PREVALENCE AND INCIDENCE OF MALARIA IN TORA TOWN AND CHILDHOOD MALARIA IN TORA PRIMARY HOSPITAL, SILTE ZONE, SOUTH CENTERAL ETHIOPIA.

By

Shemsi Shewmolo

A Thesis submitted to the Department of Zoological Sciences in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology (General Biology).

Advisor

Hassen Mamo (PhD)

August, 2019

Addis Ababa

Ethiopia

Declaration

I the undersigned, declare that this thesis is my own original work and it has not been presented in other university for similar degree or other purpose

Shemsi Shewmolo	_____	_____
Name	Date of Submission	Signature

Supervisor Statement

I, the Undersigned, Confirm that this thesis is approval for Submission.

Dr Hassen Mamo	_____	_____
Name	Date	Signature

Acknowledgements

I am grateful indeed to the Almighty Allah, the Merciful and Compassionate.

Second, I express my deepest gratitude to my advisor Hassen Mamo (PhD) for his esteemed, constructive and consistent follow-ups and guidance throughout the work devoting their valuable time.

Third, I would like to my special thanks to my wife Leyla Yasin, Tora town health office, Tora Primary hospitals, Abdulfeta Shewmolo, Abduletif Shewmmolo, Aman Gunda, Nuredin Kemal, Kedir Awol Tajudin Abdurehman, Aman Roba and Kedir Darsebo for data and financial support without which the research work could not have been done in the form present here.

Fourth, I would like to thanks Institute of Review Board-Addis Ababa University for constrictive comments.

Last but not least, I would like to thank my family, relatives, friends and others who helped me and contributed helpful and smart on advice in accomplishing my thesis work.

Abstract

Malaria is caused by a protozoan Parasites belonging to the genus, Plasmodium. There are five Plasmodium species: P. falciparum, P. vivax, P. ovale, P. malariae, and P. knowlesi. Malaria is taking life of a child every two minutes in Sub-Sahara Africa. During the main transmission seasons from September to December but, the lowest transmission seasons in April to May following short rains. Thus, the public health burden of malaria is huge in Ethiopia. Children, particularly under-five including new born and infants less than 12 months of age are one of the most vulnerable groups to malaria. This study was intended to investigate the prevalence and incidence of malaria in the Tora town. They were used secondary and primary data collection methods, and also simple random sampling techniques were used based on the available data. The retrospective survey was conducted in Tora health office, and prospective survey was conducted in Tora primary Hospital. These data were analyzed by Statistical Package for Social Sciences *version 23 and Chi-squared (X^2). On average 770 slide confirmed cases visited in Tora health office in each year. Over the whole 2741 (50.8%) and 2650 (49.2%) of the case were attributed to P. falciparum and P. vivax mono-infectious, respectively in Tora health office. However, no positive results confirmed in six months in 2019. From 2012 to 2018 prevalence malaria were decreasing, the variation were statically significant, and 2019 Six months no malaria cases confirmed and the variations were statically significant. Both secondary and primary data showed decreasing trend of malaria in the town. The study gives a hint that planning for elimination of the disease in the locality may be achievable in the near coming. Nevertheless, Malaria control interventions must be maintained and scaled-up to sustainably reduce its risk and possibly decrease from the locality.*

Keywords: - Prevalence, Malaria, Incidence, Tora Town, *P. falciparum, P. vivax, Anopheles mosquitos*

Table of Contents

List of Tables

Tables Page

List of Figures

List of Acronyms

ACD	Active Case Detection
ACTs	Artemisinin-Based Combination Therapies
An	Anopheles
AL	Artemether Lumefantrine
DALYs	Disabilities Adjusted Life Years
DDT	Dichloro-Diphenyl-Trichloroethane
FMoH	Federal Ministry of Health
GDP	Gross Domestic product
GTS	Global Technical Strategy
HRP2	Histidine-Rich Protein 2
IRS	Indoor Residual Spray
ITNs	Insecticide-Treated mosquito Nets
LLINs	Long-Lasting Insecticide-treated nets
PMI	President's Malaria Initiative
RDTs	Rapid diagnostic techniques
SPSS	Statistical Package for Social Sciences
SNNPR	South Nation Nationality People Representative
SSA	Sub Saharan africa
SZ	Silte Zone
UNCEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHO	World Health Organization

1. Introduction

1.1 Background of the study

Malaria is caused by a protozoan belonging to the genus, *Plasmodium,* which are obligate intracellular protozoa. *P. falciparum* (60%) and *P. vivax* (40%) are the two key Causes of malaria. *P. falciparum, P. vivax, P. ovale, P. malaria*, and *P. knowlesi* infect humans (Snow *et al*., 2005) and *P. falciparum* is the most highly virulent species and is responsible for nearly all of the 1.7–2.5 million deaths worldwide caused by malaria and *P. falciparum* remains the single most important threat to public health at a global scale, accounting for more than 90% of the world's malaria mortality (Baird, 2013). The disease is passing on to humans through a bite from one of 40 species of female *An. mosquitoes*. There are almost 3,500 species of mosquitoes grouped into 41 genera. of over 430 *An.* species, only 30-40 transmit malaria in nature and the mosquitoes which act as vector for this disease are *An. funestus, An moucheti, An. gambiae, An. arabiensis* (Karl *et.al*., 2014; WHO, 2015).

About 75% of the total landmass of Ethiopia is malarious and 60% of the population is at-risk of malaria (FMoH, 2015). The World Malaria Report 2015 document shows that 26,400,000 (27% of total population) reside in malaria high spread areas (>1 confirmed cases per 1000 population), 39,600,000 (41%) in low (1 case per 1000 population) and 31,000,000 (32%) malaria free (0 cases per 1000 population) in 2014. During the major spread season from September to December, following the main rains June through August, a large peak in malaria case occurs. A second but less pronounced peak occurs during the second transmission seasons in April and May following short rains. Although the economic burden of malaria in terms of average absent work days and Disabilities Adjusted Life Years (DALYs) during malaria episode is not thoroughly examined nationwide, in northern Ethiopia there was an attempt some 16 years back. It was estimated that the average lost work days was 18 for adults and the average cost of sickness per episode for adults ranged from 46-151 Ethiopian Birr with overall malaria accounting for 10.4% of the total 59,125 DALYs per 100,000 populations (Tulu, 1996).

In Ethiopia malaria control activities have been in action for long. The history of IRS and mosquito larval control dates back to the early 1960s. Patients of all ages are receiving malaria

diagnostic test free of charge in the public sector since that time. But, cyclic malaria epidemics kept on unabated in the country with the latest epidemic in 2004 and 2005 (SNNPR, 2005, and Guthmann *et al.*, 2007).

In recent years, however, there has been heavy financial support by global donors and refreshed political commitment of governments in malaria endemic countries to curb the disease. Moreover, clear operational plans including a long-term vision for malaria control were formulated in which sustained scale-up of proven malaria control tools would progressively lead to malaria elimination in Africa, with the ultimate goal of worldwide malaria eradication by 2040-2050 (PMI, 2018). The proven malaria intervention tools being extensively used in Ethiopia, like elsewhere, are:- Insecticide-Treated mosquito Nets (ITNs), Indoor Residual Spray (IRS), prompt diagnosis and treatment with Artemisinin-Based Combination Therapies (ACTs). Although Ethiopia is still in malaria control stage it has set a plan to eliminate malaria in selected low transmission settings by 2020 (PMI, 2018). There were no studies conducted on the problem so as to investigate the prevalence and incidence of malaria in Tora town and childhood malaria in Tora primary hospital. Therefore this study is very important to show the prevalence and incidence of malaria. Regardless of these, to overcome the above problem the researcher designed to investigate the prevalence and incidence of malaria in the study area.

1.2 Statement of the problem

According to World Malaria Report (2015) malaria is among the most frequently occurring and distracting phenomenon that affects an average 26,400,000 (27% of total population) reside in malaria high transmission areas (>1 confirmed cases per 1000 population), 39,600,000 (41%) in low (1 case per 1000 population) and 31,000,000 (32%) malaria free (0 cases per 1000 population) in 2014. Children, particularly under-five, including newborns and infants less than 12 months of age are one of the most exposed groups affected by malaria bearing 69% of the above deaths. Point out that in high malaria transmission areas infants become vulnerable to malaria at approximately 3 months of age, when immunity acquired from the mother starts to wane and are at increased risk of rapid disease progression, severe malaria and death. Severe anemia, hypoglycemia and cerebral malaria are features of severe malaria which are particularly common in this age group (WHO, 2016).

During the major transmission season from September to December, following the main rains June to August, a large peak in malaria case occurs. A second but less pronounced peak occurs during the second transmission seasons in April and May following short rains (Tulu, 1996). Due to this unstable and seasonal transmission pattern of malaria in the country, protective immunity of not only children but the general population is low and all age groups are highly vulnerable to the disease. Thus the public health burden of malaria is huge in Ethiopia (FMoH, 2015).

There were no studies conducted on the problem so as to investigate the prevalence and incidence of malaria in Tora town and childhood malaria in Tora primary hospital. Therefore, this study is very important to show the prevalence and incidence of malaria. Regardless of these, to overcome the above problem the researcher designed to investigate the prevalence and incidence of malaria in the study area.

