This Malaria Operational Plan has been approved by the U.S. Global Malaria Coordinator and reflects collaborative discussions with the national malaria control programs and partners in country. The final funding available to support the plan outlined here is pending final FY 2019 appropriation. If any further changes are made to this plan it will be reflected in a revised posting.

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ETHIOPIA

Malaria Operational Plan FY 2019

TABLE OF CONTENTS

ABBREVIATIONS and ACRONYMS **3**

I. EXECUTIVE SUMMARY **5**

II. STRATEGY **9**

1. Introduction 9
2. Malaria situation in Ethiopia 10
3. Country health system delivery structure and Ministry of Health organization 14
4. National malaria control strategy 16
5. Updates in the strategy section 17
6. Integration, collaboration, and coordination 18
7. PMI goal, objectives, strategic areas, and key indicators 19
8. Progress on coverage/impact indicators to date 20
9. Other relevant evidence on progress 22

III. OPERATIONAL PLAN **23**

1. Vector control 23
   a. Entomological monitoring and insecticide resistance management 25
   b. Insecticide-treated nets 31
   c. Indoor residual spraying 34
2. Malaria in pregnancy 38
3. Case management 40
4. Cross-cutting and other health systems strengthening 50
   a. Pharmaceutical management 51
   b. Social and behavior change communication 55
   c. Surveillance, monitoring, and evaluation 59
   d. Operational research 64
   e. Other health systems strengthening 66
5. Staffing and administration 69

ABBREVIATIONS and ACRONYMS

ACT	Artemisinin-based combination therapy
AL	Artemether/lumefantrine
ANC	Antenatal care
API	Annual parasite incidence
APTS	Accountable Pharmaceutical Transactions and Services
CB	Community-based
CDC	Centers for Disease Control and Prevention
DDT	Dichloro-diphenyl-trichloroethane
DHIS-2	District Health Information System-2
eCHIS	Electronic Community Health Information System
EFETP	Ethiopian Field Epidemiology Training Program
EPHI	Ethiopian Public Health Institute
EUV	End-use verification
FELTP	Field Epidemiology and Laboratory Training Program
FMHACA	Food, Medicine and Health Care Administration and Control Authority
FMOH	Ethiopian Federal Ministry of Health
FY	Fiscal year
GHI	Global Health Initiative
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria
GoE	Government of Ethiopia
G6PD	Glucose-6-phosphate dehydrogenase
HDA	Health development army
HEP	Health extension package (or program)
HEW	Health extension worker
HLC	Human landing collection
HMIS	Health management information system
HSDP	Health Sector Development Plan
HSTP	Health Sector Transformation Plan
iCCM	Integrated community case management
IDSR	Integrated Disease Surveillance Report
IPLS	Integrated Pharmaceutical Logistics System
IPTp	Intermittent preventive treatment for pregnant women
IRS	Indoor residual spraying
ITN	Insecticide-treated mosquito net
LSI	Look Ahead Seasonality Index
MCST	Malaria Control Support Team
M&E	Monitoring and evaluation
MIP	Malaria in pregnancy
MIS	Malaria Indicator Survey
MNCH	Maternal Neonatal and Child Health
MOP	Malaria Operational Plan
NFM	New Funding Model
NGenIRS	Next Generation Indoor Residual Spraying Project
NGO	Non-governmental organization

NMCP	National Malaria Control Program
NMSP	National Malaria Strategic Plan
ORHB	Oromia Regional Health Bureau
PEPFAR	President's Emergency Plan for AIDS Relief
PFSA	Pharmaceutical Funds Supply Agency
PHCU	Primary Health Care Unit
PHEM	Public Health Emergency Management
PMI	U.S. President's Malaria Initiative
QA/QC	Quality assurance/ quality control
RA	Resident Advisor
RBM	Roll Back Malaria
RDT	Rapid diagnostic test
RRF	Report and requisition form
RHB	Regional Health Bureau
SBCC	Social and behavioral change communication
SM&E	Surveillance, monitoring, and evaluation
SNNPR	Southern Nation & Nationalities Peoples' Region
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

I. EXECUTIVE SUMMARY

When it was launched in 2005, the goal of the U.S. President's Malaria Initiative (PMI) was to reduce malaria-related mortality by 50 percent across 15 high-burden countries in sub-Saharan Africa through a rapid scale-up of four proven and highly effective malaria prevention and treatment measures: insecticide-treated mosquito nets (ITNs); indoor residual spraying (IRS); accurate diagnosis and prompt treatment with artemisinin-based combination therapies (ACTs); and intermittent preventive treatment of pregnant women (IPTp). With the passage of the Tom Lantos and Henry J. Hyde Global Leadership against HIV/AIDS, Tuberculosis, and Malaria Act in 2008, PMI developed a U.S. Government Malaria Strategy for 2009–2014. This strategy included a long-term vision for malaria control in which sustained high coverage with malaria prevention and treatment interventions would progressively lead to malaria-free zones in Africa, with the ultimate goal of worldwide malaria eradication by 2040-2050. Consistent with this strategy and the increase in annual appropriations supporting PMI, four new sub-Saharan African countries and one regional program in the Greater Mekong Subregion of Southeast Asia were added in 2011. The contributions of PMI, together with those of other partners, have led to dramatic improvements in the coverage of malaria control interventions in PMI-supported countries, and all 15 original countries have documented substantial declines in all-cause mortality rates among children less than five years of age.

In 2015, PMI launched the next six-year strategy, setting forth a bold and ambitious goal and objectives. The PMI Strategy for 2015-2020 takes into account the progress over the past decade and the new challenges that have arisen. Malaria prevention and control remains a major U.S. foreign assistance objective and PMI's Strategy fully aligns with the U.S. Government's vision of ending preventable child and maternal deaths and ending extreme poverty. It is also in line with the goals articulated in the Roll Back Malaria (RBM) Partnership's second generation global malaria action plan, *Action and Investment to defeat Malaria (AIM) 2016-2030: for a Malaria-Free World* and the World Health Organization's (WHO's) updated *Global Technical Strategy: 2016-2030*. Under the PMI Strategy 2015-2020, the U.S. Government's goal is to work with PMI-supported countries and partners to further reduce malaria deaths and substantially decrease malaria morbidity, towards the long-term goal of elimination.

In 2017, consistent with an increase in annual appropriations, PMI again launched new country programs in Cameroon, Côte d'Ivoire, Niger, and Sierra Leone, and expanded an existing program in Burkina Faso to PMI focus country status. With the addition of these new focus countries, PMI now has programs in 24 countries in sub-Saharan Africa, in addition to two bilateral programs and targeted support in the Greater Mekong Subregion in Asia.

Ethiopia began implementation as a PMI focus country in FY 2008.

This FY 2019 Malaria Operational Plan presents a detailed implementation plan for Ethiopia, based on the strategies of PMI and the National Malaria Control Program (NMCP). It was developed in consultation with the NMCP and with the participation of national and international partners involved in malaria prevention and control in the country. The activities that PMI is proposing to support fit in well with the National Malaria Control strategy and plan and build on investments made by PMI and other partners to improve and expand malaria-related services, including the Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund) malaria grants. This document briefly reviews the current status of malaria control policies and interventions in Ethiopia, describes progress to date, identifies challenges and unmet needs to achieving the targets of the NMCP and PMI, and provides a description of activities that are planned with FY 2019 funding.

The overarching goals of the PMI Program in Ethiopia include: 1) Increasing PMI support, especially for vector control, in high burden districts in high burden regions, 2) Continued ITN procurement and distribution to support ITN universal coverage, 3) Continued procurement of antimalarials to address national gaps, and 4) Strengthening national level surveillance along with district level support in low malaria burden districts to assist in achieving subnational elimination. The proposed FY 2019 PMI budget for Ethiopia is $36 million. PMI will support the following intervention areas with these funds:

Entomological monitoring and insecticide resistance management:

Insecticide resistance in Ethiopia is a concern and Ethiopia has updated its national resistance monitoring and management strategy. The goals are to minimize insecticide selection pressure, ensure vector control interventions are guided by evidence, develop and implement a national plan for insecticide resistance monitoring and management, and provide timely analysis and interpretation of data. From 2014-2017, PMI supported entomological resistance monitoring of 11 insecticides from 4 insecticide classes in 8 permanent sites, and mosquito behavior studies in 3 sites. The insecticide resistance monitoring test results show that local vectors are generally resistant to dichloro-diphenyl-trichloroethane (DDT) and pyrethroids. With FY 2019 funds, PMI plans to continue supporting behavioral monitoring of malaria vectors, insecticide resistance surveillance and support the coordination of insecticide resistance data for more timely reporting and analysis of data.

Insecticide-treated nets (ITNs):

As per the National Malaria Strategic Plan (NMSP) 2014-2020, the Ethiopian Federal Ministry of Health (FMOH) conducted a mass campaign in 2015-2016, distributing 29.6 million long-lasting insecticide-treated mosquito nets (ITN) to protect all Ethiopians living in areas with ongoing malaria transmission, representing 60 percent of the total population. The Global Fund contributed the majority of the ITNs with PMI supporting the remaining gap. PMI cumulatively procured over 30.8 million ITNs between 2008 and 2017. With FY 2015 funds, PMI has procured and distributed 6 million ITNs to high risk communities to replace old nets, protect new households and new household members. Further, with FY 2016 funds 4.4 million ITNs are currently in the procurement process. With FY 2017 funds, PMI will procure an additional 3.6 million ITNs for distribution as part of Ethiopia's 2019 rolling mass campaign. With FY 2018 funds, PMI plans to procure an additional 2.23 million ITNs for distribution as replacement for worn-out nets. With FY 2019 funds PMI plans to procure 500,000 ITNs for continues distribution through community-based health extension program and 1,990,000 ITNs for mass distribution. PMI also plans to continue supporting the implementation of an ITN distribution tracking system to ensure all ITNs are reaching their intended users.

Indoor residual spraying (IRS):

The FMOH's NMSP aims to provide 100 percent IRS coverage as a key malaria prevention measure in areas where malaria burden is high and in highland fringe areas with the potential for malaria outbreaks. According to the new FMOH malaria risk stratification, 14.8 percent of the country's total population is targeted for IRS as compared to 17 percent in the 2014 stratification. PMI has been implementing IRS in Ethiopia since 2008 and has supported a comprehensive range of IRS-related activities, including targeting and enumeration of areas for IRS operations, improved logistical planning and support, environmental compliance monitoring, entomological surveillance, and technical assistance and operational support. The PMI-supported IRS program protected between 1 million to 2.9 million people annually since its launch. In the 2017 IRS campaign, PMI supported the spraying of 738,810 structures

and protected 1,877,154 people from malaria in 44 districts of Benishangul-Gumuz and Oromia Regions, achieving a 98.7 percent coverage rate. With FY 2019 funding, PMI will continue to support safe and effective IRS implementation within 44 high burden districts in the Benishangul-Gumuz, Gambela, and Oromia Regions, in addition to continuing to provide limited IRS support to 60 graduated districts.

Malaria in pregnancy (MIP):

The FMOH's NMSP does not support IPTp with sulfadoxine-pyrimethamine due to the relatively low intensity of malaria transmission in most of Ethiopia. Malaria in pregnancy in Ethiopia is addressed through improving prompt access to diagnostics and treatment, prioritization of ITN use by pregnant women, and enhanced social and behavior change communication (SBCC) activities targeting pregnant women in malaria endemic areas. PMI supports pre-service training for midwives and health extension workers (HEWs) to improve malaria case management services for pregnant women. With FY 2019 funds, PMI will continue to strengthen malaria case management of pregnant women at both the facility and community levels by improving the overall performance of primary health care units and ensuring access to ITNs through community-based continuous distribution. PMI supports strengthening malaria in pregnancy case management through an integrated health approach targeting maternal health issues broadly. PMI has supported the development of a new malaria case management training manual, which includes malaria in pregnancy. SBCC messages are being developed based on these guidelines.

Case management:

The NMSP aims for robust coverage with high quality diagnostic and treatment services universally, especially at public sector health facilities in rural areas in order to diagnose 100 percent of suspected malaria cases within 24 hours of fever, and treat all confirmed cases according to the national guidelines. Since the launch of PMI, a total of 9,240,000 rapid diagnostic tests (RDTs) and 15,046,630 ACT treatment doses have been procured. In addition, in collaboration with regional and district health offices, PMI has supported health worker training, mentoring and supervision for quality malaria diagnosis using microscopy, and the management of malaria at district-level health centers and community-level health posts through integrated community case management (iCCM). Coordinating with Global Fund, no additional procurement of ACTs or RDTs with FY 2018 funding is planned, as there will be no unmet commodity gaps. With FY 2019 funds, however, PMI will procure 500,000 RDTs and 250,000 treatment doses of ACT in case of delays with the next Global Fund grant. Additionally, PMI will procure 287,000 treatments of chloroquine and primaquine, 40,000 doses of rectal artesunate, 250,000 vials of injectable artesunate, and 300 microscopes and laboratory kits for microscopy, and continue to strengthen case management activities in the public and private sector as well as strengthen microscopy capacity.

Health systems strengthening and capacity building:

As outlined in the NMSP, substantial resources are needed to strengthen health systems and to provide capacity building for malaria control and elimination in Ethiopia. PMI has historically strengthened the health systems in Ethiopia through support to pharmaceutical management and logistics systems, including quantification of malaria commodities (through an annual micro-planning exercise), strengthening routine malaria surveillance systems, and building the capacity of health staff through both pre- and in-service training. Additionally, PMI has supported the training of Ethiopian Field Epidemiology Training Program (EFETP) residents in malaria prevention, outbreak investigation and

response. With FY 2019 funds, PMI will provide health systems coordination, EFETP training, and pre-service training of HEWs for malaria prevention and control activities.

Social and behavior change communication (SBCC):

In the NMSP 2014–2020, the SBCC objective states that "By 2020, all households living in malaria endemic areas will have the knowledge, attitudes and practices towards malaria prevention and control." In order to achieve this objective, the NMSP will utilize HEWs, health development armies (HDAs), and model family households to deliver SBCC interventions. In 2013, PMI initiated and supported community-based malaria SBCC activities that targeted school children and religious leaders. In addition, starting in July 2015, PMI supported SBCC activities that utilized an integrated campaign platform, which organizes health messaging including malaria in a coherent and coordinated way through multiple channels to support community-based health workers. With FY 2019 funds, PMI plans to continue supporting SBCC capacity building at the national and local level through SBCC message harmonization, mass media efforts, and school-based SBCC activities that promote malaria prevention and control with a focus on migrant populations in the western development regions such as Benishangul-Gumuz and Gambela.

Surveillance, monitoring and evaluation (SM&E):

According to the NSP 2017-2020, the goal of the national SM&E plan for malaria control in Ethiopia is to provide reliable information on sustaining malaria control and accelerating progress towards elimination. High priority malaria SM&E activities through 2020 for Ethiopia include: national household surveys such as the Malaria Indicator Survey (MIS), strengthening surveillance data management capacity, supporting routine surveillance in 42 districts and 7 town administrations in Oromia Region, monitoring ITN durability, conducting annual program review meetings to examine malaria data, and bi-annual supportive supervision. PMI has historically provided substantial financial resources and technical assistance for many of these SM&E activities, including support for the MISs in 2007, 2011, and 2015. PMI's ongoing support to routine malaria surveillance aims to enhance reporting from rural health posts where half of all malaria morbidity is detected and treated. The annual micro-plan collects comprehensive malaria burden and commodities quantification data. With FY 2019 funds, PMI will continue to support and strengthen national surveillance systems, supervision in elimination districts to monitor data quality, and national malaria micro-planning exercises.

Operational research (OR):

PMI has supported OR in Ethiopia to address key program bottlenecks especially in building the evidence to improve *Plasmodium vivax* case management. Through FY 2014, PMI has supported OR projects including assessments of drug adherence, glucose-6-phosphate dehydrogenase deficiency prevalence, malaria serology studies exploring relationships between school-based children and community malaria prevalence, and the role of serology in MIS in low transmission settings. With FY 2015-2017 funding, PMI is planning OR projects to evaluate the effect of targeted mass drug administration and reactive case detection on malaria transmission and elimination in Ethiopia, hematologic monitoring to assess the safety of using primaquine for radical cure of *P. vivax* infections, and monitoring mosquito and human behavior to better understand malaria transmission in agricultural development areas in Ethiopia. No OR studies are planned with FY 2019 funding.

II. STRATEGY

1. Introduction

When the U.S. President's Malaria Initiative (PMI) was launched in 2005, its goal was to reduce malaria-related mortality by 50 percent across 15 high-burden countries in sub-Saharan Africa through a rapid scale-up of four proven and highly effective malaria prevention and treatment measures: insecticide-treated mosquito nets (ITNs); indoor residual spraying (IRS); accurate diagnosis and prompt treatment with artemisinin-based combination therapies (ACTs); and intermittent preventive treatment for pregnant women (IPTp). With the passage of the Tom Lantos and Henry J. Hyde Global Leadership against HIV/AIDS, Tuberculosis, and Malaria Act in 2008, PMI developed a U.S. Government Malaria Strategy for 2009-2014. This strategy included a long-term vision for malaria control in which sustained high coverage with malaria prevention and treatment interventions would progressively lead to malaria-free zones in Africa, with the ultimate goal of worldwide malaria eradication by 2040-2050. Consistent with this strategy and the increase in annual appropriations supporting PMI, four new sub-Saharan African countries and one regional program in the Greater Mekong Subregion of Southeast Asia were added in 2011. The contributions of PMI, together with those of other partners, have led to dramatic improvements in the coverage of malaria control interventions in PMI-supported countries, and all 15 original countries have documented substantial declines in all-cause mortality rates among children less than five years of age.

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2. Malaria situation in Ethiopia

Seasonality, weather, geography, and climate

In Ethiopia, the interaction of mountainous terrain with variable winds, seasonal rains, and ambient temperatures creates diverse micro-climates for malaria transmission. Ethiopian weather is also influenced by tropical Indian Ocean conditions and global weather patterns, including *El Niño* and *La Niña*. When a micro-climate creates local puddles, flooding conditions, and warm ambient temperatures that persist for several weeks within a malarious area with low population immunity, the resulting *Anopheles* mosquito proliferation may cause focal malaria transmission to accelerate, sometimes rapidly. In Ethiopia, malaria is highly seasonal in many communities, but may have nearly constant transmission in some other areas; at the district level, malaria outpatient caseloads may vary several-fold from year to year in an "unstable" epidemic-prone transmission pattern. Peak malaria transmission occurs between September and December in most parts of Ethiopia, after the main rainy season from June to August. In addition, some areas experience a second minor malaria transmission period from April to June, following a short rainy season from February to March. January and July typically represent low malaria transmission seasons in most communities. Since peak malaria transmission often coincides with the planting and harvesting season, and the majority of malaria burden is among older children and working adults in rural agricultural areas, there is a resultant heavy economic burden in Ethiopia. Although historically Ethiopia has been prone to periodic focal and widespread malaria epidemics, malaria epidemics have been largely absent since 2004, after the scale up of malaria control interventions.

Vector species and abundance

Anopheles arabiensis, a member of the *An. gambiae* complex, is the primary malaria vector in Ethiopia, with *An. funestus, An. pharoensis*, and *An. nili* as secondary vectors. The sporozoite rate for *An. arabiensis* has been recorded to be as high as 5.4 percent. The host-seeking behavior of *An. arabiensis* varies with the human blood index collected from different areas ranging between 7.7 percent and 100 percent. *An. funestus*, a mosquito that prefers to feed exclusively on humans, can be found along the swamps of the Baro and Awash rivers and shores of lakes in Tana in the North and the Rift Valley areas. *An. pharoensis* is widely distributed in Ethiopia and has shown high levels of insecticide resistance, but its role in malaria transmission is unclear. *An. nili* can be an important vector for malaria, particularly in Gambela Regional State. Insecticide resistance among these vectors has become an important issue, with implications for vector control strategies.

Parasite prevalence, altitude strata, and annual parasite incidence (API):

Plasmodium falciparum and *P. vivax* are the major malaria parasites in Ethiopia, with several recent therapeutic efficacy trials documenting that ACTs and chloroquine continue to have adequate effectiveness for treating these pathogens, respectively. To date, there have been no major problems detected yet with emerging drug resistance, or with counterfeit or substandard antimalarial drugs in Ethiopia; however, constant vigilance is needed regarding these important issues that have adversely affected the malaria control programs of many other countries.

Typical human and mosquito behavior results in most malaria parasite transmission occurring indoors during nighttime hours within rural households in lowlands and middle elevations, and only occasionally in the highland fringe areas of Ethiopia greater than 2,000 meters above sea level (asl). Malaria transmission may also sometimes occur outdoors during nighttime work or social activities, or may be

associated with temporary overnight travel to other districts in malarious areas. Recent published and unpublished reports indicate an increased malaria incidence among migrant laborers in various parts of the country, most importantly in the northwest development corridors of the country bordering Sudan and South Sudan. Many Ethiopian communities have low and unstable malaria transmission patterns that result in low host immunity and significant clinical malaria illness risk after malaria infections, increased tendency for rapid progression to severe malaria, and propensity for malaria epidemics affecting all age groups. The epidemiology of malaria in Ethiopia, therefore, contrasts with that of many other countries in Africa with high malaria transmission where malaria morbidity and mortality mainly affect young children. Emerging data from episodic special outbreak investigations and unpublished anecdotes from Ethiopian malaria partners suggest that older boys and men may be at special risk for malaria from occupational and travel-related factors, such as engaging in seasonal migrant farm work.

The 2007 Malaria Indicator Survey (MIS) indicated that parasite prevalence (as measured by microscopy) in Ethiopia was 0.7 percent and 0.3 percent, respectively, for *P. falciparum* and *P. vivax* below 2,000 meters (asl). The 2011 MIS indicated that 1.3 percent of individuals were positive for malaria using microscopy and 4.5 percent were positive for malaria using RDTs below 2,000 meters, with only 0.1 percent prevalence above 2,000 meters elevation. *P. falciparum* constituted 77 percent of infections detected below 2,000 meters. The 2011 MIS demonstrated a remarkable demarcation of malaria risk at an altitude of 2,000 meters, with a13-fold higher malaria prevalence at lower altitudes compared to higher elevations. There was essentially no *P. falciparum* detected by microscopy among persons surveyed within households having measured elevations above 2,000 meters in the 2011 MIS. The 2015 MIS data indicated that parasite prevalence in Ethiopia was 0.5percent by microscopy and 1.2percent by RDTs for areas below 2,000 meters and less than 0.1percent prevalence above 2,000 meters.

In 2017, the Ethiopia Federal Ministry of Health (FMOH) updated the country's malaria risk strata based upon malaria API, calculated from micro-plan data from more than 800 districts, with strata as shown and defined in Table 1. A malaria risk map from this API analysis is shown in Figure 1, showing areas with malaria transmission risk by API classified as High (≥100 cases/1,000 population/year), Medium (≥5 - <100), Low (>0 - <5), and Malaria-Free (~0). Areas with the highest malaria transmission risk as stratified by district API appear to be largely in the lowlands and midlands of the western border with South Sudan and Sudan. Many densely populated highland areas were newly classified as malaria-free (API=0), including the capital city of Addis Ababa. Based on the current stratification, the proportion of the population at risk of malaria is about 60 percent (see Table 1) with 54 (6.4 percent) *woredas* having high transmission.

