walls with and without spraying the ceilings. Construction of the experimental huts has been finalized in Kulaa Village in Northern Ghana, and data collections will commence in May/ June 2017.

2.2 MHEALTH

During the reporting period, the project used the mobile tools in the following spray countries: Kenya, Mozambique, Rwanda, Tanzania, Zambia and Zimbabwe. Kenya, Mozambique, Rwanda, Tanzania and Zambia used all three of the Dimagi-supported mHealth tools: bulk SMS job aids, the Performance Management Tracker (PMT), and the CommCare-based supervision application. Zimbabwe used only two of the three tools as its MOH doesn’t support the use of the PMT. Each country required alterations of the tools and close follow up with setup, training, and implementation of the tools. Dimagi, Abt’s technology partner on the project, led all configuration changes and directly guided the in-country teams on the use, roll-out, and management of the tools. Dimagi supported all countries remotely with

the exception of Kenya as they were using Dimagi-supported tools for the first time and required closer supervision in person.

In addition to the existing supervisory forms on the ODK platform, AIRS Zimbabwe piloted a digitized version of the Directly Observed Spray (DOS) form for spray quality supervision. Due to constraints in data access and entry, the AIRS mHealth team saw an opportunity to try a mobile version of this critical form in a country with adequate infrastructure and a smaller-sized campaign.

For the third year, technology partner Akros continued implementing the mobile data collection and decision-making system, mSpray, in Zambia. In an attempt to optimize the mSpray teams, the project created a new position of team leader assistants for the 2016 campaign. This assistant is solely responsible for data collection on tablets, allowing mSpray team leaders to effectively supervise their team of SOPs. Additionally, to increase the speed and ease of data verification and cleaning on the back end, the M&E team incorporated a unique spray form ID code on the SOP data collection form.

2.3 COST EFFICIENCY

AIRS continued implementing a series of cost-efficiency initiatives in several countries. In Tanzania, AIRS piloted a new CB-IRS strategy by using community health workers as SOPs and supervisors during the spray campaign, thereby reducing the number of SOPs to be recruited during the campaign. CB-IRS also reduces the use of rental vehicles as local SOPs and supervisors can walk and bicycle to sites.

Other cost-efficiency measures by individual countries included: reducing the number of spray campaign days; minimizing the number of district warehouses; regularly maintaining soak pits and site offices during the non-spray period, subsequently reducing high renovation costs; assigning the mobilization and supervision components to the local government; decreasing the number of mobilizers; staggering spray starts each day to reduce vehicle rental; negotiating lower costs with local suppliers; acquiring free operational sites from local authorities; reproducing in-house most of the items that were previously outsourced to printing companies; reducing the number of printed manuals and IEC tools by using previous year's documents; giving database ownership to countries and limiting the use of the Client Technology Center; and minimizing external reliability on partners/subcontractors.

2.4 GENDER

The project continued building a gender-balanced seasonal workforce through our country-based gender focal points. In a new south-to-south mentorship program, new gender focal points in Tanzania and Kenya were matched with experienced gender focal points in Ghana and Rwanda. Country teams' continued efforts to recruit and train women for the seasonal workforce showed positive results. For example, in Kenya, women comprised 48% of this year's seasonal staff. In Tanzania, Goizper trained staff in office-based roles traditionally held by women (receptionist, office coordinator, finance assistant) as pump technicians. These women are now able to travel to the field and support SOPs in that capacity.

The project scaled-up the provision of menstrual hygiene products to additional countries, in an effort to reduce absenteeism, and based on positive feedback from the pilot countries of Ghana and Rwanda. Additional countries including sanitary products as part of women's PPE included Kenya, Tanzania, and Zambia, where local labor law permits a day of paid leave monthly for menstruating women. AIRS Zambia ensured female staff and their managers were aware of this provision and able to take the paid leave allowed by law.

AIRS Ghana developed a new poster on sexual harassment for use at operational sites. The new design is more visually engaging while conveying the same essential message that harassment is not allowed.

The project completed a quantitative analysis of spray performance data in Ghana and Zambia, a complement to the qualitative study conducted earlier in 2016. The findings, summarized in a report, provide further evidence that female SOPs are as effective as their male counterparts, as measured by

the number of refusal rates and structures sprayed each day. The project continued administrating the gender norms survey begun in Year 1 in Ethiopia, Madagascar, Rwanda, and Zimbabwe.

2.5 ENVIRONMENTAL COMPLIANCE AND SAFETY

- Prepared, submitted and received approval for the Kenya SEA.
- Completed Letter Reports for Tanzania, Ghana, and Benin.
- Managed the development of an Environmental and Social Impact Assessment for Mali.
- Updated the Environmental Monitoring and Mitigation Plan and Incident Report Form for IRS.
- Disseminated new guidelines with a limit of 50 spray operators to be accommodated at a soak pit. Developed and implemented a new design for soak pits in eight of 12 countries.
- Developed and implemented triple rinse procedure with flushing of the lance, CFV, and nozzle.
- Continued to develop options for PPE use in IRS, including different styles of Tyvek suits and pilot-testing wet wipes for cleaning of PPE and the outside of pumps.