1.3 Significance of the study

Both FMoH and SNNPR reports provide little evidence about detailed malaria status of the town. It is obvious that the global malaria status is the sum total of each country status, and in turn the country status is the sum total of its regional and local situations at each level. Accurate assessment of the levels and time trends in malaria burden are crucial for assessment of improvement towards goals and planning national health services and focusing future efforts. Information on the number and distribution of malaria cases and deaths is critical for monitoring malaria status in a locality and making possible adjustments in malaria control efforts. It is needed to determine which areas or population groups are most affected by malaria, so that resources can be targeted to the populations most in need. Information on the incidence of disease in relation to past levels is needed to alert programs about epidemics, so that control measures can be intensified. Data on changes in disease incidence and mortality are also required in order to judge the success of a program and to determine whether it is performing as expected or whether adjustments in the scale or blend of interventions are necessary. In light of this a number of studies at different parts of Ethiopia have been conducted and are currently underway.

The present study was therefore, aimed at estimating the prevalence and incidence of malaria in Tora town over the last seven years' period (January 2012- December 2018) and also the current situation of malaria burden on children (0-14 years) at Tora primary hospital. The study was expected to be scientific evidence usable by local and national policy makers and program planners for assessing malaria control progress and focusing future efforts.

1.4 Scope of the study

The study was conducted in Tora town. The scope of the study was delimited to the prevalence and incidence of malaria in Tora town and child hood malaria at Tora primary hospital in Tora town. Due to time and budget it did not include the prevalence and incidence of other than disease malaria.

1.5 Objective of the study

1.5.1 General objective

The general objective of this study was to investigate the prevalence and incidence of malaria in Tora town and childhood malaria in Tora primary hospital.

1.5.2 Specific objectives

The study has the following specific objectives:

1. To assess the crude prevalence of malaria in Tora town for the last seven years from January 2012 to December 2018.
2. To show the specific prevalence of yearly and seasonal pattern of malaria in Tora town for the last seven years from January 2012 to December 2018.
3. To differentiate the specific prevalence of age, sex and Plasmodium species distribution of malaria in Tora town for the last seven years from January 2012 to December 2018.
4. To examine the crude incidence of childhood malaria at Tora primary hospital from January 2019 to June 2019.
5. To indicate the specific incidence of the seasonal and Plasmodium species distribution of childhood malaria cases at Tora hospital from January 2019 to June 2019.
6. To display the specific incidence of age and sex distribution of childhood malaria at Tora primary hospital from January 2019 to June 2019.

1.6 Research Question?

Considering the objectives listed above the following research questions were forwarded: -

1. What is the status of the crude prevalence of malaria in Tora town for the last seven years?
2. What looks like the specific prevalence and of yearly and seasonal pattern of malaria in Tora town for last seven years?
3. How could be differentiate the specific prevalence of age and sex distribution of malaria in Tora town for last seven years?
4. How to determine the crude incidence of childhood malaria at Tora primary hospital from January 2019 to June 2019?
5. What do you point out the specific incidence of seasonal distribution of malaria cases at Tora primary hospital?
6. How do you demonstrate the specific incidence of age and sex distribution of childhood malaria at Tora primary hospital from January 2019 to June 2019?

2. Literature Review

2.1 Global burden of malaria

Malaria is one of the leading causes of morbidity and mortality in the world, with an estimated 3.3 billion people at risk of malaria. Malaria disease burden and spread can be assessed using incidence or prevalence in human hosts. According to the latest world malaria report, released on November 2015, there were 216 million cases of malaria in 2014, up from 211 million cases in 2013. The estimated number of malaria deaths stood at 445 000 in 2016, a similar number to the previous year (446 000). Globally, an estimated 3.2 billion people in 97 countries are at risk of being infected with malaria and developing the disease, of which 1.2 billion are at high risk (WHO, 2016). In 2010, an estimate of 219 million cases of malaria was reported by the World Health Organization and despite endless struggles to prevent its spread 660,000 people died from the infection that year. However, the same year, a systematic review assessed the global malaria mortality rate and revealed numbers exceeding over 1.2 million deaths, so the true malaria burden might be underestimated (Murray, 2012).

Globally, an estimated 3.3 billion people are at risk of being infected with malaria and developing disease, and 1.2 billion are at high risk to acquire the disease. The burden is heaviest in the WHO African Region, where an estimated 90% of all malaria deaths occur, and in children aged less than 5 years, which account for 78% of all deaths (WHO, 2014). It estimated 660,000 deaths in 2011 directly attributed to malaria, approximately half of the world's population being at risk of infection. The disease remains one of the major challenges for people's health and livelihood around the world (WHO, 2015). Nearly half of the world's population is living under the risk of malaria. As per the WHO estimates, 91 countries and territories had an ongoing transmission of malaria in 2015 with 212 million identified cases and 429,000 deaths. Most number of cases were reported from the African Region, followed by the Southeast Asia Region (WHO, 2016). WHO recently launched the GTS for malaria, which aims to reduce the incidence and mortality rates of malaria at least by 90% by 2030. However, the malaria control strategy also faces numerous challenges to achieve WHO Global Technical Strategy (GTS) targets to reduce malaria mortality and incidence rates by at least 90% by 2030.

2.2 Malaria in children

Malaria is one of the major diseases of poor people in developing countries and one of the leading effects of preventable death, especially in children and pregnant women. Sub- sahara Africa (SSA) carries the bulk of the global malaria burden, with 71% of cases and 86% of global deaths. A person in Africa dies of malaria every 10 seconds. It is a leading cause of childhood morbidity and mortality worldwide. It is estimated to account for 732,000 deaths among children age 5 or less, or about 8% of all such deaths; the share in Africa is 16% the population groups that are most at risk are children below the age of five years (Jamieson *et al.,* 1993). The increased risk of severe malaria has significant adverse consequences on the developing child (Verhoeffet *et al*., 1999). Children, particularly under-five, including newborns and infants less than 12 months of age are one of the most vulnerable groups affected by malaria bearing 69% of the above deaths. An estimated 2% of children who recover from malaria infections affecting the brain (cerebral malaria) suffer from learning impairments and disabilities due to brain damage, including epilepsy and spasticity (Murphy and Breman, 2001). The parasite burden is also peak in school age children due to low coverage of interventions, and infections may have consequences in school performance and indicate school children as good proxy for spread in a wide community. It is also estimated that, 6% of all infant deaths in malaria-endemic areas are a result of malaria infection that took place during the child's prenatal life. Although the numbers vary, there is a consensus that the malaria incidence over the last years has declined on a global scale. There are three principal ways in which malaria can contribute to death in young children. First, an overwhelming acute infection, which frequently presents as seizures or coma (cerebral malaria), may kill a child directly and quickly. Second, repeated malaria infections contribute to the development of severe anemia, which substantially growths the risk of death. Third, low birth weight frequently the consequence of malaria infection (Murray, 2012).

Malaria killed young children not capable to protect themselves from mosquitoes or access lifesaving medicine. It is the fourth leading cause of death of children below the age of five years in developing countries. It is still endemic in more than 100 countries worldwide, living children being the most vulnerable groups for infections (Legesse *et al*.,2007).

2.3 Social and Economic Burden

Malaria has significant, measurable, direct and indirect costs, and has been displayed to be a major constrain to economic development. At the macro level the economic burden of malaria is estimated at an average annual reduction in economic growth of 1.3 % for those African countries with the peak burden with an estimated 12 billion loss to the African continent's Gross Domestic product (GDP) annually. It primarily affects low and lower income countries and within endemic countries, the poorest and most marginalized communities. Most of malaria cases and deaths occur in SSA, but Asia, Latin America and to a lesser extent the Middle East and part of Europe are also affected. So, it causes repeated work absenteeism resulting in short and long term losses in productivity as the main spread periods coincide with the peak agricultural and harvesting seasons, causing poverty and hindering the development of the malaria endemic countries (WHO, 2014). .

2.4 Etiology of malaria Disease

Malaria is caused by a protozoan parasites belonging to the genus, *Plasmodium* with five species: *P. falciparum, P. vivax, P. ovale, P. malaria,* and *P. knowlesi* infect humans (Snow,2005) and is transmitted to humans through a bite from one of 40 species of female *An.* mosquitoes. *Plasmodium* is transmitted by mosquitoes. There are approximately 3,500 species of mosquitoes grouped into 41 genera. Female mosquitoes belonging to the genus *An.* are responsible for *plasmodium* transmission. Of over 430 *An.* species, only 30-40 transmit malaria in nature and *An. gambiae* complex is the most prominent *plasmodium* vector in Africa. The mosquitoes which act as vector for this disease are female *An. funestus, An. moucheti, An. gambiae, An. arabiensis* (Karl *et al.*,2014; WHO,2015). *P. falciparum* is the most highly virulent species and is responsible for almost all of the 1.7–2.5 million deaths worldwide caused by malaria and *P. falciparum* remains the single most important threat to public health at a global scale, accounting for more than 90% of the world's malaria mortality. A fifth *Plasmodium* species named *P. knowlesi,* that previously was known to only infect macaques, has also newly been shown to be able to infect humans (Baird, 2013). Malaria parasites appear to have coevolved with the human species; these two populations appear to be well adapted to each other. The various *Plasmodium* species may not even stem from the same ancestor; the genus may be polyphyletic. Although certain evidence advises that *P. falciparum* coevolved with

Homo sapiens, other observations show that it may have emerged first in a non-human host such as the chimpanzee. Parasite was discovered in 1880 by Alphonse Laveran (Mendis *et al.,* 2009). Africa had no malaria before and according to Nandi elders, malaria was introduced into Africa by African soldiers who participated in First World War in 1918 and 1919 and after coming back, 25% of the indigenous population got the disease (Lindsay and Martens, 1998). The relationship between humans and malaria may date back several million years (Escalante *et al*., 1998). Among several *Plasmodium* species that cause human malaria naturally, *P. falciparum* is by far the most severe and widespread. *P. vivax* malaria, traditionally observed as a relatively benign form of the disease, is the next dominant species and can also be a major cause of morbidity and mortality, in infants and young children. A cerebral malaria case associated with *P. vivax* mono infection in a 19-year old individual was reported in India recently. Another recent study from India reported *P. vivax* as a cause of acute respiratory distress syndrome which is commonly associated to *P. falciparum. P. ovale* and *P. malariae* are relatively rare and are usually not life-threatening. *P. ovale* has recently been shown by genetic methods to consist of two subspecies, *P. ovale curtisi* and *P. ovale wallikeri. P. knowlesi* which has so far been known in long-tailed macaques (Macacafascicularis) is a fresh addition to the list of natural human malaria parasites. It is widely dispersed in Asia and found to be potentially life-threatening. Until recently *P. knowlesi* was misdiagnosed as *P. malariae* (Cox-Singh, 2008).

