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An evaluation of the Routine Malaria Information System in Guinea in case management and commodity consumption reporting

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An abstract of
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Abstract

An evaluation of the Routine Malaria Information System in Guinea in case management and commodity consumption reporting

By Yu Sun

Background: The Routine Malaria Information System (RMIS) in Guinea was established in late 2013 to in an effort to capture both epidemiological data and commodity consumption at the health facility level. This study was done to evaluate the current capacity of the RMIS in comparison to the President's Malaria Initiative's (PMI) end-use verification (EUV) surveys in efforts to identify programmatic gaps in routine malaria surveillance systems.

Methods: This was a cross sectional study analyzing four sets of data from July and December 2014, October 2015 and August 2016 in terms of health facility reporting, stock outs, case management indicators, and stock levels. Summaries of data were analyzed using proportions, chi-square test and the Schuirmann's Two One-Sided equivalence test.

Results: RMIS had high reporting rate of health facilities (75%) and demonstrated overall high specificity for stock outs for most commodities except injectable artemether. It showed low sensitivity overall for each commodity and high variability in Kappa values. RMIS is significantly different from the EUV surveys in case management indicator reporting overall. Malaria cases reported in individuals >5 years of age were demonstrated to have consistent correct diagnoses in all the months except for in August 2016 (p value 0.002). Overall, the results show that the RMIS is more likely to overestimate than to underestimate malaria commodity stock levels. In total, all commodities were overestimated except for AS-AQ infant (mean difference: -297 at CI 90%), AL (mean difference: -708 at CI 90%), and quinine tablets (mean difference: -11 at CI 90%).

Conclusions: The RMIS has high variability in data quality and need improvement in case management and commodity consumption reporting. PMI should continue to implement the EUV surveys and implement additional trainings on case management and malaria supply chain management in collaboration with the national program and partners.

Keywords: Routine malaria information system, surveillance, supply chain management, Guinea

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Lastly, I would like to thank Dr. Peter Brown for providing me with initial guidance to help me start this project.

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List of Definitions

ACT	Artemisinin-based combination therapy
AL	Aretemether-lumefantrine
ANC	Antenatal care
AS-AQ	Artesunate-amodiaquine
BSD	*Bureau de Strategie et de Developpement*
CDC	Centers for Disease Control and Prevention
CHW	Community health worker
DIHS2	District Health Information System 2
EUV	End-use verification
EVD	Ebola virus disease
GF	Global Fund to Fight AIDS, Tuberculosis, and Malaria
GOG	Government of Guinea
HMIS	Health management information system
IPTp	Intermittent preventive treatment for pregnant women
ITN	Insecticide-treated mosquito net
IRS	Indoor residual spraying
MIP	Malaria in pregnancy
MOH	Ministry of Health
MOP	Malaria Operational Plan
NMCP	National Malaria Control Program
PMI	President's Malaria Initiative
PCG	Central Pharmacy of Guinea
RDT	Rapid diagnostic test
RMIS	Routine malaria information system (monthly malaria reporting system)
SIAPS	Systems for improved access to pharmaceuticals and services
SBCC	Social and behavior change communication
SM&E	Surveillance, monitoring and evaluation
SP	Sulfadoxine-pyrimethamine
USAID	United States Agency for International Development
WHO	World Health Organization

Chapter 1: Introduction

Context:

With about 3.2 billion people at risk of malaria in 97 countries, territories and areas, malaria remains a significant global public health burden despite being preventable and treatable (WHO, 2015). Spread through the bite of an infected female *Anopheles* mosquito carrying the *Plasmodium* parasite, malaria was still the cause of about 212 million cases and about 429,000 deaths in 2015 (WHO, 2016a). Sub-Saharan Africa carries the highest share of this burden, as 90% of malaria cases and 92% of malaria deaths comes from this region (WHO, 2016a).

The President's Malaria Initiative (PMI) was launched in 2005 with the goal of reducing malaria-related mortality by 50% across 15 high-burden countries in sub-Saharan Africa. Annually, PMI works with each host nation to develop and implement a Malaria Operational Plan (MOP) that aligns its activities and interventions with the national strategic plan developed by the National Malaria Control Program (NMCP). Depending on the country, the emphasis of the operational plan may vary, but may include interventions in: vector monitoring and control, malaria in pregnancy, case management, health system strengthening and capacity building, social and behavior change communication, surveillance, monitoring and evaluation, and/or operational research.

Guinea was selected as a PMI focus country in 2011 due to its high malaria burden and year-round transmission. With the entire population of 12 million people at risk, PMI has worked extensively with the NMCP to improve malaria prevention and control through collaboration on the national strategic plan and PMI's annual MOP. The activities proposed by PMI fit in well with the national malaria strategy and plan and build on investments made by PMI and other

partner grants. Currently, one of the objectives of the strategic plan is to strengthen monitoring and evaluation at all levels to support better health information management.

Since late 2013, the NMCP implemented the Routine Malaria Information System (RMIS) surveys to collect malaria commodity and epidemiological data on the same form, in lieu of the nonfunctioning Health Management Information System (HMIS). The RMIS, although distrusted by programs due to its high variability in quality (Jima, 2012), served as the primary source of data for the NMCP during the Ebola epidemic. However, there were still many issues with the RMIS in terms of data quality that need to be rectified. For instance, although the RMIS is improving in reporting completion, the RMIS over-estimated the available commodity of RDTs and ACTs by 6.3 million and 3.2 million, respectively, in 2015 (PMI, 2017). It is important to analyze the quality of RMIS reporting, in order to understand why this system tends towards more conservative reflections of the available stock. In an effort to improve commodity consumption and management, PMI collaborates with other partners to increase access and reduce stock outs. By implementing the similar end-use verification (EUV) surveys across the nation, it collects case management and commodity consumption data from the health facility registers. These efforts in closer monitoring of health facilities through surveys help programs to adjust procurement, delivering only the minimum amount necessary for the health facilities.

Problem Statement:

Being a malaria endemic country, Guinea's entire population of 12 million people are at risk of malaria infection and its complications. A strong malaria surveillance system is needed to understand disease trends and identify populations most affected, in order to influence Ministry of Health (MOH) programming and intervention targeting. The NMCP and PMI have been

working closely to monitor malaria in Guinea, and major efforts have been put into strengthening the RMIS. Since its conception, the RMIS has never been formally evaluated, but there are concerns of inconsistent data reporting and varying data quality. Thus, there is a need to evaluate the current capacity of the RMIS to update, revise and maintain the national malaria database to reduce stock outs in the supply chain.

Purpose of the Project:

The purpose of the project is to compare the RMIS surveys in Guinea to the reference survey, the EUV surveys conducted by PMI. Given the potential duplication between the two, it is hoped that the EUV surveys can eventually be phased out. The two surveys were compared in terms of reporting completion, case management indicators, stock out rates, and stock levels to assess the current capacity of the RMIS. The EUV surveys have not been previously utilized in any formal evaluation of the RMIS surveys in Guinea or other PMI countries. This project contributes to the identification of essential programmatic gaps in the evaluation of malaria routine information systems. By emphasizing data collection and data quality assurance, improvements can be made to the supply chain management and consumption data to influence the forecasting of program demand to avoid stock outs. The lessons learned here can also potentially be applied to the strengthening of malaria surveillance systems in other PMI countries.

Chapter 2: Review of the Literature

Background

Global burden of malaria

Even though malaria is preventable and curable, it remains a life-threatening disease, with ongoing transmission in 91 countries (WHO, 2016a). Spread through the bite of an infected female *Anopheles* mosquito carrying the *Plasmodium* parasite, malaria was still the cause of about 212 million cases and about 429,000 deaths in 2015 (WHO, 2016a). With 3.2 billion people at risk of malaria infection, this disease poses considerable social and economic burden to individuals and governments (CDC, 2016a).

Malaria transmission, symptoms, and treatment

Most commonly, malaria is transmitted through the bite of an infected female *Anopheles* mosquito, which in turns can cause either uncomplicated or severe malaria. There are five *Plasmodium* species that can be transmitted to humans: *P. vivax, P. ovale, P. malariae, P. knowlesi,* and *P. falciparum.* Among these, *P. falciparum* and *P. vivax* cause the highest morbidity and mortality, at times even leading to severe malaria and subsequent death (CDC, 2016b). Rates of transmission are dependent on the parasite, vector, the human host and the environment, but always peak during and after the rainy season, which provides ideal climatic conditions for the survival of the mosquitoes. Many malaria-endemic countries have varying levels of transmission throughout the year, due to the variation of geography and climate factors that the mosquitoes prefer. Generally, warmer, humid climates are preferred over cold, dry and high altitude environments, and mosquitoes tend to bite around dusk and dawn (CDC, 2017). Transmission is also the most intense where mosquitoes prefer to bite human hosts and have the

longest lifespan. These are the combined reasons why malaria is such a burden in sub-Saharan Africa (WHO, 2016a).

Symptoms can range from fever, headache, chills, and vomiting in uncomplicated malaria cases to severe anemia, acute kidney failure, cerebral malaria, and hypoglycemia in severe malaria cases. Often in severe malaria, if not treated early, *P. falciparum* cases can escalate to death. According to the WHO, "all cases of suspected malaria [should] be confirmed using parasite-based diagnostic testing, either microscopy or rapid diagnostic test (RDTs) before administering treatment" (WHO, 2016a). Upon parasitological confirmation, artemisinin-based combination therapy (ACT) is the WHO-recommended treatment and should be administered differently for children, adults and pregnant women under the supervision of a trained health clinician. Therefore, individuals with malaria-like symptoms are encouraged to seek urgent care in order to facilitate early treatment and reduce mortality due to malaria (WHO, 2016a).

Malaria in Guinea

The country of Guinea is composed of four distinct ecologies, which include lower Guinea (coastal lowlands), middle Guinea (mountainous region that runs in the middle of the country, from the north to the south), the Sahelian upper Guinea, and the heavy forest jungle area of southern Guinea that borders Guinea-Bissau and Senegal to the north. Guinea also borders the countries of Mali and Cote d'Ivoire on the east while Liberia and Sierra Leone touch its southern borders. There are 33 prefectures (districts) with eight administrative regions, with one of them being the capital city of Conakry and its five communes (PMI, 2017). With an estimated population of about 11.7 million people in 2015 (CIA, 2015), the entire country is risk of malaria.

Guinea is one of the poorest countries in the world, ranking at 183 out of 188 countries according to the 2016 Human Development Index (UNDP, 2016), with about 55% of the population living below the poverty line (World Bank, 2012). Plagued by multiple infectious diseases, malaria interventions are crucial in fighting against the low life expectancy of 55 years of age.

Guinea is a highly endemic country for malaria and has year-round malaria transmission with peaks from the months of July through October. As malaria continues to rank as the top public health concern, the NMCP is challenged by a high incidence rate of 92 per 1,000 per year. The three main vectors that are present are *Anopheles gambiae, An. coluzzi,* and *An. funestus,* with *Plasmodium falciparum* causing about 92% of all infections. Overall, malaria infection prevalence is about 44% nationwide in children under the age of 5 (PMI, 2017) but can range from 3% in Conakry to 66% in Faranah. In the vulnerable population of children under five, malaria accounts for 31% of hospital consultations, 25% of hospitalizations, and 14% of hospital deaths (not including data from community health facilities or private facilities). For the general population, malaria accounts for 34% of consultations, 31% of hospitalizations, and 14% of hospital deaths (PMI, 2017).

The NMCP and partners have made significant progress in malaria-related efforts but there is still much work to be done. Guinea still has not reached the goal of universal coverage of insecticide-treated nets (ITNs). Only 53% of the households had at least one mosquito net (whether treated or untreated) and barely 47% of the households owned at least one ITN with the rural areas showing a higher percentage of mosquito net and ITN ownership than urban areas (55% vs. 50% and 48% and 42%). Children under the age of five are also not consistently sleeping under these ITNs; only about a third of households reported sleeping under an ITN the

night before. Among pregnant women, only 28% reported sleeping under an ITN (33% under any net) the night before (PMI, 2017). According to the PMI indicators, there is still very low treatment coverage in across the nation as of 2016. For instance, only 37% of households surveyed with children under five with a fever sought treatment two weeks before the Demographic and Health Survey (DHS), 28% had received any antimalarial treatment, and less than 1% received an ACT on that day or the next. Of those children that received the treatment, only 4.8% of them took an ACT whereas 35.7% took choloroquine, 30.7% took quinine, 23.3% took monotherapy Amodiaquine, 6.0% took sulfadoxine-pyrimethamine (SP)/Fansidar, and 5.3% took something else. These data indicate the importance of correct case management, including treatment and follow up.

