SCHOOL OF PUBLIC HEALTH
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UNIVERSITY OF GHANA

ASSESSMENT OF MALARIA PARASITE RATE AND SYSTEM ATTRIBUTES IN THE SENTINEL SURVEILLANCE SITES IN GREATER ACCRA REGION.

BY
Thierry KALONJI MUKENDI
(10590360)

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ABSTRACT

Background

Malaria remains a major public health problem in the world. In Ghana, the entire population of 24.2 million is at risk of malaria infection. Malaria is endemic and perennial in all parts of the country, with seasonal variations that are more pronounced in the north. From 2010 to 2015, Ghana has reduced by 45% malaria deaths. Progress in reduction of malaria prevalence has been recorded in the routine surveillance system through Health Management Information System but unfortunately that data suffers from reliability from presumed malaria.

Therefore, Ghana established the sentinel surveillance system in 2013, with the aim to monitor the prevalence of malaria in the country and minimizing the proportion of cases of presumed malaria. Since this establishment the sentinel surveillance system, the indicators generated by the system show a clear progression in the control of malaria. Nevertheless, there is no evidence about how effective the system is performing.

This study seeks to evaluate the performance of the malaria sentinel surveillance system, by assessing its attributes in the Greater Accra region; and also, determine the prevalence of malaria during that same period.

Methods: This study was cross-sectional and used secondary quantitative data and methods to derive malaria positivity rate in sentinel sites in the Greater Accra region. Data on malaria indicators were extracted from District Health Management Team e-database for January 2014 to December 2016. The data were analyzed to show both slide and RDT malaria positivity rate, proportion of suspected malaria case, and testing rate. Based upon CDC the Centre for Disease Control, Atlanta updated guideline for evaluating Public health

surveillance system, keys system attributes were assessed and described. Epi info was used to generate frequencies, proportions and chi square test at 5% confidence level.

Results: In general, the rate of malaria positivity and the proportion of suspected cases of malaria prescribed with ACTs have decreased over time. From 2014 to 2016, this decrease ranged from 25% to 12.2% for malaria positivity and from 61.4% to 29.6% for proportion of suspected malaria cases. There was also an increase of testing rate from 81.7 to 98 % over the study period. Data quality is particularly poor in the Obom health center sentinel surveillance site. However, overall the internal completeness of the surveillance system was satisfactory. Data from Sentinel sites was getting more and more accurate over time, when comparing with Noguchi Memorial Institute for Medical Research data. Positive predictive value ranged from 12.0% to 20.4 % in 2014 to 2016, declining over time while Sensitivity increased leading to the increase of number of suspected cases since 2014.

Conclusion: The testing rate in the malaria surveillance sites during the study period increased, resulting in a decrease in the use of ACTs. Majority of suspected cases were tested and classified according to outcomes. Malaria positivity rate also decreased significantly in the course of these three years. The data are generally of good quality, representing very well the community in terms of place and people. The application of T3 (Test, Treat and Track) and case definition by the system, increased the systems sensitivity to the detriment of the positive predictive value.

Keys words: evaluation, Surveillance, sentinel site, malaria

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CHAPTER ONE

INTRODUCTION

Malaria remains the most important parasitic disease, being a major threat in the world and leading to some 600,000 deaths per year (Tanner et al., 2015).

In areas with high transmission of malaria, children under 5 are particularly susceptible to infection, illness and death; more than two thirds (70%) of all malaria deaths occur in this age group (WHO, 2016).

In areas with high malaria transmission, children under five years of age are particularly susceptible to infection, disease and death; More than two thirds (70%) of all malaria deaths occur in this age group.

In Africa, malaria constitutes on average 30% of all clinical consultations, most of which are only clinical. In these African countries, nearly 50% of all hospitalizations are due to malaria with high case-fatality (RBM, 2010).

"Furthermore, most cases of malaria are diagnosed on the basis of clinical symptoms and treatment is presumptive, rather than based on laboratory confirmation. The main clinical symptoms of malaria – fever and general weakness – are nonspecific and may well be due to other common infections" (RBM, 2010).

The progress of Ghana in malaria control is remarkable reducing by 45% in malaria deaths from year 2010 to year 2015 (DHIMS,2016).

In fact, through its malaria control program, Ghana aims to reduce the overall malaria morbidity and mortality by 75% (using 2012 as a baseline which was 12.6%); (NMCP, 2016).

"The development and strengthening of systems to collect, process, analyze and manage data on malaria transmission and the burden of disease is the objectives of the National Control monitoring and evaluation plan" (Ghana Health Service (GHS), 2013).

The routine service data coming from the health facilities is the main source of data for the malaria surveillance system (Ghana Health Service (GHS), 2013).

Surveillance is a method of monitoring indicators for disease control activities. It makes it possible to collect indicators of both morbidity and mortality; with a view to focusing intervention on those who need it most for efficient and effective action. It offers a greater opportunity to identify outbreaks and to understand the natural course of a disease in the population under surveillance. As a result, a public health surveillance system prevents misdirected resources. Furthermore, Surveillance provides evidence to measure progress in disease control.

1.1.Background

Malaria is a major public health problem in Ghana (NMCP, 2008). "The 2014 Ghana Demographic and Health Survey showed that the prevalence of malaria in children age 6-59 months is 36 percent as measured by RDT and 27 percent as measured by analysis of blood smears via microscopy" (Ghana Statistical Service, 2015).

In order to control malaria in the country, the Ministry of Health of Ghana is focusing on scaling up of malaria control activities (NMCP, 2008). In this context of the massive scale up of malaria interventions, there is increasing recognition of the insufficiency of Health Management Information System in surveillance systems in most African countries (Yukich et al., 2014).

Disease surveillance is one of the fundamental functions of public health systems (CDC, 2001). "Public health surveillance is the ongoing, systematic collection, analysis, interpretation, and dissemination of data related to a health event for public health action aimed at reducing morbidity and mortality and improving health" (Soucie, 2015); (CDC, 2001).

The success of malaria control and elimination depend strongly on robust and responsive surveillance systems (Najera, Gonzalez-Silva, & Alonso, 2011).

Case detection, good classification leads to the treatment practices rationalization and then to the improvement of surveillance data (Thiam et al., 2011;Yukich et al., 2012).

"In addition, due to under-utilization or lack of diagnostics and reliance on clinical diagnosis, routine surveillance data may actually overestimate the burden of malaria within the public health system. Additional challenges, such as poor data recording practices and

lack of supervision, have an unknown effect on routine system data quality." In some contexts, failure of facilities to make a complete report up in the reporting chain also results in the aggregation of incomplete data sets and widespread under-reporting of the malaria burden (Yukich et al., 2014); (Bennett et al., 2014); (Rowe et al., 2009).

Sentinel surveillance has a considerable advantage in contrast to the routine surveillance system. As it may provide better quality data for malaria surveillance (Yukich et al., 2014).

Malaria sentinel site surveillance system was established, in Ghana since 2013, to monitor malaria positivity rates across the country in order to assess the progress made in the reduction of malaria prevalence.

Therefore, this study assesses how well the Malaria sentinel surveillance system operates to meet its objectives in the Greater Accra; it assesses system attributes.