2.5 Transmission and Life cycle

The disease is spread by the bite of infected female *An. mosquitoes* (Mockenhaupt *et al*., 2002), which inoculates the parasites with its saliva at the time of biting. The disease is due to infection with one of four species of the *Plasmodium* genus, which are obligate intracellular protozoa (WHO, 2014). The cycle starts when an infected female *An.* mosquito bites an individual, and injects sporozoites, present in mosquito's salivary glands, into the host blood stream during its blood meal. These sporozoites migrate to the liver where they mature and multiply within hepatocytes. These forms are known as schizonts. This extra-erythrocytic stage is asymptomatic (Asymptomatic infection occurs when an individual is able to tolerate the presence of parasitemia without having any symptoms of the infection. And usually lasts 6 days to 14 days, although sometimes it can last up to several months or even years in the case of *P. vivax* or *P.*

ovale. These two human *Plasmodium* species can produce hypnozoites in the liver (Markus, 2011).

The life-cycle of vector-borne diseases like malaria is complex relative to that of many directly-transmitted human diseases (including bacterial or viral diseases like bacterial meningitis or HIV). The malaria parasite life cycle involves two hosts. On the whole, directly transmitted diseases require a threshold level and complexity of population agglomeration, and are therefore relatively recent phenomena perhaps evolving within the last 10 millennia (May and Anderson, 1990). Hypnozoites are a dormant form of the parasite, also called cryptic form, which can stay in the liver for long periods of time and are the cause of the disease relapse. After the liver stage, tens of thousands of merozoites will be released into the blood; where they will invade and develop within erythrocytes. The blood stage of infection includes asexual forms of the parasite that undergo repeated cycles of multiplication in erythrocytes, causing parasite numbers to rise rapidly. This phase is responsible for the symptoms of malaria. Within the erythrocyte, the asexual forms of the parasite permits through different sequential maturation stages: ring, trophozoite and schizont forms. In the end, the erythrocyte ruptures and new merozoits are released and ready to infect new erythrocytes. Some parasites will grow into the sexual forms, responsible for transmission, known as gametocytes. The female and male gametocytes (macro-gametocyte and micro-gametocyte, respectively) will be ingested by the mosquito vector during its feeding, and sexual reproduction occurs inside the mosquito midget before the parasite is transmitted to another human host and the whole cycle starts again (Greenwood *et al*.,2005).

The intensity of transmission depends on factors related to the parasite, the vector, the human host, and the environment (WHO, 2014). The transmission intensity is highly sensitive to environmental variations that affect the densities of these vectors and their ability to transmit the infection. Temperature influences the length of larval development, mosquito survival, and parasite development. Elevated temperatures accelerate the development rate of both the mosquito larvae and of the *Plasmodium* parasites (Paaijimanset *et al*. 2009). Variations in transmission intensity have been observed within very small localities due to geographical (the geographical distribution of these species varies; *P. vivax* infection is rare in Africa but common in Asia, biological or socioeconomic factors (Gebremariam,1988;Tulu,1993;Negash *et al.*,2005;Ghebreyesus *et* al.,2006). Mosquitoes breed in water with different preference, for

example some prefer shallow collection of fresh water (rice fields, hoof prints). Transmission is more intense in places where the mosquito's lifespan is longer (giving the parasite the time to complete its development inside the mosquito) and where the vector prefers to bite humans rather than other animals. These characteristics are seen in African vector species which explains the high rate (90%) of malaria deaths in Africa (WHO 2014).

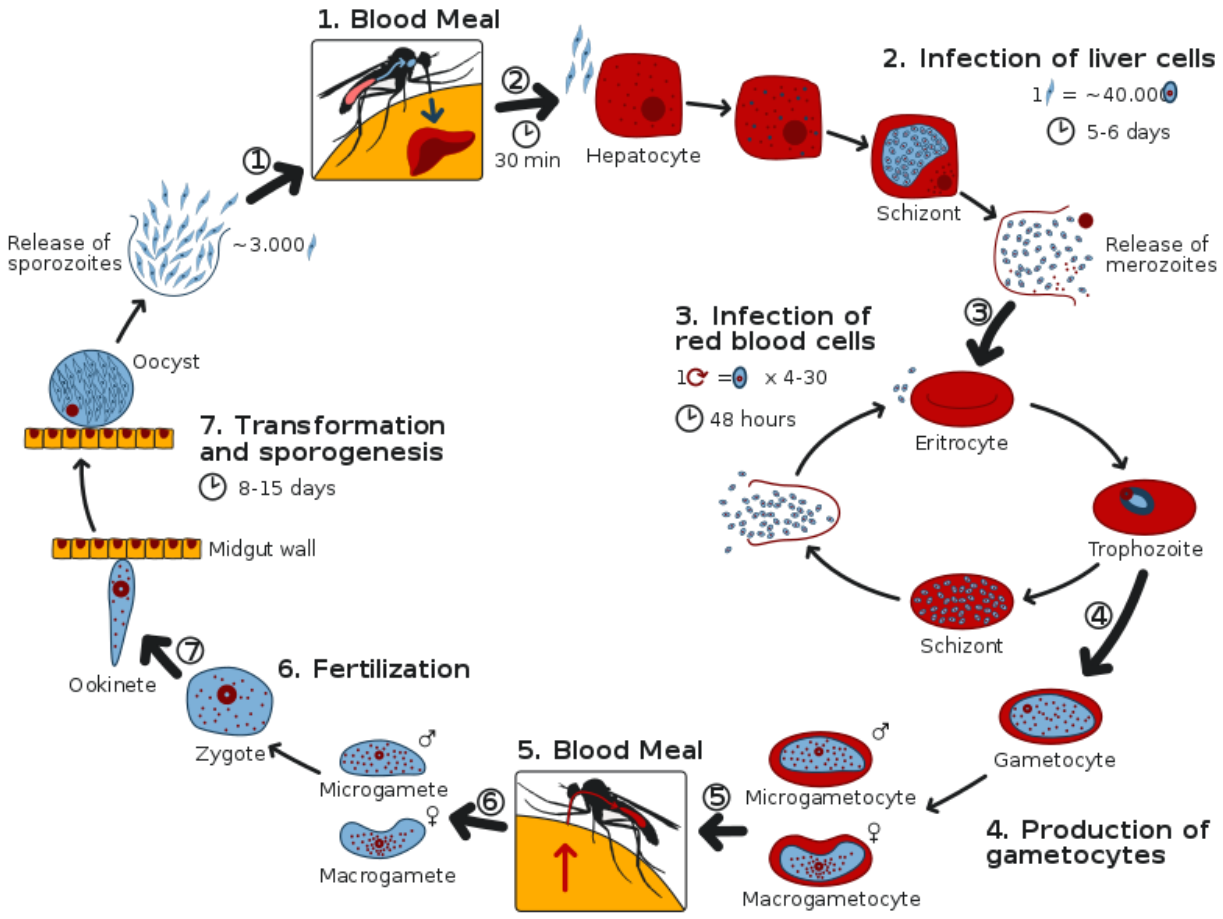


Figure 1 Life cycle of Malaria Parasite

(https://commons.wikimedia.org/wiki/File:Life_Cycle_of_the_Malaria_Parasite.svg)

2.6 Signs and symptoms of malaria

The symptoms include fever and flu-like illnesses such as shaking, chills, headache, muscle aches, tiredness and general feeling of discomfort. Nausea, vomiting and diarrhea may also happen. Malaria can cause anemia and jaundice because of harm of red blood cells. As these symptoms are so general, malaria is often misdiagnosed clinically. Most malaria signs and symptoms begin 1-4 weeks after the infective mosquito bite. Inadequately taken malaria prophylactic medicines, however, may elongate the incubation period. The symptoms of malaria are related to the asexual (blood- borne) stage of the parasite. Uncomplicated or no severe malaria accounts for more than 90% of all disease events and consists of fever, malaise, headache, myalgia and minor gastrointestinal symptoms (Newton *et al.,* 1998). The first symptom of malaria is viral illness which leads to following symptoms:- Abdominal discomfort, Headache, Joint aches, Muscle aches, Abdominal discomfort, Vomiting, Lethargy, Anorexia. According to WHO first symptoms of malaria are fever, headache, chills and vomiting that are not specific to malaria. If not preserved within 24 hours, malaria due to *P. falciparum* can progress to severe illness that can lead to death (WHO, 2014). In endemic area because of partial immunity development, asymptomatic infection can occur (WHO, 2010). Children with severe malaria can grow one or more of the following symptoms: severe anemia, respiratory distress due to metabolic acidosis, or cerebral malaria. In adults, multi-organ involvement is frequent. Repeated episodes of fever and illness reduce appetite and restrict play, social interaction, and educational opportunities, thereby contributing to poor development (WHO, 2014).