According to PMI, about 43% of the total patient records are related to malaria and of these, 31% are of children under the age of five. Among all the fever cases, 77% were diagnosed as malaria, which about 80% of these cases were confirmed by RDTs or microscopy. In the children under five who were diagnosed with malaria, about 67% of the cases were treated appropriately with ACT. It was only in 2005 that the intermittent preventative treatment for pregnant women (IPTp) method of recommending SP as part of the antenatal care (ANC) health package for pregnant women was incorporated with the support of the NMCP, PMI and other partners. This is a large area of focus, as only 18% of women reported receiving two or more doses of SP during their last pregnancy (DHS, 2012). For pregnant women and infants, there are intermittent preventive treatment of malaria that target the pregnant women and infants' immune system to prevent malaria infection. Parasites have a new site to bind to with the creation of the placenta, resulting in placental sequestration, which is the biggest cause of low birth weight. SP is the only recommended drug for use as IPTp in sub-Saharan Africa during the routine ANC

visits (Rogerson, 2017). Therefore, continuous collaboration between partners and the NMCP should include efforts in improving these interventions.

Malaria control and prevention strategies

Malaria control involves appropriate diagnosis and treatment and effective preventative interventions. The goal of most NMCPs is to reduce malaria related deaths to a level where the transmission of the disease is no longer a public health threat. One of the main prevention strategies recommended by the WHO is vector control. The two most effective forms are the proper utilization of ITNs and the correct application of indoor residual spraying (IRS). Mass campaigns of free distributions of long-lasting insecticide treated nets (LLINs) are the WHO recommended ITNs for use and the most cost-effective form of providing coverage for all individuals at risk. In a cohort study by Lindblad et al. in 2015, the use of ITNs in high malaria transmission zones in Malawi demonstrated a reduction in malaria transmission. Another effective method is the multiple application of IRS every 3-6 months. By spraying the inside walls of houses with insecticide, IRS has been an effective form of vector control and recommended by the WHO for regions aiming for malaria elimination (Bradley, 2016). While standalone successful IRS campaigns have demonstrated significant decrease in malaria morbidity (Tukei, 2017), the combination of LLIN distribution campaigns have shown a marked decline in the burden of malaria (Katureebe, 2016).

Malaria surveillance, monitoring and evaluation

The newly updated WHO's *Global Technical Strategy for Malaria 2016-2030* highlights malaria surveillance as an important core intervention – one of its three pillars of the strategy.

Over the next 15 years, national programs will aim to move towards malaria elimination through better preventative measures, better testing, treatment and disease surveillance. With the goal of reducing malaria burden by 90% by 2030, the WHO has emphasized the need to improve regional and national collaboration, including a focus on surveillance.

According to the WHO, malaria surveillance optimizes interventions and empowers programs "to advocate investment from domestic and international sources…and to allocate sources to populations most in need and to interventions that are most effective." Programs and national governments are also encouraged to regularly assess the progress and expected results of interventions to evaluate the public health impacts and overall efficiency and effectiveness of interventions (WHO, 2015). Routine monitoring and evaluation of logistics system activities can demonstrate how well a system is performing, and allows for timely feedback to improve system performance. By strengthening malaria epidemiological and commodity consumption surveillance systems, programs can strengthen surveillance, monitoring and evaluation (SM&E) activities (USAID, 2011).

Surveillance in high-transmission settings allows for large quantities of aggregated data to monitor populations at a national level. Data should be reported in an accurate and timely manner to ensure simultaneous tracking of cases and commodities to reduce mortality and to prevent commodity stock outs. In settings of low-transmission, effective surveillance should be able to detect every infection, leading to timely outbreak responses. Malaria vector control is an important aspect of entomological surveillance. Through the assessment of the different vector species, integrated vector management programs can gain understanding of the insecticide susceptibility status and the underlying mechanism of resistance (WHO, 2016b). Coupled with continued studies on transmission, this strategy is essential in assessing interventions.

Another important aspect of malaria surveillance is case management, which is defined as the proper diagnosis and treatment of malaria (CDC, 2015). The WHO recommends that "every suspected malaria case be confirmed by microscopy or an RDT before treatment" so that this accurate diagnosis "improves the management of febrile illnesses and ensures that antimalarial medicines are only used when necessary". Correctly diagnosed cases should all be given ACT as the first choice of treatment for uncomplicated malaria. Timely and accurate reporting of all suspect and confirmed cases can help track and manage the surveillance data in the area. Case management trainings for CHWs should also focus on providing the appropriate medications for the appropriate populations, helping to prevent drug resistance and commodity stock outs at health facilities (CDC, 2015).

Optimal malaria surveillance entails effective vector control and entomological surveillance and monitoring and evaluation so data can be collected on the insecticide resistance along with vector behavior. This generates valuable data for the SM&E of programmatic efforts and bioefficacy studies that contribute to the net-replacement strategies and spraying methods and activities. By establishing an effective national surveillance system, routine data collection on the progress of program interventions and capacity will better inform strategies for improved malaria control. Most governments lack an effective surveillance system to track and manage every case of malaria infection, however, strengthening of malaria surveillance is crucial in accelerating progress especially in malaria endemic countries. A good surveillance system can help governments identify programmatic gaps, detect outbreaks, and assess the impact of interventions, further assisting and adapting to effective policy changes (WHO strategy, 2016).

Most endemic countries lack a strong malaria surveillance system. Supporting such a system nationally can be costly and difficult to set up. However, investment in a routine

monitoring system provides crucial information that can benefit program planning, implementation, and evaluation (WHO, 2015). In the NMSPs, a carefully drafted M&E plan should contain goals and objectives that target scale up efforts of strengthening program management capacity, M&E, and procurement and supply management that address the needs of all stakeholders. An effective M&E program should have "clearly defined indicators and methods for collecting necessary data and should also establish supervisory roles and responsibilities for malaria program staff at all supply chain levels" (USAID, 2011). Each level of health data needs to be aggregated to reflect case management and quality controls, enabling NMCPs to detect disease trends, health facility needs, commodity flow, and finances. Looking at aggregated data at the regional or district level helps the NMCPs to better evaluate the malaria surveillance system by assessing the completeness of health facility reporting since surveillance systems do not detect all malaria cases. This may be because not all malaria patients may seek care or at a health facility that is within the surveillance system. If patients do seek care, they may not receive the appropriate diagnostic test or treatment. Furthermore, none of this information may be recorded correctly or reported at all within the system, resulting in incomplete data collecting and reporting (WHO, 2016b). Aggregated data from routine information systems can also provide other programmatic support: drawing geospatial malaria density maps and estimating malaria cases by age groups (especially children under the age of five). This information provides program managers the ability to observe surveillance coverage and disease trends at the national level since it is nearly impossible to report every individual case in endemic countries (Chilundo, 2004).

A major challenge in supporting an efficient malaria surveillance system is the maintenance of adequate amounts of commodities, especially in rural settings. This requires a

dedicated and well trained group of staff to commit to supervision and M&E of the commodities in order to provide early and appropriate diagnosis and treatment to malaria patients (USAID, 2011). Antimalarial stock outs could lead to increased number of untreated cases and malaria related mortality. In one example, CHWs in Ghana were sometimes forced to borrow commodities from their peers at neighboring health facilities during stock outs, leading to further data quality errors when reporting commodity inventories (Carlo, 2015). Stock outs are an important indicator of health system readiness and sudden interruptions in the supply chain may lead to more stress for healthcare staff and further affect the quality of service and health programs (Wagenaar, 2014). To ensure timely feedback, monthly health facility reports should be produced to inform commodity consumption and trends in infection and disease. However, due to the varying quality of routine malaria surveillance data, there is distrust in their quality assurance and thus, sometimes the large amount of data collected are never collated (Jima, 2012).

The Government of Guinea (GOG) has made strengthening of the malaria surveillance program one of its core goals. Specifically, they focus on routine data collection on programmatic performance on case management indicators and malaria commodity use (PMI, 2017). To better evaluate the system, it is important to measure its achievements by comparing its surveillance progress to that of PMI's EUV reports. A good indicator of a strong surveillance system is its completeness of health facility reporting. In 2015, 40 out of 47 countries demonstrated at least 80% in reporting completeness. However, this does not include endemic countries due to lack of specification in the number of health facilities, number of reports submitted, or both. These malaria surveillance systems were able to detect 19% of the cases that occurred globally and case detection rates have increased by 10% since 2010 due to the

improvements in case diagnosis (WHO, 2016b). Therefore, efforts in strengthening malaria information systems via correct case management indicators and managing malaria commodities are crucial in the path towards a malaria-free Guinea.

Health system in Guinea

Nationally, it is MOH that governs the health care system. Within the MOH lies the NMCP that is responsible for managing all malaria related efforts in country. Locally, healthcare is delivered according to the specific regional administrative ruling. Each of the eight regions is then divided into 38 health districts, which in turn are composed of 334 rural municipalities and 38 urban municipalities (PMI, 2017).

There are three levels of public health facilities that are divided into primary, secondary, and tertiary health care. The first level is composed of the health districts and is further divided into three types of health facilities: (1) Health posts: there are 963 health posts that are able to provide basic primary care while serving multiple villages, ranging to about 3,000 people. These health posts are staffed by a clinical officer (*agent technique de sante)* with at least three years of formal training. (2) Health centers: there are 413 centers that serve 10,500 people each and provide mainly preventive and curative care as well as supervising the health posts. These centers are staffed mainly by health professionals such as clinicians, nurses and midwives. (3) District hospitals: there are 26 hospitals that serves about 285,777 people, which serves as the reference point for health centers. The second level is composed of the regional hospitals, which receive referrals from the districts. In total, there are 7 regional hospitals and 9 municipal hospitals that serve about 1.4 million people. The third level is the highest level of reference

(specialized care) and is composed of university hospitals that receive referrals from the entire nation (PMI, 2017).

In addition to the public health facilities, there is also a growing number of private health facilities that provides both basic as well as specialized care to communities. In the rural areas, CHWs are essential to the prevention and management of diseases, like malaria, at the community level. The CHWs are an integral part of community health management as they are trained on the basic case management of malaria as well as on other priorities in the national health programs, such as HIV/AIDS, neglected tropical diseases, nutrition, reproductive health and family planning, and other maternal and child health areas (PMI, 2017).

Despite the numerous public structures, private facilities, traditional practitioners, and CHWs at the community level, access to care remains a major issue in Guinea with only 55% of the population having access to public health care services. To increase access at the health facility and at the community level, the NMCP set forth a strategic plan for "the pharmaceutical system to provide better access to malaria diagnosis and treatment to 100% patients at health facilities and the community level" (PMI, 2017).

Established in 1992, the central medical store, also known as the Pharmacie Centrale de Guiniee (PCG), is the main institution that implements the government's policies on pharmaceuticals. The PCG's main mission is to improve healthcare commodity access so that they are available to all communities. It is responsible for the procurement of all public health needs, including medicines, vaccines, medical and surgical instruments and products, medical equipment and laboratory reagents. Health centers send commodity orders to the prefectural health authorities (DPS), where they are compiled and then sent to the regional pharmacist. These regional depots of the PCG then transports the commodities to the DPS, where the

supplies will remain until the health center workers come to retrieve them with the provided transportation fees (PMI, 2017). Despite a decentralized management of storage and distribution, the pharmaceutical system still faces many challenges to secure appropriate and timely distribution of quality commodities to health facilities to increase access and coverage.

In addition to the PCG, partners and the government aim to expand training and management of CHWs, with the goal of increasing access to care in the rural areas, especially at the community level where some regions are inaccessible. From a 2016 comprehensive mapping of CHWs in the country, there are only 5,871 CHWs in the country with a little over a half trained in health education and basic curative care in their communities. This may be due to the 2013 Ebola outbreak that caused unexpected strain on the healthcare workers and greatly impacted case management (PMI, 2017).