Table 1: Malaria risk stratification of districts and planned interventions based on annual parasite incidence, Ethiopia 2017

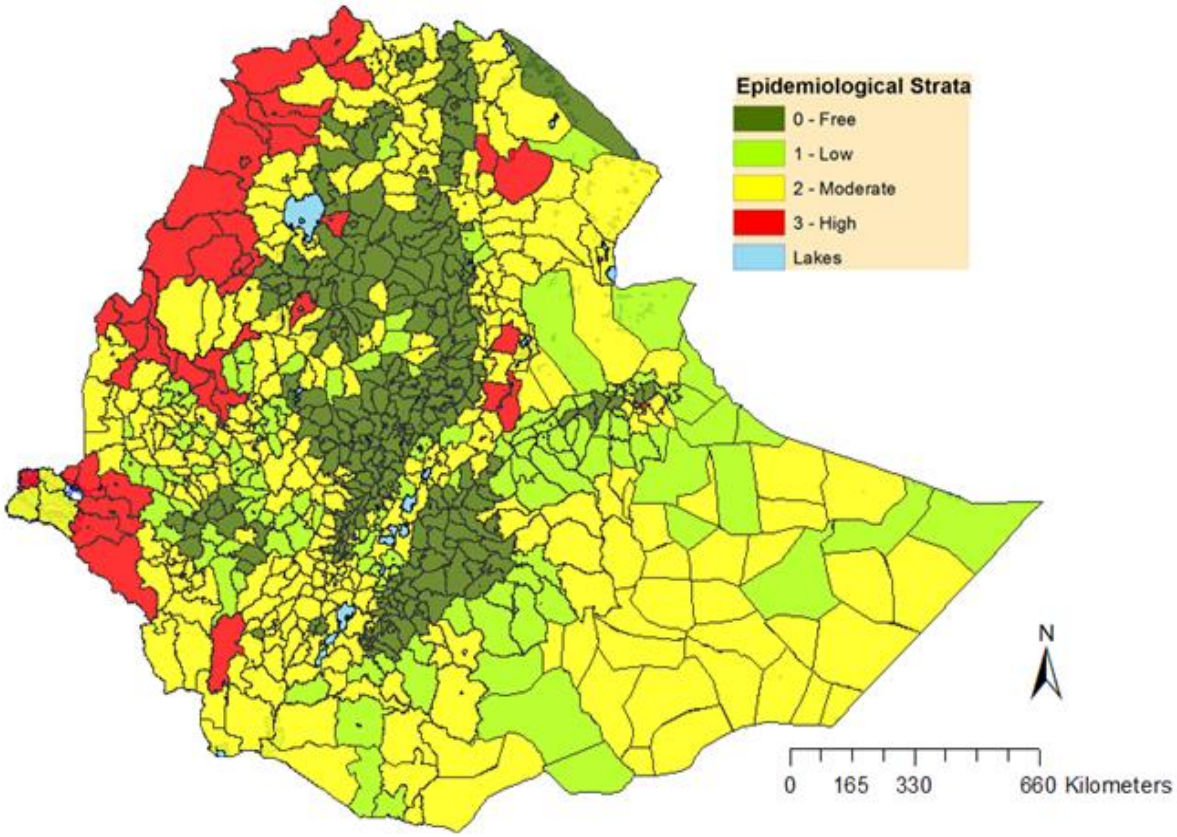
Malaria Strata	API (case/ 1,000)	Elevation (m)	Population (2017)	% Population	No. of Woreda	% Woreda	Interventions					
							ITN	IRS	Larval Control	Case Mx	Surveillance	IEC/ BCC
FREE	0	>= 2000 asl	37,083,083	40.3	280	33.1	-	-	-	X	X	X
LOW	>0 & <5	< 2000 asl	17,115,269	18.6	146	17.3	X	X*	WA	X	X	X
MODERATE	>=5 & <100		34,782,644	37.8	365	43.2	X	X**	WA	X	X	X
HIGH	>=100		3,036,580	3.3	54	6.4	X	X	WA	X	X	X
Total			**92,017,576**	**100**	**845**	**100**						

*Only 32% of at risk population in highland fringe/epidemic-prone areas will be covered by IRS

**Only 14.8% of districts at boundary of high stratum will be considered from moderate by IRS

WA: where applicable; asl: above sea level; IEC: information, education, and communication; BCC: behavior change communication

Figure 1: Malaria risk map of districts categorized by annual parasite incidence, Ethiopia, 2017



Malaria surveillance systems and malaria trends:

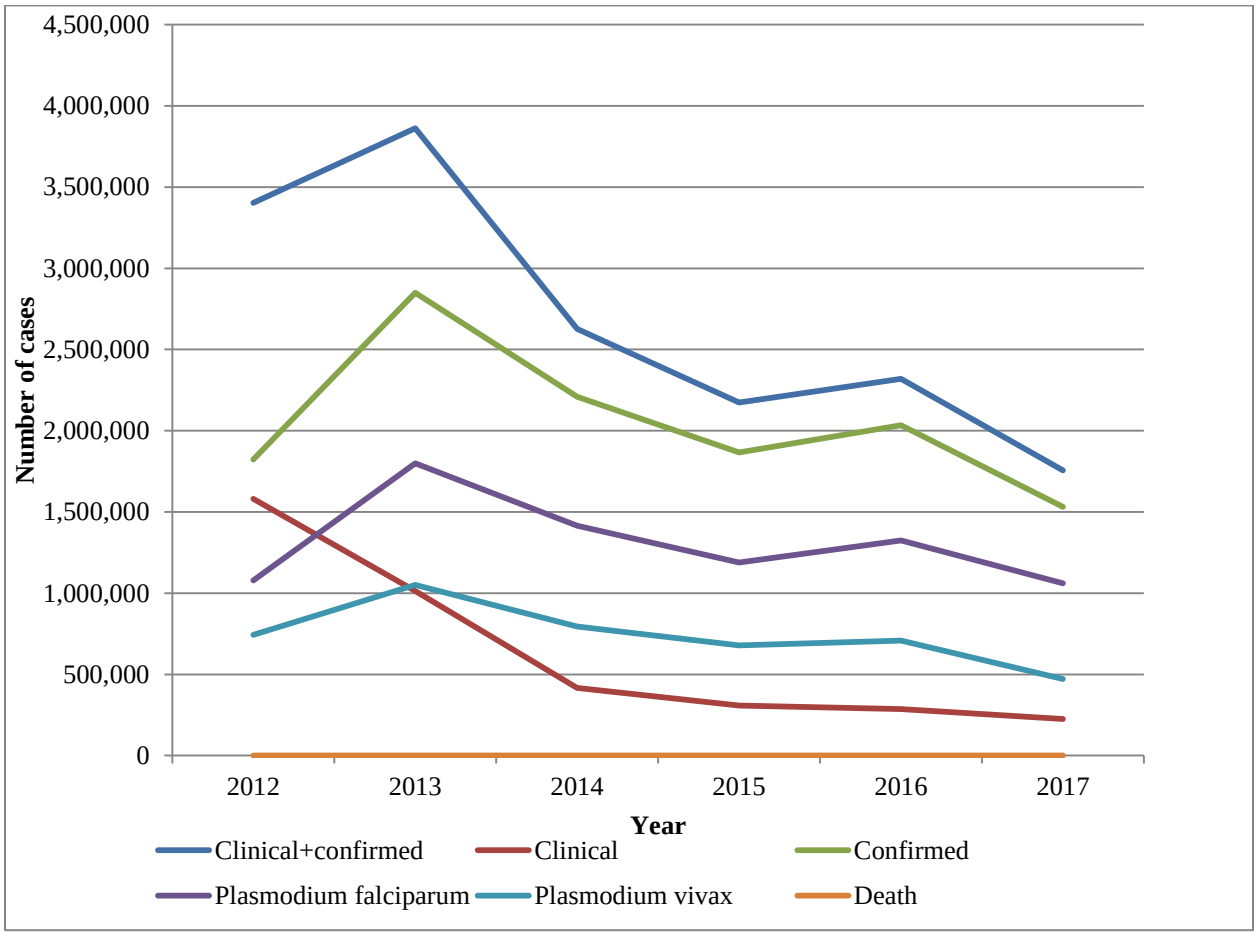
Since 2004, Ethiopia's health systems for case management and surveillance have been greatly strengthened. There are three major overlapping and complementary Ethiopian health facility-based surveillance systems that provide information about malaria trends: 1) the health management information system (HMIS) data published in the annual Health and Health Related Indicator Report and Annual Performance Report, 2) the Public Health Emergency Management (PHEM) system data published in the Ethiopian Public Health Institute's (EPHI's) Ethiopian Weekly Epidemiological Bulletin, and 3) the unpublished annual malaria commodity micro-planning data. Micro-planning is useful to fill the gaps in procurement needs and guide distribution, particularly to district levels. It is conducted in an annual meeting that takes three days with the first day dedicated for the review of malaria program implementation and the last two days for planning. Micro-planning is completed under the leadership of regional health bureaus.

The FMOH's PHEM system receives similar reports as the HMIS, but the reporting frequency is weekly while for HMIS it is monthly. The PHEM surveillance system now reports around 91.5 percent completeness. FMOH and EPHI have a weekly update meeting at the state minister's office to review the status of epidemic diseases of which malaria is the priority agenda. The weekly monitoring, reporting, and analysis for action are part of the system's ability to inform responses to any upsurge in real time. Availing the necessary interventions at the right place and time is part of the collaborative effort that PMI, NMCP and other partners have been conducting. PMI will keep following the situation of malaria with the NMCP and PMI implementing partners.

Between June 2016 and July 2017, HMIS reported 1,530,739 confirmed malaria illnesses including 1,059,847 *P. falciparum* and 470,892 *P. vivax* malaria illnesses. In addition, there were 225,009 clinical malaria cases reported for a total of 1,755,748 malaria cases. Three hundred and fifty-six deaths were reported due to malaria.

During the past six years, the number of malaria cases has declined and the proportion of cases confirmed using laboratory tests has increased (Figure 2). Triangulation with previous PHEM and Microplan reports and with other data from the micro-plan and PHEM indicates that more than 80 percent of the malaria burden in Ethiopia is among adults and children who are at least five years of age.

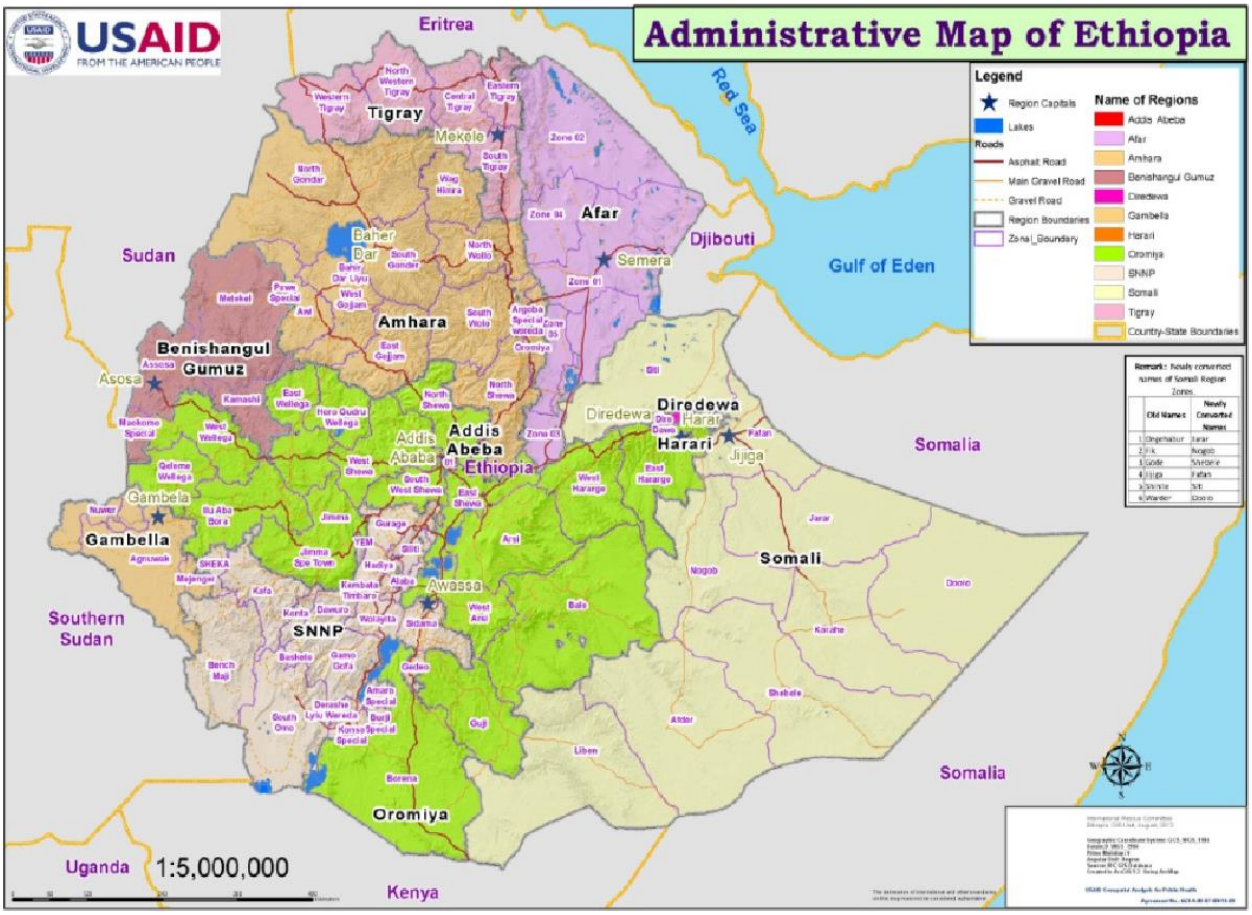
Figure 2. Malaria trends and proportion of malaria cases tested with RDT or microscopy from 2012-2017, (HMIS data)



3. Country health system delivery structure and Ministry of Health organization

Ethiopia operates under a federal system of government. Administratively, the country is divided into regional states, zones, districts (*woredas*), and communities/municipalities (*kebeles*) (see Figure 3). The official estimate for the total population for 2017 is 94.3 million. There are about 565 districts with malaria risk in Ethiopia (out of 845 total districts), with an estimated at-risk population of 60 million people as per the new stratification (see Table 1 above). The best available proxy for local malaria transmission risk in Ethiopia is household altitude below 2,000 meters above sea level, since malaria is rarely transmitted at higher elevations (unless there are weather abnormalities and widespread epidemics). Many districts have variable topographical features, with some households within communities located above and below 2,000 meters. Due in part to household locations at various altitudes and distances from efficient malaria vector breeding sites, malaria risk is unevenly distributed within many districts and *kebeles*.

Figure 3: Administrative zones and districts in Ethiopia



The health service delivery system in Ethiopia has been re-organized into a three-tier system. The lowest tier is known as the Primary Health Care Unit (PHCU), which is composed of one district hospital (covering 60,000-100,000 people), health centers (1 per 25,000 people), and their five satellite health posts (1 per 5,000 people). The second tier is the General Hospital, covering a catchment population of 1-1.5 million people, and the third, tertiary health care level, is the Specialized Hospital, covering a population of 3.5 million people. All the regional states share the same health system organizational structure. The health center provides comprehensive primary health care services and backup to the health posts by accepting referral cases, while district and general hospitals provide secondary health care. Health centers typically can provide inpatient services for up to two malaria patients, and they are equipped with injectable artesunate for severe malaria treatment. Health posts manage rectal artesunate and health extension workers (HEWs) are trained in the use of this pre-referral product.

According to the 2016/2017 HSDP IV annual performance report, currently there are a total of 266 functional public hospitals, 3,622 functional health centers, 16,660 health posts, and about 38,000 trained HEWs in Ethiopia.

The typical health post is staffed by two HEWs delivering 16 selected health packages, including one health package on malaria [http://cnhde.ei.columbia.edu/training/index.html]. HEWs are paid FMOH staff; they undergo a one-year training program after having received a high school diploma, and usually originate from the communities they serve. The HEWs focus on preventive services; however, they also provide curative health care services for malaria for all ages, and pneumonia and diarrhea in children

less than five years of age using the integrated community case management (iCCM) approach of evidence-based diagnostic and treatment algorithms. For malaria, HEWs have been trained to confirm and report malaria diagnoses among clinically evaluated acutely ill patients using malaria multispecies RDTs. Severe malaria cases are to be referred to the next appropriate health facility, with initial pre-referral management using rectal artesunate. The HEWs are encouraged to consider other diagnostic possibilities for patients who test negative by malaria RDT, and to avoid empiric treatment with antimalarials when malaria RDTs are available. The HEWs are also expected to supervise seasonal health activities, including social and behavior change communication (SBCC) and mass vaccination campaigns, participate in surveys and a range of other community health activities. The HEWs work closely with the health development army (HDA), a network of women that oversee up to five households to deliver malaria messages, to perform these tasks. HEWs are tasked with supporting ITN distribution activities through registering households and indicating their family size, keeping records of coverage, and tracking loss and damage through the regular household visits and/or from HDA reports. Additionally, HEWs have become more directly involved in supervising IRS spray teams and door-to-door mobilization for IRS. The FMOH envisages decentralizing IRS operations to the PHCU, where HEWs would be responsible for supervising the operations in their catchment area (*kebele*). The FMOH is scaling up this community-based (CB) IRS practice in a stepwise approach. Currently, HEWs are primarily responsible for organizing and executing IRS operations in the graduated six CB IRS districts.

4. National malaria control strategy

The NMSP for the years 2017-2020 was finalized in in April 2017, which was envisioned to be aligned with the next four-year health sector transformation plan (HSTP) 2015/16–2019/20 and submitted along with the Concept Note for the Global Fund New Funding Model (NFM) application. The current malaria strategic plan was developed following the MIS 2011 and 2015 results, and the national malaria program review, as well as in response to discussions and recommendations following a consultative meeting with key in-country and international malaria stakeholders. The proposed goals and objectives for the 2017-2020 NMSP include:

Goals:

- By 2020, maintain near zero malaria deaths (no more than 1 confirmed malaria death per 100,000 population at risk) in Ethiopia.
- By 2020, reduce malaria cases by 40 percent from baseline of 2016.
- By 2030, eliminate malaria from Ethiopia.

Strategic Objectives:

1. By 2020, all households living in malaria endemic areas will have the knowledge, attitudes, and practice to adopt appropriate health-seeking behavior for malaria prevention and control.
2. By 2017 and beyond, 100percent of suspected malaria cases are diagnosed using RDTs or microscopy within 24 hours of fever onset.
3. By 2017 and beyond, 100percent of confirmed malaria cases are treated according to the national guidelines.
4. By 2017 and beyond, ensure that the population at risk of malaria has universal access to one type of globally recommended vector control intervention.
5. By 2020, malaria elimination program will be implemented in 239 districts.
6. By 2020, 100percent complete data and evidence will be generated at all levels within the nationally designated time periods to facilitate appropriate decision-making.

The Ethiopia NMCP's malaria elimination objectives include the elimination of malaria in selected low transmission areas by 2020 and the elimination of malaria from Ethiopia by 2030. Ethiopia has recently declared malaria elimination efforts in 239 selected districts, encompassing 6 different regions, starting in 2017. The criteria for enrolling districts for malaria elimination included selecting districts with low or moderate malaria transmission, availability of district level surveillance data, high coverage of vector control interventions, adequate access to treatment, less cross-border population movement, and logistical feasibility. To achieve elimination targets the Ethiopia FMOH will focus on engagement and governance at different levels by strengthening partnerships from the national to community level. A strong political commitment from the regional health bureaus (RHBs) will be expected in all aspects of malaria prevention and control. Additional areas of focus in selected malaria elimination districts include maximizing health facility capabilities for active case detection and 100 percent case confirmation, community involvement and ownership, private sector roles and partnerships, investigating mass drug administration approaches, and improving surveillance systems for case detection and reporting. The Ethiopia FMOH has developed a malaria elimination technical document to guide the of malaria elimination activities.

PMI will support the national elimination goals by foremost supporting control efforts throughout Ethiopia with a focus on the highest burden districts in the highest burden regions. PMI will ensure universal coverage of ITNs and access to case management services throughout the country in coordination with the FMOH and the Global Fund. Additionally, PMI will focus prevention efforts on districts in Western Ethiopia with high rates of malaria with provision of IRS with Actellic CS. These districts are often the source of malaria transmission to low malaria districts due to agricultural migrant workers and other mobile populations and must be addressed to make sub-national elimination a reality. PMI's focus on control efforts in the high transmission areas will ensure the success of Global Fund investments directed to the elimination districts. As improved surveillance capacity is a necessary step to achieve and document malaria elimination, PMI will be supporting improved surveillance capacity specifically within the elimination districts to assist with case detection and reporting.

5. Updates in the strategy section

Because of the unstable nature of malaria in Ethiopia, adults and children are equally at risk for malaria infection and disease. Eighty percent of the cases are reported in older children and adults and since 16 percent of the Ethiopian population is under 5, this roughly reflects similar risk distribution across all ages. The NMCP targets both adults and children with all malaria interventions. ITNs are distributed for all ages, the national malaria case management training material focuses on approach to fever diagnosis and treatment in children and adults and SBCC messages are targeted for all. Furthermore young men, who seek jobs in large agricultural areas where malaria is endemic, are at higher risk of infection. Thus, the FMOH has planned to assess and identify the best strategy to prevent and control malaria in these non-resident, migrant/mobile high risk populations. The NMCP is also reviewing the national MIS and other tools to ensure inclusion of male adults in addition to women and children.

PMI is working to address the migrant worker issues, especially in Benishangul-Gumuz and Gambella Regions where large agricultural areas are present. PMI has conducted surveys to better assess the living conditions, risk factors, and malaria prevention options for migrant workers to help guide local and national health policy. This information will be incorporated into current SBCC activities to ensure key malaria prevention messages are reaching this high risk population. PMI is working with private clinics (including on-site farm clinics) to improve malaria diagnosis and treatment for migrant workers and as part of an MOH migrant worker group is helping to develop consistent health treatment policies, explore

health extension worker outreach, and create commodities distribution guidelines that will improve migrant worker access to public health facilities and antimalarial drugs. PMI has also focused IRS efforts in these two high burden regions to decrease malaria prevalence amongst the total population residing in these areas.

6. Integration, collaboration, and coordination

Maternal, neonatal and child health, family planning, and reproductive health:

Following the first National Family Fertility Survey conducted in 1990, the U.S. Government started supporting the FMOH in the delivery of key maternal, neonatal and child health (MNCH), family planning, and nutrition services at the community level including expanded immunization, family planning, essential nutrition actions, malaria prevention, control and case management, promotion of antenatal care (ANC), and water, sanitation and hygiene. These interventions are delivered through health centers, health posts, and households and focus on rural, peri-urban, and hard-to-reach populations. To date, the program has trained over 60,000 community health volunteers, provided assistance to over 15,000 HEWs, and has reached over 32 million people (35 percent of the Ethiopian population) in 301 districts in 8 of the country's 9 regional states and parts of Somali Region. Under the Feed the Future Initiative, the U.S. Government will also continue to integrate health, agriculture, and humanitarian assistance and livelihood sector platforms to maximize impact on nutrition.

Most of PMI's activities support rural HEWs and the recently scaled-up HDA at community levels with a multi-agency collaborative approach using Global Health Initiative (GHI) and United States Agency for International Development (USAID) processes and structures. PMI uses this platform to reach the most at-risk communities in malaria diagnosis and treatment, including in pregnant women, epidemic detection and response, and also to promote best practices in malaria case management by HEWs at health posts, including use of iCCM clinical algorithms.