2.6 CONFERENCES

American Society of Tropical Medicine and Hygiene Conference (ASTMH)

The PMI AIRS Project presented eight posters at the 65th annual ASTMH Conference:

- “Determining the Prevalence and Geographic Distribution of Mixed Function Oxidases in Pyrethroid Resistant *Anopheles gambiae* s.l. in relation to site selection for a trial of combination LLINs in Mali”
- “Distribution and Frequency of Insecticide Resistance in *Anopheles gambiae* s.l. in Liberia”
- “Dynamics of Entomological Inoculation Rates Following Indoor Residual Spraying (IRS) in Mali”
- “Entomological Indicators of Malaria Transmission Increase after IRS Discontinued: Findings from Savelugu Nanton District, Ghana”
- “Knock down resistance (kdr) gene in *Anopheles coluzzi* and *Anopheles gambiae* that survived the diagnostic concentration of pyrethroids and DDT in two eco-epidemiological zones (Guinea Savannah and Coastal Mangrove) of Nigeria”
- “Responsible Disposal of Obsolete Public Health DDT Stocks in Ethiopia”
- “Susceptibility Status of Malaria Vectors to Insecticides Commonly Used for Malaria Vector Control in Tanzania”
- “The Impact of Indoor Residual Spraying on the Density and Parity Rate of *Anopheles gambiae* s.l. in Oromia Region- Ethiopia”

Roll Back Malaria Vector Control Working Group

Project Director Brad Lucas and M&E Team Lead Keith Mangam attended the 12th annual RBM Vector Control Working Group (VCWG) meeting in Geneva, February 8-10, 2017.

mHealth Summit

Keith Mangam and Ashley Thomas presented twice at the 8th annual Global Digital Health Forum in Washington, D.C., in December 2016. The first presentation was an overview of the use of mHealth tools on the PMI AIRS Project as well as how these tools have evolved. The second presentation focused on using mobile technology as a method for behavior change communication based on an article

published in the journal *Global Health: Science and Practice* that summarized the results of a mobile messaging pilot conducted in Mali in 2014.

2.7 JOURNAL ARTICLES

Eight manuscripts were submitted to PMI during this reporting period, one of which was published and one which was submitted to a journal. Manuscripts include:

- *Community-Based Indoor Residual Spraying: An innovative approach to deliver effective, cost-efficient, and sustainable malaria prevention in Ethiopia* – Published in *Global Health: Science and Practice* in December 2016.
- *Insecticide resistance status of three malaria vectors: An. gambiae s.l., An. funestus and An. mascarensis from the South, Central and East Coasts of Madagascar* – submitted to *Parasites & Vectors*
- *Multi-Country Assessment of Residual Bio-efficacy of Insecticides Used for Indoor Residual Spraying in Malaria Control on Different Surface Types: Results from Program Monitoring in 15 PMU/USAID supported IRS Countries* – Revised for submission to PLoS journal.
- *Continuation of results of relationship between malaria burden and insecticide class switch in Manicaland Province, Zimbabwe* – submitted to COR and waiting on NMCP clearance.
- *A village level cluster-randomized entomological evaluation of combination long-lasting insecticidal nets containing pyrethroid plus PBO synergist in Southern Mali* – submitted and cleared by PMI.
- *A reduction in malaria transmission intensity in Northern Ghana after seven years of indoor residual spraying* – cleared by PMI and submitted to *Malaria Journal*.
- *Appeasing the Lesser Gods: Barriers to IRS in Northern Ghana* – submitted to PMI.
- *Gender and Spray Operator Performance: A review of data from Ghana and Zambia* – submitted to PMI.

2.8 COMMUNICATIONS

During this reporting period, eight success stories were written, posted on the project and PMI websites and distributed via the AIRS quarterly e-letter. AIRS distributed two e-letters (in December and March) and two e-alerts (December and March – International Women’s Day) to more than 3,700 global health professionals.

Two Tech Talks on “Definition of Eligible Spray Structures” and the “e-Inventory System” were held with COPs.

2.9 NEW EMPLOYEES

- Meghan Tammaro, M&E Specialist, backstops Ethiopia, Rwanda, and Zambia.
- Shirin Kakayeva, M&E Specialist, supports Mali, Mozambique, and Zimbabwe.
- Alexandra Hulme, Technical Program Manager, supports Burundi, Mali, and Tanzania.
- Chloe Adcock, Finance & Contract Analyst, supports Rwanda and AIRS Core activities.
- Terri Mack, Finance & Contract Manager, supports Ethiopia, Ghana, Liberia, and AIRS Core activities.
- Ximena Zepeda McCollum serves as AIRS Project Assistant.

2.10 NGENIRS PROJECT

The two NgenIRS Regional Coordinators, funded by UNITAID, started work in December 2016. Andrew Saibu is based in Accra, Ghana, and John Ngosa is based in Lusaka, Zambia. AIRS works closely with the regional coordinators on NgenIRS activities, such as forecasting of insecticide procurements.