Impact of Ebola on the health structure

Even before the Ebola epidemic, the national health system faced numerous challenges, such as the management of the NMCP and its limited human resources. Starting in December 2013, Guinea was heavily impacted by the epidemic of the Ebola virus disease (EVD), as it led to a drastic reduction in health facility attendance for all causes of fever. This severely impacted the overall case management of malaria in Guinea even though the country was declared Ebola-free in 2015 (Plucinski, 2015). Due to the outbreak, Parpia et al. estimates that there will be a 50% reduction in malaria treatment coverage, leading to the deaths of 12,825 children under the age of five. These altered care patterns have persisted through 2015 and the repercussions of the EVD on the healthcare system will most likely to continue long after this study period due to the loss of vital healthcare staff and the potential of developing drug resistance (Parpia, 2016). The

Ebola epidemic has impacted management of malaria efforts in several ways, due in large part to the similar and overlapping symptoms of EVD and malaria. In 2014, in an attempt to limit spread of EVD in healthcare settings, the WHO released new guidelines for malaria testing and treatment in the Ebola affected regions. The new recommendations called for the suspension of RDTs and microscopy testing at the health facilities that were not equipped with appropriate personal protective gear. If individuals presented with a case of fever, they were to be treated presumptively with an ACT. If there was no sign of improvement within 48 hours, then individuals are to be evaluated for the possibility of EVD. This strategy left many cases of malaria misdiagnosed and/or inappropriately treated; additionally, the suspect fever cases are also an impediment to the Ebola response (PMI, 2017).

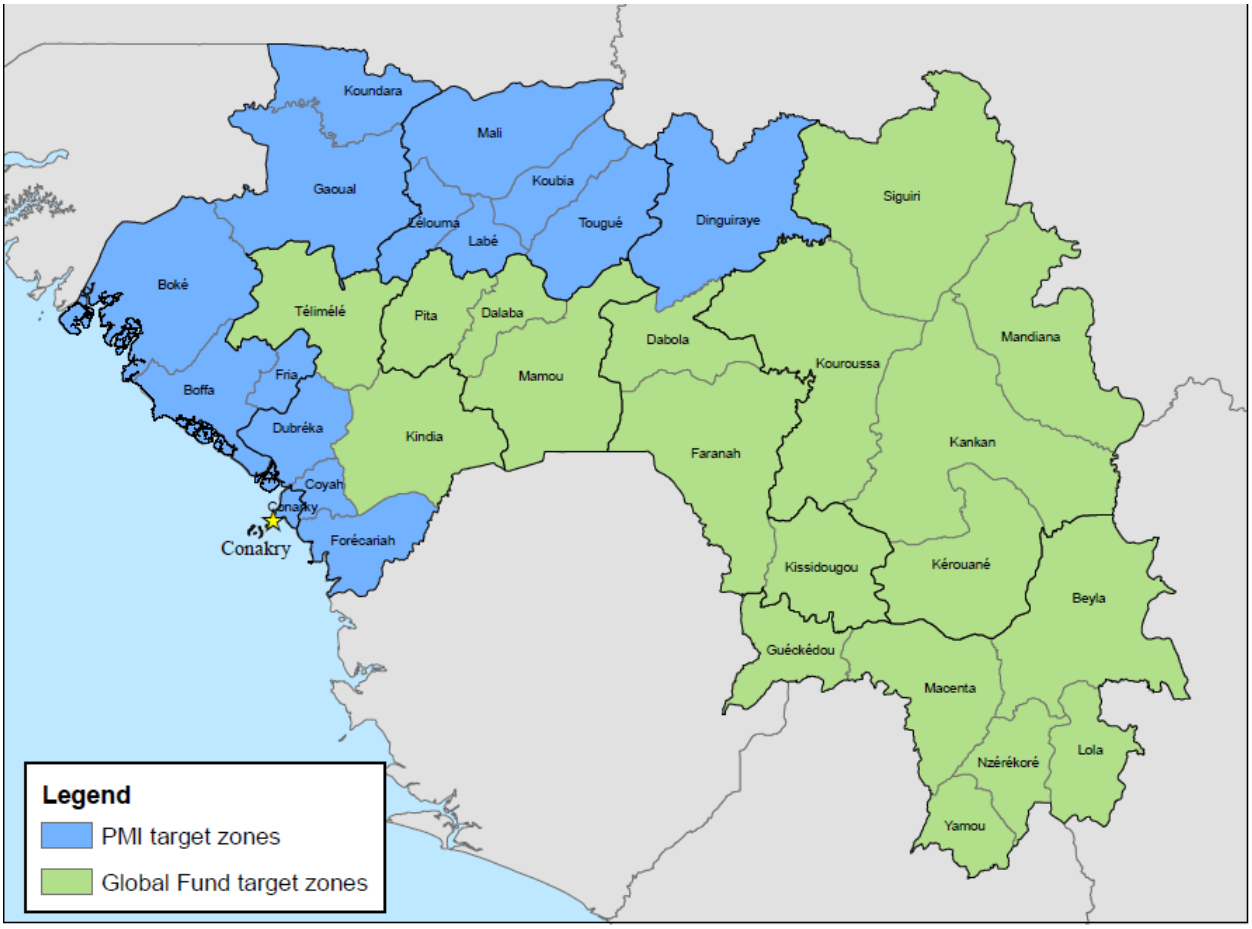
The NMCP commissioned a national survey on health facilities to measure the impact of the Ebola epidemic on malaria in terms of health facility attendance, malaria case management and commodity surveillance. The survey conducted in December 2014 included the prefectures affected by EVD, and found that there was no significant change from 2013-2014 in laboratory confirmation rates for malaria even though there was an increase in RDT. In the same prefectures, there was a decrease to 30% in RDT use by the CHWs where before the start of the epidemic, 70% of the CHWs used the RDTs. There was a significant reduction in all-cause outpatient visits by 11%, and the Ebola epidemic was estimated to have resulted in 74,000 fewer malaria cases seen at health clinics (Plucinski, 2015). According to a study done by Elston et al., about 1.5% of the healthcare workforce died from EVD. This statistic is particularly impactful in Guinea, where the combined estimated ratio of doctors, nurses and midwives is only 2.2 per 10,000 inhabitants. This mortality of healthcare workers reflects a significant decrease in capacity for providing health care to the population, especially in the rural communities.

Guinea continues to face unique challenges that require detailed and specific implementation plans to combat malaria. One of the largest partners of the NMCP, PMI, is committed to working with the GOG to improve the malaria program.

The President's Malaria Initiative

The President's Malaria Initiative was launched in 2005 with 15 malaria high-burden countries in sub-Saharan Africa under its umbrella. Its goal was to reduce malaria mortality by 50% by implementing four highly effective malaria prevention and treatment interventions: ITNs, IRS, accurate treatment with ACTs and IPTp. PMI's long-term goal is to develop and implement strategies that would ultimately lead to a malaria-free Africa, and to worldwide malaria eradication by 2040-2050. PMI started in Guinea in 2011 and has a funding of $15 million for FY 2017 to support 14 districts in the north and west of Guinea along with the five communes in Conakry. The rest of the 19 districts in the central, south and east of Guinea are supported by the Global Fund (GF) (figure 1). To ensure coordination of activities, both donors use the same materials and tools to collaborate on interventions and trainings but each fund their activities separately (i.e., community health worker (CHW) trainings, social and behavior change communication (SBCC) trainings, and commodity distributions). Collectively, PMI and GF contribute to activities, such as the national needs for malaria commodities, SM&E tools, supervision activities, the continuing impact evaluation of the Ebola crisis (PMI, 2017).

Figure 1. PMI and GF target zones in Guinea (Reproduced from PMI MOP 2017)



PMI is focused on supporting entomological monitoring and insecticide resistance management, ITNs, IRS, malaria in pregnancy (MIP), case management, health systems strengthening and capacity building, SBCC, SM&E, and operational research (OR). Under the goal of the U.S. Government, the 2015-2020 PMI strategy is to support PMI "countries and partners to reduce malaria deaths and substantially decrease malaria morbidity, towards the long-term goal of elimination" (PMI, 2017).

One of the NMCP's main efforts is to increase access to malaria diagnostics and treatment commodities with the overall goal of reducing malaria morbidity and mortality. This

expansion in access to malaria commodities will rely on an improved supply chain management system, with a focus on the delivery of RDTs and antimalarial treatments such as ACTs for uncomplicated malaria and parenteral treatment with artemisinin derivatives for severe malaria. Although access to ACTs and RDTs is made possible through the local public health facilities, there are just over 5,000 CHWs working across the entire country. Large-scale implementations of ACTs, SPs, and RDTs are now available across the country in public health facilities due to the continuous support of PMI and other partners in pharmaceutical management and IPTp activities. During the mass ITN campaigns in 2013 and the routine nets campaign in 2014, PMI was able to distribute over 5 million LLINs to communities and to ANC and immunization clinics (PMI, 2017).

In 2015, PMI launched a new set of plans for the next six years that involves a detailed implementation plan for Guinea based on the strategies PMI and NMCP consulted and developed together. The current national strategic plan covers a span of five years from 2013-2017 that aims "to reduce malaria-related morbidity by 75% from the year 2000, and to reduce malaria mortality to near zero by the end of 2017" (PMI, 2017). The proposed activities for fiscal year (FY) 2017 aligns well with the NMCP strategy and plan that PMI will continue to invest in all expansion of malaria-related services along with other partners. One of the main objectives is to strengthen the national SM&E plan, which is a key component of Guinea's malaria program. The NMCP plans to prioritize revising and maintaining the national malaria database, which includes the HMIS and supervision data. Work plans will emphasize on supporting and strengthening data collection, data quality assurance and dissemination and use of data. Currently, the NMCP is collecting data using a monthly malaria reporting tool, also known as the RMIS (PMI, 2017).

Routine malaria information system

In the past, malaria programs have relied on the evaluations of repeated population based surveys to evaluate the impact of malaria control interventions, including the demographic and health surveys (DHS) and malaria indicator surveys (MIS) (Chanda, 2012). However, significant efforts have been made to improve the routine malaria surveillance data through standardization of case definitions, collection and collation due to the overall distrust of their variability in quality (Jima, 2012). Recently, examples of successfully implemented routine malaria surveillance data have shown essential contributions and impact of control measures on the overall malaria burden. Recognition of such improvement on their quality have led to more geographic mapping of malaria trends in Africa (Gething, 2006). Improved quality data have also helped document trends in malaria case and death reductions in all age groups in settings with high coverage of vector control measures (Chanda, 2012).

One of the primary goals of the MOH is to strength their routine malaria surveillance in the absence of a functional HMIS. The HMIS has not been functional due to the vacancy in the position of the Bureau de Strategie et Developpement (BSD) Director General and the Health Information and Research Division Chief positions that manage the production of the HIMS (PMI, 2016b). This lack of production of reports has led to coordinated efforts amongst donors to work closely with the MOH to strengthen the BSD. Guinea is thus focused on integrating and coordinating existing program information systems that focus on malaria, Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), Expanded Program on Immunization (EPI), tuberculosis (TB), and the Ebola Coordination, in order to transition to the open source District Health Information System 2 (DHIS2) platform. This platform has already been adopted by the Global Fund, United States Agency for International

Development (USAID), President's Emergency Plan for AIDS Relief (PEPFAR), and Economic Community Of West African States (ECOWAS) member states as the regional HMIS database. Thus, the BSD has prioritized the revitalization of the DHIS2 platform in hopes of phasing out any parallel reporting systems by various health programs. There are multiple complementary reporting systems that report on commodity data and the RMIS contributes to commodity data reporting by providing regular data from the health facility level, which eventually this information will be integrated into a functional HMIS. The NMCP, PMI and other partners have worked extensively to support the RMIS, providing sufficient budget to produce quality information for management, planning, procurement, and inventory control at the regional, district and national level (PMI, 2016b).

Starting in the last 2013, the NMCP implemented the RMIS to collect malaria epidemiological data and malaria commodity data simultaneously across all health facilities in Guinea (PMI, 2017). The RMIS was first rolled out in the PMI zones then into the GF zones in mid-2014 and has not been formally assessed at the population level. In an effort to further support NMCP's M&E plan, PMI supported the BSD and the NMCP by revising and including some indicators. The revised form is more detailed and includes the following case management indicators: "number of suspect malaria cases, cases tested (stratified by microscopy and RDT), cases confirmed positive (stratified by microscopy and RDT), cases treated with ACT, severe cases treated, cases referred, and deaths among severe cases" (PMI, 2016b). Data are reported by CHWs from the health facilities and revisions were also made to include data from ANC visits, number of pregnant women receiving first dose of PS, number of pregnant women receiving at least three doses of SP and the number of pregnant women who were sensitized at the ANC (PMI, 2016b). For the commodity stock reporting, rows were added to better reflect commodity

management for RDT, ACT, SP, aretemether-lumefantrine (AL), quinines, and ITNs. Each facility also had to report (for each commodity) the stock at the beginning and end of the month, quantities received, quantities delivered to the CHWs and the health posts, quantities consumed, expired, near expiry, and days of stock outs (figure 1; appendix). Collectively, with commodity consumption and stock levels, a monthly report is generated and then digitized at the health district level. A monthly malaria bulletin is produced as a final summary of the aggregated data for electronic dissemination. The RMIS is therefore an important surveillance tool, especially since the national integrated disease surveillance and response (IDSR) system does not have adequate malaria key indicators, is not stratified by age, and does not have complete data from the community health posts.