PEPFAR, GHI, and other U.S. Government programs:

PMI is working with President's Emergency Plan for AIDS Relief (PEPFAR) within the GHI framework through USAID and Centers for Disease Control and Prevention (CDC) structures, to harmonize the Ethiopia FY 2019 Country Operational Plan, with the USAID Health team's Operational Plan for Family Health and Infectious Diseases to ensure the respective plans complement and strengthen each other. Thus, at this time, approximately 15 percent of PMI's budget is allocated to "wrap around" activities with PEPFAR, i.e., either through the co-funding of an award or by leveraging resources that have been established through previous PEPFAR support (e.g., laboratory infrastructure strengthening overlapping with HIV and tuberculosis diagnosis, malaria SBCC harmonization with other health messages, pharmaceutical system and supply chain strengthening, and pharmaceutical quality management). PMI also has other malaria prevention projects with Peace Corps and CDC (i.e., Field Epidemiology Laboratory Training Program [FELTP], known as EFETP in Ethiopia) within the GHI context.

Coordination with other partners:

The Malaria Control Support Team (MCST) provides coordinated malaria technical support to the national and regional programs and is comprised of members of the FMOH, donors and international organizations, including PMI, governmental and non-governmental organizations (NGOs), and

academia. The primary task of the MCST is to support the FMOH and RHBs through ongoing technical assistance, resource mobilization, support to epidemic preparedness and response, and malaria pre-elimination. The MCST provides a common forum to share roles and responsibilities, avoid duplication and discuss technical and programmatic issues and priorities.

Part of the MCST is the Technical Advisory Committee, which includes the main malaria stakeholders in the country, i.e., FMOH, EPHI, Ethiopian universities, Malaria Control and Evaluation Partnership in Africa, Malaria Consortium, PMI, UNICEF, WHO, etc. PMI is also a member and currently the co-chair of the Technical Advisory Committee, representing a technical core of the MCST which advises the FMOH on policy and program implementation issues, providing technical assistance on an ad hoc basis, and assisting with malaria program integration issues. PMI has also been instrumental in the development and finalization of the NMSP 2017-2020, Global Fund proposals as well as the NFM concept note, and the development and updating of in-country guidelines and strategies. PMI collaborates closely with Global Fund to improve ongoing malaria activities such as ITN distribution methodologies and supply chain evaluation as well as conducting joint commodity gap analyses to plan for future commodity procurement needs. PMI worked with partners in 2017 to support the NMCP in conducting an Ethiopia National Malaria Program Review evaluation for the past five years, which includes a desktop information review and field validation exercises. PMI also provided technical support to EPHI for malaria evaluation and research activities (e.g., the MIS 2015 data analysis and methodology development for the 2017 post-ITN campaign assessment). Non-PMI funded malaria partners and other health donors, as well as experts from the Global Fund, were consulted to inform this FY 2019 MOP document.

In addition, PMI is supporting coordination of malaria research stakeholders, academia and FMOH to fill the gap between the implementation of emerging malaria knowledge and research and the adoption of best malaria practices by researchers, practitioners, policymakers, and organizations involved in the prevention and control of the disease. Resolving this gap would serve to increase the benefits of quality research to improve prevention and control, avoid duplication of efforts and waste of resources, and inform future research needs.

7. PMI goal, objectives, strategic areas, and key indicators

Under the PMI Strategy for 2015-2020, the U.S. Government's goal is to work with PMI-supported countries and partners to further reduce malaria deaths and substantially decrease malaria morbidity, towards the long-term goal of elimination. Building upon the progress to date in PMI-supported countries, PMI will work with NMCPs and partners to accomplish the following objectives by 2020:

1. Reduce malaria mortality by one-third from 2015 levels in PMI-supported countries, achieving a greater than 80 percent reduction from PMI's original 2000 baseline levels.
2. Reduce malaria morbidity in PMI-supported countries by 40 percent from 2015 levels.
3. Assist at least five PMI-supported countries to meet the WHO's criteria for national or sub-national pre-elimination.[1]

[1] http://whqlibdoc.who.int/publications/2007/9789241596084_eng.pdf

These objectives will be accomplished by emphasizing five core areas of strategic focus:

1. Achieving and sustaining scale of proven interventions
2. Adapting to changing epidemiology and incorporating new tools
3. Improving countries' capacity to collect and use information
4. Mitigating risk against the current malaria control gains
5. Building capacity and health systems towards full country ownership

To track progress toward achieving and sustaining scale of proven interventions (area of strategic focus #1), PMI will continue to track the key household survey indicators recommended by the RBM Monitoring and Evaluation Reference Group as listed below:

- Proportion of households with at least one ITN
- Proportion of the population with access to an ITN. [Please see http://www.malariasurveys.org/documents/Household%20Survey%20Indicators%20for%20Malaria%20Control.pdf for a description of this indicator.]
- Proportion of children under five years old who slept under an ITN the previous night
- Proportion of pregnant women who slept under an ITN the previous night
- Proportion of the population that slept under an ITN the previous night
- Proportion of children under five years old with fever in the last two weeks for whom advice or treatment was sought
- Proportion of children under five with fever in the last two weeks who had a finger or heel stick
- Proportion receiving an ACT among children under five years old with fever in the last two weeks who received any antimalarial drugs
- Proportion of women who received two or more doses of IPTp for malaria during ANC visits during their last pregnancy
- Proportion of women who received three or more doses of IPTp for malaria during ANC visits during their last pregnancy

8. Progress on coverage/impact indicators to date

Since the launch of PMI, Ethiopia has conducted three national household surveys (MIS 2007, 2011, and 2015) to track the impact and outcomes of malaria control investments to date (Table 2). Although the most recent 2015 ITN ownership results failed to reach set targets, a slight improvement was noted in ITN ownership since 2011. Notably, ITN use in children under five years old and pregnant women who own an ITN was much improved, the proportion of households protected by an ITN or IRS remained above 70 percent, the proportion of women with malaria knowledge improved, and malaria prevalence by microscopy continued to remain very low at <1 percent. Table 3 shows the change in key malaria indicators reported through routine surveillance systems from 2011-2016. Figure 4 shows the trend in key routine based malaria indicators over time.

Table 2: Evolution of key survey-based malaria indicators in Ethiopia from 2007-2015

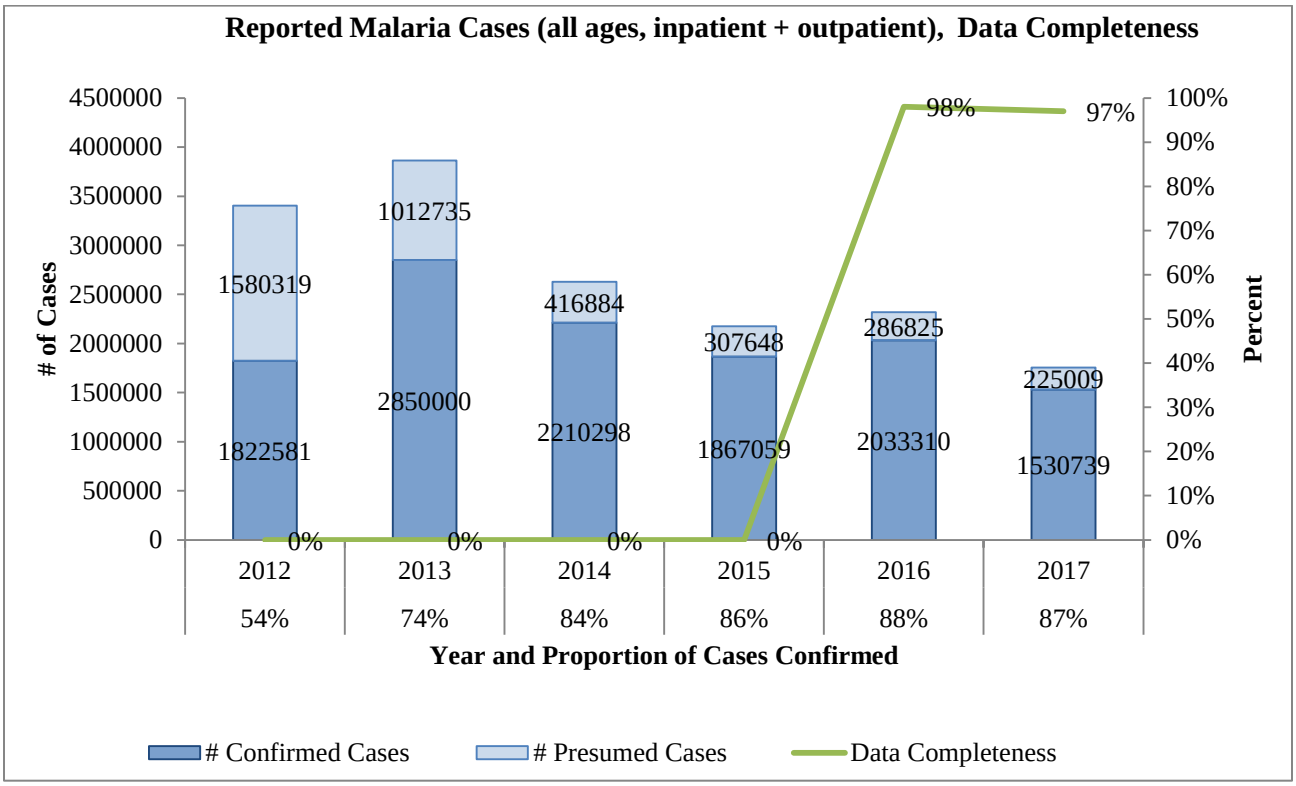
Indicator	MIS 2007 (<2000 m)	MIS 2011 (<2000 m)	MIS 2015 (<2000 m)
% Households with at least one ITN	65.3	54.8	63.6
% Households with at least one ITN for every two people	36.6	23.6	31.7
% Children under five (U5) who slept under an ITN the previous night	41.2	38.0	45.3
% of children U5 that own an ITN who slept under an ITN the previous night	60.0	64.7	69.5
% Pregnant women who slept under an ITN the previous night	42.5	34.7	44.3
% Pregnant women that own an ITN who slept under an ITN the previous night	66.2	63.8	73.9
% Households protected by at least one ITN or IRS	-	71.7	70.5
% Households sprayed in past 12 months	20.0	46.6	28.8
% Women age 15-49 years who had heard of malaria	79.5	71.3	68.4
% Women age 15-49 years who recognized fever as malaria symptom	50.8	76.0	74.6
% Women age 15-49 years who reported mosquito bite as a cause of malaria	41.1	71.2	74.6
% Women age 15-49 years who reported that ITNs prevent malaria	38.2	63.4	77.1
% Children under five years old with fever in the last two weeks	24.0	19.7	15.7
% Children under five years old with fever in the last two weeks for whom advice or treatment was sought	16	51	38.1
% Children under five years old with fever in the last two weeks who received any antimalarial drugs	11.9	32.6	32.9
% Children under five years old who took an antimalarial drug the same or next day	4.8	8.5	19.6
% Prevalence of malaria by microscopy	0.9	1.3	0.5

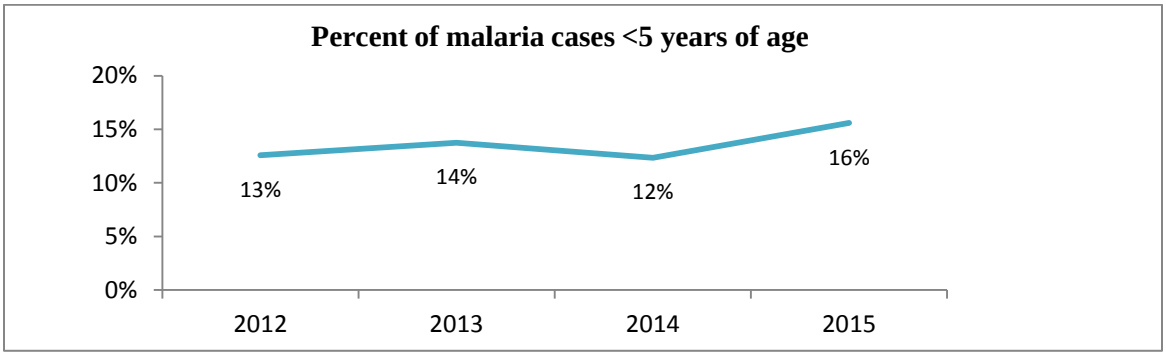
Table 3: Key malaria indicators reported through routine surveillance systems, 2012–2017. (HMIS data)

Indicator	2012	2013	2014	2015	2016	2017
Total # Tested by RDT or Microscopy	NA	NA	NA	5,679,932	6,378,352	6,246,949
Total # Cases	3,402,900	3,862,735	2,627,182	2,174,707	2,320,135	1,755,748
Total # Confirmed Cases	1,822,581	2,850,000	2,210,298	1,867,059	2,033,310	1,530,739
Total # Clinical Cases	1,580,319	1,012,735	416,884	307,648	286,825	225,009
Total # <5 Cases	427,826	530,560	324,203	338,874	NA	NA
Total # inpatient malaria deaths	253	644	213	662	510	356
Data Completeness* (%)	NA	NA	NA	NA	98	97
Test Positivity Rate (TPR)	NA	NA	NA	33%	32%	25%

NA: not available

Figure 4: Trends in key routine surveillance malaria indicators, 2011–2015 (HMIS data)





Data Source: Ethiopia Ministry of Health Annual Review Meeting Reports

9. Other relevant evidence on progress

N/A

III. OPERATIONAL PLAN

PMI supports all elements of the NMCP's national malaria strategy in Ethiopia except larval source management, including larviciding. PMI's support aligns with Government of Ethiopia's Health Structure Transformation Plan (HSTP) (2015-2020) and the National Malaria Strategic Plan (NMSP) (2017-2020). PMI's support strategy for Ethiopia has evolved since PMI began its activities in FY 2008, but remains consistent with the U.S. Government's updated PMI, and USAID Global Health strategies, and with country strategies within the U.S. Embassy/Addis Ababa and USAID/Ethiopia. PMI funding is targeted to fill gaps in activities that are not already supported by the FMOH, Global Fund, or other donors. PMI support has been flexible and responsive to the FMOH's evolving needs, including the occasional reprogramming of resources to provide critical malaria commodities that were not adequately funded by other sources.

Additionally, PMI has provided considerable technical support and expertise for FMOH through malaria technical experts within CDC/Atlanta, USAID/Washington, PMI/Ethiopia team and the various implementing partners and collaborative support with the Global Fund, academia, and international development organizations.

Beginning in FY 2008, funding limitations required PMI to initially focus support primarily within the Oromia Regional State, based upon size and evidence at that time showing Oromia Regional State had the highest relative malaria burden and gaps in malaria services compared to other regional states. Initially, there was substantial funding from the Global Fund and availability of other malaria partners to support most malaria-related activities in the other regional states. However, it was later evident that several other regional states, especially Gambela and Benishangul-Gumuz Regional States had consistently higher malaria prevalence compared to Oromia Regional State. The availability of increased PMI funding for malaria activities since 2010 and progress made in Oromia Region allowed PMI to progressively support additional NMCP activities beyond Oromia Regional State to meet national program gaps and increase our focus on the highest burden regions in Ethiopia.

1. Vector control

NMCP/PMI objectives

Insecticide-based vector control remains a key component of malaria prevention and control in Ethiopia. The NMSP (2017-2020) vector control objective is "to ensure that the population at risk of malaria has universal access to one type of globally recommended vector control intervention by 2017 and beyond," which is in line with PMI's vector control objectives. The two major vector control interventions implemented to prevent malaria in Ethiopia are the IRS of houses and the distribution of ITNs. As stated in the current NMSP (2017-2020) IRS policy involves targeting areas where malaria burden is high or where there is a risk of epidemics, such as highland fringe areas. The proposed ITN policy plans to achieve and maintain universal ITN coverage for populations residing in malaria risk areas through "catch-up" campaigns and to achieve and maintain ITN use levels above 80 percent by all age groups through SBCC activities.

The MIS 2015 results continue to highlight the sustained levels of ITN ownership in Ethiopia, but ownership and use levels are still both below target levels. There are likely several factors to account for the findings. According to a PMI-supported study in five districts in Jimma Zone, the barriers for use

were the shape of the nets, low risk perception due to seasonality of malaria, saving nets for future use, decreased awareness, negligence, and perceived low efficacy of ITNs. In another cross sectional survey, the two factors strongly associated with use of ITNs were knowledge of malaria transmission by mosquito bites and ITNs being washed at least once by households (Berkessa et al. *BMC Public Health* (2016) 16:106). However, the largest barrier to ITN use is the insufficient availability of ITNs at the household level compounded by the lack of an ITN distribution tracking system down to the users.

According to the FMOH's NMSP 2017-2020 malaria risk stratification based on API from 2015 micro-plan data, 60 percent of the population is residing in malaria risk areas (i.e., below 2000 meters asl). This translates to 60 percent of the population in the country that needs to have access to ITNs. Primary distribution occurs through the PHCU, specifically health posts, where an average of one ITN per two persons is distributed to all target households every three years in campaigns to attain universal coverage. The ITN mass distribution campaign is mainly handled by the HEWs in collaboration with the HDA and local authorities. HEWs receive technical assistance and supervision from the district health offices and health centers. HEWs identify and confirm the need for ITNs through their routine household visits and from HDA reports. However, in discussion with the Global Fund, WHO, UNICEF and PMI, the NMCP has agreed to pilot continuous distribution in 20 to 30 districts using Global Fund resources in 2019. Continuous distribution of ITN is not included in the national malaria strategic plan (2017-2020), however it is included in the more recent revised national malaria guidelines (2017). In order to inform future implementation plans, FMOH will pilot continuous distribution in 20-30 districts in 2019 using Global Fund resources. In this MOP PMI has budgeted for a limited amount of ITNs for continuous distribution pending favorable results from the pilot. The Ministry does not have a specific continuous distribution strategy to prioritize pregnant women and children. However, all households in malarious areas are targeted for ITNs, so pregnant women and children will be covered under the campaigns, and the HEWs are instructed to prioritize pregnant women and children under five years of age in case there happens to be insufficient number of ITNs for the community.

According to the new malaria risk stratification, 14.8 percent of the country's total population is targeted for IRS as compared to 17 percent in the 2014 stratification. Due to the varied topography and heterogeneity of malaria transmission in the country and even within districts, not all communities in a specific district are targeted for spraying. There are instances of having foci of high malaria burden communities within low or medium burden districts. Hence, specific IRS-targeted communities are selected based on malaria case load, altitude (< 2000 meters), presence of nearby *Anopheles* breeding sites, agriculture and water development practices, epidemic records, and other economic or social factors. In general, PMI does not conduct blanket spraying in supported districts in Ethiopia but works closely with the FMOH for sub-district targeting of spraying based on the criteria outlined above.

Malaria transmission in Ethiopia is seasonal, lasting for about three months usually from September to November (except in Gambela and Benishangul-Gumuz Regions where transmission could be as long as six months) after the main rainy season. Depending on the residual life of the insecticide used and timing of spray operations, one spray round per year could give the required protection against malaria. IRS remains one of the long-standing malaria control tools in the country, and the FMOH is annually implementing IRS in all regions of the country. Updating of IRS implementation plans following the new stratification has not been achieved to date and requires further effort from the FMOH and RHBs to fully and effectively realign their programs with the NMSP. Much more effort is needed to improve the quality of IRS and environmental compliance practices in Government supported district. In 2017, the FMOH has conducted spraying in more than 5.1 million structures inhabited by more than 12.6 million people.

Regular insecticide resistance monitoring in selected sites throughout the country is one of the objectives of the NMSP which is aimed to provide critical information to develop or revise insecticide policy and implement insecticide resistance management.

a. Entomological monitoring and insecticide resistance management

Progress since PMI was launched

PMI started supporting insecticide resistance monitoring studies on four insecticide classes in 2008 in five sites in Oromia Region. High dichloro-diphenyl-trichloroethane (DDT) resistance and decreased susceptibility to deltamethrin in the local populations of *An. gambiae* s.l. was observed at all five sites. Based on these preliminary results, the FMOH recognized the need for expanding the testing nationwide. From 2008 through 2011, PMI supported resistance monitoring in 15 sites in the country. Other stakeholders (WHO and EPHI) joined PMI in insecticide resistance monitoring and the total sites for insecticide resistance monitoring reached 35 in 2011. Site selection was coordinated among stakeholders and resistance monitoring results were shared with the FMOH for decision making. Results from different sites and different stakeholders were consistent and the local malaria vectors exhibited high levels of DDT and pyrethroid resistance. On the basis of results from sites supported by PMI, WHO, and EPHI, the FMOH decided to discontinue using DDT for IRS in 2010 followed by discontinuation of pyrethroids for IRS in 2012. A decision was also made against the use of only one class of insecticide for IRS across the country. Instead the program will use more than one class of insecticide for the IRS program in Ethiopia (i.e., different insecticides will be used in different geographic locations based on insecticide resistance test results). PMI continued supporting entomological monitoring including vector density, vector behavior, insecticide susceptibility, mechanism of resistance and residual efficacy of insecticides after the spraying campaign. Further, PMI has supported a study to determine the decay rate of three insecticides used for IRS on different wall types using experimental huts. In addition, the FMOH in collaboration with partners has developed national insecticide resistance monitoring and management strategy that was disseminated in June 2016.

Progress during the last 12-18 months

In 2017, PMI continued supporting entomological resistance monitoring of 7 insecticides from 4 insecticide classes using WHO tube tests in 12 sites, in addition to limited testing of 2 new insecticides, chlorfenapyr and clothianidin. The insecticide resistance monitoring tests indicate resistance at an increased number of sites that remained consistent with previous year's results. Study results show local vectors from all 12 sites were fully susceptible to pirimiphos-methyl. Susceptibility to bendiocarb and propoxur was reported in 11 out of 12 sites. Resistance to propoxur and suspected resistance to bendiocarb were reported from one site each. In all 12 sites *An. gambiae* s.l. populations were resistant to DDT and permethrin. Resistance and suspected resistance to deltamethrin were reported in ten and two sites, respectively. *Anopheles gambiae* s.l. was susceptible to malathion in one out of nine sites tested and suspected resistance or resistance was reported in five and three sites, respectively. Clothianidin (one of the new insecticides) was tested to determine the baseline susceptibility status of wild *An. gambiae* s.l. and susceptible *An. arabiensis* from the Adama insectary using interim diagnostic dosage 13.2 mg a.i per filter paper (provided by Sumitomo Chemicals). Test mortality rates after a seven day holding period were 98.8 percent and 99 percent for wild *An. gambiae* s.l. and *An. arabiensis* from the Adama insectary, respectively. Furthermore, chlorfenapyr (the second new insecticide) was tested to determine its diagnostic concentration against wild *An. gambiae* s.l. and susceptible *An. arabiensis* from

the Adama insectary for 12.5, 25, 50, 100, 200µg using CDC bottle bioassay. As the result after three day holding period showed survival of wild *An. gambiae* s.l. at the higher concentration of chlorfenapyr (200µg), the test is being repeated to assess reproducibility. Insecticide resistance monitoring results from the 12 sites are presented in Table 4 and the multi-year results in Table 5.