1.2.Problem statement

According to Ghana Health Service, malaria diagnosis based on presumption over the year may lead to data of poor quality on actual prevalence of malaria in the country. In 2013, the proportion of suspected malaria cases put on ACTs was 86.2%, while only 53.7% of them were tested either by RDTs or microscopy (DHIMS,2016). Therefore, based on it alone, policy decisions become difficult (Ghana Health Service (GHS), 2015)

As the proportion of suspected and presumed of malaria cases is high, making the diagnosis of malaria tedious, as most are not fevers due to malaria. Malaria surveillance cannot in any way be based on these counts (Chilundo, Sundby, & Aanestad, 2004) ; (WHO, 2012).

Due to that, in 2013, 30 sentinel sites were set by NMCP for the monitor of malaria positivity rates across the country in addition to District Health Information Systems-11. The sentinel sites will help in the assessment of the progress of malaria interventions (Ghana Health Service (GHS), 2015).

In 2015, proportion of suspected malaria cases put on ACTs dropped to 57.4% from 86.2% in 2013. While only 73.6% of them has been tested during the same year, 2015 (DHIMS,2016).

Thus, burden measures that detect only clinical diseases will not provide good estimates of transmission in progress.

Despite the recorded progress indicators in recent years across the country, and since the system was set up in 2013, there has not been an evaluation of these sentinel sites to assess the effectiveness of the malaria surveillance system attributes though the sentinel surveillance system was established to provide prevalence based on the results of parasitological test rather than a presumptive diagnosis as it was some years ago.

This study seeks to evaluate the surveillance system to determine the relevance, effectiveness and impact of activities in relation to the system objectives and to assess the system attributes.

1.3.Justification of the study

The public health surveillance system should function in order to allow effective dissemination of health data so that decisions at all levels can be made in the line with implications of information. The desired performance of surveillance systems is to generate

information for timely action to help reduce mortality, disability and morbidity for targeted diseases

In Ghana and elsewhere in the world, decision-making and action is based on information generated by the Surveillance system. Thus, assessing the attributes of the malaria surveillance system allows obtaining of evidence about the performance of the system. This is to reassure accuracy and quality of the measures or indicators generated by the system. Assessing the system in these days, is a favorable approach to validating progress in the fight against malaria. This study findings may provide an insight on the effective operation of the system in achieving these objectives; including the quality and reliability of generated data, which may help in evidence-based decisions and policy making for future malaria control interventions.

Conceptual framework: Influence of Effective public health surveillance system to the improvement of health

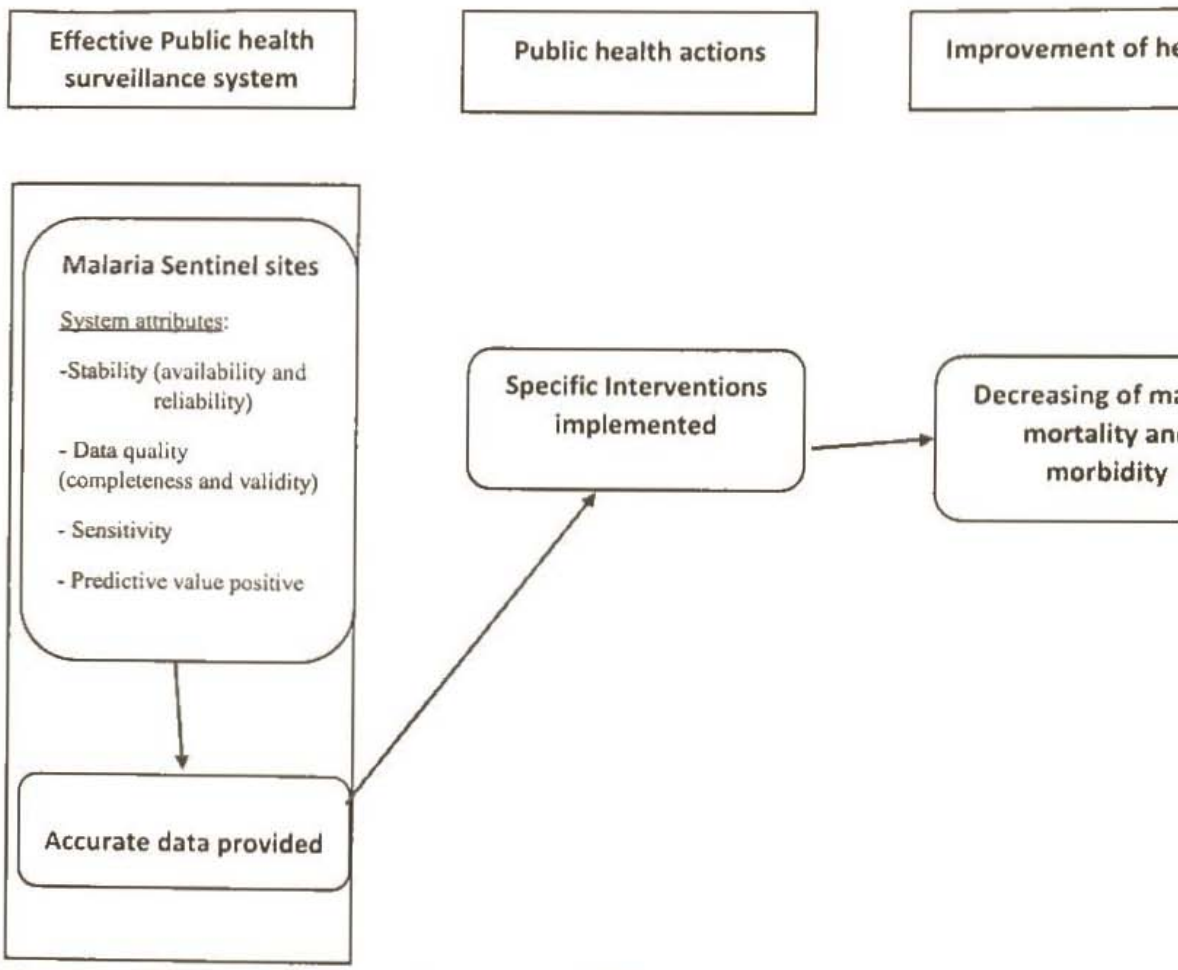

Figure 1.1. Conceptual framework-Influence of Effective public health surveillance system to the improvement of health

Effective public health surveillance system ensures the availability of Data provided properly without failure (Stability). This process must be done over a rational time (timeliness) period, providing valid and complete data (Data quality), detailing both the proportion of the total number of cases detected and the proportion of reported cases that have the disease under surveillance (Sensitivity and Predictive value positive).

Those accurate measurements generated by public health surveillance system are useful as they allow public health practitioners to undertake specific interventions in order to decrease disease morbidity and mortality.

1.4.Objectives

1.4.1. General objective

- To assess malaria parasite rate and system attributes in the sentinel surveillance sites in Greater Accra region.

1.4.2. Specifics objectives:

1. Determine the malaria positivity rate from 2014 to 2016
2. Determine the malaria test positivity rate
3. Determine the malaria slide positivity rate
4. Determine the proportion of suspected malaria cases put on Artemisinin-based Combined Therapy.
5. Assess system attributes of four malaria prevalence sentinel in Greater Accra Region.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter is sub-divided into 8 sections. From section 2.2 to 2.5 it takes a look at the global burden of malaria, followed by interventions and strategies to control and manage malaria in the world. The epidemiology and diagnosis of malaria in Ghana is then presented. Section 2.6 and 2.7 provides literature on surveillance system in general and that of malaria in particular; and also, indicators for surveillance in Ghana. The last, section 2.8. describes the evaluation of the monitoring system attributes according to updated guidelines for evaluating Public health system

2.2. Global malaria burden

Malaria is a health burden in the world. "According to the latest WHO estimates, released in December 2015, there were 214 million cases of malaria in 2015 and 438 000 deaths" (WHO, 2015b).