The 2016 WHO Malaria Report identifies the completeness of health facility reporting as a good indicator of a surveillance system's performance. In order to achieve a high reporting rate, health facilities need to adhere to a number of processes, including "the enumeration of a complete list of reporting units, compliance with reporting requirements and monitoring of that compliance" (WHO, 2016b). In a highly endemic country like Guinea, along with the tracking of health facilities that report, a high reporting rate is also critical to the interpretation of indicators, such as proportion of expected health facility reports received at the national level or proportion of malaria cases detected by surveillance systems (WHO, 2016b).

With its most recent report produced in 2011, the HMIS was nonfunctional during the Ebola epidemic and perceived as not a valid data source. The RMIS became the primary source for reporting data on malaria for the NMCP. With 36 out of the 38 districts reporting consistently, this tool is performing with completion ranging from 76% to 100% (PMI, 2017). Since its scale up in 2014, the RMIS has demonstrated improved reporting completion,

increasing from 66% in November 2014 to 92% in 2015 and then reaching a reporting completion 97% in January 2016 (PMI, 2016a). These improvements demonstrate the success of the collaborative work and efforts of the NMCP and partners in implementation and training. According to the RMIS conducted in 2015, there were about 2.7 million RDTs and 3.4 million ACTs available in the country. These data were the result of the first nationwide collection of monthly malaria reports. The RMIS' quantification system allowed for accurate, data-driven commodity gap analyses. In contrast, the previous system estimated malaria cases and commodity stock levels from population-based models, leading to over- and under-estimation of the amounts of RDTs and ACTs actually needed (PMI, 2017).

However, reporting errors still remain in the RMIS, as consumption data (based on stock estimates) are often much greater than the reported total number of suspect malaria cases tests and treated. In 2015, the RMIS over-estimated the available commodity of RDTs and ACTs by 6.3 million and 3.2 million, respectively, resulting in the halt in new commodity shipment by PMI in order to avoid overstock and potential expiry of the supplies (PMI, 2017). It is important to analyze the quality of the reporting of the RMIS, in order to begin to understand why this system tends towards to an overly optimistic reflection of the available stock. In an effort to improve commodity management, PMI collaborates with other partners to increase access and reduce stock outs. Efforts will include a closer monitoring of health facilities through surveys, such as the EUV surveys, to make timely and necessary adjustments and procuring and delivering only the minimum amount necessary to for the health facilities to support their beneficiaries.

End-use verification surveys

Aside from the RMIS, PMI collects its own commodities stock data through the EUV surveys, which were implemented at the end of 2012. EUV surveys are conducted semi-annually and collect data on malaria commodities and limited case management indicators through register review, based on a convenience sample of health facilities on a regular basis (PMI, 2010). At the end of EUV data collection and analysis, a summary report is produced, indicating the date of collection, number of facilities and regions visited, if it is the rainy season along with key observations, recommendations, and next steps. The EUV surveys also provide valuable information to PMI in terms of capturing complementary data (figure 2; appendix). In the annual PMI MOPs, EUV results in the past 12-18 months are reported for use in case management training activities and progress. When they were first introduced, the EUVs documented high levels of commodity stock outs in the first three months as well as low numbers of trained staff in case management. The EUVs have also been able to identify problems with case management and data quality issues at the health facility level. The first survey, conducted in January 2013, showed that only 36% of the healthcare staff were trained in case management and about half of all malaria cases were diagnosed based on clinical symptoms alone. About a third of these malaria cases did not receive appropriate antimalarial therapy. Although there has been demonstrated progress in commodity management, the EUV survey results showed that there were still considerable gaps in case management practices (PMI, 2015). The EUV was an important tool during the Ebola outbreak since healthcare workers had to differentiate the malaria cases from the Ebola cases due to their shared similar onset of symptoms. The EUV was able to detect low rates of stock outs of RDTs and ACTs and various problems with case management during the crisis, contributing to the steady supply chain of commodities required

during these urgent times (PMI, 2017). The EUV surveys were so well-received by the NMCP that they were expanded to all regions in July 2014 (as opposed to the original plan of focusing in three PMI target zones).

Although the RMIS has been implemented since 2013, PMI continues to implement the EUV to check the quality of data collection and reporting on a biannual basis. To best maximize resources, efforts need to focus on identifying and strengthening this RMIS surveillance system, to where eventually there is no need for the implementation of the EUV, avoiding duplication of efforts (WHO, 2016b). Conducting multiple surveys will not only cost programs extra financial burden but it also be taking away already limited human resources that could be utilized elsewhere in the healthcare system.

Box 1. A comparison of the RMIS and EUV surveys

	RMIS	**EUV**
Frequency	Monthly	Semi-annually
Coverage	All health facilities	Randomly selected
Start date	December 2013	January 2013
Ownership	MOH Guinea	PMI/SIAPS
Data collected	Epidemiological, commodity consumption at the health facility, regional, and national levels on a national scale	Case management, commodity consumption at the health facility, regional, and national levels on a national scale
Data collection time	Monthly	No more than 15 work days
Training	Healthcare workers at the health facility and regional levels trained in malaria knowledge and case management	One- to three-day training, including if possible a visit to the facility and practicum with forms

Significance

In all 19 PMI countries, there has never been a formal evaluation of the country's RMIS. This study compares Guinea's RMIS to PMI's EUV surveys to assess the current capacity of the routine malaria surveillance system. Further weakened by the Ebola outbreak, an effective surveillance system of malaria-related cases and deaths "is essential for identifying which areas or population groups are most affected by malaria, and for targeting resources to communities most in need" (WHO, 2016b).

The method of comparing corresponding indicators between the RMIS and the EUV surveys can serve as an accurate evaluation of the RMIS in Guinea by helping to identify gaps in data quality and more importantly, can inform PMI if this methodology is accurate for measuring the capacity of the RMIS. Since the improvement efforts of the RMIS and health system strengthening, an evaluation of the current RMIS capacity will aid the national government and partners in identifying programmatic gaps and influence operational strategies for the strengthening of the malaria surveillance system.

By taking the lead in examining the capacity of the RMIS in Guinea, the methods and lessons learned in this study can be generalized to other PMI countries to better outline an evaluation strategy of the RMIS using the EUV surveys.

Chapter 3: Manuscript

An evaluation of the Routine Malaria Information System in Guinea in case management and commodity consumption reporting

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Abstract

An evaluation of the Routine Malaria Information System in Guinea in case management and commodity consumption reporting

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Background: The Routine Malaria Information System (RMIS) in Guinea was established in late 2013 to in an effort to capture both epidemiological data and commodity consumption at the health facility level. This study was done to evaluate the current capacity of the RMIS in comparison to the President's Malaria Initiative's (PMI) end-use verification (EUV) surveys in efforts to identify programmatic gaps in routine malaria surveillance systems.

Methods: This was a cross sectional study analyzing four sets of data from July and December 2014, October 2015 and August 2016 in terms of health facility reporting, stock outs, case management indicators, and stock levels. Summaries of data were analyzed using proportions, chi-square test and the Schuirmann's Two One-Sided equivalence test.

Results: RMIS had high reporting rate of health facilities (75%) and demonstrated overall high specificity for stock outs for most commodities except injectable artemether. It showed low sensitivity overall for each commodity and high variability in Kappa values. RMIS is significantly different from the EUV surveys in case management indicator reporting overall. Malaria cases reported in individuals >5 years of age were demonstrated to have consistent correct diagnoses in all the months except for in August 2016 (p value 0.002). Overall, the results show that the RMIS is more likely to overestimate than to underestimate malaria commodity stock levels. In total, all commodities were overestimated except for Artesunate-amodiaquine (AS-AQ) infant (mean difference: -297 at CI 90%), AL (mean difference: -708 at CI 90%), and quinine tablets (mean difference: -11 at CI 90%).

Conclusions: The RMIS has high variability in data quality and need improvement in case management and commodity consumption reporting. PMI should continue to implement the EUV surveys and implement additional trainings on case management and malaria supply chain management in collaboration with the national program and partners.

Keywords: Routine malaria information system, surveillance, supply chain management, Guinea

Contribution of Student

For the project described in this manuscript, I helped develop the analysis plan with the guidance of Dr. Mateusz M. Plucinski. I also reviewed the literature to help guide the writing. I performed all analysis on the data collected and wrote the discussion with the guidance and suggestions of Dr. Sophia A. Hussen (thesis committee chair), Dr. Mateusz M. Plucinski (thesis committee member), and Ryan E. Wiegand (Center for Disease Control and Prevention, Atlanta, GA).

Background

Guinea is a highly endemic country for malaria and has year-round malaria transmission with peaks from the months of July through October. Malaria continues to rank as the top public health concern, as the National Malaria Control Program (NMCP) is challenged by the high incidence rate of 92 per 1,000. According to the Ministry of Health (MOH), among all consultations at public health facilities, malaria infections are responsible for 34% of consultations, 31% of hospitalizations, and 14% of hospital deaths (PMI, 2016b). Thus, the burden of provision of care is a challenge for the NMCP. In Guinea, there are three levels of public health facilities that are divided into primary (health posts), secondary (health centers), and tertiary health care (district hospitals) within each of the eight regions. Each region is then divided into 38 health districts, which is composed of 334 rural municipalities and 38 urban municipalities. Despite the many numbers of public and private facilities, access to care remains a large issue with only about 55% of the population having access to public health care services (PMI, 2017). In addition to the issue of healthcare commodity access, the overall management of the NMCP needs strengthening, especially post the recent Ebola epidemic, requiring a health system recovery plan emphasizing on the community level (PMI, 2017).

With the entire population of 12 million people at risk, the President's Malaria Initiative (PMI) has worked extensively with the NMCP since 2011 to control and prevent the disease through the collaboration on the national strategic plan and PMI's annual Malaria Operational Plan (MOP). Currently, one of the objectives of the strategic plan is to strengthen the monitoring and evaluation at all levels to support better health information management.

According to the World Health Organization (WHO), malaria surveillance optimizes interventions and empowers programs "to advocate investment from domestic and international

sources…and to allocate sources to populations most in need and to interventions that are most effective." The newly updated WHO's *Global Technical Strategy for Malaria 2016-2030* places malaria surveillance as an important core intervention – one of its three pillars of the strategy. Over the next 15 years, national programs will aim to move towards malaria elimination through better preventative measures, better testing, treatment and overall disease surveillance. With the goal of reducing malaria burden by 90% by 2030, the WHO has emphasized the need to improve regional and national collaboration, including as a part of the focus on surveillance (WHO, 2015).

Most endemic countries lack a strong malaria surveillance system. Supporting such a system nationally can be costly and difficult to set up. However, such a routine monitoring system provides crucial information that can benefit program planning, implementation, and evaluation (WHO, 2015). A major challenge in supporting an efficient malaria treatment system is the maintenance of adequate amounts of commodities, especially in rural settings. Antimalarial stock outs could lead to increased number of untreated cases and malaria-related mortality. In one example, community health workers (CHWs) in Ghana were sometimes forced to borrow commodities from their peers at neighboring health facilities during stock outs, leading to further data quality errors when reporting commodity inventories (Carlo, 2015). Stock outs are an important indicator of health system readiness and sudden interruptions in the supply chain may lead to more stress for healthcare staff and further affect the quality of service and health programs (Wagenaar, 2014). To ensure timely feedback, monthly health facility reports should be produced to inform commodity consumption and trends in infection and disease. However, due to the varying quality of routine malaria surveillance data, there is distrust in their quality assurance and thus, sometimes the large amount of data collected are never collated (Jima,

2012).

The Government of Guinea (GOG) has made strengthening of the malaria surveillance program one of its core goals. Specifically, they focus on routine data collection on programmatic performance on case management indicators and malaria commodity use (PMI, 2017). Since the late 2013, the NMCP implemented a parallel Routine Malaria Information System (RMIS) to collect malaria commodity and epidemiological data on the same form in parallel of the nonfunctioning Health Management Information System (HMIS). The RMIS served as the primary source of data for the NMCP during the Ebola epidemic. Since the RMIS scale up in 2014, significant improvements have been made in reporting completeness. The RMIS has demonstrated improved reporting completion, increasing from 66% in November 2014 to 97% in January 2016. With 36 out of the 38 districts reporting consistently, this tool is performing with 76% to 100% completion (PMI, 2016a). These figures reflect the intense efforts of the NMCP and collaborative work with the partners in addressing issues and promoting best practices for data collection. However, data quality of the RMIS was still a concern that needed to be addressed.