Table 4. Summary of PMI supported insecticide resistance tests using WHO tube test in 2017

Percent mortality of wild *An. gambiae* s.l.												
Insecticide	**Sites**											
	Abaya	Omonada	Ziway	Babile	Abobo	Amibara	Metema	Bahirdar	Seleklaka	Humera	Halaba	Jinka
DDT	59	25	22	17	50	40	ND	67	65	30	18	89
Malathion	97	93	ND	100	93	ND	85	78	65	91	ND	96
Pirimiphos-methyl	100	100	100	100	100	100	100	100	98	100	100	100
Bendiocarb	100	91	100	99	100	100	100	100	99	100	100	100
Propoxur	100	86	100	98	100	100	100	100	99	100	100	100
Deltamethrin	32	20	10	49	30	13	89	93	30	52	22	98
Permethrin	46	34	36	50	30	61	89	85	76	70	48	88

ND: not determined

Table 5. Multi-year insecticide resistance results in different sites using WHO tube test

Insecticide	Year	% Mortality of *An.gambiae* s.l at different study sites							
		Omonada	Ziway	Chewaka	Bahirdar	Halaba	Alamata	Gambela	Amibara
DDT	2012	4	13	3	6	0	ND	ND	ND
	2013	9	26	22	16	ND	ND	ND	ND
	2014	7	6	6	9	ND	13	19	ND
	2015	4	ND	14	11	25	40	24	48
	2016	10	27	ND	ND	ND	25	37	67
	2017	25	22	ND	67	18	ND	50	ND
Deltamethrin	2012	13	27	12	44	1	ND	ND	ND
	2013	26	36	51	20	ND	ND	ND	ND
	2014	42	11	46	25	ND	44	18	45
	2015	32	32	49	25	43	45	11	49
	2016	8	76	ND	81	ND	50	33	53
	2017	20	10	ND	93	22	ND	30	ND
Permethrin	2012	11	ND	ND	ND	ND	ND	ND	ND
	2013	22	ND	ND	ND	ND	ND	ND	ND
	2014	16	3	31	66	ND	10	28	19
	2015	22	13	20	9	25	89	28	61
	2016	5	57	ND	80	ND	27	20	68
	2017	34	36	ND	85	48	ND	30	ND
Bendiocarb	2012	93	100	90	87	98	ND	ND	ND
	2013	92	100	100	75	ND	ND	ND	ND
	2014	86	100	100	87	ND	96	92	100
	2015	95	100	100	87	100	100	100	100
	2016	80	100	ND	100	ND	97	98	99
	2017	91	100	ND	100	100	ND	100	ND
Propoxur	2012	98	100	96	100	99	ND	ND	ND
	2013	98	100	100	96	ND	ND	ND	ND
	2014	100	100	100	99	ND	98	100	100
	2015	100	100	100	99	100	100	100	100
	2016	100	94	ND	97	ND	100	100	100
	2017	86	100	ND	100	100	ND	100	ND
Pirimiphos-methyl	2012	100	ND	ND	100	ND	ND	ND	ND
	2013	100	100	100	100	ND	ND	ND	ND
	2014	100	100	100	100	ND	100	100	100
	2015	98	100	100	100	100	100	100	100
	2016	98	99	ND	100	ND	92	100	100
	2017	100	100	ND	100	100	ND	100	ND

ND: Not done

The longitudinal insecticide resistance results show consistent vector population resistance to DDT, deltamethrin and permethrin except random variation from year to year and site. There is no clear reversal of resistance to DDT though its use for IRS was discontinued for the last seven years.

In 2016 and 2017, PMI supported activities to understand intensity of insecticide resistance of local vectors to deltamethrin and permethrin. Accordingly, intensity assay of deltamethrin and permethrin at 5X and 10X concentrations were carried out in the entomological monitoring sites. Classification was made according to WHO's test procedures for insecticide resistance monitoring (http://apps.who.int/iris/bitstream/handle/10665/250677/9789241511575-eng.pdf;jsessionid=DD5E265D6E24024B01011806665930D7?sequence=1). As presented in Table 6 below, *An. gambiae* s.l. exhibited resistance to deltamethrin 1x in 9 sites out of 10which was expressed by low percent mortality. Susceptibility test result ≥98 percent with deltamethrin intensity concentration 5x denotes low intensity resistance. Test result ≥98 percent with deltamethrin intensity concentration 10x denotes medium intensity resistance and when <98 percent mortality obtained with deltamethrin intensity concentration 10x, it will be classified as high intensity resistance. Accordingly, deltamethrin results show low intensity at one site, moderate intensity at three sites and high intensity resistance in five sites according to WHO intensity category classification. For permethrin, *An. gambiae* s.l. showed low intensity resistance in four sites and moderate intensity resistance in six sites.

Table 6. Result of insecticide resistance intensity assay for deltamethrin and permethrin, 2017

Insecticide	**Percent mortality of wild *An. gambiae* s.l.**									
	Abaya	Omonada	Ziway	Babile	Abobo	Amibara	Seleklaka	Humera	Halaba	Jinka
Deltamethrin 1X	32	20	10	49	29.7	13	30	52	22	98
Deltamethrin 5X	63	27	81	99	76	88	95	82	89	*ND
Deltamethrin 10X	85	67	97	*ND	100	96	100	84	99	
Permethrin 1X	46	34	36	50	30	61	76	70	48	88
Permethrin 5X	62	100	90	99	85	99	97	75	96	100
Permethrin 10X	100	*ND	99	*ND	100	*ND	99	99	98	*ND

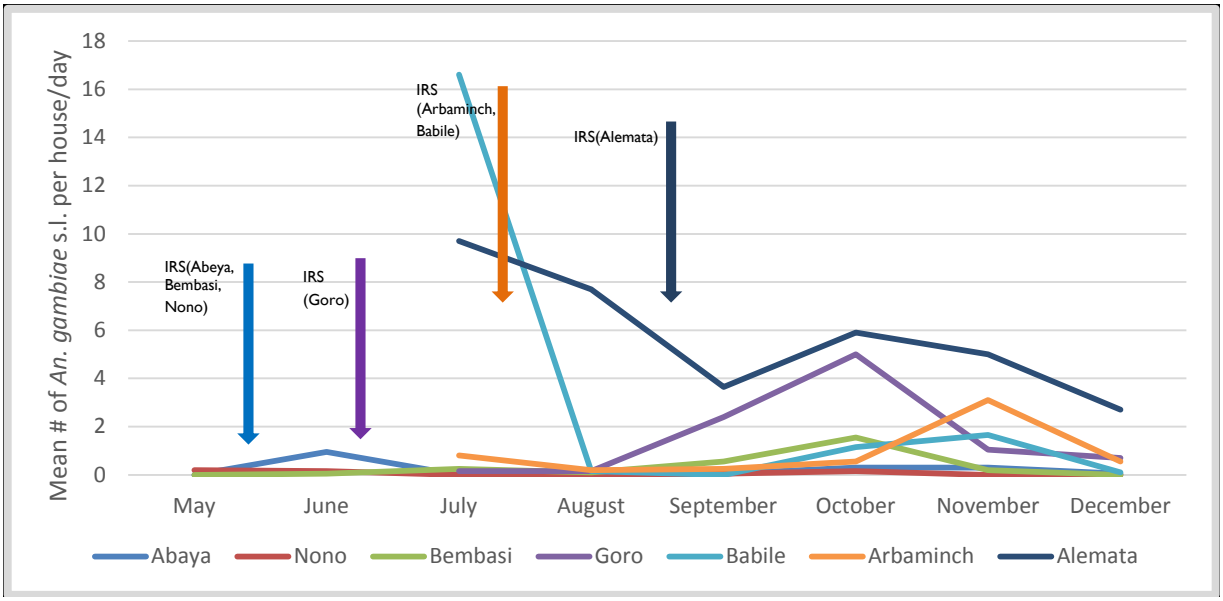
*ND – Not done

Synergist assays were conducted to assess the involvement of metabolic resistance mechanisms in the expression of *An.gambiae* s.l. resistance to deltamethrin and permethrin. The test results show pre-exposure to PBO fully restored susceptibility to deltamethrin in seven of nine sites (98.7-100 percent mortality) and permethrin in six of nine sites (98-100% mortality). Pre-exposure to PBO improved test mortality rates but didn't restore susceptibly to deltamethrin in two sites, and to permethrin in three sites. This high resistance as demonstrated through the intensity resistance assay appears to be mediated mainly by metabolic oxidase enzymes in most sites. However, in Omonada, pre-exposure to PBO did not restore susceptibility of both deltamethrin and permethrin, suggesting involvement of other mechanisms.

In 2017, PMI continued supporting malaria vector density, species composition and behavioral monitoring to understand the abundance, seasonal patterns, and biting behavior of mosquitoes. PMI also wanted to assess the impact of IRS in three PMI IRS supported sites (Abaya, Bambasi, and Nono) and four government operated IRS sites (Alamata, Arbaminch, Babile, and Goro). These efforts were conducted in collaboration with Jimma, Jigjiga, Arbaminch, Addis Ababa, and Mekele Universities using pyrethrum spray catch, CDC light trap, and human landing collection (HLC) methods. Species composition analysis showed that *An. gambiae* s.l. was the most prevalent species in all monitoring

sites. In 2017, 887 *An. gambiae* s.l. from 11 sites in six regions were PCR tested for species identification and results were obtained for 835 specimens and all were *An. arabiensis*. Alternatively, the practice was to keep naming *An. gambiae* s.l. unless the actual samples were tested and confirmed, as other members of the *An. gambiae* complex (namely *An. amharicus*) are present in Ethiopia. The results of behavioral monitoring from July to December 2017 in the three PMI supported IRS sites and four Ministry of Health IRS sites showed that the indoor resting density of *An. gambiae* s.l. using pyrethrum spray catch collection generally decreased after spraying (Figure 5).

Figure 5. *An. gambiae* s.l. indoor resting density from pyrethrum spray collections in Abaya, Bambasi, Nono, Goro, Babile, Arbaminch, and Alemata sites* (May to December 2017)

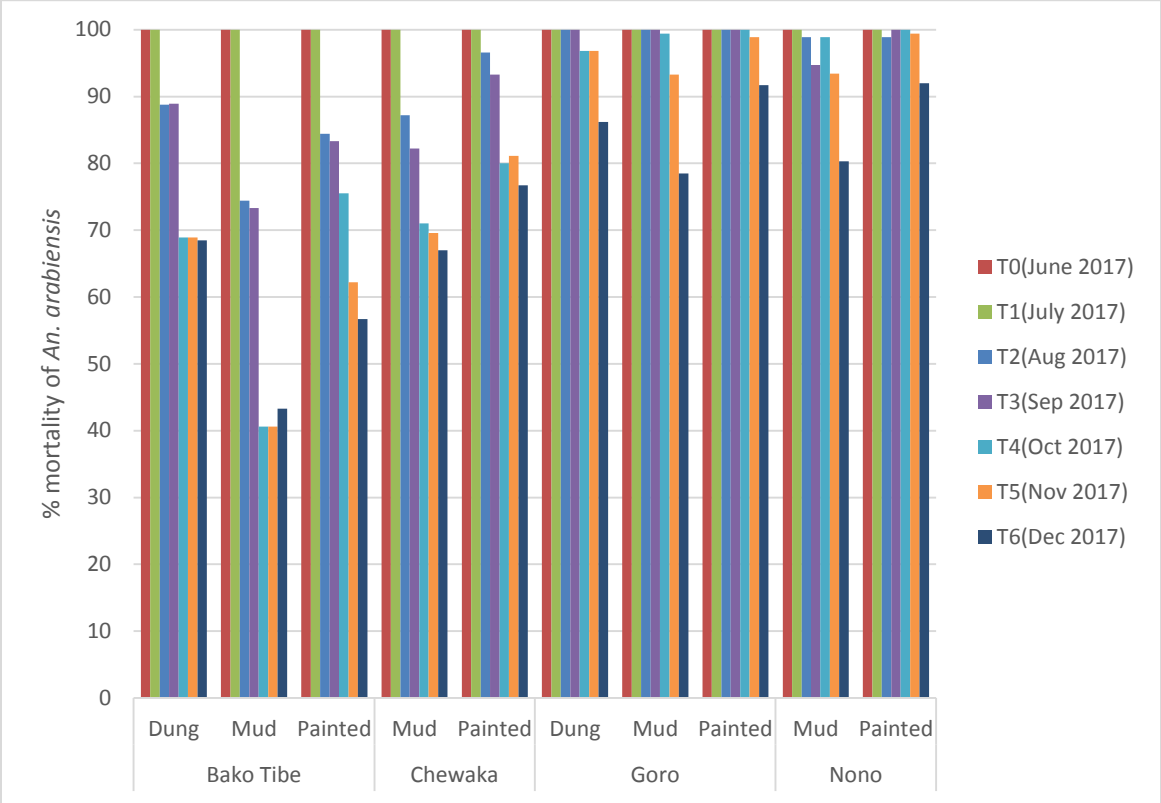


* All are IRS sites. Abaya, Bambasi and Goro are PMI supported and the rest are government supported districts.

From May to December 2017 in seven monitoring sites, 3,039 *An. gambiae* s.l. were collected attempting to feed on human bait. Of these, 72.8 percent were collected outdoors while attempting to feed on human bait. These results suggest exophagic tendency in the local malaria vectors. On the other hand, the feeding time of the main malaria vector varies by site. For instance, in Nono the peak feeding time was 8:00-9:00 PM while bimodal peak feeding times were seen in Bambasi from 1:00-2:00 AM and 4:00-5:00 AM (please see Figures 8, 9, and 10 in the annual partner report https://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/ethiopia-2017-entomological-monitoring-final-report.pdf?sfvrsn=4). Further, PMI supported the study of malaria vector behavior in relation to human night activity and behavior in Dangur, Benishangul-Gumuz Region, in agricultural farm sites. At these farm sites, migrant workers were believed to come for a short time and live in poorly constructed shelters, if any. Migrant worker activities could include night time work outdoors depending on the farm type. Entomological study results show that, like other study sites, *An. arabiensis* is the most abundant vector in the area and human landing collection shows a high tendency of *An. arabiensis* to bite throughout the night with peak activity at 9:00–10:00 PM and 12:00 AM–1:00 AM both indoors and outdoors with almost equal tendency (please see Fig 19 here https://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/ethiopia-2017-entomological-monitoring-final-report.pdf?sfvrsn=4) which differs from other sites. This biting behavior will put the migrant workers at more risk while working outdoor during the night.

A wall cone bioassay assessed the quality of IRS within seven days (time zero) after spraying and continued monthly to monitor the decay rate of pirimiphos-methyl in four districts (Bako, Chewaka, Goro, and Nono) using laboratory-reared susceptible mosquitoes. The results from wall cone bioassays show a mortality rate of 100 percent at time zero and one month after spraying on all wall types in all four sites. Variations were observed on the performance of pirimiphos-methyl on different wall types and different sites from the second month and beyond after spraying. Average mortality at Bako and Chewaka sites were 83 percent and 90 percent, respectively, two months after spraying. Average mortality continues to fall below the expected performance level in successive months. On the other hand, pirimiphos-methyl demonstrated durable performance in Goro and Nono sites on all wall types for five consecutive months after spraying (Figure 6). In general, mortality on mud wall surfaces was lower than dung and painted surfaces and variation between sites might be due to the variation in wall surfaces, as well as other environmental factors.

Figure 6. Results of pirimiphos-methyl residual efficacy monitoring



Recently the Asian malaria vector mosquito, *An. stephensi*, was discovered in Kebridehar town, Ethiopian Somali Region. *An. stephensi* is a competent vector for both *P. falciparum* and *P. vivax.* It is recognized as an important vector of malaria in urban areas in Asia. Further, PMI proposes to determine the spread and density *An. stephensi* in eastern part of Ethiopia. The presence of malaria parasites in *An. stephensi* will be tested using ELISA. This entomological monitoring will determine the feeding behavior and susceptibility of *An. stephensi* to different insecticides in different locations in Eastern Ethiopia.

Plans and justification for proposed activities with FY 2019 funding:

With FY 2019 funds PMI will maintain the FY 2018 level of insecticide resistance and entomological monitoring support and will continue to work closely with the FMOH, RHBs, EPHI, and local universities. The objective of this support is to monitor and ensure the effectiveness of vector control interventions being implemented in the country. In collaboration with partners, PMI will continue monitoring the density and behavior of malaria vectors over time to document vectors' responses to interventions and inform decision making. Monitoring quality of IRS through wall cone bioassays and decay rates of different insecticides on different wall types will also be supported. PMI continues to support insecticide resistance and decay rate tests of new insecticides as they become available post WHO pre-qualification.

Malaria elimination has become a key focus of the FMOH and capacity building of entomology experts is a crucial area of support for PMI. The FMOH has already endorsed an insecticide resistance management plan, which calls for 25 sentinel sites for insecticide resistance and monitoring. Although PMI will only directly support data collection in eight of these sentinel sites, PMI will support the coordination of and data compilation from all sites through seconding a qualified staff member to the FMOH or EPHI. FMOH through GF resources has allocated funding for the establishment of sentinel sites, which will be operated by EPHI. EPHI has conducted consultative meetings with stakeholders on the scope and modalities of operationalizing the sentinel sites. The sentinel sites represent 25 districts from different eco-epidemiological settings of the country and will be situated in appropriate health centers. Capable and committed staff is needed to regularly conduct the necessary entomological monitoring, compile, analyze, interpret, and report the results. The activity will be coordinated amongst various stakeholders, particularly with local universities, and their staff will supervise, analyze, interpret, and use generated information for appropriate decision making. In collaboration with the NMCP and Jimma University, PMI is planning to prepare a modular training curriculum to train Ministry of Health malaria experts at district and national levels to enable them to conduct entomological monitoring.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

b. Insecticide-treated nets

Progress since PMI was launched

Between FY 2007 and FY 2018, PMI procured a total of 30.8 million ITNs, which were distributed to malaria risk communities. The FMOH's NMSP 2017–2020 aims to sustain the universal vector control coverage through ITNs and/or IRS interventions in malaria risk areas where applicable. The last ITN distribution campaign was conducted in 2015/16 and over 30 million ITNs were distributed to households in malaria risk areas throughout the country. The next universal campaign is scheduled for 2019. According to MIS 2015 in a household owning at least one ITN, use of ITN by children and pregnant women was 70 percent and 74 percent, respectively. PMI supported districts to transport ITNs from district level to health posts and communities. All activities were coordinated with the local authorities and HEWs in order to ensure that engagement of targeted districts is maximized, ITNs were distributed before the malaria transmission season, and communities are educated to use ITNs properly and care for them appropriately.

Progress during the last 12-18 months

In 2017, PMI procured 5.3 million ITNs and distributed to communities at risk for malaria (from districts to households). In 2018, PMI procured a total of 6 million ITNs and distributed to households as per the distribution plan agreed upon with the FMOH. Additionally, 4.4 million ITNs are currently in the procurement process.

To move ITNs effectively and in a timely manner to the households, PMI is providing technical assistance to the RHBs, district health offices, and health facilities. In February 2018, support was provided to Afar and Tigray RHBs to organize ITN distribution launching events at Lugudi health post in the Atsibi *woreda* of the Tigray Region and Hadi Burri *kebele* health post in the Afambo *woreda* of the Afar Region. The launching events were organized to officially kick off the distribution of PMI procured 670,394 ITNs in 16 districts of Tigray Region and 522,838 ITNs in 16 districts of the Afar Region. These events created awareness and mobilized the community to be prepared for ITN distribution. These efforts included supporting RHBs to organize district level ITN distribution consultations and orientation workshops. Workshops were led by regional, zonal, and district level health department heads and attended by malaria experts, district administrators, district malaria and logistics experts, health center heads, HEWs, health extension supervisors, *kebele* leaders, police officers, and supervisors of ITN distribution at the health post level. At the end of the workshop, detailed district-level ITN orientation and distribution implementation plans were drafted to further cascade the distribution to health posts and household levels.

Amhara, Benishangul-Gumuz, and Oromia RHBs conducted regional level post campaign review meetings. RHB deputy heads and malaria team leads organized events to share experiences for future ITN distribution campaigns and hold discussions on ITN distribution practices to document lessons learned. Participants included FMOH malaria experts, district health office heads, malaria focal persons at each level, and RHB disease prevention core process owners. The post campaign review and assessment was also supplemented by an after action review to develop action plans which define next steps for the *kebeles* that didn't finalize the ITN distribution within the proposed timeline. Major lessons learned include that the engagement of all concerned (management & technical staffs) at FMoH, RHBs, zonal health departments, *woreda* health offices, and *kebele* level is crucial for a successful distribution campaign. In addition, close monitoring and follow up of the distribution campaign at health posts proved to be essential to maintain the campaign momentum and complete the activities within the planned period.

ITNs dashboard development was supported in the Pharmaceutical Funds Supply Agency (PFSA) Health Commodity Management Information System to increase visibility and to better manage the ITNs distribution process and campaign performance in real time. In order to extend functionality of the ITNs dashboard and to improve stock visibility at the health post level, PMI funded a pilot project using mobile technology for ITNs distribution tracking. The objective of the pilot was to implement an automated solution to provide end to end visibility into ITNs balances and transactions. During the pilot the system was able to track and confirm ITNs received from the *woreda* health office and ITNs distributed to targeted households during a campaign period. The system now has the capability to ensure visibility of ITNs from the minute a pre-shipment notice is generated down to when household distribution has been completed. This dashboard is also expected to be used in monitoring ITN campaign progress and performance.

Commodity gap analysis

Table 7. ITN Gap Analysis

Calendar Year	2018	2019	2020	2021
Total Targeted Population	10,243,555	35,911,812	4,897,440	10,966,741
Continuous Distribution Needs	**0**	**0**	**0**	
Channel #1: Community Health extension program	0	0	500,000	
Estimated Total Need for Continuous Channels	0	0	500,000	
Mass Campaign Distribution Needs				
Mass distribution campaign(s)	5,690,864	19,951,007	2,720,800	6,092,634
Estimated Total Need for Campaigns	5,690,864	19,951,007	2,720,800	6,092,634
Total ITN Need: Routine and Campaign	**5,690,864**	**19,951,007**	**3,220,800**	**6,092,634**
Partner Contributions				
ITNs carried over from previous year	[2]6,000,000	4,709,136		1,502,287
ITNs from MOH				0
ITNs from Global Fund[1]		10,313,013	0	2,604,000
ITNs from other donors				0
ITNs planned with PMI funding [3]	4,400,000	4,928,858	4,723,087	
Total ITNs Available	10,400,000	19,951,007	4,723,087	4,106,287
Total ITN Surplus (Gap)*	4,709,136	0	1,502,287	(1,986,347)

[1]Per Ethiopia malaria gap analysis submitted to GF, 10.3 million ITNs will be procured by 2019 though the GF

[2]Six million ITNs already procured and distributed in 2018. The remaining 4.4 million planned to be delivered in Oct/Nov 2018

[3]PMI will procure 4.9 million ITNs from FY 2017 funding for 2019 campaign, and 4.7 million ITNs from FY 2018 funding and FY 2019 to fill the subsequent forecasted need in 2020.

*Gap (surplus): It is anticipated that the next Global Fund grant will address the large ITN gap in 2021.

Note: The primary reason for different target population in different years is that different population sizes receive ITNs in different years and the replacement time will differ accordingly. In addition, new households will be considered in the target.

Plans and justification for proposed activities with FY 2019 funding

ITN planning is based on the WHO recommendation of 1 net for 1.8 people. PMI supports the FMOH policy to distribute ITNs to the most at-risk communities in significant malaria transmission areas as per NMSP 2014-2020 malaria stratification. In addition to the ITN procurement and distribution, PMI in collaboration with FMOH and other in-country stakeholders, will continue to support the quantification and distribution process.

The ITN need to achieve universal coverage is 19,951,007 ITNs in 2019 (as per the new FMOH gap analysis) and 2,720,800 ITNs in 2020. In 2018, PMI procured and distributed 6 million ITNs, and 4.4 million ITNs from MOP FY16 are in the process of procurement. PMI plans to procure 4 million ITNs with MOP FY17 funds and 2.23 million ITNs with FY 2018 funds. With FY 2019 funds, 500,000 ITNs will be procured for continuous distribution and 1,990,434 ITNs will be procured for the mass campaign which will be implemented through HEWs to replace those ITNs distributed in 2017. Current information shows Global Fund will procure 2,604,000 ITNs for the 2020 -21 campaign.