In general, symptoms include periodic chills and fevers, malaise, lethargy, headache, nausea, abdominal pain and sometimes vomiting and diarrhea. *P. falciparum* is the major strain that can cause severe disease such as severe anemia, cerebral malaria, pulmonary edema, acute respiratory distress syndrome and renal failure, and thus is the strain causing most deaths (White *et al*.2013).

2.7 Diagnosis and treatment

Malaria diagnosis might be clinical in rural settings or laboratory-based, microscopy. The diagnosis of malaria is usually made by examining a peripheral blood slide for the presence of parasites. Malaria microscopy uses a blood film test (WHO, 2010). While a single positive blood

test result may evidence the existence of malaria, a single negative test is insufficient to exclude it. If malaria is suspected at least three negative blood film tests can be done to rule out it. This process requires some laboratory training and equipment and is time consuming. In skilled hands, this is still the most sensitive means of detecting infection Rapid Diagnostic Tastes (RDTs) are also employed. RDTs, by which parasite antigens are detected in a drop of blood applied to a test strip, have become more widely available in recent years, but their cost remains prohibitive in many countries. The currently available RDTs detect one or more of the parasite anti-gens, HRP2 lactate dehydrogenase and aldose and are usually specific for *P. falciparum* infections or mixed infections containing *P. falciparum.* Malaria indicative signs and symptoms are important for its diagnosis. In most SSA, there is insufficient staff or resources available to perform blood tests whether by microscopy or by RDTs – on every patient with suspected malaria. Interpreting the results of a RDT or blood film is, in some circumstances, fraught with difficulty. In much of the world where malaria is endemic, asymptomatic infection is common and the presence of parasites in the blood does not equate to disease (Baired, 1998).

Malaria is treated with certain types of prescription medicines depending on the *Plasmodium* species detected, level of disease severity, patient age, pregnancy status and the overall malaria control policy of the country in question. If untreated, *P. falciparum* malaria may lead to death particularly in under-five children within hours of the onset of signs and symptoms. Severe malaria during pregnancy can also result in failure, low-birth weight infants, developmental disabilities and other related later difficulties (Clark, 1915; Cot and Deloron, 2003).

Malaria control is mostly based on prompt case detection and treatment in addition to vector control measures. Treatment of Malaria most available anti-malarial drugs were designed to target the symptomatic blood stages and thus act only against the sexual blood forms (Baired,2005). Chloroquine succeeds as the first-line treatment for *P. vivax* infections in Ethiopia (including other SSA countries) (Mekonnen *et al.,* 2014). Drugs are used to prevent (chemoprop hylaxis) and treat infection in individuals. While many new anti-malarial drugs have been developed in the last 20 years (mefloquine, halofantrine, artmisinin, malarone, atovaquone and proguanil, co-artemether) (Mohammed *et al.,* 2015). Treatment of an individual diagnosed with *P. falciparum* malaria is of great concern because contrary to the other species, it can be rapidly fatal (White *et al*., 2013).

Individuals can protect themselves against malaria by wearing protective clothing and using insect repellents and bed nets (Zerihun *et al*., 2007). ACT, distribution of LLINs, and IRS are important in the reduction of malaria burdens (WHO, 2015; Griffin *et al*., 2010).

2.8 Malaria in Africa

2.8.1 Health burden

Malaria is one of the greatest severe public health problems worldwide with 300 to 500 million cases and about one million deaths reported to date, 90% of were reported from SSA. Malaria is a public health problem in the developing world particularly in SSA countries where malaria kills a child every two minutes (WHO, 2015). Globally, an estimated 212 million cases of malaria occurred in 2015, 90% of the cases were in the WHO African Region and 57.8% (114 million) malaria cases were reported from SSA. In 2015, 303 000 malaria deaths were estimated to have happened among below-five, accounting for 70% of the global total (WHO, 2016). Of 438,000 registered malaria deaths in 2015, approximately 80% of the deaths were concentrated in just 15 countries, mainly in Africa (FMoH, 2014; WHO, 2015).

In SSA abundant of the malarial morbidity and nearly all of the mortality affect young children (Snow *et al*., 1999). An estimated one million people in Africa die from malaria each year and most of these are children under 5 years old (WHO, 2015). In 2010, it was estimated that over 500 million school age children were at risk of malaria infection, 200 million in SSA (Gething *et al*., 2011). Studies in Africa have shown that 7–10% or more of newborns have malaria parasites in their placental blood and significant part of the spread of parasites from the mother to the child happens well before the time of delivery. In areas of high spread, the main burden of malaria, including nearly all malaria deaths, is in young children (Snow &Marsh, 2002; Carneiro *et al*., 2010). Congenital malaria has been documented in malaria endemic areas for many years. It is estimated, that in 2001, there were 1.21 million deaths due to malaria, most of which were in Africa and in young children (Lopez *et al*., 2001). Malaria is also responsible for a huge amount of illness and absence from school (Breman, 2001).

Recent estimates are that malaria kills up to 2.7 million persons yearly, and that 90 percent of these deaths occur in Africa, where most of the losses are children under the age of 5 years. It is

estimated that 300 million episodes of clinical malaria happen each year in the African region, but the actual figure could be much higher than this (Samba, 2001).

Malaria affects more than 24 million pregnant women and kills more than one million children each year in SSA while more than 300 million children get sick of malaria annually (WHO, 2013; Steketee *et al*., 2001). The incidence of malaria worldwide is estimated to be 216 million cases per year, with 81% of these cases happening in SSA. Malaria kills approximately 655,000 people per year; 91% of deaths occur in SSA (mostly in children under five years of age). Malaria continues to be the most significant mosquito-borne disease globally but it holds a particularly heavy burden across many countries in Africa where in 2018, 88% of global cases and 90%of global deaths due to malaria were recorded WHO.
(http://www.who.int/mediacentre/factsheets/fs094/en).

2.8.2 Malaria control and prevention in Africa

Initiative and from the African national governments, there has been a massive scale-up of anti-malarial interventions in the past decade. These interventions have led to wide-scale reductions in malaria morbidity and mortality and have changed the landscape of malaria epidemiology in Africa. For example, many studies have shown that household ITN ownership has reached more than 80 % in Eastern Africa (Kateera *et al*, 2015). Reducing the burden of malaria particularly in SSA is linked to several of the sustainable development goals (WHO, 2015). Many studies have shown that household ITN ownership has reached more than 80 % in Eastern Africa and that the scaling-up of malaria control has greatly reduced malaria-related burdens (Quinones *et al.*, 2015). By the late 1990s, there was a considerable body of evidence that the use of ITNs reduced childhood mortality in sub-Saharan Africa (Lengeler, 2004).

2.9 Malaria in Ethiopia

2.9.1 Health burden

About 75% of the total landmass of Ethiopia is malarious and 60% of the population is at-risk of malaria (FMoH, 2015). The World Malaria Report 2015 document shows that 26,400,000 (27% of total population) reside in malaria high spread areas (>1 confirmed cases per 1000 population), 39,600,000 (41%) in low (1 case per 1000 population) and 31,000,000 (32%) malaria free (0 cases per 1000 population) in 2014. In Ethiopia malaria is mainly unbalanced and seasonal unlike it is in many other countries. During the major transmission season from September to December, following the main rains June to August, a large peak in malaria case occurs. A second but less pronounced peak happens during the second transmission seasons in April and May following short rains (Tulu, 1996).

Due to this unstable and seasonal transmission design of malaria in the country, protective immunity of not only children but the general population is low and all age groups are highly vulnerable to the disease. Thus the public health burden of malaria is huge in Ethiopia. Although the economic burden of malaria in terms of average lost work DALYs during malaria episode is not thoroughly investigated nationwide, in northern Ethiopia there was an attempt some 16 years back. It was estimated that the average lost work days was 18 for adults and the average cost of illness per episode for adults ranged from 46-151 Ethiopian Birr with overall malaria accounting for 10.4% of the total 59,125 DALYs per 100,000 populations. Apart from its unstable nature malaria in Ethiopia has another peculiar feature that *P. vivax* accounts for about 40% of reported cases. *P. vivax* is less frequent in Africa except in Eritrea, which was part of Ethiopia before 1991, where reports show 26% presence (WHO, 2015).

In Ethiopia, *P. vivax* may be co-dominant with *P. falciparum* although noticeable spatial and temporal variations are noticed (Yimer *et al.,* 2015). A few *P. malariae* cases are recorded in some localities in the country (Tulu, 1996, SNNPR, 2015). *P. oval* is also recorded although it is very rare. A recent molecular study in northwest Ethiopia revealed *P. ovale curtisi* and *P. ovale wallikeri* (Alemu *et al.,* 2013).