The variability in data quality is a major concern in its contribution to the supply chain of malaria commodities. For instance, although the RMIS is improving in reporting completion, in 2015, the RMIS over-estimated the available commodity of rapid diagnostic tests (RDT) and artemisinin-based combination therapies (ACT) by 700,000 and 1.6 million, respectively (PMI, 2017). It is important to analyze the quality of the reporting of the RMIS, in order to understand why this system tends towards an overly optimistic reflection of the available stock.

In an effort to improve commodity consumption and management, PMI collaborates with other partners to increase access and reduce stock outs. By implementing the similar end-use

verification (EUV) surveys across the nation together with United States Agency for International Development's (USAID) Systems to Improved Access to Pharmaceuticals and Services (SIAPS), it collects case management and commodity consumption data from the health facility registers. The first survey conducted in January 2013 showed that only 36% of the healthcare staff were trained in case management and about half of all malaria cases were diagnosed based on clinical symptoms alone, and about a third of these cases did not receive appropriate antimalarial. Although there has been demonstrated progress in commodity management, the EUV survey results showed that there were still considerable gaps in case management practices (PMI, 2015). The EUV was able to detect low rates of stock outs of RDTs and ACTs and various problems with case management during the crisis, contributing to the steady supply chain of commodities required during these urgent times (PMI, 2017). The EUV surveys were so well-received by the NMCP that it was expanded to all regions in July 2014, although the original plan was to focus only on three PMI target zones.

Although the RMIS has been implemented since 2013, PMI continues to implement the EUV to check the quality of data collection and reporting on a biannual basis. To best maximize resources, efforts need to focus on identifying and strengthening this RMIS surveillance system, to where eventually there is no need for the implementation of the EUV, avoiding duplication of efforts (WHO, 2016b). Conducting multiple surveys will not only cost programs extra financial burden but it also be taking away already limited human resources that could be utilized elsewhere in the healthcare system. These efforts in closer monitoring of health facilities through semiannual EUV surveys help programs to adjust in procurement, delivering only the minimum amount necessary for the health facilities.

The purpose of the project is to compare the RMIS in Guinea to the reference survey, the EUV conducted by PMI and SIAPS to evaluate the routine malaria surveillance data quality in hopes of phasing out the EUV surveys. The data collected in both were compared in terms of reporting completion, case management indicators, stock out rates, and stock levels to assess the current capacity of the RMIS. Since no formal evaluation of the RMIS has been conducted in other PMI countries by using the EUV surveys, this project contributes to the identification of essential programmatic gaps in the scaling up of malaria routine information systems. By emphasizing data collection and data quality assurance, improvements can be made to the supply chain management and consumption data to influence the forecasting of demand for programs to avoid stock outs. The lessons learned here can be applied to the strengthening of malaria surveillance systems in other PMI countries.

Methods

Introduction

This was a retrospective analysis that aimed to evaluate the malaria surveillance capacity of the Guinean NMCP by comparing the RMIS to the PMI/SIAPS EUV reports (these were used as the gold standard). We compared the four most recent EUV and RMIS reports: July 2014, December 2014, October 2015, and August 2016. The EUV surveys were provided by the USAID SIAPS Team in Guinea. The RMIS data was provided by the NMCP of Guinea.

Survey area

The four sets of data used in this research were collected in the months of July 2014, December 2014, October 2015, and August 2016, from 129 health facilities that covered the

regions of Conakry, Labe, Kindia, Faranah, Boke, N'zerekore, Mamou, and Kankan, stratified into PMI and GF zones (figure 1; appendix).

Data collection and entry

RMIS data was collected in paper format and entered into Microsoft Excel by trained health facility staff. EUV data was collected by trained PMI/USAID staff and imported into Microsoft Excel spreadsheets. Relevant data for analysis was then abstracted into and cleaned in Microsoft Excel by the first author.

Descriptive analysis

A comparison between the RMIS and the EUV total mean stock levels per health facility and the total average percent difference for each health facility per commodity were graphed using Microsoft Excel. The total mean percent difference was calculated by finding the mean RMIS stock level per commodity to indicate the RMIS stock level per health facility. Then to calculate the percent difference, we subtracted the EUV stock level from the RMIS stock level and divided this number by the EUV stock level for each health facility per commodity. Only the total minimum, maximum, and mean percent difference was used for analysis.

Statistical analysis

Proportions of the matched health facilities were calculated. "Matched" is defined as the health facilities reported in the EUV that were also reported in the RMIS. The proportion is calculated by the total number of health facilities reported in both RMIS and EUV surveys divided by the total number of health facilities reported in the EUV surveys. Health facilities

were stratified into the PMI and global fund (GF) zones and by health facility type ("Hospital/Communal Medical Center (CMC)" and "Health Center"). Proportions are calculated for the four months and a total proportion was also calculated. Each health facility was given a unique code to using its region, district and structure type.

Our sample consisted of health facilities surveyed in both the EUV and the RMIS. The list of commodities and case management indicators were determined by identifying the common items reported in both data sets. A stock out was defined as the health facility reporting zero amount for a commodity or reporting at least one day of stock out in the RMIS. In the EUV, a stock out is when there is zero amount reported in the "stock physique" row. Sensitivity, specificity, and Cohen's Kappa value were used to determine the presence or the absence of stock outs reported in the RMIS each year and the overall total across the four sets of data.

We analyzed four indicators of case management practices. The first indicator compared the proportions of correctly diagnosed confirmed malaria cases out of all consulted cases. The second indicator compared the ratio of correctly diagnosed malaria cases by age groups (less than 5, equal to or older than 5 years of age). The third indicator compared the proportion of fever cases diagnosed as malaria cases by abstracting data for confirmed malaria cases. The fourth indicator compared the proportions of confirmed patients with malaria treated with ACT by age groups (less than 5, equal to or older than 5 years of age). The corresponding case management indicators were abstracted from each survey before analysis. A chi-square test was performed to determine the statistical significance of any differences between the proportions reported for the four case management indicators for each survey and all surveys together.

A comparison of the stock levels per commodity reported in the RMIS was compared to those reported in the EUV by calculating the mean difference in each stock level for each year

and total months. The EUV stock levels for each commodity were taken from survey that corresponded to the code of each health facility. The stock level from the RMIS was represented by a mean stock level, which was calculated from each RMIS by abstracting the stock level at the beginning of the month and at the end of the month. The AL stock level abstracted from the EUV was a sum of the four age groups ("infant", "small child", "child", "adult"). In the July and December 2014 EUVs, there was no data available for AL and thus was not included for analysis. A Schuirmann's Two One-Sided Test (TOST, at 90% confidence interval) (Schuirmann, 1987) was performed for each commodity to determine the significance in mean difference between reporting.

Missing data were excluded from analysis. Data analysis was done in SAS 9.4 (SAS Institute Inc.).

Results:

Out of the 171 health facilities sampled by the EUV, 129 health facilities had data in both the RMIS and the EUV in the months of July 2014, December 2014, October 2015, and August 2016 and their case management indicators and commodity consumption data were used in analysis.

In total, on average, commodities of SP, AL, and injectable quinine were the only ones where the RMIS underestimated compared to the EUV reporting. SP demonstrated the largest difference in the total absolute stock levels between the RMIS and the EUV reporting. On average per health facility, the RMIS underestimated by 795 mean units of SP. When compared to the EUV, the RMIS underestimated AL by 166 units and underestimated injectable quinine by 150 units on average per health facility. RDT was the most overestimated commodity on average per health facility by the RMIS by 223 units. In total, there was high variability in the mean

percent difference in reporting between the RMIS and EUV per commodity (lowest: -34%, highest: 1112%). RDT was the clear outlier where it demonstrated the highest total mean difference of 1112% (10% percentile: -72%, 90% percentile: 187%). Injectable artemether had the lowest total mean difference of -34% (10% percentile: -100%, 90% percentile: 39%). The range of total mean difference was -34% to 1112%.

Health facilities reported in RMIS and EUV

There was a total of 75% (n=129, N=171) match of the facilities reporting in the RMIS compared with the EUV. In the PMI zones, 80% (n=78, N=98) matched and 70% (n=51, N=73) matched in the Global Fund zones (Table 1). In Total, 68% (n=23, N=34) of the hospitals in both zones were matched and 77% (n=106, N=137) of the health centers matched. In the GF zone, 63% ((n=10, N=16) of hospitals/CMC matched and 72% (n=41, N=57) of the health centers matched. In the PMI zone, 72% (n=13, N=18) of hospitals/CMC matched and 77% (n=106, N=137) of the health centers matched. There was only one health facility in the PMI working zone that did not have a structure name to be matched in the RMIS (classified as "NA") and was not included in the analysis.

Stock outs reported in the RMIS and EUV

Demonstrated by very high specificity across all months (0.83-1.00), results showed that overall, when the RMIS reports a stock out, there is very likely to be a true stock out (i.e., no false positives). When looking at the four months together, all commodities, except injectable artemether (specificity of 0.64), demonstrated high specificity (above 0.80). Similar high specificity trends were observed in the months of October 2015 (except for injectable artesunate,

specificity of 0.75) and August 2016 (except for injectable artemether, specificity of 0.50). Overall, the RMIS demonstrated very low sensitivity for detecting stock outs across all months. In the total four months, only the commodities aretemether-lumefantrine (AL) (0.94), injectable artesunate (0.88), and injectable artemether (0.91) demonstrated high sensitivity when reporting stock outs. Similar trends were observed in August 2016 where all but four commodities (AS-AQ adult: 0.83; AL: 0.94, injectable artesunate 0.85; injectable artemether: 0.90) reported low sensitivity. There were also low reporting rates in the three months of July 2014, December 2014, and October 2015 with multiple data missing for commodities, leading to the inability to calculate sensitivity, specificity, and kappa values. In total, there was low agreement between the reporting of stock outs of the RMIS and the EUV as the Cohen's Kappa values were generally low, except for AL (kappa=0.88), and varied dynamically across the commodities. There was discordant data in the month of December 2014, SP and injectable artemether showed a negative kappa value, -0.07 and -0.05, respectively, and in the month of October 2015, ITNs showed a negative kappa value of -0.05. Only injectable artemether demonstrated to have high sensitivity in each month (table 2; appendix).

Case management indicators reported in the RMIS and EUV

In general, results showed that when comparing the proportions of EUV and RMIS data, the RMIS was significantly different from the EUV in case management reporting. In the total months, all case management indicators demonstrated statistically significant differences in reporting malaria cases except for reporting malaria cases in individuals >5 of age (p value 0.14) and for reporting confirmed malaria cases in children <5 (p value 0.32). Only the data from the

month of August 2016 did the RMIS report significantly different from the EUV for all four case management indicators (table 3; appendix).

Stock levels reported in the RMIS and EUV

Overall, the results show that the RMIS is more likely to overestimate than to underestimate malaria commodity stock levels. In total, all commodities were overestimated except for AS-AQ infant (mean difference: -297 at CI 90%, p value 0.97), AL (mean difference: -708 at CI 90%, p value 0.81), and quinine tablets (mean difference: -11 at CI 90%, p value 0.31). The month of December 2014 had the most overestimate of commodities with all commodities being overestimated except for AS-AQ infant (mean difference: -189 at CI 90%, p value 0.91) and injectable artesunate (mean difference: -3 at CI 90%, p value 0.31). In total, the RMIS showed only the commodity of AS-AQ child was correctly reported within 20% of the EUV reports (mean difference: 43 at CI 90%, p value 0.01). In the July 2014 report, the RMIS showed only the commodity of AS-AQ adult was correctly reported within 20% of the EUV reports (mean difference: 24 at CI 90%, p value 0.04). In the December 2014 report, the RMIS showed only the commodities of AS-AQ child (mean difference: 9 at CI 90%, p value 0.05) and AS-AQ adult (mean difference: 20 at CI 90%, p value 0.04) were correctly reported within 20% of the EUV reports. (table 4; appendix).