To ensure that all procured ITNs reach the end-user, PMI will continue to support the NMCP and PFSA in maintaining the ITN distribution tracking and monitoring system (ITNs dashboard) as well as invest in more effective distribution methodologies to ensure ITNs reach health post and household targets. In addition, PMI will advocate for the implementation of NMCP's strategy that prioritizes pregnant women and children for ITNs coupled with other malaria prevention SBCC activities. According the NMSP, the SBCC activities will be focusing on community empowerment and mobilization to increase ITN utilization.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

c. Indoor residual spraying

Progress since PMI was launched

From the beginning of PMI IRS support in Ethiopia, insecticide resistance and entomological monitoring have been part of the efforts with the findings guiding insecticide selection. The FMOH discontinued the use of DDT for IRS due to PMI supported insecticide resistance test results in 2010 followed by discontinuation of pyrethroid use for IRS in 2012. Further, through the insecticide decay rate monitoring, PMI has shown that bendiocarb's persistence on different wall types in local settings is below the expected time period and fails to cover the critical transmission season. On this basis it was replaced by organophosphate class insecticides. Monitoring of pirimiphos-methyl decay rates showed it performed for three months in two sites while it remained effective for at least five months on all wall types in two other monitoring sites (Figure 6). PMI continued supporting insecticide resistance monitoring and the results were consistent with previous findings that showed local malaria vectors are fully susceptible to pirimiphos-methyl and resistant to DDT, deltamethrin and permethrin. Emergence of resistance to bendiocarb, propoxur, and malathion was also reported in some places.

Since 2008, PMI has been providing targeted IRS to high malaria burden *kebeles* in PMI-supported districts according to the NMCP's national guidelines. The PMI-supported IRS program in Ethiopia has expanded significantly from its initial coverage of 316,000 structures in 2008, peaking at 858,657 structures sprayed in 2011 (Table 8). PMI's IRS coverage increased from 19 districts in 2008 to 50 districts in 2011. Through a graduation process that PMI and Oromia RHB started in 2011, 60 districts (24 districts graduated in 2012, 10 districts graduated in 2017 and 26 more districts graduated in 2018) have graduated from full PMI IRS support and 44 districts are currently receiving full support. The districts receiving full support are 20 from Benishangul-Gumuz Region, 14 from Gambela Region and 10 from Oromia Region. Graduated districts continue receiving minimal support for micro-planning, supportive supervision, and IRS equipment to address gaps. Districts considered for graduation must meet the following criteria: low burden of malaria; sufficient financial resources and technical expertise to successfully implement an IRS program; and possess adequate storage facilities,

equipment, and supplies. Hence, the bulk of IRS operations, including the procurement of insecticide, financial, and programmatic support is taken over by the graduated districts. The rationale for this graduation approach is that as districts build capacity through extended PMI support over the years, they will gain the ability to sustain IRS operations with their own resources. PMI funds could then support IRS in other higher-burden districts. This model has shown to be effective as the 34 graduated districts (24 graduated in 2012 and 10 in 2017) achieved a 93 percent IRS coverage rate in 2017, spraying 521,108 structures and protecting 1,553,909 people.

Based on a request from the FMOH, PMI has piloted, evaluated, and supported the implementation of CB IRS using HEWs since 2012 (implemented in one district in 2012 and six districts from 2013–2016). The involvement of HEWs in IRS as part of the CB IRS strategy, as indicated in the NMSP 2017-2020, further underscores expanding the use of health extension programs (HEP) in the implementation of IRS. The performance of the CB IRS approach was evaluated in 2013 and 2014 to assess if it met the required quality and environmental compliance standards. The evaluation findings were positive and concluded that CB IRS could be an alternative approach to the district-based IRS operations and potentially more sustainable long-term. PMI's CB IRS program is considered to be a model for government-supported CB IRS nationwide.

From the initiation of PMI-supported IRS in 2008, ensuring that robust environmental compliance practices were implemented has been a major area of focus. Environmental compliance training was made compulsory as part of the overall IRS operations training for all personnel participating in IRS. Storage facilities for insecticide, IRS equipment, and materials for dealing with insecticide-contaminated waste were made available in all districts that receive PMI support for IRS. Previously built evaporation tanks, used to contain DDT effluent waste, were decommissioned and soak pits were built in all districts receiving IRS support. Considerable efforts were made to remove obsolete DDT from PMI-supported sites. Through PMI's efforts, capacity has been created in Ethiopia for the handling of obsolete insecticide which the country can leverage when needed.

Table 8. PMI-supported IRS activities 2008–2020

Calendar Year	Number of Districts[1] Sprayed	Insecticide Used	Number of Structures Sprayed	Coverage Rate	Population Protected
2008	19	DDT	316,829	92.0	1,000,526
2009	23	DDT	459,402	91.8	1,539,163
2010	30	Deltamethrin	646,870	96.5	2,064,389
2011	50	Deltamethrin + Bendiocarb	858,657	98.6	2,920,469
2012	36	Deltamethrin + Bendiocarb	547421	98.8	1,506,273
2013	36	Bendiocarb	635,528	99.6	1,629,958
2014	36	Bendiocarb	667,236	99.5	1,647,099
2015	36	Bendiocarb (28 districts) + Pirimiphos-methyl CS (8 districts)	704,945	99.5	1,655,997
2016	36	Pirimiphos-methyl CS	715,541	99.7	1,688,745
2017	44	Pirimiphos-methyl CS	738,810	98.7	1,877,154
2018[2]	44	Pirimiphos-methyl CS	~ 595,618	TBD	~1,622,386
2019[2]	44	TBD	~ 650,000	TBD	~ 1,775,880
2020[2]	44	TBD	~ 650,000	TBD	~ 1,775,880

[1]Or equivalent geographic divisions.
[2]Represents targets based on the 2018 IRS work plan, and/or projected targets based on national strategic plan and/or discussions with the NMCP.

Progress during the last 12-18 months

IRS Operations: In 2017, PMI graduated another 10 districts from Oromia Region specifically where the burden of malaria was significantly lowered and identified 10 new districts in Oromia Region for full IRS support. In the same year, discussions were held to expand PMI support to new districts with high malaria burden in Benishangul-Gumuz Region. Eight districts from that region were identified for PMI support in 2017 making a total of 44 districts receiving full IRS support. In 2017, PMI supported the spraying of 738,810 structures and protected 1,877,154 people from malaria in 44 districts of Benishangul-Gumuz and Oromia Regions, achieving a 98.7 percent coverage rate. The insecticide used in PMI-supported districts in 2017 was pirimiphos-methyl in all 44 districts. The NMCP showed interest in future use of pirimiphos-methyl in the government spray programs as part of the national insecticide resistance management strategy. However, currently NMCP has decided to continue with bendiocarb and propoxur. In 2017, a total of 3,078 people (15.14 percent female) were trained to effectively deliver IRS operations. Technical support was provided to the graduated districts

for IRS planning and the identification of resource gaps for their 2018 IRS campaign.

Community-Based IRS: In 2017, PMI continued supporting CB IRS in five districts in Oromia Region. Kersa district was the first CB IRS district to graduate. Through PMI support, these five CB IRS districts achieved comparable results to the district-based model in terms of coverage and quality of spraying. In the 2017 CB IRS districts, 151,403 (99.9 percent) structures were sprayed, and 379,534 people were protected. In addition, results from wall bioassays conducted in the CB IRS districts were found to be comparable to results obtained from the district-based IRS districts in 2016.

Obsolete DDT Removal: Significant progress was made between 2015-2017 to remove 115 metric tons of obsolete DDT and DDT-contaminated waste from PMI-supported districts. Environmental health and safety specialists were subcontracted to support the safe repackaging, export, and disposal of DDT. A comprehensive training on DDT waste removal was conducted in October 2015. In total, 56 people were trained (including staff from the FMOH and Ministry of Environment) to serve as technicians and supervisors to support this process. DDT was repackaged in 46 sites throughout PMI-supported districts following the training and shipped to a central store in Addis Ababa. In June 2016, 101,600 kg of obsolete DDT had been shipped out of Ethiopia and arrived in Poland for proper incineration. In addition, all DDT-contaminated packaging and materials were shipped to Poland for incineration, which was completed in January 2017. Significant quantities of obsolete DDT, however, remain in the country in most of the government-supported IRS districts. Through this technical support, PMI helped create in-country expertise to facilitate subsequent removal activities by the NMCP and other stakeholders.

Next Generation Indoor Residual Spraying Project (NGenIRS): Ethiopia has participated in the UNITAID-funded NGenIRS Project since 2016. This market intervention project includes a short-term co-payment schedule to accelerate the reduction of price for long-lasting IRS insecticides. The price reduction enabled Ethiopia to expand coverage of effective, long-lasting IRS from baseline levels, and participation in the NGenIRS Project confirms Ethiopia's commitment to do so.

Plans and justification for proposed activities with FY 2019 funding:

Since the beginning of PMI in Ethiopia, the main support for IRS has been going to Oromia Region where the risk of malaria was originally the highest. Through concerted efforts for the last 10 years, it has become evident that malaria in Oromia Region has been markedly reduced except in a few districts while the risk for malaria remains high in other parts of the country, specifically Benishangul-Gumuz and Gambela Regions. The MIS 2015 showed Benishangul-Gumuz and Gambela Regions were the most malaria affected regions with 18.4 percent and 10.4 percent prevalence, respectively, amongst all ages using RDT whereas the national average was 1.2 percent. Similarly, the FMOH annual review report for 2016/2017 shows API of 236.6 and 243.1 for Benishangul-Gumuz and Gambela Regions, respectively, while the national level API is 27.7. The PMI IRS policy and the NMSP (2017-2020) clearly underscore that high malaria burden areas be targeted for IRS. Accordingly, PMI has targeted the high malaria risk districts in Benishangul-Gumuz and Gambela Regional States through graduating IRS supported districts in Oromia Region, which had been receiving full support for a number of years. According to the new malaria risk stratification (NSP 2017-2020), most districts in Oromia Region are now classified as low malaria risk and do not, therefore, require IRS intervention as the main vector control tool.

With FY 2019 funds, PMI will maintain the FY 2018 level of IRS support and will support IRS operations in 44 districts with a focus on high risk districts in the highest malaria risk regions.

Specifically, IRS will be conducted in 20 districts in Benishangul-Gumuz, in all 14 districts in Gambela, and 10 districts in Oromia Regions. In these districts, approximately 650,000 structures will be sprayed and 1.78 million people protected. The 2019 target is based on the 2018 work plan figure plus natural population growth and 7 percent contingency to address the potential influx of population into the lowland areas. PMI, through close collaboration with the FMOH, RHBs, and other partners, will continue providing minimal support (at roughly 10 percent of the funding levels provided for fully supported districts) and will monitor the status of malaria in the 60 graduated districts using health facility and micro-planning data. In addition, through discussions with RHB, PMI will determine how best to expand PMI's CB IRS implementation to new districts. With FY 2019 funding, there will likely be fewer structures sprayed due to the fact that the high burden districts are often less densely populated and logistical costs can increase given the distance between spray sites. In Gambela Region the housing structures were markedly smaller compared to other places as witnessed from site visits which imply less insecticide requirement in this area. IRS operations, IRS environmental compliance assessment and environmental compliance trainings will also be delivered with the ultimate goal of building local capacity in IRS operations.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

2. Malaria in pregnancy

NMCP/PMI objectives

The Ethiopian FMOH's NMSP (2017-2020) does not support IPTp with sulfadoxine-pyrimethamine because of the relatively low intensity of malaria transmission in most of Ethiopia, and the anticipated minimal expected benefits compared with the relatively high costs of implementation. Malaria in pregnancy (MIP) in Ethiopia is addressed through: 1) improving prompt access to care and treatment at all levels of the health system (health posts, health centers and hospitals), 2) prioritizing the use of ITNs by pregnant women within households, and 3) enhanced SBCC activities and outreach for pregnant women.

The 2016 Demographic Health Survey (DHS) showed that 62 percent of women received at least one antenatal care visit from a health professional for their most recent birth during the five years preceding the survey. This has improved from 34 percent, which was noted in the 2011 DHS. The 2016 DHS also showed that 32 percent women had four or more antenatal visits for their most recent live birth. Increasing ANC coverage is one of the FMOH's priorities and is supported by USAID/Ethiopia MNCH, family planning, and reproductive health funding. From the last published Integrated Disease Surveillance Report (IDSR) (2008-2009), pregnant women accounted for 1.7 percent of all reported outpatients with malaria (14,864/1,104,157), 2.9 percent of reported malaria hospitalizations (574/20,130), and 1.7 percent of reported inpatient malaria deaths (10/585). Since that time, however, the IDSR was folded into the PHEM system and specific MIP morbidity and mortality data were not collected. However, in recent years, Amhara Region is collecting malaria in pregnancy morbidity data by modifying their PHEM reporting form and laboratory registers. Currently, malaria in pregnancy indicators have also been added in the registers and forms for malaria elimination targeted districts. As malaria elimination efforts get scaled up MIP related data will become increasingly available.

The 2017 National Malaria Case Management Guidelines, consistent with WHO guidance, recommend oral quinine for uncomplicated *P. falciparum* malaria in the first trimester followed by oral artemether-

lumefantrine during the second and third trimesters. For uncomplicated mono-species *P. vivax* malaria, oral chloroquine is recommended in all trimesters. For severe malaria, IV artesunate is recommended. Recent PMI-supported *in vivo* monitoring studies have documented that *P. vivax* infected persons in Ethiopia experience an average of two, but up to eight, recurrent infections within the following 12 months. Such illness relapses could be especially harmful to pregnant and breastfeeding women who are unable to take primaquine, have impaired immunity, an impaired nutritional status, and an increased risk of progression to severe or complicated malaria illnesses. Primaquine radical cure is contraindicated during pregnancy and WHO recommends weekly chloroquine prophylaxis until delivery and completing breastfeeding for pregnant women who have *P. vivax* infection. However, this has not been included in the national malaria treatment guidelines.

The ITN replacement scheme presented in the NMSP is the policy framework for continuous ITN distribution primarily through the HEP. Nearly all ITNs are distributed by HEWs through mass campaigns every three years. HEWs are instructed to make sure that pregnant mothers and children less than five years of age have preferential access to ITNs in these mass campaigns and educate communities to give priority to pregnant mothers and children in the event there are too few ITNs per household, resulting in an insufficient number of nets to cover the entire family.

Progress since PMI was launched

Based on the MIS 2007, 2011, and 2015, 43 percent, 35 percent, and 44.3 percent of pregnant women slept under an ITN, respectively. To respond to low access and utilization of ITN, PMI started to support ITN distribution to household level with more efficient mechanism and better documentation. Since 2017, ITN is distributed via a strong community network of health extension workers assisted by local administration and health development army with better commitment, SBCC, and advocacy. In addition, PMI has supported pre-service training of midwives and HEWs, and thus contributed to the graduation of 12,728 midwives and 21,509 HEWs between 2013 and 2018.

There is no new surveillance data from IDSR since 2009 concerning trends in the specific burden of malaria amongst pregnant women, but as mentioned above, the relatively complete malaria surveillance data shows the malaria situation has been steadily improving. The Health and Health Related Indicators Report from HMIS data documented "female" malaria outpatient morbidity from *P. falciparum* in 2011-2012 and 2014-2015 at 775,052 and 405,490, respectively. These HMIS surveillance reports indicate that "female" morbidity—predominantly of women of childbearing age—has also declined since 2011, along with that of the general population.

Progress during the last 12-18 months

PMI has supported the development of a new malaria case management training manual for clinicians at health center and hospitals, which includes MIP. This training manual has been finalized and is in use nationwide. SBCCmessages are being developed based on these guidelines. PMI has supported malaria prevention and treatment efforts since January 2017 in Tigray, Amhara, Oromia, and Southern Nation and Nationalities Peoples' (SNNP) Regions, and since May 2017, in Gambela, Benishangul-Gumuz, Afar, and Somali Developing Regions. These activities aim to improve the overall performance of PHCUs with malaria-specific outcomes, mainly related to pregnancy and malaria case management at the health post level. PMI is supporting a malaria diagnosis and treatment for pregnant women at AC clinics. According to a random follow up assessment conducted in January-March 2018 in Amhara, Tigray, Oromia, and SNNP Regions, 66 percent (175/265) of health centers provide malaria diagnosis and treatment at antenatal care clinics.

Plans and justification for proposed activities with FY 2019 funding

PMI continues to support the current FMOH policies that address pregnant women's special needs through malaria prevention and control, and improving prompt access to malaria diagnosis, and appropriate care and treatment services. The maternal health technical working group is currently reviewing the 2016 WHO ANC guidelines to increase the number of contacts. Although IPTp itself is not part of the national strategic plan, with FY 2019 funding, PMI will support prompt diagnosis and management of acute malaria in pregnant women. PMI will ensure that health providers counsel mothers to seek care for fever and use an ITN consistently. This activity will be closely coordinated with PMI support for case management strengthening and supportive supervision for health care workers at health centers and HEWs at health posts. In addition, PMI will continue support for pre-service trainings for midwives and HEWs to improve malaria case management services for pregnant women.

PMI will continue to work with the FMOH to identify and review all available surveillance data and to encourage the future routine collection, analysis, and publication of disaggregated MIP data once again into the FMOH's annual surveillance reports which has begun in Amhara Region. These enhanced surveillance efforts would aim to provide an appropriate evidence basis for any possible future health policy changes related to MIP in Ethiopia.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

3. Case management

NMCP/PMI objectives

The NMSP 2017-2020 aims for universal access to prompt malaria diagnosis and highly effective treatment services for the entire Ethiopian population, whether living in malaria-free or malaria-endemic areas. The NMSP strategic objective for malaria diagnosis specifies that by 2017, 100 percent of suspected malaria cases are diagnosed using RDT or microscopy within 24 hours of fever onset. The FMOH's policy is for microscopy to be the primary means of malaria diagnosis at hospitals and health centers, and for malaria RDTs to be the diagnostic method at rural health posts. The NMSP aims to train all HEWs in RDT testing and laboratory professionals in malaria laboratory diagnosis and provide quality assured diagnostic commodities at all health facilities.

In addition, Ethiopian Public Health Institute developed the national laboratory master plan that establishes integrated quality assured national laboratory systems for improved routine quality assured diagnosis and treatment practices including malaria. The laboratory system in Ethiopia is a four-tiered system where the national and regional laboratories in the first and second tier, respectively, play a role in policy development, capacity building, and coordination of quality assurance activities. Whereas the third tier is hospital laboratories that provide laboratory services and serve as EQA centers for health centers, the last tier is health centers and health posts that provide laboratory diagnostic services only. The quality assurance (QA)activities include blind rechecking, panel testing and onsite supportive supervision conducted quarterly, three times and two times a year, respectively.

The NMSP states that ACTs, specifically artemether-lumefantrine, should be available at all public health facilities to treat all *P. falciparum* infections, whereas chloroquine continues to be first-line treatment for *P. vivax* cases. Oral quinine remains the treatment of choice for uncomplicated *P. falciparum* for pregnant mothers during the first trimester of pregnancy, and as second-line for treatment

failures. Rectal artesunate should be available at rural health posts for pre-referral treatment for children less than six years of age, and parenteral artesunate or artemether (alternate) should be available at health centers and hospitals for the treatment of severe malaria. The NMSP recently updated the malaria treatment guideline to include primaquine (3.5mg/kg total dose over 14 days) for radical cure of *P. vivax* and also single, low-dose primaquine for transmission reduction against *P. falciparum* (Table 9). Regarding implementation, single dose primaquine will be deployed nationally while primaquine radical cure will be rolled out in the 239 elimination targeted *woredas* and then scaled up to remaining parts of the country.

MIS 2007 and 2015 surveys suggested that about 24.1-36.4 percent of people initially receive care for febrile illnesses through the private sector. The NMSP states that partnership with the private sector will be promoted through public private partnership framework and regulations. The private sector can be involved in malaria case management, distribution of ITNs, IRS, and other operational activities.

Table 9. Status of Case Management Policy in Ethiopia

Status of Case Management Policy in Ethiopia according to updated treatment guidelines 2017		
What is the first-line treatment for uncomplicated *P. falciparum* malaria?	Artemether-lumefantrine and single dose primaquine	Yes
What is the first-line treatment for uncomplicated *P. vivax* malaria?	Chloroquine and primaquine (14 days)	Yes
What is the second-line treatment for uncomplicated *P. falciparum and P. vivax* malaria*?	Oral quinine	Yes
What is the first-line treatment for severe malaria?	IV/IM artesunate	Yes
In pregnancy, what is the first-line treatment for uncomplicated *P. falciparum* malaria in the first trimester?	Oral quinine	Yes
In pregnancy, what is the first-line treatment for uncomplicated *P. vivax* malaria in all trimesters?	Chloroquine	Yes
In pregnancy, what is the first-line treatment for uncomplicated *P. falciparum* malaria in the second and third trimesters?	Artemether-lumefantrine	Yes
In pregnancy, what is the first-line treatment for severe malaria?	IV/IM artesunate	Yes
Is pre-referral treatment of severe disease recommended at peripheral health facilities? If so, with what drug(s)?	First dose of IM artesunate (Health Centers)	Yes
Is pre-referral treatment of severe disease recommended for community health workers? If so, with what drug(s)?	Rectal artesunate (Health Posts)	Yes
If pre-referral rectal artesunate is recommended, for what age group? (note: current international guidelines do not recommend administrating to those ≥ 6 years)	The guideline was updated to exclude those ≥ 6 years	Yes

Progress since PMI was launched

In 2011, Ethiopia adopted a policy that all patients with suspected malaria should receive a confirmatory diagnostic test before treatment with an antimalarial. FMOH has scaled up quality-assured diagnostic testing at both health facility and community level with support from PMI and the Global Fund. An analysis of HMIS data indicates that Ethiopia has made significant progress in scaling-up diagnostic testing for malaria: the percentage of all suspected malaria cases reported that were confirmed by either RDT or microscopy increased from 54 percent in 2012 to 87 percent in 2017, leaving only 225,009 presumed malaria cases (i.e., those cases that were clinically treated without laboratory confirmation). Figure 2 shows the trend of malaria and confirmatory testing in Ethiopia.

From 2008 through 2017, PMI procured 9,240,000 million RDTs, 15,046,630 ACT treatments, 7,145,000 chloroquine tab and 977,448 chloroquine syrup/treatments, 153,000 artesunate suppositories, and 336,000 vials of parenteral artesunate. The Global Fund and Millenium Development Goals pooled funds have provided sufficient quantities of ACTs, primaquine, and RDTs for the malaria program at the national level, although focal stockouts and drug expiry issues still exist in the periphery.

In order to achieve NMSP targets of universal coverage of quality diagnosis at health centers, PMI has supported procurement of 1,094 microscopes, laboratory supplies, and reagents to scale up quality assurance systems for malaria microscopy. PMI also supported the training of 4,151 health care workers and university students in malaria microscopy and 22,000 health workers in malaria case management, as well as providing supervision of HEWs' management of the sick child through iCCM training, including performance of RDTs for managing acute febrile illnesses in all ages.