A notable global progress in the fight against malaria between 2000 and 2015 was recorded. A reduction of 37% and 60% respectively in the malaria incidence and mortality rate among populations at risk. An estimated 6.2 million malaria deaths have been averted globally since 2001 (WHO, 2015c).

Malaria mortality is at least 20% in African countries. Malaria is endemic to the majority of countries in sub-Saharan Africa, with almost all 90 % of malaria cases in the world. Children under five are the most vulnerable (UN Millennium projet, 2005).

"In 2015, the region was home to 88% of malaria cases and 90% of malaria deaths. Some 15 countries – mainly in sub-Saharan Africa – account for 80% of malaria cases and 78% deaths globally" (WHO, 2015a).

Ghana is an endemic country for malaria which is perennial in all regions although more pronounced in the north. Due to reduced immunity, children under five and pregnant women are at increased risk of severe malaria (Usaid, 2014).

Ghana is growing rapidly, the 2010 census demonstrating that more than 50% of the population now lives in urban areas. Malaria parasite was 80.2% in rural areas, but only 6.6% in Accra and Kumasi in children under five with recent fever (Usaid, 2014); (Ghana Statistical Service, 2015).

2.3. Control and management of malaria

Strategies for the control of malaria are perceived as effective and widely implemented, mainly for indoor residual spraying (IRS) vector control and case management based on definitive diagnosis and treatment with artemisinin combined therapy ACT(Conteh, Sharp, Streat, Barreto, & Konar, 2004). Effective control of the malaria vector is necessary to protect people at risk as recommended by WHO. The use of mosquito nets and indoor residual spraying are two effective ways to achieve this goal.

Current strategies to contain malaria are through the prevention and treatment of malaria cases (WHO, 2008). Control strategies have been to provide insecticide-treated bed nets (ITNs) for children under 5 years of age, pregnant women and people living with HIV / AIDS.

There is also the use of intermittent presumptive treatment (IPT) during pregnancy and indoor residual spraying (IRS) if appropriate as preventive measures (Kiwuwa & Mufubenga, 2008).

In addition, to ensure a rapid and effective treatment of malaria, the World Health Organization has introduced home-based malaria management in Africa where transmission is severe (WHO,2008).

LLIN (long-lasting insecticide-treated net) coverage for all people at risk of malaria has been increased with distribution campaigns (WHO, 2016).

"Chemoprevention for pregnant women and children under 5 years of age is also a preventive strategy" (Ministry of heath-ghana, 2014).

The effective case management of malaria reduces incidence and transmission. It thus prevents from death. Artemisinin-based combined therapy (ACT) is first line medication ,particularly for *P. falciparum* malaria (WHO, 2016).

"Over the past two decades, Ghana has consistently improved malaria control, increased resources for malaria and rapidly adopted international technical standards. Ghana successively adopted ACTs as primary antimalarials and sulfadoxine-pyrimethamine (SP) for IPTp in 2003 and 2004" (Usaid, 2014).

In the front, every effort is made to adapt malaria control interventions and case management to the unique needs of different localities (Usaid, 2014).

"Ghana is now implementing a malaria control programme through comprehensive health sector development, improved strategic investment in malaria control and increased

coverage of universal access to malaria treatment and prevention interventions" (Usaid, 2014).

2.4. Epidemiology of malaria in Ghana

Malaria is endemic in Ghana. However, there is insufficient data to clearly define the current malaria epidemiological profile at the district level in Ghana. Greater Accra Region is hypoendemic according to the 2011 Multiple Indicator Cluster Survey (MICS) in children under five years (Ghana Health Service (GHS), 2013).

According to the GDHS 2014 malaria prevalence in children measured by microscopy is 37.9 in rural Ghana and 13.5 urban Ghana. Prevalence is much higher among children in families of lower wealth quintiles and less educated mothers.

Malaria is predominantly caused by Plasmodium falciparum, mainly transmitted by An.gambiae s.l. and An. funestus, in all the ecological zones. So far P. vivax has not been reported in the country (Ghana Health Service (GHS), 2013).

2.5. Malaria diagnostic

The WHO Global Malaria Program recommends a diagnostic test before treatment for all suspected cases of malaria. Treatment solely on the basis of clinical suspicion should be considered only where diagnosis test is not accessible (i.e Not available within 2 hours of the patient presenting at a point of care) (WHO 2011). "A policy of presumptive treatment of fever with antimalarial medication, once advocated in many countries where malaria is endemic, was revised in Ghana in 2010. The current policy emphasizes testing before treatment" (Ghana Statistical Service, 2015).

In the control phase, the objective of malaria programmes is to reduce the incidence of and mortality from malaria as rapidly and economically as possible (WHO, 2012).

"In the elimination phase cases occur sporadically or in distinct foci and imported cases may comprise a significant proportion of all cases. The aim of malaria programmes is to stop local transmission of malaria, and surveillance is a principal strategy for achieving this" (Tambo et al., 2014).

An effective surveillance and response system must provide information for timely action that contributes to the decline of mortality, disability and morbidity for targeted diseases (Perry et al., 2007).

Technically, greater coverage of the intervention is encouraged to maintain and sustain what has already been achieved and this cannot be achieved through very effective program management (Zhou et al., 2013); (Henderson, 1987).

2.7. Indicators for Malaria surveillance system in Ghana

The passive collection of data in Ghana is through the Routine Surveillance System providing the indicators for surveillance and monitoring trends of malaria morbidity and mortality suspected malaria cases.

Routine data in Ghana is collected through the DHIMS II and data collected is on suspected malaria cases that receive a parasite-based test and confirmed malaria case, malaria admissions and deaths/Case fatality by age under five, and above and pregnant women, by time and health facility and districts.

Children under 5 years of age and pregnant women who are at higher risk of malaria morbidity and mortality have been targeted for surveillance under the program although the whole population is under surveillance for malaria.

Malaria surveillance in Ghana basically comprises three different surveillance systems which are a vertical malaria surveillance system owned by the NMCP (National Malaria Control Programme), electronic-based surveillance system named the District health information system (DHIMS) owned by the Centre for health information management (CHIM) of GHS (Ghana Health Service) collecting monthly out-patients and in-patients morbidity and mortality returns; and integrated disease surveillance and response system (IDSR) focused on priority diseases including malaria..

Started in 2009, the three systems have been integrated into a web-based system, the Ghana Health Service District Health Information Management System (DHIMS1) and now DHIMS II.

This web-based system is centrally hosted by the CHIM; it provides a platform for collecting these data. Actually, the NMCP relies on DHIMS II for data for routine surveillance for monitoring of indictors.

Sentinel surveillance system

A sentinel surveillance system is useful for collecting data of high quality needed which are difficult to obtain through a passive system.

"While most routine surveillance systems receive data from as many health care workers or health services as possible, a sentinel system deliberately involves only a restricted network of carefully selected reporting sites.

Data collected in a well-designed sentinel system can be used to identify outbreaks, signal trends and monitor the burden of disease in a community, providing a rapid, economical alternative to other surveillance methods" (World Health Organization, 2013).