Discussion

The results show that the RMIS demonstrates variability in data quality and will require further improvement if it is to be used as a tool for forecasting demand of malaria commodities and alerting stock outs due to the inconsistency in matching reports when compared to the EUV

surveys. There was high variability in the total mean stock levels per health facility and in the total mean percent difference in reporting for each commodity. Although the RMIS demonstrated moderately high levels of health facility reporting, it is inconsistent in data reporting in terms of malaria commodity stock outs and case management indicators. PMI should continue to collect data on commodity consumption and case management indicators through the EUV surveys to provide accurate, rapidly available information for the NMCP and partners. These findings are consistent in all four monthly datasets and in the overall total months, indicating the need to continue implementing the EUV surveys across both the PMI and GF zones. The ability of the RMIS to detect most commodity stock outs is poor and therefore, should not be relied upon as a tool to alarm the health facilities of stock outs. However, its high specificity in almost all commodities reveal that the RMIS will almost always be reliable when it reports a stock out in a commodity. The varying degrees of agreement in stock out reporting between the RMIS and the EUV should be taken into consideration when looking at the data in the RMIS. The RMIS also differed significantly from the EUV in terms of reporting malaria case management indicators. The reporting of stock levels in general reflected the RMIS survey's tendency to overestimate the commodities at each health facility. This overestimation of stock levels is not an accurate but overly optimistic view of the commodities available for treatment.

The strong reporting rates across the datasets can be explained by the malaria report template and e-processing established in 2013 in the PMI zones. This can be attributed to the collaboration between SIAPS and the NMCP to promote regional meetings with a focus on the sharing of best practices and reviews of collected data in order to efficiently organize and improve the pharmaceutical management information system (PMIS) (SIAPS, 2015).

The poor detection of commodity stock outs and poor accuracy of reporting stock levels is still not properly addressed. According to the PMI 2015 EUV report, only 53% overall or 64% health facilities in the PMI zones have reference guides for stock management available for its healthcare staff. This realization should trigger the NMCP and partners to organize more stock management trainings for all healthcare staff at every level. The NMCP and SIAPS should implement trainings that consider incorporating components of the national strategic plan for the pharmaceutical system so healthcare workers understand the national strategies for strengthening of the supply chain management and how healthcare worker capacity for supply management is important in health access and management. Frequent malaria stock outs can change provider prescription behavior over time. In a systematic review done by Hensen et al., if prescribers know that ACT was out of stock, they are less likely to prescribe ACT and prescribe an alternative, traditional mono-therapy drug. The inefficiency in distributing commodities to health facilities may be a reason for stock outs. The stock outs of commodities directly attribute to malaria mortality because the lack of essential and appropriate medicines is a concerning factor, especially in rural areas where there are even fewer alternatives such as private pharmacies or clinics (Hensen, 2011). There have not been many studies that have examined the factors that affect stock levels and the availability of essential health commodities in sub-Saharan Africa at the health levels, thus, it is difficult to identify specific characteristics in the supply chain that require more attention (Hasselback, 2014). However, the national government should focus on the continuous provisions of commodities, especially for RDTs, ACTs, and injectable artemether, since they demonstrated the lowest stock levels. These are also essential commodities that fit into the national program of ensuring universal testing of all suspect malaria

cases with RDTs and providing treatment with ACTs for uncomplicated malaria and injectable artesunate or artemether for severe malaria (PMI, 2017).

Even though case management training and supervision has increased since 2014, there is still a large discrepancy in its indicator reporting. According to the 2015 PMI EUV report, only 67% of the facilities surveyed received supervision on case management even when the malaria treatment guidelines are widely available in many health facilities (84% country-wide or 96% in the PMI zones). As malaria is still a great public health threat, seeking urgent care and receiving proper treatment is crucial in preventing malaria related mortality. If there are inadequate stock levels, patients may try to use their own money to obtain alternative treatment from elsewhere that may lead to negative health consequences or mortality if treatment was not sought on time (Hensen, 2011). Program managers should also have the capacity to use this data to made programmatic changes and corrective action on why the data quality is so poor.

A strength of this study was the large sample size of the health facilities incorporated in this study (n=129). The selection of health facilities in regions and districts in the EUV surveys was randomized so this reduces bias. Another strength of this study is that it was able to analyze four sets of surveys collected in the span of three years, providing a progression of reporting capacity of the RMIS.

There were multiple limitations to this study. Incomplete data was a major issue. Although monthly health facility reporting completeness was 92% in 2016 (calculated as number of monthly reports received from health facilities divided by the number of health facility reports expected), the data quality was poor (PMI, 2017). In the July 2014 EUV report, there was one health facility that was reported but did not indicate a health facility name. Thus, this was excluded from the overall health facility count. Still, many health facilities had matched

reporting in corresponding EUV surveys, but there were numerous missing data sections from each set of surveys. These were not included in the analysis and consequently could have affected the evaluation of the accuracy of stock outs. In the months of July and December 2014, there was no data collected in the EUV for AL and thus, AL consumption could not be evaluated. This issue in data quality may have also affected the reporting in difference in stock levels. The incomplete reports on each commodity may have skewed the actual commodity levels at site.

A limitation in reporting discordant stock outs and stock levels by the two surveys may be due to the timing of data collection or how data were aggregated. This is because EUV is a survey that is done semi-annually, collecting data at health facilities that reports a point estimate of the case management indicators and commodity consumptions. This one-time inspection of health facility indicators may be greatly impacted by when the commodities are distributed, (i.e., may capture or miss the intended distribution of commodities). However, the RMIS collects data throughout the month and will include all the provided commodities in its reports. Thus, a single missed commodity distribution day may greatly affect the reporting of the EUV.

Since the two surveys did not report on identical indicators for either case management or commodity consumption data, a limitation is that some abstracted raw data from the EUV may not accurately represent the indicators presented in the RMIS. There was inconsistency in reporting in the EUV where some cases were double counted in the sample subsection, leading to difficulties comparing some case management indicators such as fever cases and suspect cases. However, this was not unexpected of this RMIS because newly established RMIS tend to face similar issues like poor data quality (Khamsiriwatchara, 2012).

Lastly, the July and December 2014 RMIS data may have been skewed due to the Ebola outbreak since the virus greatly affected the overall management of malaria cases in Guinea. In both areas affected and unaffected by EVD, CHWs reported the changes in health facility in terms of decreased health facility attendance, patient visits, fever cases, and number of patients treated for malaria. This may have been explained by the overall fear of visiting health facilities experienced by the public (Plucinski, 2015). Data reported in the July and December 2014 RMIS may have been skewed due to this change in behavior, consequently affecting cases reported and commodity consumption.

Additional training in case management or frequent malaria refresher trainings are suggested for CHWs and supervisors. The NMCP and partners should plan to include activities that support surveillance, monitoring and evaluation as training priorities to address the issues around data quality. Until further trainings are provided and reporting results have improved, the RMIS should not be relied upon as a tool to alert stock outs or serve as a commodity forecasting tool.

In order to strengthen the supply chain management, there needs to be better coordination and communication between programs and partners. The RMIS is composed of commodity data and epidemiological data, therefore it is strongly influenced by the availability of stocks and how many malaria cases there are. The coordination amongst the PCG, the NMCP and PMI needs to be stronger to better triangulate the flow of commodities to ensure there are no ruptures in the supply chain. Routine meetings should be set up to communicate challenges, review information collected, and make collaborative decisions towards next steps. Ideally, the RMIS should serve as a tool that can recognize and alert any deviations from the expectations so the routine system

can operate at its optimal capacity. Any of these deviations should be communicated to decision makers in a timely manner to initiate a response (Hasselback, 2014).

The PMI team should continue to implement the semiannual EUV surveys to evaluate the RMIS surveys in terms of case management indicators and commodity consumption at the health facility level. The RMIS did not have the ability to appropriately detect and report stock levels and stock outs with proper case management due to its poor data quality in reports. More programmatic support is needed to strengthen proper data collection and reporting in conjunction with further training in case management and pharmaceutical management. The NMCP and partners should provide work plans that include training in improved strategies in commodity consumption management, integration of malaria-specific supervision and data verification strategies. The key outcomes and observations of the monthly reports should be disseminated to guide procurement plans and malaria specific training manuals for healthcare workers.

Appendix

Table 1. Proportions of health facilities reported in both the EUV and the RMIS stratified by program zones and health facility type

	July 2014	December 2014	October 2015	August 2016	Total
Program zones	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**
GF	7/8 (88)	9/ 13 (69)	10/20 (50)	25/32 (78)	51/73 (70)
Health Facility	**n*/N* (%)**	**n*/N* (%)**	**n*/N* (%)**	**n*/N* (%)**	**n*/N* (%)**
Hospital/CMC	1/2 (50)	1/3 (33)	2/4 (50)	6/7 (86)	10/16 (63)
Health Center	6/6(100)	8/10 (80)	8/16 (50)	19/25 (76)	41/57 (72)
Program zones	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**
PMI	20/23 (87)	15/18 (83)	20/25 (80)	23/32 (72)	78/98 (80)
Health Facility	**n † /N † (%)**	**n † /N † (%)**	**n † /N † (%)**	**n † /N † (%)**	**n † /N † (%)**
Hospital/CMC	5/5 (100)	3/4 (75)	3/5 (60)	2/4 (50)	13/18 (72)
Health Center	15/18 (83)	12/14 (86)	17/20 (85)	21/28 (75)	65/80 (81)
Total Program Zones	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**	**n/N (%)**
	27/31 (90)	24/31 (77)	30/45 (67)	48/64 (75)	129/171 (75)
Total Health Facility	**n ‡ /N ‡ (%)**	**n ‡ /N ‡ (%)**	**n ‡ /N ‡ (%)**	**n ‡ /N ‡ (%)**	**n ‡ /N ‡ (%)**
Hospital/CMC	6/7 (86)	4/7 (57)	5/9 (56)	8/11 (73)	23/34 (68)
Health Center	21/24 (88)	20/24 (83)	25/36 (69)	40/53 (75)	106/137 (77)

CMC: Communal Medical Center

n: Total number of health facilities reported in both RMIS and EUV surveys

N: Total number of health facilities reported in the EUV surveys

n*: Total number of health facilities reported in both RMIS and EUV surveys in the GF zone

N*: Total number of health facilities reported in the EUV surveys in the GF zone

n † : Total number of health facilities reported in both RMIS and EUV surveys in the PMI zone

N † : Total number of health facilities reported in the EUV surveys in the PMI zone

n ‡ :Total number of health facilities reported in both RMIS and EUV surveys in both program zones

N ‡ :Total number of health facilities reported in the EUV surveys in both program zones

Table 2. Accuracy of commodity stock out status reporting of the RMIS compared to the stock out reporting of the EUV

	July 2014			December 2014			October 2015			August 2016			Total		
	HF matched (%)			HF matched (%)			HF matched (%)			HF matched (%)			HF matched (%)		
	27/31 (90)			24/31 (77)			30/45 (67)			48/64 (75)			129/171 (75)		
Commodity	**se**	**sp**	**k**	**se**	**sp**	**k**	**se**	**sp**	**k**	**se**	**sp**	**k**	**se**	**sp**	**k**
RDT	0.25	1.00	0.36	-	1.00	-	0.80	1.00	0.87	0.11	1.00	0.13	0.23	1.00	0.32
AS-AQ Infant	0.25	1.00	0.36	-	1.00	-	0.00	1.00	0.00	0.56	0.94	0.54	0.43	0.98	0.51
AS-AQ Small Child	-	1.00	-	-	1.00	-	-	1.00	-	0.50	1.00	0.55	0.45	1.00	0.58
AS-AQ Child	-	1.00	-	-	1.00	-	-	1.00	-	0.30	0.97	0.34	0.21	0.99	0.30
AS-AQ Adult	0.33	0.91	0.25	0.25	0.95	0.25	1.00	1.00	1.00	0.83	0.97	0.81	0.57	0.96	0.57
AL Total	-	-	-	-	-	-	-	1.00	-	0.94	0.90	0.84	0.94	0.94	0.88
SP	0.50	0.95	0.50	0.00	0.94	-0.07	-	1.00	-	0.13	0.97	0.14	0.18	0.97	0.20
Injectable Artesunate	1.00	0.00	0.00	1.00	1.00	1.00	0.33	0.75	0.09	0.85	1.00	0.44	0.88	0.90	0.71
Injectable Artemether	1.00	-	-	0.95	0.00	-0.05	1.00	0.83	0.59	0.90	0.50	0.42	0.91	0.64	0.57
Injectable Quinine	1.00	0.96	0.65	0.40	0.94	0.40	0.44	0.94	0.44	0.43	0.85	0.28	0.47	0.93	0.42
Quinine Tablets	0.87	0.63	0.51	0.89	0.75	0.58	0.73	0.94	0.68	0.28	1.00	0.32	0.68	0.91	0.58
ITNs	1.00	1.00	1.00	0.55	1.00	0.50	0.00	0.95	-0.05	0.70	1.00	0.67	0.70	0.98	0.70