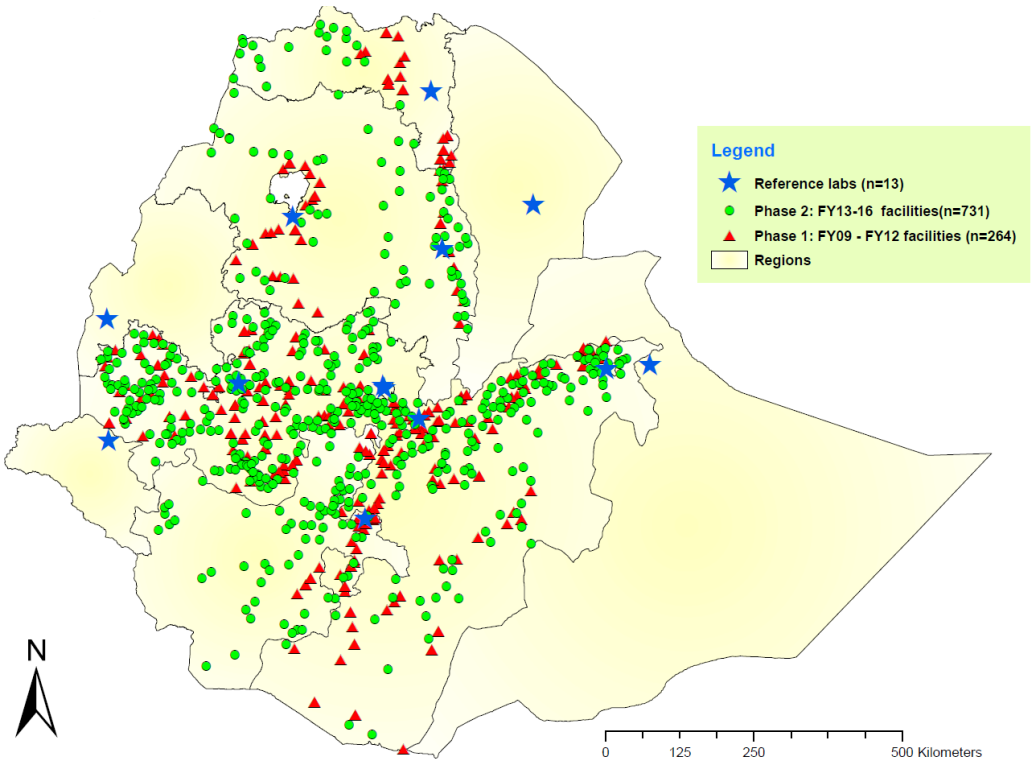
On average there are one to two and five to eight laboratory professionals in health centers and district hospitals, respectively. To date, PMI has supported the training of 1,788 laboratory personnel, targeting all lab professionals at selected 1,022 facilities on an integrated malaria-HIV laboratory diagnosis and quality assurance/quality control system. Additionally, 190 laboratory supervisors from regional reference laboratories have received training-of-trainers training. These supervisors are cascading basic trainings in all regional states of Ethiopia using funds from Government of Ethiopia and technical assistance from PMI. To improve the pre-service training of laboratory professionals and medical students on malaria diagnosis and treatment, training was provided to 162 laboratory and 243 clinical university instructors from 8 major universities. In addition, PMI has supported the WHO malaria microscopy accreditation course for 12 laboratory professionals from regional and national laboratories and 8 were certified as level 1, with the remainder qualifying as level 2.

PMI has supported quality assurance/quality control activities in 1,022 health facilities (Figure 7) which has largely focused on microscopy in health centers, regional reference laboratories and hospitals, including supportive supervision of microscopy and RDT testing processes to minimize common errors. PMI has supported treatment activities in 171 malarious *woredas* of which 88 are targeted for malaria elimination. A random follow up visit was conducted in 347 health posts between January and March 2018 to assess the status of the performance of the health system including malaria. The average HEWs performance on RDT quality score using a standard checklist was 80.7 percent In order to reach more facilities and ensure sustainability, PMI has built the capacity of EPHI to establish a national malaria slide bank, which will be used for training as well as proficiency testing. To date, 10,742 standard slides have been produced validated by WHO and archived at EPHI.

PMI supports private-public partnerships in collaboration with PEPFAR in order to improve private sector case management of malaria. Through U.S. Government support, the Government of Ethiopia has recognized the importance of the private sector as a source of health care for a significant proportion of the population. This is evidenced by the establishment of public-private partnerships in health units in the FMOH, inclusion of representatives from the private health sector in development of new licensing and quality standards by the Food, Medicine and Health Care Administration and Control Authority (FMHACA), inclusion of the private health sector as one of the six pillars in the country's new vision for primary health care, and recognition of the new private health facility associations. Working together with the RHBs and 168 private health facilities in 8 regional states, PMI supported increased access to quality malaria services including diagnostic testing and free antimalarial treatment to the clients in the private sector. Private health facilities that are involved in the partnership will only charge consultation and diagnosis fee and will not charge patients for free commodities received from the government. The private health sector clinics obtain free commodities and supplies for diseases of public health

importance through PFSA thus increasing demand for care and will also provide health and surveillance information to districts and regions. However, much work is still needed to improve collaboration and strengthen implementation of the FMOH public private partnership framework and regulations, in order to strengthen formal platforms to share national malaria guidelines, malaria commodities and best practices to other private facilities currently not receiving PMI support.

Figure 7. PMI-supported laboratory facilities from 2009-2017



Progress during the last 12-18 months

The FMOH's 2017 Health and Health related indicators report, which reported on HMIS data (July 2016-June 2017), stated that "*out of the total 1,755,748 malaria cases reported, 1,530,739 (87 percent) were confirmed by either microscopy or RDT, out of which 1,059,847(69.2 percent) were P. falciparum and 470,892 (30.7 percent) were P. vivax*." Although there are some differences in completeness and representativeness of these surveillance data, it is evident that the majority of malaria cases are now being laboratory confirmed.

PMI has assisted the revision of national malaria treatment guidelines and malaria strategic plan to incorporate recent updates. A competency based malaria case management training manual was developed to improve the skills of health workers on clinical management of uncomplicated and severe malaria, malaria data recording and reporting, and appropriate utilization of malaria commodities supply chain forms. The training manual has been pre-tested and approved by the Human Resource Directorate of the FMOH. Training of trainers and cascade trainings are planned to be given to clinicians using Global Fund resources. PMI has provided technical assistance to support the training of 86 trainers on malaria case management with Global Fund resources that was then cascaded to 2,085 trainees.

As of 2017 in Ethiopia, there are 3,622 health centers and 266 hospitals with microscopy diagnostic capacity, of which 75 percent (2,916) of the facilities are estimated to be in malarious areas. The public-sector health workforce comprises of 7,728 physicians, 6,933 health officers, 44,418 nurses and 42,336 HEWs.

PMI supported onsite clinical training, a 4-day training provided to clinicians on fever and malaria case management for 260 clinicians in 2017. In addition, PMI has supported several rounds of onsite supportive supervision and mentorship. PMI currently supports training, a 5-day course on malaria microscopy, and supervision of malaria diagnosis in 1,022 health centers with laboratories in malarious areas in Ethiopia. Laboratory strengthening activities for malaria microscopy include quality improvement, purchasing laboratory equipment and additional supplies, supportive supervisions for treatment processes, and activities to improve private sector case management.

During the past 12 months, 458 health facilities were involved in an external quality assurance scheme of the target 1,022 facilities. It has been recognized that there is insufficient human and financial resources to support all facilities in malarious areas, therefore, facilities that score greater than 80 percent using the WHO checklist on four successive rounds of mentoring and supervision will be considered "graduated" so that additional facilities can be enrolled to the program. To date, 386 health facilities have been graduated. PMI ensures minimum support for graduated facilities via less frequent but continuous supportive supervisory visits.

Progress has been made in expanding supportive supervision to more health facilities in Oromia Regional State with 71 percent of the facilities (706/990) in malarious areas having received support. In addition, PMI has assisted other regional states to strengthen sub-regional reference laboratories and support hospital laboratory staff to supervise nearby facilities that are not currently receiving supportive supervision. The FMOH and EPHI planned to scale up malaria microscopy external quality assurance using Global Fund resources with PMI providing technical assistance. However, the relatively large number of health facilities in Ethiopia has posed challenges to scaling up external quality assurance to all facilities as it requires skilled human resources and logistics to reach all facilities. In addition, there are gaps in the timely supply of quality reagents and laboratory supplies as well as lack of quality maintenance of microscopes and laboratory equipment.

In 2017, PMI supported the provision of malaria case management in 168 of 7,307 private for-profit health facilities. A total of 98,638 suspected cases were diagnosed, of which 22,550 (22.8 percent) were positive for malaria. PMI is also supporting updating maps of workplace clinics that provide services to clients at the small and large-scale farms and factories in malarious areas in Amhara, Oromia, Tigray, Gambela, and SNNP Regional States.

PMI completed two therapeutic efficacy studies in 2010 and 2014 which were started in 2009 and 2012 respectively (Table 10). The vivax efficacy study completed in 2014 and published in May 2017 noted high rates of recurrent vivax parasitemia by day 42 in both the chloroquine and artemether-lumefantrine treatment arms while the addition of primaquine to either regimen significantly improved day 42 outcomes and resulted in a 5-fold reduction in the number of relapses experienced over a year. In 2018, data collection for a therapeutic efficacy monitoring study of artemether-lumefantrine and dihydroartemisinin-piperaquine for *P. falciparum* and chloroquine and dihydroartemisinin-piperaquine for *P. vivax* has been completed and data cleaning is in process.

Recent studies have confirmed high rates of HRP2-deletions in Eritrea and Sudan, thus PMI Ethiopia has incorporated the HRP2 deletion test in the TES samples collected in September 2017. In addition, there is a collaborative effort between WHO and EPHI to conduct a larger survey of several health facilities and investigate the occurrence of HRP2 deletion in districts in Gambela, Tigray and Amhara bordering Sudan and Eritrea.

Table 10. TES Studies

Completed TES Studies				
Year (start)	**Site name**	**Treatment arm(s)**	**PCR corrected ACPR on day 28**	**Plan for K13 Genotyping**
2009	Bulbula Health Center and Bishoftu Malaria Center	1. AL for vivax 2. CQ for vivax 3. AL for falciparum	91.1% for AL and 97.2% for CQ for *P. vivax** 100% for AL for *P. falciparum***	Not done
2012	Bishoftu Malaria Center and Batu Health Center	1. AL for vivax 2. AL+PQ for vivax 3. CQ for vivax 4. CQ+PQ for vivax	88% for AL 87.7% for AL + PQ 96% for CQ 100% for CQ+PQ[$]	Not done
Ongoing TES Studies				
Year	**Site name**	**Treatment arm(s)**		
2017	Pawe and Arbaminch Health Centers	1. AL for falciparum 2. DP for falciparum 3. CQ for vivax 4. DP for vivax		Planned to be tested with PARMA
Planned TES Studies FY 2018				
Year	**Site name**	**Treatment arm(s)**		
2019	TBD	1. AL for falciparum 2. CQ for vivax		TBD

TES: Therapeutic Efficacy Study; AL: artemether-lumefantrine; CQ: chloroquine; PQ: primaquine; DP: dihydroartemisinin-piperaquine; TBD: to be determined

*Hwang J, Alemayehu BH, Reithinger R, Tekleyohannes SG, Takele Teshi, Birhanu SG, et al. (2013) In Vivo Efficacy of Artemether-Lumefantrine and Chloroquine against *Plasmodium vivax*: A Randomized Open Label Trial in Central Ethiopia. PLoS ONE 8(5): e63433. https://doi.org/10.1371/journal.pone.0063433

** Hwang J, Alemayehu BH, Hoos D, Melaku Z, et al. (2011) *In vivo* efficacy of artemether-lumefantrine against uncomplicated *Plasmodium falciparum* malaria in Central Ethiopia. Malaria Journal 201110:209 https://doi.org/10.1186/1475-2875-10-209

[$]Abreha T, Hwang J, Thriemer K, Tadesse Y, Girma S, Melaku Z, et al. (2017) Comparison of artemether-lumefantrine and chloroquine with and without primaquine for the treatment of *Plasmodium vivax* infection in Ethiopia: A randomized controlled trial. PLoS Med 14(5): e1002299. https://doi.org/10.1371/journal.pmed.1002299

All TES analyses are done by pooling the samples from both study sites.

Commodity gap analysis

Table 11: RDT Gap Analysis

Calendar Year	2018	2019	2020
RDT Needs			
Total country population	94,410,033	96,864,694	99,383,176
Population at risk for malaria *	56,646,020	58,118,816	59,629,906
PMI-targeted at-risk population	56,646,020	58,118,816	59,629,906
Total number of projected fever cases**	9,063,363	9,299,011	9,540,785
Percent of fever cases tested with an RDT***	47%	47%	47%
RDT Needs [2]	**4,259,781**	**4,370,535**	**4,484,169**
Total RDT need ****	**4,685,759**	**4,807,588**	**4,932,586**
Partner Contributions (to PMI target population if not entire area at risk)*			
RDTs carried over from previous year	5,191,550	9,606,118	11,921,723
RDTs from Government	0	0	0
RDTs from Global Fund	8,674,349	6,686,140	7,551,693
RDTs from other donors	0	0	0
RDTs planned with PMI funding******	0	0	500,000
Total RDTs Available	**13,865,899**	**16,292,258**	**19,973,416**
Total RDT Surplus (Gap)	**9,606,118**	**11,921,723**	**15,489,247**

* Based on Central Statistics Agency (CSA) population estimates.
** Based on MIS 2015, fever prevalence of 16%
*** Based on microplanning data, 2014
**** Added 5% buffer and 5% for Reactive Case Detection activity
***** Planned to procure RDTs with PMI funding only if Global Fund resources are unavailable or delayed

Table 12: ACT Gap Analysis

Calendar Year	2018	2019	2020
ACT Needs			
Total country population	94,410,033	96,864,694	99,383,176
Population at risk for malaria	56,646,020	58,118,816	59,629,906
PMI-targeted at-risk population *	56,646,020	58,118,816	59,629,906
Total projected number of malaria cases	1,580,173	1,422,156	1,279,940
Total projected number of PF cases**	1,156,370	1,040,733	936,660
Total ACT Needs * **	**1,445,463**	**1,300,917**	**1,170,825**
Partner Contributions (to PMI target population if not entire area at risk)			
ACTs carried over from previous year	3,007,650	6,052,058	7,691,870
ACTs from Government	0	0	0
ACTs from Global Fund	4,489,871	2,940,730	1,333,290
ACTs planned with PMI funding	0	0	250,000
Total ACTs Available	7,497,521	8,992,787	9,275,160
Total ACT Surplus (Gap)	6,052,058	7,691,870	8,104,335

* Based on CSA Population estimates

**The source of the data is Health and Health Related Indicators 2017 (HMIS data) and outward years are estimated based on a 10% reduction of malaria cases per year as indicated in FMOH NMSP. Of the total confirmed cases, 70% are Pf and 30% are Pv.

*** Added 5% buffer and 20% for reactive case detection activity in elimination districts and active case detection in migrant population

Table 13: Chloroquine Gap Analysis

Calendar Year	2018	2019	2020
ACT Chloroquine Needs			
Total country population*	94,410,033	96,864,694	99,383,176
Population at risk for malaria	56,646,020	58,118,816	59,629,906
PMI-targeted at-risk population	56,646,020	58,118,816	59,629,906
Total projected number of malaria cases	1,580,173	1,422,156	1,279,940
Total projected number of *P. vivax* malaria cases*	423,803	381,423	343,280
Total Chloroquine Needs (treatment doses both tablets and syrup)**	**444,993**	**400,494**	**360,444**
Partner Contributions (to PMI target population if not entire area at risk)[1]			
Chloroquine carried over from previous year***	927,536	1,461,575	1,061,081
Chloroquine from Government	0	0	0
Chloroquine from Global Fund	0	0	0
Chloroquine planned with PMI funding	979,032	0	287,000
Total Chloroquine Available	1,906,568	1,461,575	1,348,081
Total Chloroquine Surplus (Gap)	1,461,575	1,061,081	987,637

* Based on CSA Population estimate
**The source of the data is Health and Health Related Indicators 2017 (HMIS data) and outward years are estimated based on 10% reduction of malaria suspected cases per year as indicated in FMOH NMSP. Of the total confirmed cases 70% are Pf and 30% are Pv.
*** PMI procured

Quantification of microscopes

Quantification of microscopes is based on the number of health centers that will be included each year for quality assessment activities. In FY 2019, a total of 300 new health facilities will be enrolled for external quality assurance support. Procurement of laboratory equipment and supplies will be dependent on a facility baseline assessment of equipment needs for new facilities.

Quantification of IV artesunate

One percent of malaria cases are expected to be severe. There were 1,755,748 malaria cases from June 2016 to July 2017. One percent of this number is 17,558. Artesunate injection is given for a maximum of five to seven days and taken for an average of three days before patients change to Arthemether lumefantrine tablets. One patient will need 10 vials of Artesunate so multiplying 10 by 17,558 will equal 175,580 vials of Artesunate, which will be enough to treat 5 to 6 patients per health facility. All severe

malaria cases are expected to be treated with parenteral artesunate and quinine is to be used only if there is no artesunate.

Quantification of rectal artesunate

Rectal artesunate is used for pre-referral at health post level for children less than six years old with evidence of severe malaria. While there are more than 16,000 health posts, quantification took into consideration only those health posts in malaria endemic areas to determine needs. Given 75 percent of the total health posts are located in malaria endemic areas, there are about 12,000 potential health posts where pre-referral for severe malaria with rectal artesunate would be appropriate. Since the number of severe malaria cases is low, the amount of rectal artesunate needed for pre-referral were estimated at 40,000 doses, assuming a minimum stock of 3 to 4 doses per facility.

Plans and justification for proposed activities with FY 2019 funding:

PMI plans to regularly reassess the commodity availability and distribution using data and information gathered from the Integrated Pharmaceutical Logistics System (IPLS) and monitor the procurement and distribution of commodities through the established malaria commodity technical working group. The commodity gaps identified and not covered by the Global Fund or other resources may be provided by PMI. To ensure that the country is not overstocked, putting commodities at risk for expiry, we will be monitoring the stock status in real time through IPLS. Working closely with Global Fund and FMOH, PMI will update the quantification yearly through the national malaria supply chain technical working group platform. Procurement plans will be revised to account for actual stock status.

PMI will continue health worker training/mentoring and supportive supervision to ensure early laboratory diagnosis and prompt treatment of all reported and confirmed malaria cases. Priority will be given to remote high burden hard-to-reach malarious areas and elimination districts. HEW training will be conducted as part of iCCM training and specific training for clinicians will be conducted at regional levels.

Emerging data from episodic outbreak investigations and available epidemiological reports from routine surveillance suggest that older boys and men may now have special risks for malaria from occupational and travel-related activities such as performing seasonal farm work. Therefore, in addition to current private sector support for health facilities and clinics, PMI will continue to work with the FMOH, RHBs, and private sector employers. With FY 2018 funding, PMI plans to support an operational research study to test innovative prevention and control strategies to reach migrant workers especially in the development corridor where sesame farms and traditional gold mining are prevalent.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

4. Cross-cutting and other health systems strengthening

In order to successfully implement the aforementioned activities, PMI Ethiopia supports a suite of activities that cut across and benefit insecticide- and drug-based prevention and case management activities. For example, availability of high-quality commodities is necessary to ensure high ITN coverage and effective case management, and improved health behaviors of individuals and communities is necessary to improve coverage of all interventions. In addition, the gains achieved in malaria control in Ethiopia can only be sustained with strong health systems and local capacity. Hence,

systems strengthening and capacity building are intrinsic in all PMI intervention-specific activities previously mentioned (e.g., training and supervision of health workers, technical assistance for planning and monitoring interventions, etc.). Non-intervention specific or cross-cutting health systems strengthening activities are described below.

a. Pharmaceutical management

NMCP/PMI objectives

The NMCP's goals of universal access to effective malaria case management requires best practices of pharmaceutical management and robust supply chains of malaria diagnostic and treatment commodities to ensure access to quality commodities.

The FMOH and PMI have been working to address multiple supply chain problems within all levels of the national drug management system, including malaria commodity bottlenecks that lead to stockouts and expiry. In 2005, the FMOH developed a Pharmaceutical Logistics Management Plan and later, in 2007, created the PFSA. Through PEPFAR and Global Fund support, the FMOH radically redesigned the governance, policies, and infrastructure of the existing logistics system, establishing drug distribution regional hubs to directly supply health centers, health posts, and hospitals. Health commodities, including malaria, are monitored by the health center workers by collating monthly Report and Resupply forms, which roll up from health posts. Although PFSA began managing malaria commodities initially in 2011, the FMOH determined PFSA at that time, lacked the necessary capacity to successfully manage malaria commodities and issued a directive requiring that all malaria procurements would be done by UNICEF and distributed through each of the RHBs, leaving all other commodities (i.e., HIV, family planning, essential medicines, etc.) under the management of PFSA. During this time, PMI supported distribution of antimalarial medicines to the health facility level, primarily through the provision of technical assistance to RHBs and health centers. As of November 2015, however, FMOH issued a new mandate requiring *all* commodities from all donors, including antimalarials, to be managed and distributed through PFSA. For ITNs, once at the district level, they are then distributed down to the household level through the HEP.

The Ethiopian FMHACA, organizationally under the FMOH, is responsible for regulating and registering medicines and ensuring the safety and quality monitoring of all medicines. It is also responsible for establishing and implementing QA systems for the country, including post-market drug quality monitoring, creating public awareness on quality assured medicines, and taking legal and regulatory actions for fraudulent drugs and other malfeasant activities related to medicines.

Progress since PMI was launched

PMI has historically supported antimalarial drug management systems strengthening largely at hospital and health center levels. In addition, PMI also supported PFSA and FMHACA in strengthening the pharmaceutical supply chain system and antimalarial drug quality assessments, respectively. In support of the antimalarial drug management system and pharmaceutical supply chain strengthening, PMI has been implementing several interventions in selected facilities. These interventions included antimalarial drug management support through rational drug use, Accountable Pharmaceutical Transactions and Services (APTS) supporting the establishment of Drug Therapeutic

Committees, the establishment of Drug Information Centers, and the implementation of end-use verification (EUV) surveys.

PFSA is currently providing pharmaceutical services for both public and private health facilities through 19 regional-level hubs throughout Ethiopia. Until 2011, PMI has imported and distributed most of its malaria commodities (including ACTs) for Oromia Regional State. Since 2012, however, PMI has been procuring drugs, including ACTs, for national coverage. PMI also supported the Oromia Regional Health Bureau to develop legislation to establish a system for APTS. APTS is a comprehensive intervention intended to improve medicines availability, reduce wastage/expiry, and improve revenue. As part of the implementation, APTS tools – including financial vouchers, receipts and dispensing registers – were developed and used. Additionally, PMI supported the integration of malaria commodities into the IPLS system. The purpose of IPLS is to streamline the LMIS system (recording, reporting and feedback system), standardizing the pharmaceutical storage and inventory control practices, optimizing commodity resupply and distribution as well as defining the roles and responsibilities of staffs working in the system.

PMI supported strengthening drug quality and safety monitoring capacities at FMHACA via post-marketing surveillance activities, including use of Minilabs®. The Minilabs® are portable kits used to collect drug samples and provide preliminary field testing, through thin-layer chromatography, on the quality of sampled medicines at branch laboratories, customs check points, airports, and border ports of entry. There are seven ports of entry where samples are tested. Any sample that fails this preliminary screening will not be permitted to enter the market but if the result is doubtful then it will be sent to Product Quality Assessment Directorate Laboratory for confirmatory compendial testing.