Primarily the collection records of Ethiopian malaria eradication service personnel, publications of foreign workers, notably the Italians, and field trip reports of the (USAID) and the WHO

from the early 1940 through 1965 showed original entomological surveys in Ethiopia where *An.* gambiae, *An. funestus*, *An. pharoensis* and *An. nili* were incriminated as malaria vectors across Ethiopia (O'Connor, 1967). Entomological findings conducted so far indicated the presence of about 42 *An.* species, but only *An. arabiensis* (which now belongs to *An. gambiae* complex) is known to play a crucial role in malaria transmission in the country. *An. funestus* and *An. pharoensis* are broadly dispersed but play a secondary role, *An. nili* entails spread in localized areas (FMoH, 2000).

2.9.2 Malaria control and prevention in Ethiopia

In Ethiopia malaria control doings have been in action for long. IRS and mosquito larval control dates back to the early 1960s. Patients of all ages are receiving malaria diagnostic test free of charge in the public sector since that time. But, cyclic malaria epidemics kept on unabated in the country with the latest epidemic in 2004 and 2005 (SNNPR, 2005; Guthmann *et al.*, 2007).

In recent years, however, there has been heavy financial support by global donors and refreshed political commitment of governments in malaria endemic countries to curb the disease. Moreover, clear operational plans including a long-term vision for malaria control were formulated in which sustained scale-up of proven malaria control tools would progressively lead to malaria elimination in Africa, with the ultimate goal of worldwide malaria eradication by 2040-2050. The proven malaria intervention tools being extensively used in Ethiopia, like elsewhere are ITNs; IRS; prompt diagnosis and treatment with ACTs. Although Ethiopia is still in malaria control stage it has set a plan to eradicate malaria in selected low transmission settings by 2020 (PMI, 2018).

The aggressive malaria intervention policies and strategies of Ethiopia are supported by major external funders (Global fund, World Bank, USAID/PMI, WHO and others) since 2005. The funding reached peak in 2013 and then declined in 2014 as FMoH sources demonstrate. Mosquito nets are being distributed free of charge to all age groups since 2004. In 2014, the proportion of the at-risk population estimated to have access to an ITN in their household exceeded 50% (WHO, 2015).

IRS was used with the protected proportion of the at-risk population exceeding 60%. Parathyroid resistance has been confirmed in Ethiopia since 2010 and DDT resistance is also common (Balkew *et al.,* 2010). Carbamate resistance has also been reported for at least one malaria vector, and organophosphate resistance has been reported for Ethiopia (Yewhalaw *et al.,* 2011). Currently propoxur or bendiocarb are in use as per the WHO recommendation Ethiopia has adopted AL, one form of ACTs as first-line treatment policy since 2004 (FMoH, 2004) for uncomplicated *P. falciparum a*nd for *P. vivax* chloroquine remains the drug of choice. AL is free for all ages since 2004, sell of oral artemisinin-based monotherapies is never allowed since 2004, no single dose of primaquine is used for gametocidal medicine for *P. falciparum*, no for radical treatment of *P. vivax*, no directly observed treatment with primaquine is undertaken. However, a system for monitoring adverse reactions to anti-malarials has never been in existence. Surveillance for ACD for case investigation, and ACD of febrile cases at community level, mass screening, have never been there. The therapeutic efficacy of AL remains high in Ethiopia (Nega *et al.,* 2016). with a median treatment letdown rate of less than 10% observed. The world malaria report 2015 reported that it was not possible to assess malaria trends between 2000 and 2014 because of inconsistent reporting, or changes in health service accessibility or diagnostic testing.

However, a study of 41 hospitals with complete data for analysis (of the total 62 hospitals below an altitude of 2000 meters) found a 66% decrease in confirmed cases between 2001 and 2011 (Aregawi *et al.,* 2014), which is consistent with the WHO estimate of a 50-75% decrease in case incidence by 2015. Estimates of malaria case incidence inferred from surveys of parasite prevalence proposed that Ethiopia had decreases in case incidence of more than 75% between 2000 and 2015 (WHO, 2015).

Ethiopia fact sheet of health statistics 2016 based on WHO 2015 delineates the following regarding malaria. Under-five death by malaria in 2000, 2005 and 2010 was 2.0%. The number of these children with fever who received treatment with any anti-malarial in 2014 was 26.0%. In same year the proportion of these children sleeping under ITNs was 30.0%. Malaria mortality rate (per 100,000 populations) was 17.0% in 2012 and 15.0% in 2013. Malaria incidence rate (per 100,000 populations) in 2012 was 4563. In its latest annual report (FMoH, 2015). The FMoH indicated that up to August 2015 a cumulative total of 75,876,866 LLINs were distributed

nationwide to the at-risk population. The coverage was more than double compared to the status in September 2010 (35,237,701). A total of 5.3 million unit structures (89.8% out of the target) in malaria endemic areas were sprayed. A total amount of 6.8 million doses of ACTs, 35,000 vials of artesunate injection, 1.17 million doses of chloroquine and 13 million RDTs were distributed for malaria intervention previous year. This latest report revealed not only high coverage of malaria vector control tools, diagnostics and drugs the country has also shown massive expansion of its health facility infrastructure and professional staff. Currently there are 16,447 health posts .The maximum number of health posts is found in Oromia Region (6519), accounting for 39.6% of the total, followed by SNNPR having (3,842) and Amhara (3336) Regions. The cumulative total of available health centers is 3,586 in August 2015 with 180 under construction. The highest number of health centers was found in Oromia Region (1320), accounting for 36.8% of the total, followed by Amhara (834) and SNNPR (752) Regions. During the same period there were 189 functional hospitals and 147 under building in eight Regions in addition to Federal hospital. In SNNPR totally 77 hospitals were available (41 functional, 36 under construction).

Health extension workers are the main resources for implementation of health extension program in Ethiopia. The aim of Health extension workers advancement program is to improve the quality of health extension services at community and household levels. A total of 8,647 Level III Health extension workers were enrolled to be upgraded to Level IV qualifications. Out of enrolled in last 3 years, a total of 3,667 graduated and deployed back to their respective health posts. The remaining 4,970 were on training and planned to graduate at the end of 2015. Level III replacement exercise had been ongoing in line with the upgrading program in all Regions.
Although there are major improvements challenges remain ahead. The report stipulated that there were budget constraints at woreda level to conduct IRS actions; delay in LLIN procurement to replace the "old" ones; and inadequate utilization of LLINs. So, malaria continues to be a major public health challenge although drastic reduction was achieved.

The aforementioned latest annual performance report presented that between September 2014 and August 2015 a total of 2,174,707 malaria cases (confirmed plus clinical) and 662 deaths were documented with case fatality rate of 0.03%. The number of microscopy or RDT confirmed were 1,867,059 (85.9%) of which 1,188,627 (63.7%) were *P.falciparum* and 678,432 (36.3%)

P.vivax. The monthly pattern showed an increase in September through January peaking in November, followed by a decrease until April. There was no clear pattern of seasonal difference in the distribution of the two species although in October, November and December there was a sharp increase and a drop thereafter for *P. falciparum, P.* vivax appeared to show a lower profile and nearly a reliable pattern throughout. No mixed cases were reported. The highest number of total malaria cases was reported from Amhara (610,486) followed by Oromia (430,969) and SNNPR (375,746). The number of total malaria cases at national level was halved compared to the previous year.

2.9.3 Malaria status in SNNPR

The SNNPR is located in the southern and southwestern part of Ethiopia. The Region has an area of 110,931km^2 that is around 10% of the country's total area (SNNPR, 2016). The estimated population of the Region in 2016 was 18,719,008 which accounted for about 20% of the total population of the country. At the time of this study the Region had 15 administrative Zones and four special woredas. The Zones consisted of 131 woredas (districts) and 22 town administrations. The woredas included 3,602 rural kebeles (lowest administration units) and 324 town centers. Hawassa is the administrative capital of the Region. In the Region about 26% of the population is at-risk of malaria and the disease is a primary cause of outpatient and inpatient consultations and hospital deaths (SNNPR, 2015a). The 2005 Regional Health Bureau annual performance report (SNNPR, 2005) indicated that between September 2004 and August 2005 totally 220,936 ITNs (1 ITN per household) were dispersed uplifting the previous year 10% coverage to 22%. That means the coverage was about 11% when 2 ITNs per household were considered. DDT was in use in that year for IRS. An epidemic occurred in the same year in 110 kebeles of 47 malarious woredas in the Region.

Clinically 394,021 cases were treated. Blood examination was undertaken for 277,037 people and malaria-confirmed cases were 121,013 (*P. falciparum* 74,713; *P. vivax* 34,668; *P. malariae* 1,777 and *P. falciparum* 74,713; *P. vivax* mixed infections 2855). The report does not hold fatality cases and CFR. Age, sex, zonal, woreda or kebele distributions of the epidemic were not available. SNNPR malaria trend from 2003 to 2012 was investigated by Abebe 2014 and the following key findings were established. The study utilized malaria surveillance database of SNNPR health bureau and FMoH/EHNRI, now EPHI. A total of 15,722,005 cases suspected of

malaria were tested by RDT/microscopy and 4,094,332 (26%) had confirmed malaria. Clinical plus confirmed cases treated during these periods were 12,065,332. Of these 3,802,626(31.5%) were under-five children. Malaria inpatients were 171,701 and there were 3,580 deaths with CFR of 2.1%. *P. falciparum* was accountable for 2567,716 (63%) cases, and *P. vivax* was identified among 1,526,616(37%) patients. The author did not report the over 1000 *P. malariae* cases registered in the Region's 2005 annual performance report. Malaria cases decreased from 2004 to 2009 and from 2010 to 2012 an increasing drift was noticed. But, malaria deaths declined consistently. Cases were found throughout the Region in varying degree Alaba special woreda having the highest malaria incidence in 2012.