HF: Health facilities
n: Total number of health facilities reported in both RMIS and EUV surveys
N: Total number of health facilities reported in the EUV surveys
se: sensitivity
sp: specificity
k: Cohen's Kappa value
RDT: Rapid diagnostic tes
AS-AQ: Artesu-te-Amodiaquine
SP: Sulfadoxine pyrimethamine
ITNs: Insecticide treated nets

Table 3. A comparison of the difference in ratios of cases by age groups in the RMIS and the EUV

Case Management Indicator	EUV July 2014 (%)	RMIS July 2014 (%)	p value*	EUV December 2014 (%)	RMIS December 2014 (%)	p value✢	EUV October 2015 (%)	RMIS October 2015 (%)	p value ✝	EUV August 2016 (%)	RMIS August 2016 (%)	p value ✡	Total EUV (%)	Total RMIS (%)	p value ✠
Malaria cases vs. non malaria cases															
Confirmed malaria cases all ages	17	35	<0.0001	25	28	<0.0001	41	34	<0.0001	26	35	<0.0001	26	34	<0.0001
Malaria cases by age group															
Malaria cases <5	37	36	0.56	35	33	0.03	27	28	0.33	40	36	<0.0001	35	34	0.0014
Malaria cases >5	63	65	0.06	67	67	0.55	71	72	0.60	60	62	0.002	65	65	0.14
Fever cases diagnosed as malaria cases															
Confirmed malaria cases	45	69	<0.0001	53	57	<0.0001	61	71	<0.0001	50	72	<0.0001	52	69	<0.0001
Malaria patients given ACT															
Confirmed malaria cases <5	69	87	<0.0001	82	92	<0.0001	81	90	<0.0001	92	82	<0.0001	85	85	0.32
Confirmed malaria cases >5	56	78	<0.0001	72	79	<0.0009	79	88	<0.0001	72	84	<0.0001	70	83	<0.0001

*Comparison of the proportions of EUV and RMIS data reported in July 2014
✢Comparison of the proportions of EUV and RMIS data reported in December 2014
✝ Comparison of the proportions of EUV and RMIS data reported in October 2015
✡ Comparison of the proportions of EUV and RMIS data reported in August 2016
✠Comparison of the proportions of EUV and RMIS data reported in total

EUV: End-use verification
RMIS: Routine Malaria Information System
ACT: Artemisinin-based combination therapy

Table 4: A comparison of the RMIS and the EUV's malaria commodity stock levels reported in mean difference using the Schuirmann's Test ✢

	July 2014		December 2014		October 2015		August 2016		TOTAL	
Commodity	**Mean difference [90% CI]**	**p value**	**Mean difference [90% CI]**	**p value**	**Mean difference [90% CI]**	**p value**	**Mean difference [90% CI]**	**p value**	**Mean difference [90% CI]**	**p value**
RDT	-16 [-248, 216]	0.06	412 [-350, 1174]	0.51	-118 [-509, 273]	0.21	365 [-91, 822]	0.63	179 [-57, 415]	0.30
AS-AQ Infant	-132 [-225, -39]	0.95	-189 [-383, 5]	0.91	-191 [-360, -22]	0.84	-509 [-1056, 38]	0.92	-297 [-506, -88]	0.97
AS-AQ Small Child	536 [219, 854]	0.98	1215 [626, 1804]	0.98	355 [20, 689]	0.80	-195 [-759, 369]	0.63	357 [92, 623]	0.86
AS-AQ Child	18 [-32, 67]	0.06	9 [-81, 99]	0.05	-20 [-133, 94]	0.06	111 [-11, 234]	0.26	43 [-11, 98]	0.01
AS-AQ Adult	24 [-15, 63]	0.04	20 [-49, 88]	0.04	-83 [-265, 100]	0.42	234 [-13, 482]	0.78	79 [-21, 179]	0.38
AL Total	-	-	-	-	-415 [-1012, 182]	0.75	-775 [-1784, 233]	0.79	-708 [-1524, 108]	0.81
SP	949 [-549, 2447]	0.70	53 [-1271, 1378]	0.20	689 [-896, 2274]	0.52	-397 [-1519, 725]	0.28	217 [-454, 888]	0.13
Injectable Artesunate	-	-	-3 [-22, 16]	0.31	199 [-19, 418]	0.90	-3 [-11, 6]	0.52	30 [-6, 66]	0.80
Injectable Artemether	-	-	-	-	-149 [-434,135]	0.46	265 [-125, 654]	0.85	194 [-132, 520]	0.77
Injectable Quinine	74 [-46, 194]	0.29	62 [-51, 174]	0.53	5 [-15, 26]	0.05	-27 [-93, 39]	0.55	19 [-21, 60]	0.11
Quinine Tablets	-819 [-2289, 651]	0.80	60 [-24, 143]	0.71	-1 [-176, 174]	0.11	361.30 [-94.03, 816.60]	0.77	-11 [-347, 325]	0.31
ITNs	-31 [-61, -1]	0.09	80 [-83, 243]	0.62	267 [-245, 778]	0.70	138.30 [-2.61, 279.30]	0.71	127 [2, 251]	0.73

✢ Schuirmann's Two One-Sided Test at 90% Confidence Intervals
CI: Confidence interval
RDT: Rapid diagnostic test
AS-AQ: Artesunate-Amodiaquine
SP: Sulfadoxine pyrimethamine
ITNs: Insecticide treated nets

Figure 1. RMIS indicators, January-December 2015 (Reproduced from PMI MOP 2017)

Indicators [Data source for all indicators is RMIS (monthly malaria reporting system)]	**Value**	**Comments**
Total number of reported malaria cases	918,412	
Total diagnostically confirmed cases	891,175	"Diagnostically confirmed cases" are estimated based on the total number of reported malaria cases minus the total number of clinic/presumed/unconfirmed cases reported by the NMCP
Total clinical/presumed/unconfirmed cases	27,237	"Cases treated, not confirmed" (cases treated-confirmed cases)
If available, report separately for outpatients and inpatients		Not reported by outpatient/inpatient but by uncomplicated and severe cases
Number of reported uncomplicated malaria cases	800,314	
Diagnostically confirmed	N/A	Diagnostic confirmation information is not captured for uncomplicated versus severe malaria on the current NMCP reporting form
Clinical/presumed/unconfirmed	N/A	Not captured on report form
Number of reported severe malaria cases	118,098	
Diagnostically confirmed	N/A	Diagnostic confirmation information is not captured for uncomplicated versus severe malaria on the current NMCP reporting form
Clinical/presumed/unconfirmed	N/A	Not captured on report form
Total number of reported malaria deaths	846	
Diagnostically confirmed	846	
Clinical/presumed/unconfirmed	N/A	Not captured on report form
Malaria test positivity rate (outpatients)	70%	
Numerator: Number of outpatient confirmed malaria cases	891,175	

Denominator: Number of outpatients receiving a diagnostic test for malaria (RDT or microscopy)	1,279,109	
Completeness of monthly health facility reporting	92% (Jan-Dec)	District level: 98% complete
Numerator: Number of monthly reports received from health facilities	5,070	District level: 447
Denominator: Number of health facility reports expected (i.e., number of facilities expected to report multiplied by the number of months considered)	5,496	District level: 456 (38 districts x 12 months) Out of 426 missing health facility reports, 182 were from hospitals (43%)

Figure 2. EUV Indicators (Reproduced from PMI EUV Guidance 2010)

SUPPLY CHAIN INDICATORS			
Indicator	Form	Rationale	Numerator/Denominator
1. *Percentage of facilities that have unexpired product on the day of the supervisory visit*	Stock Status Table	To measure the availability of quality malaria medicines and commodities in HF and medical stores	*Numerator*: For each product, include if Physical Inventory > 0
			Denominator: Include all facilities that manage the product
2. *Percentage of facilities with expired X on the day of the supervisory visit*	Stock Status Table	To measure the availability of quality malaria medicines and commodities in HF and medical stores	*Numerator*: For each product, include if the quantity expired today > 0
			Denominator: Include all facilities that manage the product
3. *Percentage of facilities with stock outs of X for 3 days or more in last 3 months*	Stock Status Table	To ensure continuous availability of medicines and supplies	*Numerator*: For each product, include if it was stocked out for longer than 3 days in the previous 3 months
			Denominator: Include all facilities that manage the product and that have an updated stock card for that product
4. *Avail ACT for uncomplicated malaria* Calculated for each facility, and	Stock Status Table	To determine whether or not there are facilities that are completely unable to treat	*Numerator*: Number of ACT presentations that the facility has in stock

also as a pie chart representing the whole, with each slice representing the number of facilities with no presentations, 1 presentation, 2 presentation and so on.		malaria with ACTs, due to being stocked out of all 4 presentations.	
			Denominator: Total number of ACT presentations each facility is expected to have in stock
5. *Percentage of facilities with up-to-date stock cards*	Stock Status Table	To improve medicines management by identifying areas of improvement	*Numerator*: Number of facilities with updated stock cards
			Denominator: Include all facilities that manage the product
7. *Months of Stock*	Stock Status Table	To provide context to the overall stock levels reported	*Numerator:* sub-numerator: For each product, sum the physical inventory sub-denominator: For each product, divide the number of issues in the last three months by the number of months of data available
			Denominator: Include the number of facilities that manage the product and have a stock card for that product
8. *Duration of stockout*	Stock Status Table	To ensure continuous availability of medicines and supplies	*Numerator*: For each product, sum the total number of days stocked out

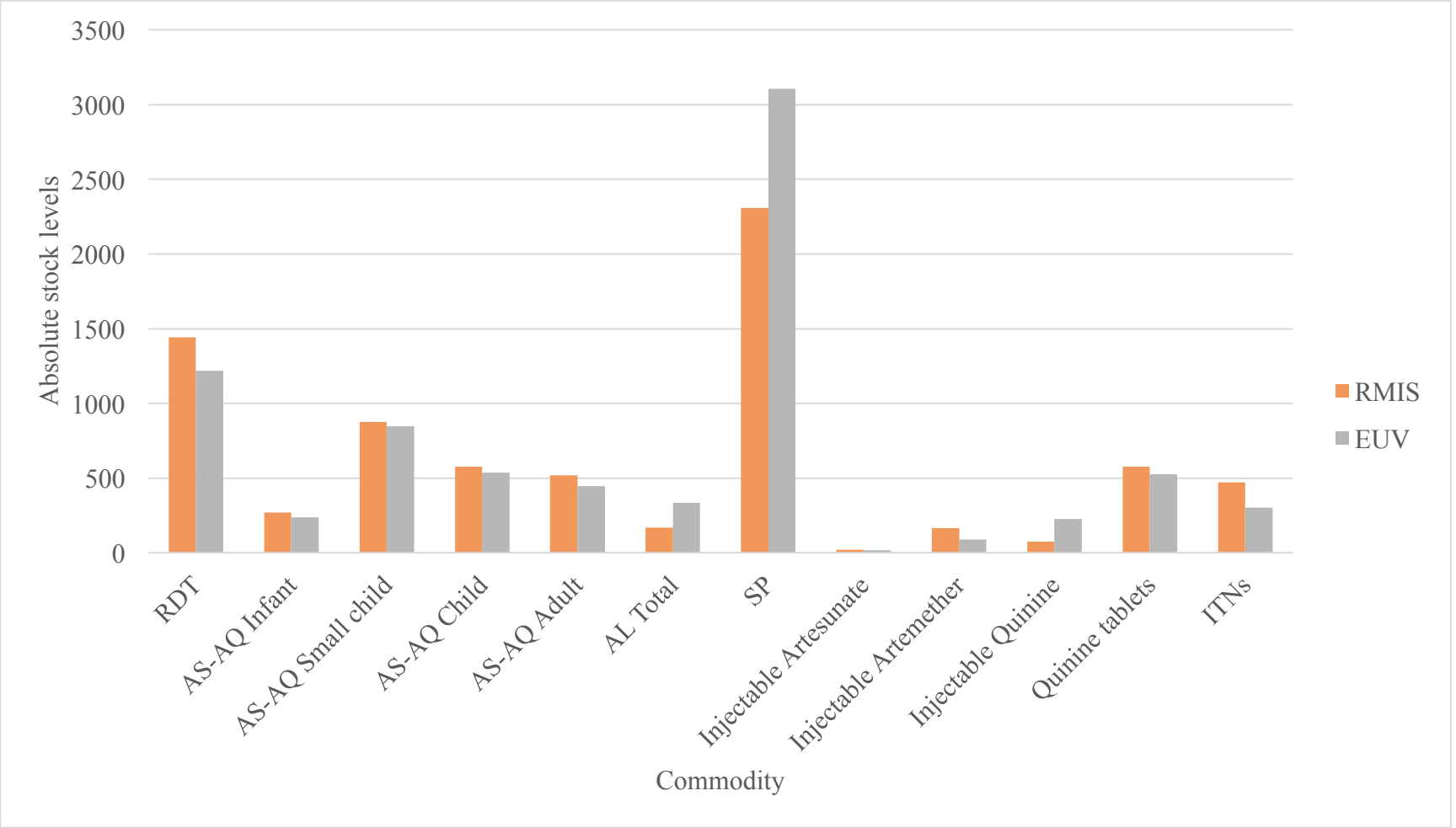
			Denominator: For each product, the total number of stockouts lasting longer than 3 days
9. *Shipped vs. Received: Percentage of facilities falling into each of three categories:* • *Received less than what was shipped* • *Received more than what was shipped* • *Received what was shipped*	Shipped vs. Received	To monitor the distribution system and identify problems such as compliance with delivery SOPs and record keeping	*Numerator*: Facilities will be separated into one of the following 3 numerators: 1. Quantity shipped is greater than what was received 2. Quantity shipped is less than what was received 3. Quantity shipped equals what was received
			Denominator: All three of the above numerators will be divided by the same denominator – the total number of facilities for which there are records for what was shipped and what was delivered for the most recent shipment.
10. *Ordered vs. Received: Percentage of facilities falling into each of three categories:* • *Received less than what was ordered* • *Received more than what was ordered*	Ordered vs. Received	To determine the magnitude of discrepancy between quantity ordered and quantities received to assess ordering adequacy, product availability and identify related areas of intervention	*Numerator*: Facilities will be separated into one of the following 3 numerators: 1. Quantity shipped is greater than what was ordered 2. Quantity shipped is less than what was ordered 3. Quantity shipped equals what was ordered