Ghana has established 30 sentinel sites which health facilities, performing their normal work but with the only added duty that is to collect the sample of every third suspected case of malaria (both RDT & microscopy) for the laboratory of Noguchi Memorial Institute for Medical Research (NMIMR) to analysis.

"This involves ensuring that all suspected malaria cases are given a diagnostic test and properly classified according to the test result, that there is a quality management system for both microscopy And Rapid Diagnostic Tests (RTD), and that the registration and reporting of health facilities are complete and consistent" (WHO, 2012).

2.8. Evaluation of public health system attributes

The evaluation of public health system attributes allows us to obtain evidence on the performance of the Surveillance System. This is to reassure the accuracy and quality of the measures or indicators generated by the system.

Evaluation is defined as an attempt to determine as systematically and objectively as possible the relevance, effectiveness and impact of activities in relation to their objectives (WHO, 2012).

The objective of the evaluation of surveillance systems is to ensure that it is monitored effectively and efficiently. Evaluation of surveillance systems should be periodic, and include recommendations to improve quality, efficiency and usefulness.

The evaluation of surveillance systems should involve an assessment of the system's attributes. Considering the attributes that are of highest priority for a given system and its objectives. Because the priority of the attributes differs from one monitoring system to another system. A public health surveillance system should focus on the most important attributes to its objectives. An assessment of the surveillance system should therefore take into account the priority attributes.

System attributes (CDC, 2001).

Description of each System Attribute

a. Simplicity

Definition. The simplicity of a public health surveillance system refers to both its structure and its ease of operation. Monitoring systems should be as simple as possible while meeting their objectives.

Simplicity is closely linked to acceptance and speed of execution. Simplicity also affects the amount of resources required to operate the system.

b. Flexibility

Definition. A flexible public health surveillance system that can be adapted to changing information needs or operating conditions with little time, personnel or funds. Flexible systems can accommodate, for example, new health-related events, changes in case definitions or technology, and variations in funding or reporting sources.

c. Data Quality

Definition. Data quality reflects the completeness and validity of the data recorded in the public health surveillance system.

In addition, to assess data quality, the calculation of sensitivity and Positive predictive value for the system's data fields might be useful.

"The quality of the data is influenced by the performance of screening and diagnostic tests (ie case definition) for health-related events." Different facets can influence the clarity of the forms used (electronic or not), the quality of the people responsible for completing these forms, in terms of training and supervision, and the care exercised in data management. Examine these different elements provides an indirect measure of data quality.

d. Acceptability

Definition. Acceptability reflects the willingness of persons and organizations to participate in the surveillance system.

Acceptability refers to the willingness of the sponsoring organization's people to operate the system and people outside the sponsoring organization (e.g, people who are invited to use the system).

The points of interaction between the system and its participants are important for assessing acceptability.

To generalize the results of surveillance data to the general population, data from a public health surveillance system should accurately reflect the characteristics of the health-related event under surveillance. These characteristics generally concern time, place and person.

h. Timeliness

Definition. Timeliness reflects the speed between the steps of a surveillance system.

"Timeliness of a public health surveillance system should be assessed in terms of the availability of information for the control of a health-related event, including immediate control efforts, prevention of continued exposure, or planning of the program."

i. Stability

Definition.

Stability means reliability (ie the ability to collect, manage and provide data properly without failure) and the availability (the ability to be operational when necessary) of the public health.

The lack of dedicated resources might affect the stability of a public health surveillance system.

CHAPTER THREE

METHODOLOGY

3.1. Study design

This study was a descriptive secondary data analysis of an original surveillance data generated by the routine district health information system and the Noguchi Memorial Medical Research institute for four malaria sentinel sites in the Greater Accra region. It consisted of quantitative descriptive components of the malaria parasite rate and attributes in sentinel surveillance system in Greater Accra. A retrospective review of Malaria sentinel site specific case summary data from January 2014 to December 2016 were carried out.

3.2. Study Area

Greater Accra, located in the south of Ghana, has an estimated population of 4,010,054 in 2010 of which 11.7% less than 5 years old (Ghana Statistical Service, 2012).

"The Greater Accra Region is the smallest of the 10 administrative regions in terms of area, occupying a total land surface of 3,245 square kilometers or 1.4 per cent of the total land area of Ghana" (GOG, 2015).

The region is divided into sixteen districts namely, Accra, Ada east, Adentan, Ada West, Ashaiman, Ga central, Ga east, Ga south, Ga west, Kpone-katamanso, La Dade-kotopon, Ledzokuku-krowor, La Nkwantanan-madina, Ningo-prampram, Shai osudoku, Tema. Accra is its regional capital and also doubles as the national capital city. "The region is relatively dry since it falls within the dry coastal equatorial climatic zone with temperatures ranging between 20° and 30° Celsius and annual rainfall ranging from 635 mm along the coast to 1,140 mm in the northern parts. There are two rainfall peaks notably in June and

October. The first rainfall season between April and July is associated with the major cropping season in the region" (GOG, 2015). Malaria positivity rate in children under 5 years of age was 11,8% according to RDTs and 11.2% according to microscopy in Greater Accra (Ghana Statistical Service, 2015).

Greater Accra Region has four malaria sentinel sites. All of them were selected for this study. The facilities in these four sites were Danfa Health Centre, Oboom Health Center, Shai Osudoku Hospital, and Lekma Hospital; located respectively in La Nkwantanan-madina, Ga south, Ledzokuku-krowor and Shai Osudoku.

The objectives of these sentinel sites are: 1) To set-up a surveillance system for generating data on malaria positivity rates across Ghana. 2)To monitor malaria positivity rates by Rapid Diagnostic Tests (RDTs) in selected health facilities across Ghana. 3)To monitor malaria positivity rates by microscopy in selected health facilities across Ghana.

3.3. Study population

The study population was malaria parasite sentinel surveillance sites. Data were extracted from reviewed Out-Patient Department (OPD) malaria cases.

3.4. Data source and variables

A total of 91,723 OPD malaria cases were reported from the sentinel sites dataset containing the following monthly information for a three-year period (Jan. 2014 – Dec. 2016): number of suspected malaria cases, number of suspected malaria cases that received a parasite-based test, number of suspected malaria testing positive by microscopy, number

of suspected malaria testing positive by RDT, number of confirmed malaria cases and number of suspected malaria cases who received ACTs.

Dataset from Noguchi Memorial Medical Research Institute provided information such as name of sentinel site, results of slide malaria diagnosis by month and species on 25,952 samples collected from the sentinel sites.

Due to the availability of data and the large sample size, the whole data were analyzed for maximum statistical production.

3.5. Sample size

Secondary data were generated from Greater Accra region, which was conveniently selected out of the 10 regions of Ghana, taking into account access to the sentinel sites and the fact that these sentinel sites had not been evaluated. In Greater Accra, four sentinel sites were selected for this study.

All annually OPD (Out-Patient Department) suspected malaria cases recorded data from 2014 to 2016 from the sentinel surveillance system were extracted as the sample size for this study. A total of 91,723 cases were recorded over the three-year (study) period.

3.6. Data collection methods

A structured compilation form was designed and used for data collection in this current study. For every sentinel site and according to the year, information needed were monthly grouped and collected.

The method used in the attributes surveillance system evaluation was based upon the updated Guidelines for Evaluating Public Health Surveillance Systems published by the

Center for Disease Control and Prevention (Atlanta USA). This Guideline describes the critical attributes that a surveillance system should have to be effective and efficient.