According to SNNPR Health Bureau annual report August, 2015 (SNNPR, 2015a), between September 2014 and August 2015; 2,820,320 people attended the Region's health facility outpatient departments. Of these; 1,488,835(53.0%) were malaria suspects examined by RDT or microscopy with 317,667(21.5%) having confirmed malaria. Of these, 175,052(55.1%) were *P. falciparum*, 136,113(42.8%) *P. vivax* and 6503(2.0%) mixed infections by both species. However, malaria treatments were prescribed for a total of 367,766 people including 50,109(13.6%) who were unconfirmed cases. More than half of the febrile cases were of non-malarial origin. The report delineated that in some woredas malaria incidence declined substantially and the number of malaria patients was very low compared to previous years. There were no epidemics in the fiscal year. In the absence of epidemics 30-40% malaria prevalence is expected and the 21.5% recorded during the year showed the decrease of malaria cases in the Region. However, presumptive malaria treatment remains widely practiced in the Region showing that the WHO's 'universal testing for malaria' is yet to be achieved. From the report it was not clear how only 50,109 clinical cases were selected and treated from other suspects.

The report contains monthly (July to June) total malaria cases (confirmed and clinical) in 2011 through 2015. In 2011/12; April (125,286), October (115,114) and May (111,194) had the highest cases. August (57073) was the lowest. In October 2012 and 2013 the highest number (101842, 68097) were, respectively registered. November 2014 was the highest (32967). However, cases were encountered throughout the years considered almost comparably. In 2013/14 confirmed malaria cases were highest for Wolaita Zone (>77000) followed by Gurage (nearly 60000), Gamo Gofa (~50000), Hadiya (> 42,000), Kambata Tambaro (~40000), Silt'e

(>32000) and Yem the least (~1100). On the other hand, in 2014/15 there was tremendous drop in the number of confirmed malaria cases in all zones and special woredas of the Region. Wolaita was still leading (~38100), Gamo Gofa (~35100), Hadiya (~29000), Gurage (~27100), Kambata Tambaro (~15800), Silt'e (~6500).

According to FMoH annual report 2015, in SNNPR between September 2014 and August 2015 the population at-risk of malaria was 12,238,426. The number of people suspected and tested for malaria was not indicated in the report. Total malaria cases were 375,746(17.3%), incidence per 100,000 populations was 3,070, death 166 and CFR 0.04%. This is not consistent with SNNPR health bureau annual report for same year. The latest Regional report illustrates that in 831 kebeles in high malaria transmission woredas of the Region (64.3%), 906,871(85.7%) households (housing 2,907,085 people) were sprayed by 121,841kg propoxur (Baygon) and 51240kg bendiocarb. But this was lower than the previous year due to shortage of insecticides. Overall IRS coverage in the past 12 months was 66.7% and the plan was to achieve 100%. Regional LLIN coverage (1 net for 1.8 people) was 97.9 %(6,667,421). Coverage of at least 1 LLIN per household in risk population was 98% (the plan was 100%); pregnant women sleeping under net was 75.2% (the plan was to achieve 86%), and number of under-five children sleeping under net was 66.5% (plan 86.0%). The Regional record described that for larval source reduction 2,621,555 people participated in environmental control for mosquito breeding sites destruction, and 849,460 temporary and 164,177 permanent sites were drained or filled using women development groups. In sites where drainage and filling was not feasible 2,020,036 cc chemical (Abate larvicides) was sprayed to kill mosquito larvae.

In 2014/15 there was a steep drop in the number of cases compared to the data as recent as 2013 suggesting the effectiveness the ongoing control interventions. However, the 2015 data itself shows that out of 1000 people 7 were malaria positive and the intended plan to lower the number below 2 (SNNPR, 2015b) was not achieved requiring more effort. Malaria transmission is still high (>1 case out of 1000) in most settings in the Region. SNNPR health bureau public health emergency management core process weekly bulletin was published for epidemiological week 33 (of the Ethiopian fiscal year 2006, corresponding to 2015/2016). According to the document, there were 4,614 governmental health facilities in the Region in 2016 and there was a practice of weekly malaria report. In the 33rd epidemiologic week, a total of 31,625 suspected malaria cases

were examined by RDT/microscopy and 5,321 cases were reported as confirmed malaria. Of which, *P. falciparum* cases were 3,335 (63%) and *P. vivax* 1,986 (37%). In general, a total of 5,604 confirmed and clinical cases of malaria were reported in the Region during that year. Of these cases, 5,555 (99%) were outpatients and 49 (1%) inpatients. The number of malaria cases during the week decreased by 188 compared to the previous week (a total of 5,792 confirmed malaria cases were reported in week 32). The number of cases was decreasing slightly since week 29. In addition, it was lower than the same week of the previous year.

The highest malaria incidence rate was observed in Basketo special woreda with 255 cases per 100,000 populations in week 33. The case remained high in the special woreda for the previous two months. The special woreda reported 283 and 174 cases per 100,000 populations in weeks 31 and 32 respectively. South Omo and Konta reported the second and third highest cases with 110 and 100 malaria cases per 100,000 populations in the week respectively. Among ordinary woredas, Salamago reported the highest malaria case in the week with 340 cases. The case remained high in the woreda for the previous four months.

2.9.4 Malaria in Silte Zone

The total population of SZ, one of the administrative Zones in SNNPR, was 704,835 and in 2013/14 totally 221,458 nets were distributed out of 391,575 LLINs required. In 2014/15 out of 146,650 needed 368,108 nets were provided with percentage coverage of 94% (SNNPR, 2015a). More recently, in 3 woredas in SZ a total number of 8600 nets were distribute (SNNPR, 2016).

As it is mentioned earlier in 2014/15 confirmed malaria cases in SZ were about 6500 which was significantly lower than what was found in 203/14 where there were >32000. Although the total population of each Zone and special woreda is required to compare the number of cases in Zones or the woredas it looks that Silt'e had the lowest malaria cases in both years. In 2013/14 the cases in SZ were higher than only that of Yem special woreda.

However, malaria remains one of the major health problems in the administrative town of Silte zone. In 2009, 8.5% of Silt'i population was malaria slide-positive showing the high public health burden of the disease in the population. But, little published reports are available on recent malaria impact between children, and its seasonal arrangements in the administrative town of SZ. Both FMoH and SNNPR reports provide little information about detailed malaria status of the

town. It is obvious that the global malaria status is the sum total of each country status, and in turn the country status is the sum total of its regional and local situations at each level. Accurate assessment of the levels and time trends in malaria burden are crucial for assessment of progress towards goals and planning national health services and focusing future efforts. The present study aimed to evaluate the species-specific malaria outbreaks in the administrative town of Silte zone, from the year 2012–2018. The results offer an overview of malaria statistics and also help to know the status of malaria in the town and to take an appropriate intervention.

3. Materials and methods

3.1Description of the study area

Tora town is located at 225 Kilometers away from the capital city of Addis Ababa to south and 160 km in north direction of the regional capital city, Hawassa. And also which is located at 28 km from east of worabe town to border line of Zeway. Geographically, the town is located at $7^0$35'0"N to $7^0$56'0" N latitude and 38^0 12'0" E to 38^0 30'0"E Longitude. Its average altitude is 1980 m.a.s.l. the town is a residential and commercial area, with a land cover of 4459.8 Hectares (Fig 2).

3.1.1 Demography and Topography

The total population of the study area were 8207 (male), 7147 (female) total 15354 peoples live. From the above total population under 15 age were male 2810 and female 2501 sum total 5311 between 15-64 age categories were male 2713 female 2431 sum total 5144 and 65 age and above were male 2684 female 2215 sum total 4899 peoples were lived (Tora town population Affaires Directorate Report, 2018). Topographically Tora town are comprises mountainous, plateau and a little bit lowland/plain area.

3.1.2. Climate

Kolla and dry weyna Dega is the agro climatic zone that prevails in the district, the heaviest rains fall from May to September. And a weaker rainy season occurs in October and April. The peak months of the rainy season are the months of June and July. A longer dry season from December to March. The mean monthly rainfall between May and September is about 200 mm while in December and March it is down to 55 mm and in January, it is as low as 25 mm. However, the mean monthly rainfall through the year is about 100 mm, while the total annual rainfall is almost 1200 mm (Ethiopian Weather Forcasting Directorate, 2015).

The main dry season is accompanied by monsoon Asian winds from the Indian Ocean which between December and early February can be quite strong. The average temperature in January is 27˚C and for July it is 25˚C. On average the hottest month is March with a mean temperature of 29˚C while July is the coolest month but still there doesn't exist much of the hot months (Ethiopian Weather Forcasting Directorate, 2015). Dominantly the town is falls on

dry ever green ecological zone, and patch of trees (Tora town admnistration Agriculture Office Report, 2018). Malaria is the most prevalent seasonal disease in the area before 2019. In the tora town health center September to November is the peak malaria transmission season in the area and both *P. falciparum* and *P. vivax* exist in the area.