• *Received what was ordered*			
			Denominator: All three of the above numerators will be divided by the same denominator – the total number of facilities for which there are records for what was ordered and what was received for the most recent shipment.
11. *Percentage of facilities with at least one person trained in X*	Facility Questionnaire	To determine availability of human resources trained in managing supply chain issues, malaria case management and diagnosis at each level of the health system	*Numerator*: For each training area, the number of facilities that have at least one person trained
			Denominator: Total number of facilities visited
11. *Percentage of staff working in X that is trained in X at each level of supply chain*	Facility Questionnaire	To determine availability of human resources trained in managing supply chain issues, malaria case management and diagnosis at each level of the health system	*Numerator*: For each training area, sum total of people trained
			Denominator: For each training area, sum total of the people working in that area

12. *Percentage of facilities receiving supervision for logistics/inventory management during the previous 6 months*	Facility Questionnaire	To measure capacity building efforts for improved for inventory management	*Numerator*: Total number of facilities receiving supervision in logistics/inventory management during the previous 6 months
			Denominator: Total number of facilities visited
13. *Percentage of facilities receiving supervision for malaria case management during the previous 6 months*	Facility Questionnaire	To measure capacity building efforts for improved case management of malaria	*Numerator*: Total number of facilities receiving supervision in malaria case management during the previous 6 months
			Denominator: Total number of facilities visited
14. *Percentage of facilities with reference guidelines for malaria case management*	Facility Questionnaire	To measure the availability of guidelines for malaria case management	*Numerator*: Total number of facilities with guidelines for malaria case management available commodities
			Denominator: Total number of treating facilities visited
15. *Percentage of facilities with SOPs for management of malaria commodities*	Facility Questionnaire	To measure the availability of standard operating procedures	*Numerator*: Total number of facilities with SOPs available for the management of malaria commodities
			Denominator: Total number of facilities visited

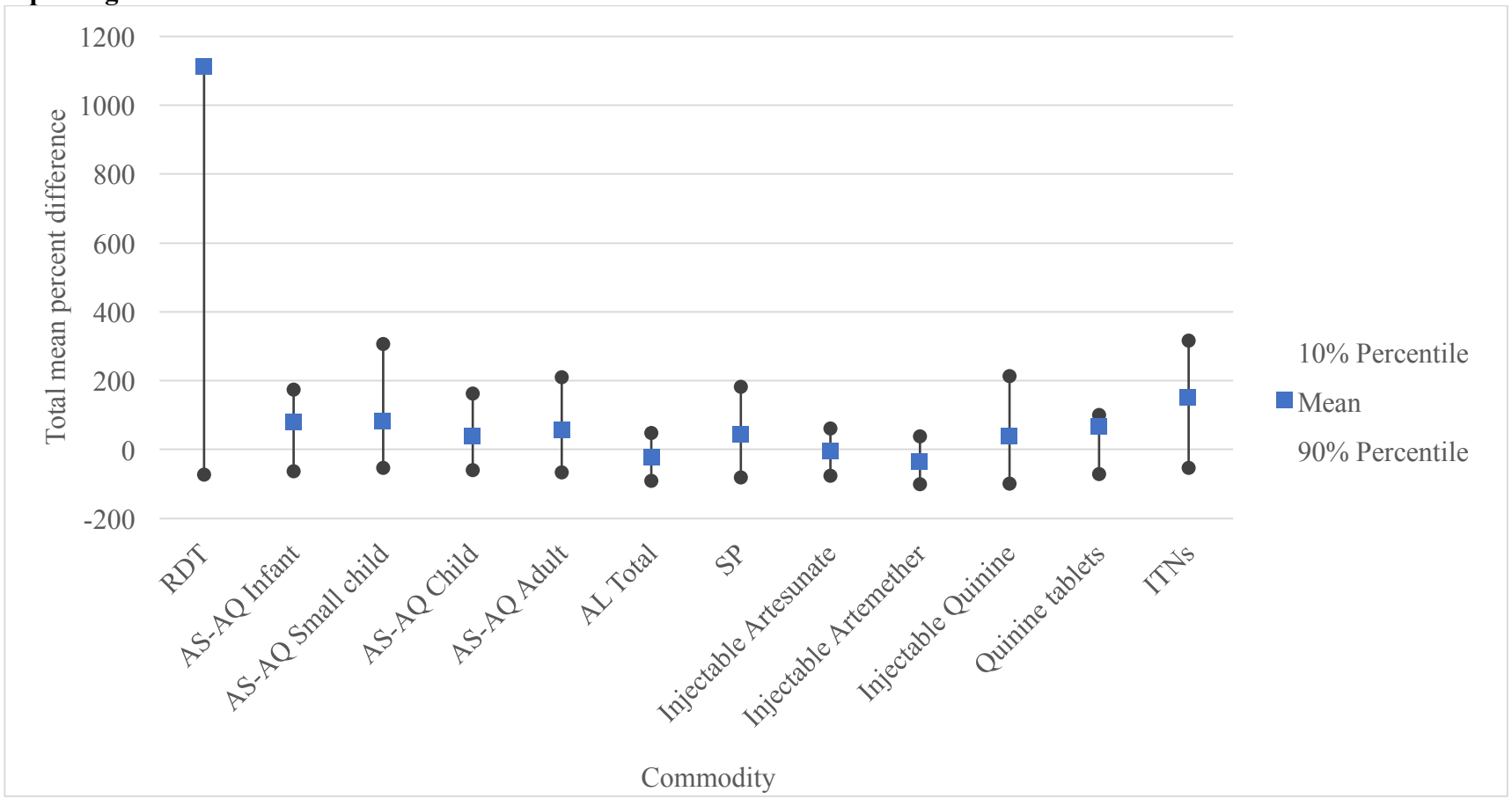
16. *Reporting Rates*	Facility Questionnaire	To determine whether information on stock levels is passed on to the higher level for monitoring and planning purposes	*Numerator*: Total number of facilities reporting on time for the last reporting period
			Denominator: Total number of facilities visited
17. *Percentage of facilities with acceptable storage conditions on day of the visit*	Storage Conditions Form	To measure the extent to which appropriate storage conditions exist	*Numerator*: Total number of facilities with appropriate storage conditions on the day of the visit
			Denominator: Total number of facilities visited

Figure 3. Total mean absolute stock levels between RMIS and EUV reporting



RMIS: Routine malaria information system
EUV: End-use verification
RDT: Rapid diagnostic test
AL Total: Aretemether-lumefantrine of all ages
SP: Sulfadoxine-pyrimethamine
ITNs: Insecticide treated ne

Figure 4. The total mean percent difference (with 10%, 90% percentiles) per malaria commodity between RMIS and EUV reporting



RMIS: Routine malaria information system
EUV: End-use verification
RDT: Rapid diagnostic test
AL Total: Aretemether-lumefantrine of all ages
SP: Sulfadoxine-pyrimethamine
ITNs: Insecticide treated nest

Chapter 4: Conclusions and Implications

With Guinea's entire population of 12 million people to be at risk and a year-round malaria transmission, the malaria burden in country is high (PMI, 2017). The NMCP has a national strategic plan that aims to reduce malaria mortality to near zero by the end of 2017. Since the late 2013, the NMCP has been collecting epidemiological and commodity consumption data through the RMIS in order to strengthen the SM&E activities in malaria surveillance. To evaluate the capacity of this malaria surveillance system, this study compared the case management indicators and commodity consumption data to that collected by the EUV surveys implemented by PMI. The results have shown that the RMIS requires significant improvement in order to be at the capacity to be the lone routine information system reporting on malaria information. Our findings suggest that for the time being, PMI should continue to implement the biannual EUV surveys in both the PMI and GF zones to provide a more accurate depiction of the malaria information at the health facility levels that will provide the NMCP and partners rapidly available and actionable information. Although completeness in reporting at the health facility level was high at 92% (PMI, 2017) and 75% of the health facilities in the RMIS contributed data, the RMIS demonstrated poor quality in data. An ideal malaria routine monitoring system should incorporate well trained staff that can collect and report reliable data that enables tracking of trends and patterns in coverage, case management and consumption over time (Guenther, 2014). Quality-controlled data are the foundation of a strong public health surveillance tool that can influence and develop strategic plan for routine system strengthening. Not being able to accurately alert a stock out in the supply chain due to its inconsistency in reporting stock levels indicates that the RMIS needs to be improved.

Since the new millennium, malaria incidence and mortality rates have decreased by 37% and 60% globally with about 70% of those reductions coming from the countries in sub-Saharan Africa due to the tremendous efforts made in malaria interventions (Cibulskis, 2016). However, an increase in access and treatment programs is not sufficient without a timely functioning supply chain management of the commodities and appropriate case management skills to ensure the proper diagnosis and treatment of malaria. The NMCP and partners should also focus on the training of healthcare workers and data collected from private facilities in an effort to harmonize strategies and maximize opportunities for technical support. Governments should also implement more programs on CHW training with a more rigorous malaria curriculum that incorporates some management skills of the commodities.

While additional training for healthcare workers may seem essential, the extensive programs may strain both human and financial resources of the NMCP, partners and the workers. Long hours and time away from health posts equates to health workers' time away from their regular jobs, patients, and family responsibilities. Health programs may need to budget additional finances to support the logistics of training, cost of materials, per diem, and other miscellaneous costs required to provide for the event (Harvey, 2008). With most trainings scheduled before the rainy reasons in Guinea, taking CHWs away from their farm work is a potential problem, causing these workers unnecessary stress (Siribie, 2016). Therefore, we suggest that the NMCP provide more administrative interventions that target the key stakeholders such as the PCG, the health facilities, and implementing partners to promote the strengthening of the RMIS.

This study analyzed four sets of data collected over the span of two years. Of note, with the disruptions caused by the Ebola epidemic during this time period, malaria reporting was also

affected. Our results may therefore underestimate the ability of the RMIS to serve as a good alert system of stock outs and overall good surveillance system during routine non-epidemic time periods. More analysis is needed to incorporate a longer time frame and preferably with no other simultaneously occurring epidemics or health emergencies. In the hopes of a revised RMIS, future analysis may reevaluate the survey using similar indicators, but stratify also by pregnant women in the case management analysis and analyze where the stock outs cluster using geospatial analysis to better improve the access to healthcare.

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