PMI continued supporting four (out of six regional) FMHACA branch laboratories and to further improve the regulatory capabilities of FMHACA. Additionally, through support from PMI and PEPFAR, the national reference laboratory under FMHACA achieved ISO-17025 accreditation in 2011, demonstrating a higher level of quality including employment of standard operating procedures and an overall laboratory quality system. ISO certification was re-accredited on January 2017 and enables the laboratory to conduct various analytical pharmacopeia testing procedures for human drugs.

PMI has been supporting post-market surveillance of antimalarials since 2009. A total of 2,763 antimalarial drugs have been collected and tested from both public and private outlets. In summary, these surveillance assessments have shown: the presence of antimalarial medicines without marketing authorization, both locally manufactured and imported products, was 77 percent (315/410) in 2009, compared to 15.1 percent (68/400) in 2017; the presence of substandard antimalarial medicines in the market ranges from 12 percent (49/410) in 2009 to 15.1 percent (63/400) in 2017. Based on findings from these surveys, FMHACA has taken regulatory steps, including the withdrawal/recall of primaquine and quinine, closure of select drug outlets, and social communication activities to increase public awareness about poor quality and counterfeited drugs.

Progress during the last 12-18 months

PMI supported PFSA by embedding qualified personnel within their facilities, and by providing resources for the development of standard operating procedures and forms for the quantification, requisition, drug exchange/transfer, and management of malaria commodities. Additionally, PMI supported the development of the IMPACT team linking PFSA and other supply chain stakeholders.

The purpose of the team was to create a culture of data use. The IMPACT teams will be placed in all 19 PFSA hubs and will use standard indicators selected to monitor across the hubs including stockout rate, on time and in full delivery, over all reporting rate, product wastage, report and requisition form (RRF) data quality, months of stock on hand, and forecast accuracy. A RRF dashboard was also developed to visualize and analyze facility RRF (granular and aggregate) data. The tracking page provides analysis on overall facility commodity management practice and performance (percent stock out, percent with optimal stock level, percent over stock), whereas the monitoring page provides analysis on RRF quality (RRF completeness, timeliness, accuracy, legibility, legality).

Out of the 900 service delivery points (in 738 hospitals/health centers, 100 health posts, and 50 *woredas*) visited quarterly, 80 percent are in malarious areas and are supported by PMI. These facilities are all over the country including emerging regions. As part of the supportive supervision activity capacity building trainings were provided mainly on IPLS and malaria commodity security which enhanced use of data for decision making. Stock status data is regularly collected from visited facilities for USAID priority program commodities: including malaria. Data on availability of anti-malarial commodities at health facilities showed that stockout of all artemether-lumefantrine presentations at service delivery points was only 1.5 percent in Q2 as opposed to 3.2 percent in Q1, chloroquine stockouts substantially dropped from 29.4 percent in Q1 to 13.8 percent in Q2. In Q1 and Q2, a total of 34 and 28 health facilities graduated from supportive supervision (113 percent and 93 percent of the quarter target, respectively). In order to graduate a facility one of the criteria is maintaining the minimum requirement on the IPLS process indicators for three consecutive visits in the last six months. The PMI supported project will continue to monitor performance of the graduated facilities with minimal support.

PMI supported the development of the national supply plan for malaria program commodities. A Procurement Planning and Monitoring Report for malaria was also prepared quarterly as required by PMI headquarters. The End-use verification survey was conducted at the end of December 2017 in 138 service delivery points (33 hospitals, 45 health centers, and 60 health posts) and eight PFSA branches. Data collected from health facilities were entered and analyzed based on the standard supply chain indicators. Results of the analysis showed that 99 percent of the surveyed service delivery points (health centers and hospitals) and 92 percent health posts could treat uncomplicated falciparum malaria on the day of visit based on available stock in the facilities (at least one formulation of artemether-lumefantrine). Seventy-six percent of the health facilities and 40 percent of health posts could treat *P. vivax* malaria patients with chloroquine on the day of the visit in line with national malaria guidelines. While 75 percent of suspected malaria cases were treated after laboratory confirmation, the remaining 25 percent received presumptive treatment based only on clinical evaluations.

Additionally, the EUV report showed availability of ACTs at PFSA warehouses (stores) was 100 percent availability for artemether-lumefantrine 4x6 presentation, with lower availability for the other formulations: 37 percent for 1x6, 62 percent for 2x6 and 18 percent for 3x6 across the eight PFSA stores surveyed. Stock status reports were shared with respective district and health facility experts who recommended the reallocation of excess and near expiry products between health facilities to improve availability and reduce the wastage of antimalarial drugs.

PMI and other USG provided technical support, including training and supportive supervision, to a total of 198 APTS sites. Of the 198 sites, 77 sites were transitioned from the Systems for Improved Access to Pharmaceuticals and Services (SIAPS) program while 121 are newly added sites. Among the new sites, renovations of the store, dispensary counters, and shelves were completed for 15 HFs and renovations are in progress for 16 additional sites. In addition, 22 HFs were provided with technical support for the measurement, design and requirements for APTS minor infrastructure improvements.

PMI has worked to strengthen the supply chain for distribution of ITNs. An assessment was completed with support from PMI, which recommended the development of an ITN dashboard for ITN distribution and tracking. PMI supported the development of a national malaria technical working group supporting supply chain issues. PMI has been supporting the FMOH ITN distribution campaign process. This support includes conducting regional-level post-campaign ITN distribution review meetings to assess performance, document lessons learned, and share best practices to inform future ITN distribution campaigns. At the end of the workshop, detailed *woreda*-level ITN orientation and distribution implementation plans were prepared to continue the distribution to health posts and household levels.

To improve stock visibility of ITNs at the health post level, PMI supported piloting of an ITN tracking campaign in Tigray Region including through the development of a mobile phone-based technology to track ITN distribution. The objective of the pilot was to implement an automated solution to provide end-to-end visibility into ITN balances and transactions at the *kebele* level. The system was able to track and visualize procurement and distribution of about 2.1 million ITNs to all relevant health offices. The system could allow for increased visibility to better manage the process and performance in real time in future ITN campaigns.

PMI supported four out of six regional FMHACA laboratories to strengthen post-marketing drug quality monitoring. Currently, PMI strengthened the capacity of regional laboratories by training 14 analysts and seconding 1 analyst each at the 4 regional laboratories. In FY 2017, 400 antimalarials were tested with 69 antimalarials failing. Consequently, FMHACA took regulatory action by recalling the drugs from outlets where the substandard product was initially sampled, and cancelled the outlets' licenses. In addition, FMHACA reported the finding to the WHO Alert system. PMI has been working with FMHACA to ensure sustainability of post-market surveillance activities, and FMHACA introduced a fee for all importers to increase their revenue, facilitating ongoing support for post-market surveillance.

PMI also supports inspection activities at FMHACA. This support ensures defective products are reported to FMHACA and regulatory actions are taken. In addition, 68 inspectors were trained to implement the audit-based inspection of retail outlets in Addis Ababa and will continue to scale up in major regions. In FY 2017, 20 adverse drug events were entered into the Uppsala Monitoring Center database of WHO alert system.

PMI continued supporting Look Ahead Seasonality Index (LSI), a model to calculate malaria commodity resupply needs accounting for seasonality, implementation in collaboration with PFSA. The analysis incorporating LSI shows more facilities understocked and fewer overstocked compared to months of stock calculated with simple consumption. For example, months of stock estimated using simple consumption that 50 percent of facilities are overstocked with artemether-lumefantrine 6x4 whereas LSI estimates 40 percent are overstocked. Currently LSI is being implemented in all 19 PFSA hubs, and LSI indices have been incorporated in the health commodities warehousing management information system's software to better predict malaria commodities needs in advance of predicted spikes in malaria transmission.

Plans and justification for proposed activities with FY 2019 funding:

The increasing mandate and emerging capacities of PFSA and FMHACA provide an opportunity to assume more responsibility for the pharmacy supply chain and antimalarial drug quality monitoring, respectively, in the future. Strengthening pharmaceutical and malaria commodity supply chains will be long-term PMI investments. PMI is providing ongoing support, in addition to other health partners, to

the FMOH and PFSA for IPLS implementation at health facilities. Each quarter, the project will monitor various key IPLS indicators including use and quality of data in report and requisition forms at 750 health facilities (including hospitals and health centers) with all regions represented and 80 percent in malarious areas. There is also a small sample of 100 health posts selected every quarter for support. Data will be compiled and shared on a quarterly basis with relevant stakeholders. Malaria commodity availability will be assessed and on-the-job mentoring will be provided as part of the supportive supervision. Strengthening antimalarial drug supply management will be needed throughout Ethiopia through a closer working relationship with PFSA.).

PMI will support the incorporation of the LSI system in all hubs and provide ongoing technical support to all 19 hubs till they can proficiently use the LSI on their own. Additionally, there is a need for continuous support in collaboration with PFSA in revising and updating the LSI indexes using recently published Public Health Emergency Management (PHEM) data and giving TA to hubs in the implementation. APTS will also improve the quality of pharmacy services through facilitating appropriate storage, strengthening stock recording, enabling proper review of prescriptions, and increasing appropriate dispensing of medicines, including antimalarial drugs.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

b. Social and behavior change communication

NMCP/PMI objectives

In the NMSP 2017-2020, the SBCC objective states that "By 2020, all households living in malaria endemic areas will have the knowledge, attitudes, and practices towards malaria prevention and control." The importance of prevention, health promotion, and SBCC were highlighted in the Ethiopian Health Sector Transformation Plan 2016-2020. SBCC is designated under the strategic theme "Excellence in health service delivery," which refers to the promotion of good health practices at individual, family, and community levels. In order to achieve this objective, the NMSP utilizes HEWs, HDAsand model family households to deliver proven SBCC interventions. Model family households are families who have practiced healthy behaviors and have demonstrated an improved uptake of those high impact health behaviors across the comprehensive package of health areas.

Despite the absence of a malaria-specific communication strategy, the National Health Promotion and Communication Strategy 2016-2020 provides guidance for all areas of health, including malaria prevention and control. The objectives of this strategy include: guiding and harmonizing health education and communication interventions; improving knowledge, attitudes, and practices; addressing barriers for behavior change and community empowerment; promoting multi-sectoral involvement in addressing social determinants that impact health and encouraging mainstream health promotion in sectors including influencing policy and legal support. The strategy also outlines major activities to empower communities and mobilize malaria prevention efforts with the development and integration of malaria-specific communication messaging for a national communication strategy. This national strategy also looks towards increasing the use of mass-media to reach a larger population, integrating key malaria prevention and control directly into school programs, and developing messages targeted to gain strong commitment of the local leaders in malaria elimination districts.

These approaches, and other SBCC-focused activities, are utilized to improve malaria prevention behaviors (e.g., ITN utilization, IRS, early diagnosis, and treatment compliance). For behavior change

communications activities related to RDTs and ACTs in particular, PMI works with health providers at different levels of the health system to strengthen their patient communication skills.

Table 14. Behavioral and Communication Objectives for Key Malaria-Related Behaviors

Behavioral Objective	**Baseline**	**Target**
Proportion of population that slept under an ITNs the previous night with at least one ITN	59%	75%
Communication Objective (s)	**Baseline**	**Target**
Proportion of people who know sleeping under ITNs can prevent malaria.	23%	85%
Proportion of people who are confident in their ability to sleep under ITNs	40%	75%
Behavioral Objective	**Baseline**	**Target**
Proportion of children under five years old with fever in the last two weeks for whom advice or treatment was sought	19%	45%
Communication Objective(s)	**Baseline**	**Target**
Proportion of people who know the main symptoms of malaria	45%	80%
Proportion of people who recognize fever as symptom of malaria	49%	85%
Notes		
Data Source: USAID/PMI funded *Communication for Health* project baseline survey conducted in September 2016.		

Progress since PMI was launched

Since 2009, PMI has provided assistance to the FMOH to carry out malaria-related SBCC activities. PMI has implemented critical SBCC activities working with the regional, zonal, and district offices as well as HEWs and HDAs. These activities included focus on increasing demand for ITNs, sustained use of ITNs, improving treatment seeking behavior and increasing community awareness about malaria prevention and control. Additionally, PMI worked to increase awareness in communities about the effectiveness of IRS to reduce refusal of IRS and the re-plastering of insecticide-sprayed walls following IRS. The 2015 MIS results indicate that 68 percent of women in malarious areas have heard about malaria. Though the proportion of women 15–49 years old who had heard about malaria was similar across 2007, 2011, and 2015, the proportion who recognized fever as symptom of malaria, who knew malaria is caused by mosquito bites, and who reported ITNs as a prevention method had increased in 2015 compared to 2007 and 2011.

In 2013, PMI initiated and supported community-based malaria SBCC activities that targeted school children and religious leaders. Starting in July 2015, PMI supported SBCC activities that utilized an integrated communications campaign platform which organizes health messaging, including malaria, in a coherent and coordinated way through multiple channels to support community-based health workers.

Since 2014, PMI has initiated and supported two local organizations' community-based malaria SBCC activities as part of the USAID/Ethiopia Local Capacity Development program. These community-based malaria SBCC activities have been implemented in selected zones of Oromia and Amhara. PMI's support to these activities is intended to complement national level malaria SBCC activities through

capacity building of selected schools and faith-based organizations in high malaria transmission areas. Starting from July 2015, PMI also supported an integrated SBCC activity implemented in four major regions namely Oromia, Amhara, SNNP and Tigray. The support focused on malaria communication capacity building at national and regional levels, messaging and implementation of SBCC activities through integrated platforms and monitoring and evaluation (M&E) of malaria SBCC.

Progress during the last 12-18 months

In 2017-2018, PMI continued school-based malaria SBCC activities focusing on a development corridor area in the Amhara Region. School- and community-based malaria communication interventions were implemented in 75 schools in 75 *kebeles* in 5 malarious districts. Capacity building training for basic malaria communication was given to 3,380 individuals which included students, teachers, health professionals, HEWs, and HDAs. In addition, 2,500 malaria peer-to-peer student communication manuals were distributed to 100 schools to sustain the scholastic peer education program. Using these manuals, 8,242 peer-to-peer education sessions were provided to 12,750 students and then to 13,500 communities using peer-to-peer student leaders. During this period, 700 students have graduated and these students have reached out to 6,245 people in the community to communicate malaria health messages. PMI supported 75 schools' anti-malaria clubs with school mini-media tools and drama materials and key malaria messages, reaching close to 23,000 students.

In PMI-supported districts of Amhara Region, many community members migrate seasonally to agricultural regions to work, which usually coincides with the malaria transmission season. Upon returning home, these seasonal workers become sources of imported cases contributing to the malaria burden. According to information from Amhara RHB, approximately 33 percent of total malaria cases in nine districts are imported cases from other development areas. To address this health challenge, students in the 75 *kebeles* were taught to report when migrant workers return to their neighborhood. HEWs then follow up to ensure appropriate diagnosis and treatment is provided through home visits. In 2017, 455 migrant workers were tested with 20 percent testing positive for malaria.

Utilizing an integrated health communication mechanism focused on higher level national communication efforts, PMI supported SBCC activities to strengthen the capacity of national and sub-national malaria control activities. PMI is working on a variety of malaria communication approaches in 153 districts. With the support of this activity, pregnant women conferences were conducted and malaria in pregnancy and ANC visits are major topics discussed. Maternity waiting room videos were produced for ANC waiting rooms where the prevention of malaria in pregnancy and under than five children is discussed. This integrated health communication mechanism also developed a mobile device app for mothers and fathers. The malaria messages included in this app promote ITN use, prioritize ITN use for pregnant women and all children under five, and promote quick treatment of fevers.

PMI is also currently producing a radio program to promote healthy behaviors around six focus health areas including malaria. The program follows an entertainment-education approach, combining serial drama and real stories of individuals from the communities. The radio program is currently being produced in Amharic, Afaan Oromo, and Tigrigna in-house. During the last 18 months, malaria messages were aired in 9 of the 24 radio program episodes. The radio program format was designed as a community action plotline. The topics include: using ITNs correctly and consistently, malaria symptoms, and treatment and malaria in pregnancy. The radio program aired in Amhara, Tigray, and Oromia Regional radio stations with a collective catchment area and potential reach of an estimated 37.5 million people (2.5 million in Tigray, 15 million in Amhara, and 20 million in Oromia). In addition, this

activity organized zonal level strategic health communication trainings in which 1,063 health workers from 23 zones, 145 *woredas*, and 13 local implementing partners attended in addition to trainings for 77 telephone hotline counselors and supervisors for the 952 expanded hotline programs. The trainings included health communication, message development, and communication skills, among others.

An assessment of socio-cultural perceptions, barriers and facilitators that influence malaria health service utilization has been conducted and the results will be disseminated in the near future. This study had been conducted in Oromia, Tigray, Amhara, and SNNP Regions to identify social norms around priority health areas including patterns of malaria communication and household communication which will guide the development of health communication materials in these regions. A midline evaluation is planned for FY 2018 and will assess malaria communication outcomes through communication for health activity interventions.

Plans and justification for proposed activities with FY 2019 funding:

To achieve malaria control and elimination goals there needs to be significant improvement in malaria prevention behaviors such as the use of ITNs. Communication for health activity is an integrated program working in six different health areas including malaria. It works in four regions namely; Amhara, Oromia, SNNPR and Tigray. Eighty percent (124/151) of targeted districts are malarious with 18 percent (27) high, 42 percent (64) moderate and 22 percent (33) low malaria transmission districts. PMI supported activities are mainly intended to address ITN use and treatment-seeking behavior through social mobilization approach in schools and communities, interpersonal communication, mass media and capacity building, and coordination of interventions utilizing evidence-based and consistent key messages in all supported districts. These SBCC activities are aimed to address behavioral factors related to knowledge, misconceptions, self-efficacy, and perceived risks. PMI will continue to support SBCC community activities to improve key malaria prevention behaviors and also support national malaria SBCC strategies. Mass mobilization activities will complement SBCC support provided to HEWs at the community level. With community health mobilization efforts, HDAs are required to identify pregnant women in their neighborhood and conduct regular pregnant mothers' conferences to raise awareness about safe pregnancy and delivery. PMI will utilize this platform by supporting HEWs with MIP communication tools and materials (e.g., flip charts, posters and billboards) explaining about the use of ITNs and seeking early diagnosis and treatment of malaria.

Low transmission area SBCC activities will include messaging to ensure a high level of awareness for early diagnosis of all fever cases and prompt treatment as well as sustaining ITN utilization. In addition, PMI supported schools will carry out social mobilization activities with HEWs and HDAs to communities to promote communities to become actively involved in the identification of migrant workers and other individuals with malaria symptoms to help facilitate testing through HEWs.

With FY 2019 funds, PMI plans to continue supporting SBCC capacity building, coordination, message harmonization, and school-based SBCC activities that promote malaria prevention and elimination. PMI also will expand the current school-based SBCC activities that have a strong record of success to high burden regions such as Gambela and Benishangul-Gumuz.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

c. Surveillance, monitoring, and evaluation

NMCP/PMI objectives

The Ethiopian NMCP M&E plan (2014- 2020) emphasizes the need for effective and robust surveillance, monitoring, and evaluation (SM&E) system to measure progress towards achieving the stated goals. The NMSP describes the SM&E core activity areas: 1) collecting data actively and passively to monitor the operational aspects of the program and measuring impact, outcome, or process indicators to ensure that the activities are yielding desired results and moving the program towards achieving its operational targets and objectives; 2) monitoring changes in epidemiological indicators and appropriately interpreting results and informing revisions in policies or strategies, when needed, to help ensure progress; and 3) documenting progress towards malaria elimination through case and foci investigation and classification. In addition to the malaria morbidity and mortality impact indicators, elimination-specific indicators are to be tracked. The FMOH has drafted an elimination surveillance manual that details the surveillance activities needed at each phase from transmission reduction to elimination.

In 2009, the PHEM surveillance system was developed to cover the entire country, encompassing reporting from health posts, health centers, and hospitals. The PHEM aims to be a weekly multi-disease reporting system that collects a range of malaria indicators, mostly related to outpatient malaria morbidity. As of March 2018, the PHEM surveillance reporting includes 88 percent of all public health facilities throughout Ethiopia by aiming to provide weekly reports from all health facilities, from health posts through district health offices. EPHI creates weekly epidemiological data summaries using PHEM reports (http://www.ephi.gov.et/images/pictures/download2010/Ethiopian_Weekly_Epidemiological_Bulletin_2018_10.pdf), though access to the PHEM reports can be limited. However, PHEM data depends on accurate and timely information reported from HEWs and health facilities; therefore, building capacity at the health post and health center levels is essential. Malaria cases are reported by two age groups (less than and more than five years of age) including clinical malaria (outpatient and inpatient), and confirmed malaria by species. Assuming that improved IRS coverage and ITN use will continue to reduce malaria transmission, the focus of malaria control and elimination efforts will increasingly turn towards enhancing surveillance with the aim of halting ongoing transmission, investigating all cases, and preventing re-introduction of transmission.

Ethiopia currently has a paper-based data collection system, which is completed at the health facility level, containing data that have not yet been optimally analyzed or used for decision-making and resource allocation at the local and regional levels. Consequently, Ethiopia's FMOH is in the process of revising the HMIS, while making most reporting electronic. HMIS reports monthly and quarterly data from health centers and hospitals, respectively, to the district level. In general, data reporting from health facilities have issues in completeness, quality, and timeliness. HMIS data are usually not published until one or two years after they were collected. HMIS has malaria indicators that are collected monthly, however the ministry of health publishes the reports every year, which is available a year or two later. Ministry of health publishes only selected malaria indicators from the HMIS. These include clinical malaria cases, P. falciparum cases, and species other than P. falciparum and malaria deaths with no disaggregation by sex and age. The full malaria related HMIS indicators are 1) Number of clinical malaria cases without laboratory confirmation from outpatient and inpatient departments and disaggregated by sex and age; 2) Number of confirmed malaria cases disaggregated by species, age, and

sex from outpatient and inpatient departments; and 3) Number of malaria deaths among clinical and species disaggregated by sex and age. HMIS also collects data on number of patients tested for malaria with either RDT or microscopy and number of patients who tested positive for malaria.

Table 15. Surveillance, monitoring, and evaluation data sources

Data Source	Survey Activities	Year								
		2012	2013	2014	2015	2016	2017	2018	2019	2020
National-level Household surveys	Demographic Health Survey*				X	X				X
	Malaria Indicator Survey (MIS)				X				X	
	EPI survey*	X								
Health Facility and Other Surveys	School-based malaria survey	X	X							
	Health facility survey*									
	SPA survey*			X						
	EUV survey			X	X	X	X	X	X	X
Malaria Surveillance and Routine System Support	Support to malaria surveillance system	X	X	X	X	X	X	X	X	X
	Support to Micro-plan	X	X	X	X	X	X	X	X	X
	Support to DHIS2 and eCHIS								X	X
Therapeutic Efficacy monitoring	In vivo efficacy testing	X					X		X	
Entomology	Entomological surveillance and resistance monitoring	X	X	X	X	X	X	X	X	X
	ITN durability monitoring				X	X	X	X		
Other malaria-related evaluations	Serology/G6PD surveys			X	X*					
Other Data Sources	Malaria Impact Evaluation			X	X	X*				
	Malaria program review*					X				

*Indicates non-PMI funded activities.

Progress since PMI was launched

Since the 2008 launch of PMI in Ethiopia, PMI has provided substantial support for SM&E strengthening activities, including support for large household surveys (e.g., the MIS 2007, MIS 2011, and MIS 2015), sentinel site data collection and analyses, and strengthening routine surveillance systems.