The surveillance attributes on which data were collected were data quality; sensitivity; positive predictive value, representativeness.

3.7. Outcome measure

Three outcomes were sought in this current study:

- Malaria positivity rate: proportion of suspected malaria cases tested positive,
- Testing rate: Proportion of suspected malaria cases tested,
- Proportion of suspected malaria cases received ACTs.

In order to assess system attributes:

Data quality: the percentage of "unknown" or "blank" responses to items on surveillance forms were examined. Data of high quality should have low percentages of such responses.

Sensitivity: Since malaria sentinel surveillance is case based surveillance, sensitivity was considered at the level of case reporting. This is the proportion of cases of malaria detected by the sentinel surveillance system. High sensitivity means that few cases are missed.

Predictive value positive: the proportion of reported suspected malaria cases that have malaria under surveillance.

3.8. Statistical analysis plan

3.8.1. Data description and exploitation

Data were collected on variables such as number of suspected malaria cases, number of suspected malaria cases that received a parasite-based test, number of suspected malaria

Positive predictive value:

$$PVP = \frac{\text{number of suspected malaria cases confirmed by parasite-based test}}{\textit{Number of suspected malaria cases diagnosed clinically}} * 100$$

3.9. Ethical considerations

Ethical clearance was obtained from the Ethical Review Committee (ERC) of the Ghana Health Service through the academic board of the School of Public Health.

Permission of Access to patients- data forms were sought from the office of the Deputy Director of Public Health of the Greater Accra Region and the respective District Directors of Health Services. All data were handled confidentially. These included data compilation forms, dataset sheets. All data were anonymized in the databases protected by a password. During data entry and validation, database files were accessible to only the Investigator Team.

CHAPTER FOUR

RESULTS

4.1. Background Characteristics of malaria cases from four sentinel sites

The number of suspected cases of malaria from the OPD (out-patient department) of the four sentinel sites and the number of suspected cases tested varied over the past three years in the malaria sentinel sites. Lekma hospital reported more cases of malaria, (44723 cases), while Obom health center reported fewer cases (7667 cases). In addition, Shai Osudoku and Danfa health centers reported respectively 27148 and 12388 cases. The total suspected malaria cases reported from all the four sentinel sites for the three years was 91,723 with the number of suspected cases increasing year by year (Table 4.1). A similar trend was observed for tested malaria cases where there was an increasing trend in number of cases tested in each year.

The Noguchi laboratory tested 25,952 samples of the 91,723 suspected cases representing 28.3%. Number of cases confirmed by the laboratory was distributed annually as follows 4647, 10649, 10656 samples from the year 2014 to 2016 (Table 4.2). During the study period, the largest sample came from Lekma hospital (12413 samples) and Shai Osudoku (7929 samples), while Danfa health centre and Obom Health centre provided only 4486 and 1124 cases respectively for microscopy confirmation.

4.2 Malaria positivity rate and proportion of suspected malaria case put on ACTs

Within the sentinel surveillance system, both Malaria positivity rate and proportion of suspected malaria case put on Artemisinin-based combined therapy (ACTs) had declined over time. Malaria positivity rate reduced from 25 % (95% C.I: 24.4 – 25.6) in 2014 to

12.2 % (95% C.I=11.8 – 12.5) in 2016. While the proportion of suspected malaria cases put on ACTs reduced from 61.4 % (95% C.I= 60.8 – 61.9) in 2014 to 29.6% (95%C.I=29.1 – 30.1) (Table 4.1).

The difference between the years was significant for the malaria positivity rate as well as proportion of suspected malaria case put in ACTs.

Table 4.1. Yearly malaria positivity rate and proportion of suspected cases put on ACTs within the sentinel surveillance system.

Characteristics	N (%)	Malaria positivity case (rate)	C.I (95%)	Proportion of suspected malaria case put in ACTs	C.I (95%)
Tested malaria case					
2014	22528 (26.8)	5634 (25.0)	24.4 – 25.6	-	-
2015	28514 (33.9)	4700 (16.5)	16.1 – 16.9	-	-
2016	33071 (39.3)	4038 (12.2)	11.8 – 12.5	-	-
Total	84113 (100.0)	14372 (17.1)	16.8 - 17.4		
p-value		< 0.01*			
Suspected malaria case					
2014	27588 (30.1)	-	-	16950 (61.4)	60.8 – 61.9
2015	30404 (33.1)	-	-	13369 (43.9)	43.3 – 44.5
2016	33731 (36.8)	-	-	10005 (29.6)	29.1 – 30.1
Total	91723 (100.0)	-	-	40324 (43.9)	43.5 – 44.2
p-value		-	-	< 0.01*	

Differences between the groups were assessed using chi-squared tests.
*Significant difference between the groups: p< 0.05

As the testing rate increased over time, the proportion of OPD malaria put on ACTs decreased (Figure 4.1). The malaria positivity rate has gradually declined from 25 % in 2014 to 12.2 % in 2016.

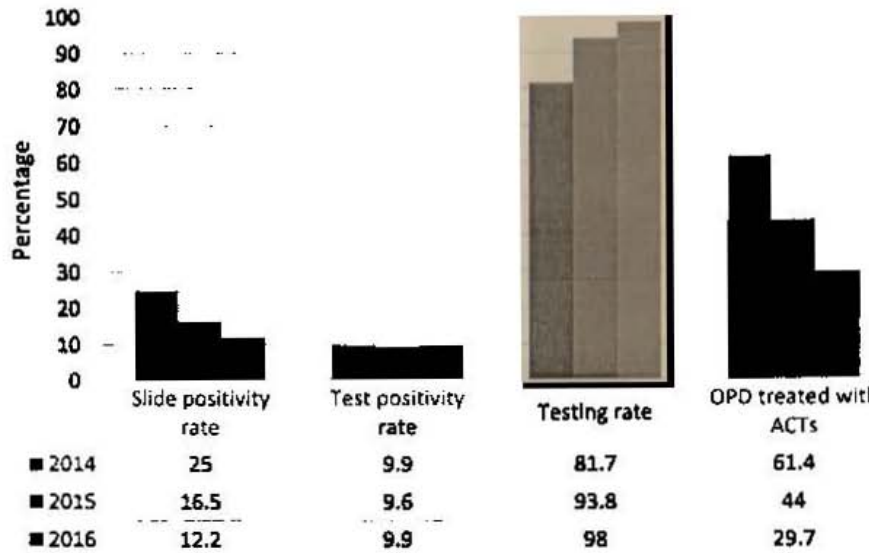

Figure 4.1. Yearly Malaria positivity rate, testing rate and proportion of OPD cases put on ACTs, within the sentinel surveillance system.

At Obom health center sentinel site (Figure 4.2), the slide and test malaria rate increased from 11.2 % to 28.4% for slide malaria rate and from 7.5 to 26.4% for test malaria rate during the study period.