ANNEX A: M&E RESULTS SUMMARY

IRS RESULTS OCTOBER 2016–MARCH 2017

Country	# Structures Sprayed	# Structures Found	Spray Coverage	Total Population Protected	Children <5 Protected	Pregnant Women Protected	# People Trained*
Kenya**	211,995	217,066	98%	906,253	127,133	16,928	1,040
Madagascar	310,426	329,395	94%	1,257,036	184,927	47,508	1,572
Mozambique	405,597	508,295	80%	1,929,654	284,468	115,639	2,129
Rwanda, Sep	198,970	200,278	99%	812,714	118,913	13,718	4,975
Tanzania**	664,622	700,085	95%	2,568,522	490,049	94,122	3,630
Zambia	559,550	612,929	91%	2,626,718	399,367	69,118	1,982
Zimbabwe**	229,377	240,044	96%	550,475	95,787	17,325	687
TOTAL	2,580,537	2,808,092	92%	10,651,372	1,700,644	374,358	16,015

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

**EOSR not yet approved.

ANNEX B: INSECTICIDE AND EQUIPMENT PROCUREMENT

Commodity	Country	Description	Total Cost	Order/PO Date	Delivery Date
Goizper Sprayers & Parts	Benin	Valves, Spare Parts	\$ 106,891.92	Mar, 2017	Mar, 2017
Personal Protective Equipment	Benin	PPE	\$ 83,612.31	Mar, 2017	Mar, 2017
Entomology Supplies	Burundi	Entomology Monitoring Supplies	\$8,307.62	Feb, 2017	*Pending
Entomology Supplies	Ethiopia	Entomology Monitoring Supplies	\$7,460.00	Oct, 2016	Nov, 2016
Micron Spare Parts	Ethiopia	Spare Parts	\$18,318.25	Feb, 2017	April, 2017
Personal Protective Equipment	Ethiopia	PPE	\$ 214,156.80	Jan, 2017	Mar, 2017
Entomology Supplies	Ghana	Entomology Monitoring Supplies	\$ 1,146.76	Jan, 2017	*Pending
Insecticides	Ghana	Organophosphates	\$ 1,071,818.80	Dec, 2016	Mar, 2017
Hudson Sprayers & Parts	Ghana	Nozzles, Spare Parts	\$ 2,902.40	Mar, 2017	Mar, 2017
Micron Spare Parts	Ghana	Spare Parts	\$ 7,333.78	Feb, 2017	Feb, 2017
Personal Protective Equipment	Ghana	PPE	\$ 55,692.63	Dec, 2016	Dec, 2016
Entomology Supplies	Kenya	Entomology Monitoring Supplies	\$ 7,989.66	Oct, 2016	Feb, 2017
Insecticides	Kenya	Organophosphates	\$ 1,430,937.39	Oct, 2016	Jan, 2017
Entomology Supplies	Kenya	Entomology Monitoring Supplies	\$ 8,937.31	Oct, 2016	Feb, 2017
Micron Spare Parts	Kenya	Spare Parts	\$ 7,131.58	Jan, 2017	Jan, 2017
Entomology Supplies	Madagascar	Entomology Monitoring Supplies	\$ 1,274.04	Feb, 2017	*Pending
Entomology Supplies	Mali	Impregnated Papers	\$ 498.20	Apr, 2017	*Pending
Hudson Sprayers & Parts	Mozambique	Nozzles, Spare Parts	\$ 2,507.00	Oct, 2016	Oct, 2016
Entomology Supplies	Mozambique	Impregnated Papers	\$ 711.35	Feb, 2017	Feb, 2017
Personal Protective Equipment	Senegal	PPE	\$ 22,504.20	Jan, 2017	Feb, 2017
Entomology Supplies	Tanzania	Entomology Monitoring	\$36,259.31	Feb, 2017	*Pending

		Supplies			
Insecticides	Tanzania	Organophosphates	\$ 3,055,932.22	Oct, 2016	Jan, 2017
Entomology Supplies	Tanzania	Entomology Monitoring Supplies	\$20,891.43	Dec, 2016	*Pending
Goizper Sprayers & Parts	Tanzania	Valves, Spare Parts	\$ 144,530.90	Dec, 2016	Jan, 2017
Micron Spare Parts	Tanzania	Spare Parts	\$ 64,738.97	Nov, 2016	Jan, 2017
Entomology Supplies	Tanzania	Impregnated Papers	\$ 12,071.28	Dec, 2016	Marc, 2017
Personal Protective Equipment	Tanzania	PPE	\$ 73,946.40	Nov, 2016	Dec, 2016
Entomology Supplies	Tanzania	Entomology Monitoring Supplies	\$ 15,157.95	Mar, 2017	*Pending
Entomology Supplies	Zambia	Entomology Monitoring Supplies	\$ 3,210.19	Dec, 2016	Feb, 2016
Insecticides	Zambia	Organophosphates	\$ 66,546.48	Nov, 2016	Dec, 2016