PMI has supported the PHEM system. This support has been targeted to enhance reporting from rural health posts where half of all malaria morbidity is detected and treated, and to enable reporting of indicators on a weekly basis. In the past, PMI had supported the collection of comprehensive, timely malaria surveillance data in ten sentinel sites. This support included data analysis, training, and supervisory support that included advanced data analysis training for 8 EPHI staff and M&E training for 52 health managers from 7 regions. PMI's experience with implementing rapid reporting to enable epidemic detection in Oromia and the lessons learned was published in a peer-reviewed journal (Yukich *et al.*, 2014). This support was then expanded to 50 districts, 1,242 health posts, and 245 health centers.

PHEM and HMIS report to different directorates within FMOH, have separate staffing and reporting structures, and serve different functions. There are no plans to integrate these at this time. Reporting completeness has rapidly improved for both PHEM and HMIS. PHEM reporting completeness was around 88 percent during March, 2018, and HMIS was 97 percent in 2017.

Besides the PHEM and HMIS, malaria micro-planning is a third source of data that collects information from all malarious districts nationwide, aggregated from both health centers and health posts. For thelast three years (2013-2016), the reporting completeness was 99 percent, representing the most comprehensive morbidity data available to supplement the PHEM and HMIS routine surveillance systems; however, data collection only occurs once a year and was not conducted for 2017. Although there are three separate sources of reported malaria cases and deaths, the systems have differing attributes and coverage (Table 16). With improving coverage of PHEM and HMIS systems, the differences in the annual reported number of malaria cases are decreasing between the three sources and the need for microplanning to collect malaria epidemiological data will be phasing out.

Data from microplanning activities are used for quantification and forecasting antimalarial commodity needs. Micro-planning is conducted on an annual basis under the leadership of RHBs with the participation of all malaria risk districts and zonal health offices to come up with health facility morbidity, consumption data for anti-malaria drugs and RDTs and community level data for ITN need. During the meetings, the health facility data (malaria cases – clinical, tested, confirmed cases – and admissions that were collected daily through routine surveillance systems i.e., HMIS and PHEM) and ITN need were compiled to identify district level needs and were aggregated at the zonal and regional levels to inform decision-makers. The last micro-plan was done in 2016 using the 2014/15 data. These data are different from the data collected by the EUV surveys. EUV data are collected at intermittent points in time and in only a fraction of health facilities. EUVs show availability of anti-malaria while micro-plan is estimating the requirements of all commodities including LLINs based on morbidity data. The primary objective of EUV activities is to inform the PMI commodities team on general ACT and RDT availability at a regional level, on a real-time basis. This helps avoid immediate stockouts, as it enables the PMI headquarters commodity team to mobilize both emergency commodity funds (i.e., for the procurement of needed commodities) and/or access PMI's ACT buffer stock. A secondary objective of the EUV is to inform the relevant Government of Ethiopia stakeholders such as PFSA,

about gross or systemic issues along the supply chain continuum, refining the technical support already provided by PMI to strengthen the supply chain system. Therefore, there is both an immediate use of the data and a longer-term, health-system strengthening purpose.

Table 16. Malaria surveillance system attributes, public sector, Ethiopia

Surveillance System	Reporting Frequency	Facilities Reporting	Publications	Comment
Health Management Information System (HMIS)	Quarterly	Hospitals, Health Centers, Health Posts	Annual (Health and Health-Related Indicators)	Most complete for inpatient malaria reporting and inpatient deaths; some stratification of data by gender and for children
Public Health Emergency Management (PHEM) System	Weekly	Hospitals, Health Centers, and Health Posts	Annual (Annual Review Meeting Report, and World Malaria Report)	Timely, complete, designed for outbreak detection; began in 2009 building upon former IDSR system; PHEM is the primary data source for Annual Review Meeting and the WHO World Malaria Reports
Micro-plan	Annual	Hospitals, Health Centers, Health Posts	Not for public distribution but used for programming	Began national collection in 2010; Includes number of persons tested and suspected malaria (clinical plus tested malaria), includes commodities data, most complete available reporting as of 2013, not stratified by age or gender; data are reported and analyzed by district while accounting for health facilities in the district

Guidelines for malaria epidemic prevention and control were updated in 2012 with support of PMI and are available on the FMOH's website. These guidelines are under revision currently. The guidelines detail the human vulnerability factors, including population movement, as well as meteorological factors, such as rainfall, temperature, and humidity, that affect the occurrence of epidemics. The guidelines include setting detection thresholds at the health post level and strategies for mapping malaria micro-foci or micro-clusters.

PMI has provided technical assistance for the selection of the elimination districts by contributing data from the micro-plan. PMI and the FMOH co-sponsored a pre-elimination conference in May 2015 to share malaria activities and tactics that are relevant to pre-elimination both from Ethiopia and from several other countries including Sri Lanka, Senegal, and Zambia. In-depth discussions with local and international experts from WHO Global Malaria Program, Malaria Control and Evaluation Partnership in Africa, and Global Fund addressed many technical and operational aspects of implementing malaria elimination (e.g., human resource and capacity, surveillance systems, M&E plan, and case management and vector control needs).

A MIS survey was conducted in Ethiopia in late 2015 with PMI financial and technical support. The MIS data have been collected, compiled, and analyzed with support from PMI. The results highlighted in Table 2 show sustained ITN ownership, although still below set targets and continued low prevalence of malaria.

Progress during the last 12-18 months

PMI has been coordinating surveillance strengthening efforts through the existing PHEM system over the past year. The support currently covers 50 districts, 246 health centers, and 1,247 health posts. Ninety staff from two zones received training and then trained an additional 1,560 HC staff and 1,315 HEWs about data quality assessment and data utilization.

With 239 districts targeted for elimination by 2020, PMI provided technical assistance with drafting the elimination strategy, operational plans, and the surveillance and M&E plan. PMI, in collaboration with the NMCP and EPHI, developed an elimination district assessment tool to help NMCP identify gaps in resources to achieve optimization of malaria intervention activities in the selected malaria elimination districts. PMI has provided TA to EPHI in designing and implementing the malaria elimination baseline assessment, which was completed in 2018; data analysis is ongoing.

Table 17: Routine surveillance indicators

Indicators	Value	Comments
1. Total number of reported malaria cases	1,755,748	HMIS data for July 2016-June 2017 (FMOH's Health and Health Related Indicators)
Total diagnostically confirmed cases	1,530,739	
Total clinical/presumed/unconfirmed cases	470,892	
If available, report separately for outpatients and inpatients		
Outpatient no. of reported malaria cases	NR	Disaggregated report is not available
Diagnostically confirmed	NR	
Clinical/presumed/unconfirmed	NR	
Inpatient no. of reported malaria cases	NR	
Diagnostically confirmed	NR	
Clinical/presumed/unconfirmed	NR	
2. Total no. of reported malaria deaths	356	Data source: PHEM
Diagnostically confirmed	NR	Disaggregated report is not available
Clinical/presumed/unconfirmed	NR	
3. Malaria test positivity rate – outpatients	28%	Data source: Micro-plan data 2016
Numerator: Number of outpatient confirmed malaria cases	NR	
Denominator: Number of outpatients receiving a diagnostic test for malaria (RDT or microscopy)	NR	
4. Completeness of monthly health facility reporting	NR	
Numerator: No. of monthly reports received from health facilities	NR	
Denominator: Number of health facility reports expected (i.e., number of facilities expected to report multiplied by the number of months considered)	NR	

NR: not reported

Plans and justification for proposed activities with FY 2019 funding:

PMI will continue its support to strengthen the country's SM&E system. The FMOH in collaboration with stakeholders started transitioning the paper-based HMIS to the District Health Information System-2 (DHIS-2) platform. DHIS-2 development, implementation and roll-out are being supported by a consortium of donors. PMI will investigate opportunities to support strengthening surveillance systems in elimination districts, including the potential incorporation of a DHIS-2 tracker for case-based reporting.

In addition, the FMOH, in collaboration with stakeholders, developed an electronic Community Health Information System (eCHIS) framework and started pilot implementation in selected areas of four major regions to address challenges with paper-based data collection at the community level. The pilot will continue until December, 2018 and will be evaluated for further refinement before scaling up. PMI will continue to work with HEWs, HEW supervisors, and health workers to collect timely, quality surveillance data in selected districts to improve timely detection of epidemics and response, and HEWs will support the electronic community health information system if implemented on a wider scale.

Although delayed in 2017, PMI will continue to support the annual microplanning exercise to help improve the accuracy of forecasting and quantification of national-level malaria commodities.

With malaria elimination goals, PMI will continue to provide technical assistance and support to the FMOH in augmenting their SM&E systems to meet the specific programmatic needs to monitor elimination efforts. Building on the elimination conference in May 2015 and the roll-out of the elimination planning tool, PMI will continue to engage with the FMOH as they design a strategic approach and outline the specific activities that will be pursued in the elimination districts. PMI will continue to work closely with the FMOH to ensure that new elimination-specific activities undertaken with Global Fund support (e.g., the roll-out of single-dose and radical-cure primaquine and reactive case detection activities) are adequately evaluated to inform future strategies for Ethiopia and other countries pursuing elimination.

PMI will continue to support periodic household surveys to monitor national progress on malaria intervention coverage, as well as ITN durability monitoring.

PMI's support and engagement with the EFETP program has also provided additional opportunities to strengthen capacity to manage the PHEM system. Throughout all these supported activities, PMI will continue to stress the importance of improving data access and transparency in FMOH systems.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

d. Operational research

NMCP/PMI objectives

The FMOH's NMSP (2017-2020) envisions the need for operational research studies to guide program decisions. Some of the priority areas for OR include studies to detect insecticide and antimalarial drug resistance, evaluation of appropriate antimalarial interventions for seasonal migrant workers and design relevant intervention for these populations, and to improve the effectiveness of antimalarial

interventions, while anticipating program needs related to elimination activities. Priority areas for PMI Ethiopia OR are informed by the PMI strategy and the PMI OR priorities. NMCP research priorities come from the NMSP. PMI has also sponsored various conferences involving universities and EPHI, the lead agency for public health research within FMOH, and partners to learn about ongoing research and to harmonize PMI Ethiopia's OR priorities with FMOH research goals. As Ethiopia embarks on implementing new elimination-specific strategies and policies (e.g., rolling out single dose primaquine for falciparum malaria, radical cure of vivax, and reactive case detection activities), there is an opportunity to rigorously evaluate these various interventions.

Progress since PMI was launched

Since the launch of PMI, several OR studies across various technical areas have been conducted to address key gaps in knowledge or bottlenecks. To address the limitations of microscopy in low transmission settings, an assessment of seroprevalence in schools was conducted which showed a wider prevalence range than microscopy for both *P. falciparum* (0-50 percent vs 0-12.7 percent) and *P. vivax* (0-53.7 percent and 0-4.5 percent). Overall, 11.6 percent (688/5,913) were *P. falciparum* seropositive and 11.1 percent (735/6,609) *P. vivax* seropositive; compared to 1.0 percent and 0.5 percent microscopy positive, respectively. Such studies could help determine transmission intensity within discrete communities in Ethiopia. PMI is also supporting an OR study to assess the utility of conducting serologic testing using previously collected dried blood spots from the 2011 MIS to provide information on collection of additional biomarkers in household surveys in settings where malaria transmission is very low and/or seasonal. The testing of these samples has been completed along with the samples that were collected during the 2015 MIS leveraging Global Fund resources and analyses are underway.

The feasibility of using the dried tube specimen method for preserving *P. falciparum* parasites for use as QC samples for RDTs was assessed in 2013 and the results published in January 2015. The study noted that for all the time points evaluated, dried tube specimens stored at both the reference laboratory and health facility were reactive on RDTs stored under the recommended temperature and under field conditions, and the dried tube specimens without malaria parasites were negative. They concluded that the dried tube specimen method can be used under field conditions to supplement other RDT QC methods and assess health worker proficiency in Ethiopia and possibly other malaria-endemic countries.

Progress during the last 12-18 months

PMI recently supported an OR study performed at EPHI which analyzed the genotypic prevalence of glucose-6-phosphate dehydrogenase (G6PD) deficiency among 1,414 dried blood spots obtained from the MIS 2011. The only G6PD deficient genotype detected was G6PD*A (A376G, 8.9 percent) with no samples positive for the clinically significant A- or Mediterranean variants, therefore suggesting a low expected frequency of drug-induced anemia from primaquine antimalarial therapy among Ethiopians. This study supported the single, low-dose primaquine for *P. falciparum* and primaquine radical cure for *P. vivax* treatment policy adoption.

Current operational research activities include: 1) Evaluation of targeted mass drug administration and reactive case detection on malaria transmission and elimination in Ethiopia, 2) Hematologic monitoring to assess the safety of the primaquine radical cure for *P. vivax* roll-out, and 3) Monitoring outdoor biting of mosquitoes and human behavior in agricultural development areas in Ethiopia.

Table 18: PMI-funded operational research studies

Completed OR Studies			
Title	**Start date**	**End date**	**Budget**
G6PD variant survey[1]	January 2014	March 2015	$90,000
School-based sero-prevalence[2]	October 2011	September 2013	$200,000
Field assessment of dried tube specimens for RDT quality control and proficiency testing[3]	January 2013	July 2013	$10,000
Ongoing OR Studies	**Start date**	**End date**	**Budget**
Title			
Malaria serology as a MIS biomarker	March 2014	Oct 2017	$70,000
Planned OR Studies FY 2015/2016			
Title	**Start date (est.)**	**End date (est.)**	**Budget**
Evaluation of targeted mass drug administration and reactive case detection around an index case on malaria transmission and elimination in Ethiopia	March 2018	September 2020	$800,000
Hematologic monitoring to assess the safety of the primaquine radical cure for *P. vivax* roll-out	September 2017	September 2020	$300,000
Monitoring outdoor biting of mosquitoes and human behavior in agricultural development areas in Ethiopia	September 2017	August 2018	$50,000

[1]Submitted to Malaria Journal

[2] Ashton RA, Kefyalew T, Tesfaye Get al. School-based surveys of malaria in Oromia Regional State, Ethiopia: a rapid survey method for malaria in low transmission settings. *Malaria Journal* 2011 10:25

[3]Tamiru A et. al., Field assessment of dried Plasmodium falciparum samples for malaria rapid diagnostic test quality control and proficiency testing in Ethiopia. *Malaria Journal* 2015 Jan 21;14:11**.**

e. Other health systems strengthening

PMI supports a broad array of health system strengthening activities which cut across intervention areas, such as training of health workers, supply chain management and health information systems strengthening, drug quality monitoring, and NCMP capacity-building.

NMCP/PMI objectives

The FMOH's NMSP (2017-2020) envisions a strengthened health system including adequate number of well-qualified and committed health workers to support malaria control efforts nationwide. It also recognizes insufficient technical support and capacity-building as well as shortages of human resources and turnover of experienced staff as major weaknesses in the health system of Ethiopia. The pre-service training of HEWs is a one-year training which includes coursework as well as field work to gain practical experience. HEWs carry out and promote 16 preventive health actions, including malaria prevention and control. The HEP has over 42,000 trained HEWs based at health posts, and these are assisted by many thousands of local volunteers within the HDA that, together, address many of the malaria health needs of their rural communities. The HDA workers typically focus on SBCC activities.

Ethiopia faces many challenges related to human resources for health service delivery, including the shortage of skilled health workers and high turnover of health professionals especially in remote and inaccessible health facilities where malaria is prevalent. Despite PMI and other donors' support, the

NMCP has limited capacity in human resources and has not been able to effectively coordinate with PMI implementing partners and other partners in their many malaria-related activities.

PMI supports the efforts of the Ethiopian government in improving and retaining a skilled health workforce for service delivery of key health services including malaria. This involves both pre- and in-service trainings and has four key result areas:

- Individual and institutional capacity of health work force strengthened
- Human resource for health (HRH) workforce optimized (planning, recruitment, tracking, training and retentions
- Capacity of FMOH to institutionalize evidence based decision making to improve HRH productivity and performance
- Program learning and research

The FMOH documented a shortage of malariologists and epidemiologists experienced in managing community-wide and large-scale malaria epidemics and complex health emergencies. Ethiopia began its own Field Epidemiology Laboratory Training, known locally as the EFETP, in October 2008 with technical assistance from CDC as a two-year, full-time, postgraduate competency-based training program consisting of about 25 percent class work and 75 percent fieldwork. The EFETP training is an in-service epidemiology training program for health workers. Trainees are supervised and provide epidemiology service to the FMOH. Graduates of EFETP receive a Master's Degree in Public Health and Field Epidemiology over the two-year training period.

Peace Corps Ethiopia

The U.S. Peace Corps has been active in Ethiopia for over fifty years with a few interruptions. The Peace Corps has provided many malaria-relevant activities and services over the years, including some educational programs for school-aged children and health promotion projects at the community level. The Peace Corps volunteers work in the areas of health, education, and environment which all contribute to malaria prevention efforts.

Progress since PMI was launched

Through FY 2017, PMI cumulatively supported training for 22,794, and 21,451, health workers in IRS operations and malaria diagnosis and treatment, respectively. As these trainings are part of a broader set of health systems strengthening activities, deliverables specific to malaria outcomes are not necessarily direct. Although this is a challenge, training inputs are primarily around strengthening various aspects of the health system. Ultimately, this will contribute to the development of a more competent and qualified workforce. The FMOH Human Resource for Health strategy was released in June 2010. PMI has contributed through supporting pre- and in-service training for HEWs, midwives, and other healthcare workers, to include best practices in malaria diagnosis and treatment and prevention of malaria among pregnant mothers and newborns.

Ethiopia FETP residents have conducted numerous malaria research projects in Ethiopia providing data for decision makers and have made significant contributions to the PHEM surveillance system including developing weekly bulletins which include malaria data. PMI has provided support to EFETP residents annually since 2008 to enhance their training and expertise in malaria and related outbreaks of acute febrile illness that can be confused with malaria. The EFETP has recently expanded to include over 400 residents from 8 different universities, with PMI providing malaria-related mentorship, training, and

technical assistance to create malaria expertise among these future public health leaders. Former FETP residents currently hold leadership positions in the FMOH and their malaria experience make them valuable advocates for malaria prevention and control goals.

There are now over 150 Peace Corps volunteers in Ethiopia who have sufficient knowledge of malaria and of PMI's programs to help provide PMI-developed resources to HEWs and other district-level officials. Peace Corps volunteers have helped with ITN distributions in some communities, and have helped to promote ITN use through programs aimed at school-aged children.

Progress during the last 12-18 months

During 2017, PMI supported training of 2,272 midwives and 6,900 HEWs. PMI has provided technical assistance and taught at FMOH's malariology training for EFETP residents, district level malaria officers, and Peace Corps volunteers.

The EFETP had expanded to include eight universities and over 370 residents covering all 11 regions and a majority of the 92 zones through 74 field sites representing diverse geographical, epidemiological, and cultural settings. PMI has remained committed to continuing to provide training through the advanced EFETP program, and five EFETP residents per cohort (total of ten) have been selected to focus on malaria activities and to receive additional malaria-specific mentorship and training opportunities. EFETP malaria activities go beyond the selected cohort as the majority of the 373 residents participate in some malaria activities (including outbreak responses, analytic projects, and surveillance evaluations) during their training.

In the last 18 months, EFETP residents have conducted 17 different malaria research investigations with the goal to present and publish their findings. Their investigations included a variety of malaria topics including issues that directly support PMI and NMCP efforts, such as understanding low ITN utilization in various communities, evaluating the quality and reliability of HEW RDT use, and assessing malaria surveillance systems in high burden regions. Other EFETP investigations included studying the adherence of patients to artemether-lumefantrine treatment for uncomplicated malaria, determining factors that delay community malaria treatment and diagnosis, and malaria prevalence studies. Since 2017, four EFETP graduates have started work in MOH malaria specific positions with another 23 EFETP graduates starting work as MOH PHEM surveillance officers (of which 12 are malaria focused) to help improve surveillance data collection and quality in Ethiopia. One graduate works as a Malaria Technical Officer for the Global Fund. Technical assistance has been provided to FETP residents with malaria-related questions or projects.

The Peace Corps has remained involved in a wide range of SBCC activities, including ITN use demonstrations, participation at World Malaria Day local events, and supporting HEWs at local health posts. PMI provides 1,000 ITNs directly to Peace Corps for outreach activities designed to demonstrate proper use of ITNs at household level within communities at malaria risk. PMI assisted with malaria trainings of Peace Corps volunteers at various locations throughout Ethiopia. PMI is also coordinating with Peace Corps to expand their malaria related activities. PMI has attended Peace Corps health stakeholder meetings to further maximize Peace Corps efforts in health promotion activities. In 2017, PMI supported the creation of a third year volunteer opportunity for Ethiopia Peace Corps volunteers interested in an additional year of malaria experience with a PMI implementing partner.

Plans and justification for proposed activities with FY 2019 funding:

While it is beyond the ability of PMI to address the system-wide capacity issues, there are several areas within the NMCP and RHBs where capacity can be strengthened with PMI assistance, including through pre- and in-service refresher trainings. The health systems strengthening and capacity building activities supported by PMI are in line with the FMOH's strategies, and support remaining gaps in training and human resources. As a major nationwide health program, HEP requires substantial investment in human resources, health infrastructure, and provision of equipment, supplies and commodities, as well as other operating costs. PMI will continue supporting the coordination of malaria activities through seconding staff to RHBs. PMI will continue supporting third year Peace Corps volunteers to conduct a variety of malaria activities including supply chain management in remote rural communities. PMI will continue to support EFETP which builds epidemiological capacity and strengthens the quality and use of PHEM data and response activities especially in elimination districts. Both the Peace Corps volunteers and EFETP residents provide valuable opportunities to identify and evaluate malaria prevention challenges at the community level and for capacity building of malaria-specific skills and knowledge.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.

5. Staffing and administration

Two health professionals serve as Resident Advisors (RAs) to oversee PMI in Ethiopia, one representing CDC and one representing USAID. In addition, one or more Foreign Service Nationals work as part of the PMI team. All PMI staff members are part of a single interagency team led by the USAID Mission Director or his/her designee in country. The PMI team shares responsibility for development and implementation of PMI strategies and work plans, coordination with national authorities, managing collaborating agencies and supervising day-to-day activities. Candidates for RA positions (whether initial hires or replacements) will be evaluated and/or interviewed jointly by USAID and CDC, and both agencies will be involved in hiring decisions, with the final decision made by the individual agency.

The PMI interagency professional staff work together to oversee all technical and administrative aspects of PMI, including finalizing details of the project design, implementing malaria prevention and treatment activities, monitoring and evaluation of outcomes and impact, reporting of results, and providing guidance and direction to PMI implementing partners.

The PMI lead in-country is the USAID Mission Director. The day-to-day lead for PMI is delegated to the USAID Health Office Director and thus the two PMI RAs, one from USAID and one from CDC, report to the USAID Health Office Director for day-to-day leadership, and work together as a part of a single interagency team. Technical expertise housed in Atlanta and Washington complements PMI programmatic efforts.

The two PMI RAs are physically based within the USAID health office but are expected to spend approximately half of their time with and providing TA to the NMCPs and implementing partners, including time in the field monitoring program implementation and impact.

The number of locally-hired staff and necessary qualifications to successfully support PMI activities either in Ministries or in USAID will be approved by the USAID Mission Director. Because of the need to adhere to specific country policies and USAID accounting regulations, any transfer of PMI funds

directly to Ministries or host governments will need to be approved by the USAID Mission Director and Controller, in addition to the U.S. Global Malaria Coordinator.

Please see Table 2 for a detailed list of proposed activities with FY 2019 funding.