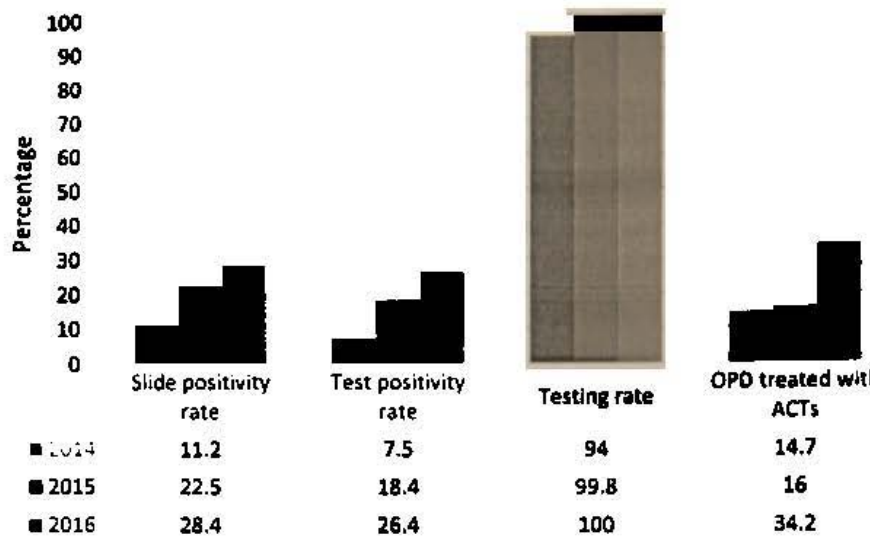

Figure 4.2. Yearly Malaria positivity rate, testing rate and proportion of OPD put on ACTs in Obom Health Centre.

However, at the Danfa health centre sentinel site (Figure 4.3), slide and test rate declined over time with slide positivity declining from 42.8 in 2014 to 18.2 % in 2016 while test positivity rate declined from 40.8 in 2014 to 23.5 % in 2016. The testing rate rose to 99.7 % in 2016.

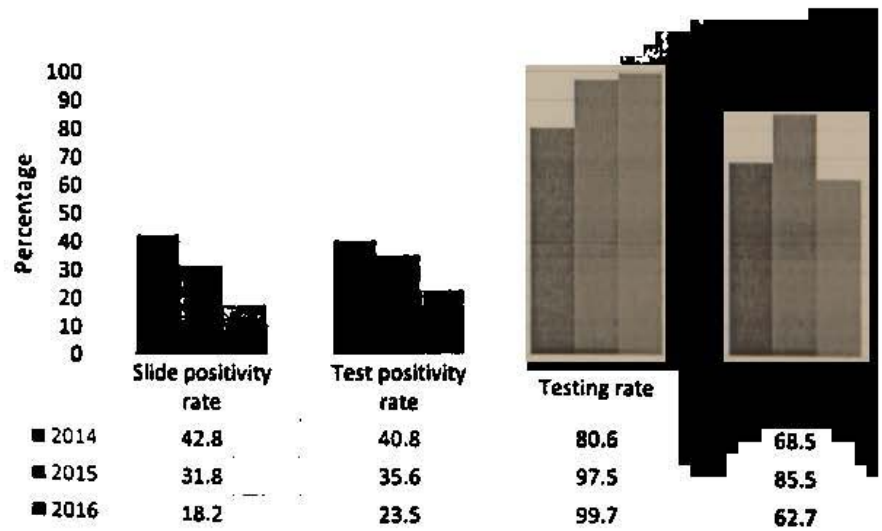

Figure 4.3. Yearly Malaria positivity rate, testing rate and proportion of OPD put on ACTs in Danfa Health Centre.

At the Lekma hospital sentinel site, both slide and RDT malaria positivity rate decreased over time with the slide rate decreasing from 14 in 2014 to 7.5 in 2016 (Figure 4.4). The RDT malaria rate also decreased from 5.4 in 2014 to 4.1 % in 2016 while the trend of testing rate and that of those of suspected cases put on ACTs remained inversely proportional.

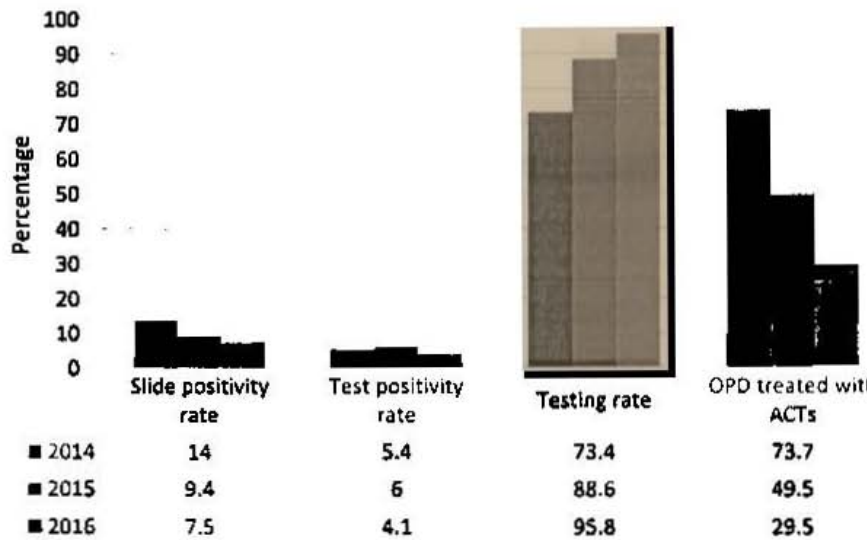

Figure 4.4. Yearly Malaria positivity rate, testing rate and proportion of OPD put on ACTs in Lekma Hospital.

Similarly, in Shai Osuduku hospital, slide positivity rate decreased from 35,5% to 10,9 % over time. The testing rate increased up to 100% over the two last years while proportion of suspected cases put on ACTs decrease to 11,1% in 2016 (Figure 4.5).

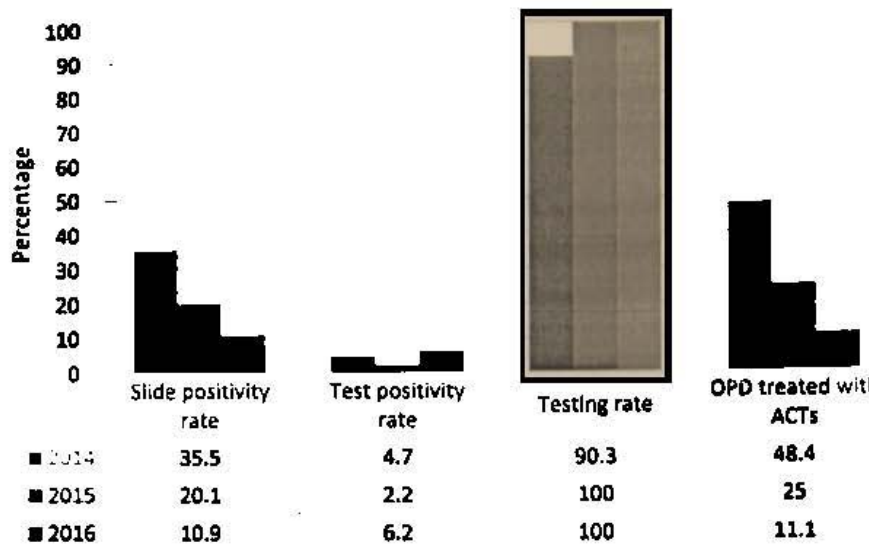

Figure 4.5. Yearly Malaria positivity rate, testing rate and proportion of OPD put on ACTs in Shai Osuduku.

4.3. Absolute difference between NMIMR and sentinel sites

The absolute difference in malaria positivity rate between the Noguchi (NMIMR) and the sentinel sites had decreased sharply from 2014 to 2016 (Table 4.2). The discrepancies between 2015 and 2016 were minimal. However, statistically the discrepancies were significant ($p<0.001$).