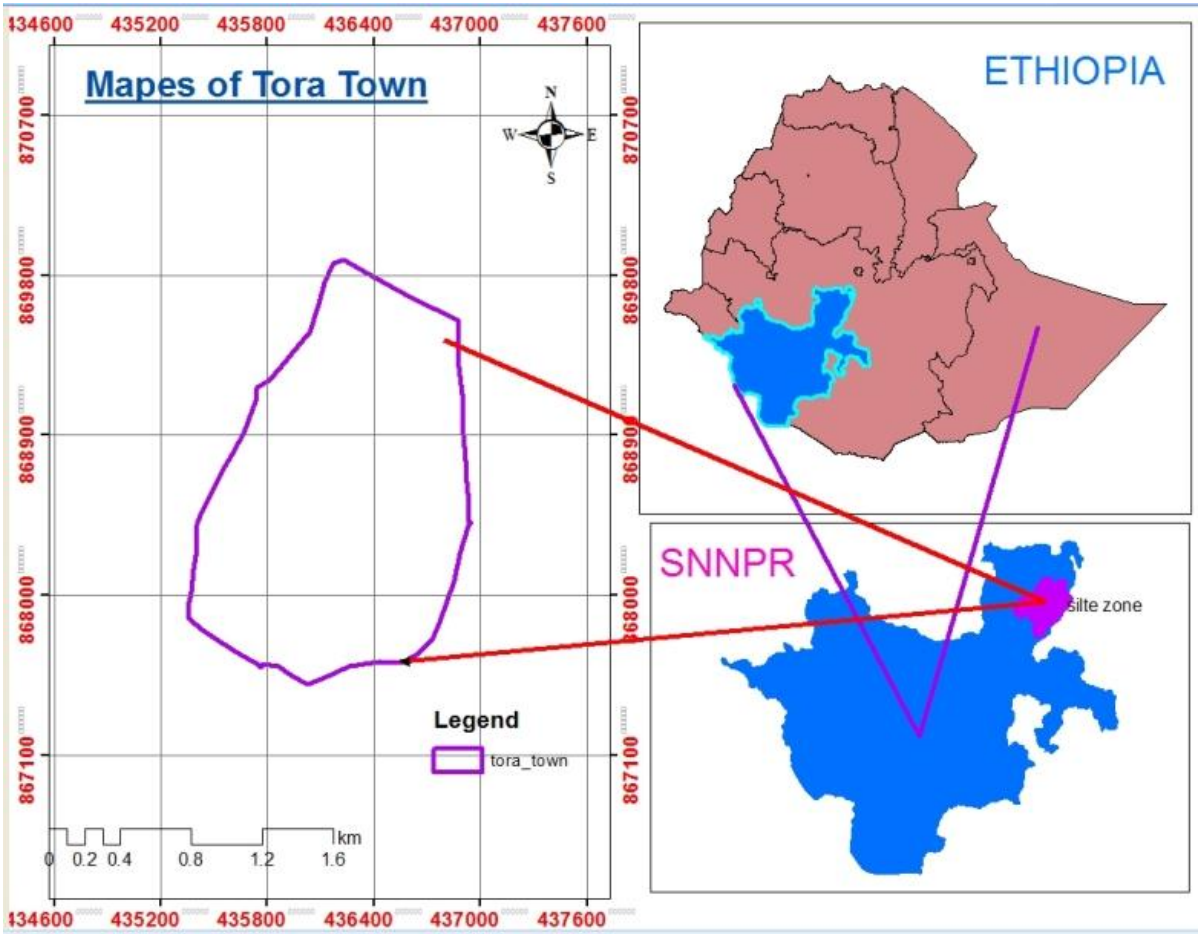


Figure 2 Location of the study area

3.2. Study design

A prospective survey was conducted to determine the incidence of malaria among children (0-14 years) attending Tora primary hospital from January 2019 to June 2019. Past seven-years (between January 2012 and December 2018) malaria trend in Tora town was also evaluated using retrospective data from the town health office.

3.3. Method of data collection

3.3.1 Retrospective data collection

Retrospective data collection methods were used, with the use of these method the past seven year malaria prevalence data (between Januarys 2012 and December 2018) was collected from Tora town health office regestrative book.

3.3.2 Prospective malaria microscopy diagnoses based data collection

Prospective data collection method Blood sample data were taken from all febrile patients at Tora primary hospital emergency or outpatient departments, and examined by experienced lab technician at the hospital following established protocol (WHO, 2010). Briefly, finger prick blood samples will be collected, thick and thin smears was prepared. The thin smear was fixed with methanol, flooded with Giemsa stain and left for 10 minutes. The slide was washed thoroughly under tap water, left to dry and backside cleaned with cotton wool. The thick film was flooded with Giemsa stain and allowed to stand for 30 minutes. The slide was washed backside wiped with cotton wool and placed in a draining rack to air dry. Both types of slides was examined to asses and determine childhood malaria in Tora primary hospital based on age, sex, seasonal distribution and *Plasmodium* species distribution.

3.4 Method of data analysis

Data was checked for completeness and consistency, and entered into statistical package for social sciences (SPSS) version 23 (IBM SPSS). The Chi-squared (X^2) test was used to test differences in malaria prevalence and incidence between years, seasons (months), sexes, and age groups for both retrospective and current prospective data in the data distribution of both dependent and independent variables. The data was showed using descriptive statistics percentage quantitative techniques were employed and finally he data was described and presented using tables.

3.5 Study population source

The patients who came to Tora primary hospital for the diagnosis of malaria and who came for treatment within six months as well as to these all people those who are suspected to malaria who live in Tora town and the surrounding area were considered within the last seven years.

3.6 Sampling techniques

For this study simple random sampling techniques were used based on the available data. Therefore, the study included all malaria disease patients belonging to the age 0-14 years presented during the study period in Tora primary hospitals and all age groups were considered with in Tora town health office registration books. On the other hand, all patients of other than malaria disease were excluded in Tora town office and malaria disease patients belonging to the age greater than 14 years in Tora primary hospitals.

3.7 Data Quality control

In order for the finding of the survey to be valid and reliable the blood sampled was examined by experienced lab technician at the hospital following established protocol (WHO, 2010).

3.8 Ethical consideration

The study was conducted after obtaining ethical clearance from the College of Natural and computational Sciences Research Ethics Review Board, Addis Ababa University and approved by Tora town health office administration and formal letter of co-operation was obtained from Tora primary hospital head office before conducting the investigation. At the beginning of the study, the objectives and purpose of the study was explained to the concerned participants. The right of participants was protected. The principle of voluntary participation requires that people should not be forced to participate in a research. Ethical consideration was addressed to treating individuals with positive results of *Plasmodium.*

4. Results

4.1 Retrospective data study

Among patients diagnosed for malaria between January 2012 and December 2018, a total suspected were 58814 among this 5391 were slide-positive and 53423 were slide negative. On average, 770 slide-confirmed cases visited Tora health facilities each year. However, the number suspected and confirmed cases showed a fluctuation trend in the years. There was successive reduction in malaria prevalence from 2012 to 2018. The highest number of malaria suspected and confirmed from 2012 years, 13320 (22.6%) and 2500 (18.8%) to 2013 years, 10231(17.4 %) and 2125 (20.8%) respectively, but the lowest number of malaria suspected and confirmed from 2017 years, 4408 (7.5%) and 31 (0.7%) to 2018 years, 2268 (3.9%) and 23 (1.0%) respectively. Therefore, the highest yearly malaria prevalence was in 2013 and 2012, the lowest malaria prevalence was 2016, 2017, 2018(Table 1).

In the yearly pattern of malaria most of slide positives were from 2012 to 2014. In terms of *Plasmodium* species 2741 and 2650 of the cases were accounted to *P. falciparum* and *P. vivax* mono-infections respectively. Both types *Plasmodium* species were reported in each year with *P. falciparum* being the predominant species in the study are. Recently, in the year 2017 and 2018 both types of species was decreasing. Compared to 2012 to 2018 years in *Plasmodium* species the difference was significant in the number of suspected and confirmed malaria cases (P <0.0001). There were *P*. vivax mono-infections more in 2013 (50.8%), 2016 (50.5%) and 2018 (52.2%) than *P. falciparum*, and the reverse was observed in from 2012 (51%), 2014 (55.5%) ,2015 (56.3%) and 2017 (54.8%) (Table 1). There were significant declines in the number of suspected and confirmed cases of malaria.

Table 1 Slide-confirmed annual malaria cases and Examined no.(2012-2018) at Tora town health office.

Year	Total Examined n. (%)	*Total positive,* n. (%)	*P. falciparum,* n. (%)	*P. vivax,* n. (%)	P. value
2012	13320 (22.6)	2500 (18.8)	1276 (51.0)	1224 (49.0)	
2013	10231(17.4)	2125 (20.8)	1046 (49.2)	1079 (50.8)	
2014	9833 (16.7)	411 (4.2)	228 (55.5)	183 (44.5)	
2015	9581(16.3)	206 (2.2)	116 (56.3)	90 (43.7)	< 0.0001*
2016	9173(15.6)	95 (1.0)	47 (49.5)	48 (50.5)	
2017	4408(7.5)	31 (0.7)	17 (54.8)	14 (45.2)	
2018	2268(3.9)	23 (1.0)	11 (47.8)	12 (52.2)	
Total	58814(100)	5391 (9.1)	2741 (50.8)	2650 (49.2)	

Key: * significant, n = number of study , % = percentage

In terms of yearly seasonal pattern of malaria in 2012-2018 in the total positive were 5391, the highest peak of malaria cases in almost all years was observed during spring (September , October and November) 685 (10.3%), 969 (13.8%), and 858 (12.2%) respectively and the minimum malaria cases were observed during winter (March, April, May) 75 (2.5%) , 83 (3.6%) and 74 (2.5%) respectively. Therefore, Seasonal prevalence of malaria were highest in September, October and November and the lowest in March , April and May (Table 2).