Table 4.2. Absolute difference of malaria positivity rate between NMIMR and Sentinel sites

year	NMIMR		All sentinel sites		Absolute proportion difference	
	N	%	n	% (95%CI)	%	p
2014	4647	17.2	22528	25 (24.4-25.6)	7.8	<0.001*
2015	10649	13.9	28514	16.5 (16.1-16.9)	2.6	<0.001*
2016	10656	14.2	33071	12.2 (11.8-12.5)	2	<0.001*

*p<0.05

4.4. Assessment of surveillance system attributes

The malaria sentinel surveillance system provided indicators for measuring progress in the fight against malaria. The information therefore provided by data were used by malaria program managers at the national level to assess the performance of the program and monitor progress in the implementation of certain activities. This information was also used for planning purposes; Budgeting and forecasting to improve response to new challenges with interventions that would improve performance and enable the program to achieve its objectives.

4.4.1. Level of usefulness

The review meetings brought together all stakeholders from National Malaria Control Programme, Noguchi test site and the various sentinel site (Prescribers, Laboratory staff) were regularly organized to improve the system by providing the necessary assistance to the sentinel sites. Four meetings since July 2016 were held. In addition, monitoring and supportive supervision were carried out quarterly.

4.4.2. Data quality and completeness

Data quality can be measured by the completeness of the reporting form. Challenges such as the incompleteness of certain field in many reports as number of suspected malaria cases tested, number of suspected malaria case treated with ACTs were being left blanks. These were some important fields for generating core surveillance indicators such as malaria positivity rate, testing rate, proportion of suspected case put on ACTs. These fields were used to measure the internal completeness of reporting details.

Completeness of health facilities reporting was 100% for all sentinel sites over the three-year period (Table 4.3).

In terms of percentage of blank responses to items on the surveillance form, the data aggregated from all sites were of high quality (Table 4.3). However, with respect to different sites, data from Obom health center were of lower quality specially for the years 2014 and 2015. Danfa health Centre and Lekma Hospital provided higher quality data (Table 4.3).

Table 4.3. Incompleteness (internal completeness) of reporting details

Sites	Number of monthly reports	Number of line list entries with blank details				
		Suspected malaria tested positive using RDT	Suspected malaria tested positive using microscopy	Suspected malaria tested using RDT	Suspected malaria tested using microscopy	Suspected malaria treated with ACTs
Danfa health centre						
2014	12	0	0	0	0	0
2015	12	0	0	0	0	0
2016	12	1(8.3)	1(8.3)	1(8.3)	1(8.3)	1(8.3)
Obom health centre						
2014	12	**8(66.7)**	**8 (66.7)**	**8 (66.7)**	**8 (66.7)**	**9 (75.0)**
2015	12	**6 (50.0)**	**11 (91.7)**	**6 (50.0)**	**11 (91.7)**	**9 (75.0)**
2016	12	1 (8.3)	2 (16.7)	0	2 (16.7)	2 (16.7)
Lekma hospital						
2014	12	0	0	0	0	0
2015	12	0	0	0	0	0
2016	12	0	0	0	0	0
Shai osudoku hospital						
2014	12	1 (8.3)	0	1 (8.3)	0	0
2015	12	**11 (91.7)**	2 (16.7)	**11 (91.7)**	2 (16.7)	2 (16.7)
2016	12	5 (41.7)	1 (8.3)	5 (41.7)	1 (8.3)	3 (25.5)
All sites						
2014	36	9 (25.0)	8 (22.2)	9 (25.0)	8 (22.2)	9 (25.0)
2015	36	17 (47.2)	13 (36.1)	17 (47.2)	13 (36.1)	11 (30.6)
2016	36	7 (19.4)	4 (11.1)	6 (16.7)	4 (11.1)	6 (16.7)

4.4.3. Predictive value positive

The Positive predictive value (PPV) gives the percentage of suspected cases that truly has malaria. The Positive predictive value decreased from 20.4 % in 2014 to 12% over time, that is, the proportion of reported suspected malaria cases that had malaria under surveillance decreased (Table 4.4).

Table 4.4. Positive predictive value in all sentinel sites

Year	Suspected malaria cases	Confirmed malaria cases	Positive predictive value (%)
2014	27588	5634	20.4
2015	30404	4700	15.5
2016	33731	4038	12.0
Total	91723	14372	15.7

4.4.4. Sensitivity

Since the number of suspects had increased since 2014 and the PPV had decreased, it meant that the sensitivity had increased. The simple and highly sensitive case definition used by the surveillance system allows easy identification of malaria cases and a low probability of missing cases. Therefore, this indicated that the system was sensitive to case detection.

4.4.5. Representativeness

A public health surveillance system that is representative accurately describes the occurrence of a health-related event over time and its distribution in the population by place and person. All sentinel sites cases were identified and reported. This gave a good representation of the disease under surveillance at regional level.

CHAPTER FIVE

DISCUSSION

The sentinel surveillance system was established in 2013 and its real application started in 2014. This system is responsible for monitoring the trend of malaria positivity rates across the country. This provides assurance on indicators of progress in the fight against malaria; and intends to respond to legislative and technical requirements of malaria control phase. These sentinel sites collect other data that is very useful to the system, which can be used for other purposes.

Conforming to global initiatives and recommendations such as Test, Treat and Track (T3), supporting parasitological diagnosis of any suspected case of malaria before treatment; Ghana is gradually shifting from clinical confirmation to parasitological confirmation as the basis of treatment. However, in situations where parasitological diagnosis (Microscopy or RDT) is not possible, treatment could be given based on presumptive diagnosis of malaria (Ministry of Health-Ghana, 2014); (Graz, Willcox, Szeless, & Rougemont, 2011).

As showed in Table 4.1, the rate of malaria positivity and the proportion of suspected cases of malaria in ACT have decreased over time. From 2014 to 2016, this decrease ranged from 25% to 12.2% for malaria positivity rate and from 61.4% to 29.6% for proportion of suspected malaria cases in ACTs.

Furthermore, increase in the testing rate has led to decrease in prescription of ACTs (Figure 4.1). This may be due not only to the expansion and availability of needed logistics, but also to the ongoing supervision and monitoring of NMCP and NMIMR in various health facilities.

The findings here corroborate with several studies conducted in other African countries stating that the introduction and scaling-up of RDT has led to a reduction of ACT consumption (Msellem et al., 2009); (Ikwuobe, Faragher, Alawode, & Lalloo, 2013); (Ansah et al., 2010); (Yukich et al., 2012).

"According to WHO, during the period when diagnostic tests are being expanded to different health facilities, it is difficult to obtain an accurate picture of trends. It is likely that the number of confirmed cases will increase while the number of presumed cases decreases (the number of suspected cases may decrease if guidance on who should be tested is more restricted)" (WHO, 2012).

The supervised review meetings are held within regular timeframes involving staff from National Malaria Control Programme, Noguchi Memorial Institute for Medical research and the various sentinel sites. This makes it possible to evaluate, give feedback to all the stakeholders and reinforce acceptability of the outcome since the flux of data in the system is organized and fairly acceptable to the system users (NMCP,2017).

With an incompleteness reported in this study, data quality is particularly poor in the Obom health center with a high blank response rate on some important data such as number suspected malaria case of tested, number suspected malaria case of treated with ACTs for the deduction of key indicators (Malaria positivity rate, testing rate and proportion of suspected malaria case put on ACTs). However, when all data are put together for all sites, it improves data quality since malaria positivity rate is less sensitive to changes in reporting rate than trends in confirmed case or incidence rate. Therefore, it may be considered in identifying areas with high malaria transmission than incidence rates (which is particularly

affected by accessibility and use of health facilities, as well as reporting rates) (WHO, 2012).

The absolute difference between the mean of a specific variable (such as number of suspected malaria tested) in the two sources of data may give information about the validity of this variable. Normally, one would expect the difference to be zero, which is hardly the case (ECDC, 2014).

The absolute difference of malaria positivity rate between NMIMR and the four sentinel sites has sharply decreased from 2014 to 2016 and the discrepancies are small between 2015 and 2016. This is relevant as it shows the progress made since the establishment of sentinel system to make the data accurate. Small differences do not usually change the course of action, but for diseases that require direct intervention, these divergences are relevant (ECDC, 2014).

Roughly, efforts have to be made in the application of the policy, as there are still a proportion of suspected cases of malaria that are treated before or after the parasitological diagnosis. This might be due to the lack of laboratory equipment (NMCP, 2017). Also, other causes of fever should be investigated and appropriately treated.

The positive value predictive (PPV) of disease reported gives a direct indication of the resources spent on a surveillance system. In sentinel surveillance system, PPV ranges from 20.4 % to 12.0%, declining over time. It is low because of the sensitivity of case definition; thus, the number of suspected cases can decrease with the expansion of the criteria on who has to be tested. This results in an apparent misdirection of resources as all suspected cases are tested in laboratory (CDC, 2001); (German, 2000).

The trade off of resources for case detection is a better option for ensuring good quality data as all people with suspected malaria may be identified and then receive a diagnostic test. Besides, it prevents the abusive prescription of ACTs, which may be more resource consuming than laboratory supplies (Western Pacific Region, 2011);(Shillcutt et al., 2008);(Uzochukwu, Obikeze, Onwujekwe, Onoka, & Griffiths, 2009).

Sensitivity depends on the surveillance objectives. To ensure good quality data, the surveillance system captures, as much as possible, suspected malaria cases that need to be tested. The definition of cases of high sensitivity is necessary in identifying each case of malaria in the population so that specific public health measures can be taken.

The number of suspected cases increased since 2014 and the PPV has also decreased thus this implies that the sensitivity increased. The simple and highly sensitive case definition used by the surveillance system allows easy identification of malaria cases and a low probability of missing cases. Therefore, this indicates that the system is sensitive to case detection (ECDC, 2014);(CDC, 2001).

The high sensitivity of the case definition results in picking up of more false positive cases. Therefore, the number of suspected cases that are truly confirmed as malaria case was small. This might be due to strict application of the case definition and compliance to policy of testing before treating (T3) policy.

The measures taken to increase the PPV of a surveillance system are the opposite of the measures taken to increase a system's sensitivity: the PPV of the surveillance system will increase if public health authorities, for example, use narrower case definitions, employ strict decision rules about electronic records, encourage clinicians and laboratories to report

only confirmed cases, and review all cases before entering the data into the system (ECDC, 2014).

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

This research shows the trend of the malaria positivity rate in the sentinel surveillance system. In order to be effective in its initial phase, the sentinel surveillance system must fulfill three essential conditions, thus, the assurance that any suspected case of malaria has been tested and correctly classified according to the result of the parasitological test; a quality management system for both microscopy and Rapid Diagnostic Test (RDT) and then ensuring that recording and reporting from health facilities is complete. In line with these conditions, the testing rate during the study period increased from 81.7% to 98.0 %, resulting in a decrease in the use of Artemisinin-based combined therapy (ACTs).

In addition, the T3 (test Teat and Track) policy has been implemented and is in force in Ghana. Thus, treatment of malaria should generally be refused to a patient who has a negative laboratory test result and adequate follow-up made, including repetition of the malaria test. Also, other causes of fever should be investigated and appropriately treated. From the study, majority of suspected cases are tested and classified according to outcomes. Malaria positivity rate also decreased significantly from 25.0% to 12.2% in the course of these three years.

The data are generally of good quality, representing very well the community. The application of T3 (Test, Treat and Track) and case definition by the system increases the systems sensitivity to the detriment of the PPV.

RECOMMENDATIONS

Since the sentinel surveillance system is established for the monitoring of malaria positivity rates across the country, it also helps in assessing the progress of interventions towards reduction in disease prevalence. To achieve this, following recommendations can be considered:

- Ghana Health Service should ensure that systems which have been instituted function effectively through continuous monitoring of data quality, including follow-up on reports; tracking missing reports and reviewing the data submitted. This provides positive feedback to health facilities that submit complete and accurate data and thus help in the facilitation of future reporting.

- Greater efforts should be made by National Malaria Control Program in the implementation of the T3 policy to promote compliance of health workers with this policy.

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Appendix

Malaria sentinel surveillance system attributes assessment in Greater Accra region

- Data quality

How many of "unknown" or "blank" responses to items on surveillance forms?

How many time monthly Data reports were not performed over period of study?

- Sensitivity

what proportion of cases of malaria is detected by the surveillance system?

- Positive predictive value

What is the proportion of reported suspected cases that have malaria?

GHANA HEALTH SERVICE ETHICS REVIEW COMMITTEE

In case of reply the number and date of this Letter should be quoted

My Ref. GHS/RDD/ERC/Admin/App/17/340
Your Ref. No.

Research & Development Division
Ghana Health Service
P, O. Box MB 190
Accra
Tel: +233-302-681109
Fax + 233-302-685424
Email: ghserc@gmail.com

Kalonji Mukendi Thierry
School of Public Health
University of Ghana
P. O. Box LG 13
Legon

The Ghana Health Service Ethics Review Committee has reviewed and given approval for the implementation of your Study Protocol.

GHS-ERC Number	GHS-ERC: 27/12/2016
Project Title.	"Assessment of malaria parasite rate and system attributes in the sentinel surveillance sites in Greater Accra Region"
Approval Date	14th March, 2017
Expiry Date	13th March, 2018
GHS-ERC Decision	Approved

This approval requires the following from the Principal Investigator

- Submission of yearly progress report of the study to the Ethics Review Committee (ERC)
- Renewal of ethical approval if the study lasts for more than 12 months,
- Reporting of all serious adverse events related to this study to the ERC within three days verbally and seven days in writing.
- Submission of a final report after completion of the study
- Informing ERC if study cannot be implemented or is discontinued and reasons why
- Informing the ERC and your sponsor (where applicable) before any publication of the research findings.

Please note that any modification of the study without ERC approval of the amendment is invalid.

The ERC may observe or cause to be observed procedures and records of the study during and after implementation.

Kindly quote the protocol identification number in all future correspondence in relation to this approved protocol

SIGNED.....
DR. CYNTHIA BANNERMAN
(GHS-ERC CHAIRPERSON)

Cc: The Director, Research & Development Division, Ghana Health Service, Accra

School of Public Health / University of Ghana, Legon

Topic: Assessment of malaria parasite rate at Malaria sentinel surveillance sites

Data collection form	Year:	Site:											
Variables	**JAN**	**FEV**	**MARCH**	**APRIL**	**MAY**	**JUN**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**	
Number of suspected malaria cases													
Number of suspected malaria cases that received a parasite-based test													
Number of confirmed malaria cases													
Number suspected malaria cases received ACT													