Despite the apparent fluctuation of malaria trends in the study area, malaria cases occurred in almost every month and season of the year. Over the whole 2741 and 2650 of the cases were attributed to *P. falciparum* and *P.vivax* mono-infections respectively (Table 2). The deference was statically significant (P < 0.0001).

Table 2 Slide-confirmed yearly seasonal patterns no.(2012-2018) and species distribution at Tora town health office.

2012-2018 Months	Total examined, n. (%)	Total positive. n. (%)	Total *P. falciparum*, n. (%)	Total *P. vivax*, n. (%)	P.value
January	4511 (7.7)	392 (8.7)	167 (42.6)	225 (57.4)	
February	3924 (6.7)	290 (7.4)	137 (47.2)	153 (52.8)	
March	3023 (5.1)	75 (2.5)	39 (52.0)	36 (48.0)	
April	2313 (3.9)	83 (3.6)	43 (51.8)	40 (48.2)	
May	2915 (5.0)	74 (2.5)	33 (44.6)	41(55.4)	
June	4014 (6.8)	253 (6.3)	125 (49.4)	128 (50.6)	< 0.0001*
July	5314 (9.0)	511 (9.6)	258 (50.5)	253 (49.5)	
August	6115 (10.4)	614 (10.0)	320 (52.1)	294 (47.9)	
September	6620 (11.3)	685 (10.3)	440 (64.2)	245 (35.8)	
October	7041 (12.0)	969 (13.8)	539 (55.6)	430 (44.4)	
November	7011 (11.9)	858 (12.2)	451 (52.6)	407(47.4)	
December	6013 (10.2)	587 (9.8)	189 (32.2)	398 (67.8)	
Over all	58814 (100)	5391 (9.1)	2741 (50.8)	2650 (49.2)	

Key: * significant, n = number of study , % = percentage

In terms of sex, 34302 (58.3%) of the total examined were males and 24512 (41.7%) were females. Of total malaria case slide-positives, 3209 (59.5%) were males and 2182 (40.5%) were females (Table 3). The data showed that from 2012 to 2018 more males were examined than females and consequently more males confirmed malaria positive results than females. And also for each year the number of malaria positive males was higher than that of females. The difference was statically significant (P =0.025).

Table 3 Sex distribution of malaria examined and slide-confirmed cases and Plasmodium species at Tora town health office.

Year	Total Examined n. (%)	Total slide positive, n.(%)	Sex		P. value
			Male, n. (%)	Female, n. (%)	
2012	13320 (22.6)	2500 (18.8)	1493 (59.7)	1007 (40.3)	
2013	10231(17.4)	2125 (20.8)	1253 (59.0)	872 (41.0)	
2014	9833 (16.7)	411 (4.2)	238 (57.9)	173 (42.1)	
2015	9581(16.3)	206 (2.2)	133 (64.6)	73 (35.4)	
2016	9173(15.6)	95 (1.0)	58 (61.0)	37 (39.0)	0.025*
2017	4408(7.5)	31 (0.7)	22 (71.0)	9 (29.0)	
2018	2268(3.9)	23 (1.0)	12 (52.2)	11 (47.8)	
Overall	58814(100)	5391 (9.1)	3209 (59.5)	2182 (40.5)	

Key: * significant, n = number of study, % = percentage

Malaria were detected in all age groups. The total number of examined in children (0-4 years) 2028 (37.6%) were positive results. Also the total number examined in children's (5-14 years) 1796 (33.3%) were slide positives. The total examined of adults (15 and above years) 1567 (29.1%) were slide positives. In relation to *plasmodium* species and age group in the study area *P. falciparum* was predominant species in the all age groups. These difference between age group with plasmodium species were statically significant (P <0.0001). The data showed that the age group 0-4years were more slide positives than 5-14 years, the age group 5-14years were more slide positive than 15 and above years.

Table 4 Age distribution of Malaria suspected and slide-confirmed cases and Plasmodium species at Tora town health office.

Year	Total Examined n. (%)	Total slide Positive, n.(%)	Age			P. value
			0-4 years, n. (%)	5-14 years, n. (%)	15 and above years, n. (%)	
2012	13320 (22.6)	2500 (18.8)	903 (36.2)	851 (34.0)	746 (29.8)	
2013	10231(17.4)	2125 (20.8)	807 (38.0)	706 (33.2)	612 (28.8)	
2014	9833 (16.7)	411 (4.2)	141 (34.3)	145 (35.3)	125(30.4)	
2015	9581(16.3)	206 (2.2)	114 (55.3)	51 (24.7)	41 (20.0)	< 0.0001*
2016	9173(15.6)	95 (1.0)	41 (43.2)	33 (34.7)	2 1(22.1)	
2017	4408(7.5)	31 (0.7)	14 (45.2)	4 (12.9)	13 (41.9)	
2018	2268(3.9)	23 (1.0)	8 (34.8)	6 (26.0)	9 (39.2)	
Overall	58814(100)	5391 (9.1)	2028 (37.6)	1796 (33.3)	1567(29.1)	

Key: * = significant, n = number of study , % = percentage

4.2 Prospective data study

Among 200 malaria suspected children diagnosed for malaria (January 2019 to June 2019), there were never malaria cases observed based on smear examination, on average 33 febrile visited Tora primary hospitals in months.

.

5. Discussion

In the study area, the prevalence rate of reported malaria was 9.1 %. In the current prospective survey the overall slide-positivity rate was 0.0 % which was lower than the previous year in the same season. The distribution of *P. falciparum* was slightly higher than that of *P. vivax in* retrospectively statically significant. In opposed our study in Ethiopia, *P. vivax* may be co-dominant with *P. falciparum* although marked spatial and temporal variations are noticed. Most of the cases tended to be mono-infectious in both cases. In a nearby setting, however, distinct and opposing seasonal pattern was observed in the relative dominance of the two species (Yimer *et al.,* 2015). The predominance of *P. falciparum* might be the current diagnostic tests cannot detect dormant forms of *P. vivax* residing in the liver and are only diagnosed when they relapse and *P. vivax* accounts for about 40% of reported cases and *P. vivax* is less frequent in Africa except in Eritrea, which was part of Ethiopia before 1991, where reports show 26% presence (WHO, 2015).

According to SNNPR Health Bureau annual report August, (SNNPR, 2016), between September and August; 2,820,320 people attended the Region's health facility outpatient departments. Of these; 1,488,835 (53.0%) were malaria suspects examined by RDT or microscopy with 317,667 (21.5%) having confirmed malaria. Of these, 175,052 (55.1%) were *P. falciparum*, 136,113 (42.8%) *P. vivax* and 6503 (2.0%) mixed infections by both species.

In this study area regarding to the age groups <5 years were highly affected age groups followed by 5-14 years and > 15 years, it was examined that children aged 1-4 years had slightly higher malaria suspected compared to the other age categories although the difference was statistically significant. Similar to our study Malaria killed young children unable to protect themselves from mosquitos or access lifesaving medicine in Assossa zone western Ethiopia (Legesse *et al*., 2007). In the other study might be due to the fact that children of 5-14 age groups are relatively more exposed to infective mosquito bites compared to younger children who are usually under family protection. Particularly infants are protected against malaria during the first 6 months of life, largely due to lesser exposure to infective bites besides the role of maternal antibodies and fetal hemoglobin (McGregor *et al*., 1984).

The study has shown that Males were more Malaria infected than females which were statically significant. However, studies suggest that adult females are better protected from parasitic diseases than age-matched males for genetic and hormonal factors (Krogstad, 1996).

On the other hand, the proportion of febrile children who visited the hospital was highest for the under-five indicating non-malarial causes of their fever. Before the availability of affordable and accurate malaria RDTs, most health care providers in malaria-endemic countries presumed that malaria was the cause of fever; the proportion of fevers due to malaria was very high in the early 1990s, and the priority was to reduce malaria mortality by any means. Various reports from different settings in indicate the over diagnosis and over treatment of malaria in children in secondary health care centers (Orish *et al.,* 2016; Serwanga *et al*., 2015).

Malaria incidence had also decreased in Ethiopia over the last decade but there has been an increase in confirmed malaria cases including *P. vivax* in the past six years. (2012, one and seven per 1,000, respectively) (WHO, 2013). This might be due to the fact that control and elimination of *P. vivax* malaria presents different challenges to those seen with *P. falciparum*, because *P. vivax* tolerates a wider range of environmental conditions and can be transmitted from infected human to mosquitoes before symptoms develop in the people infected. Therefore, prompt and effective treatment has less influence on transmission of *P. vivax* than is the case with other malaria species. And also more than 70 species of *Anopheles* mosquito can transmit *P. vivax* malaria (WHO, 2016).

In the study area, malaria was observed in almost every month of the year except 2019, although there was significant, seasonal and year played a role prevalence of malaria in the study area. The highest peak of malaria cases in almost all year groups was observed during spring (September, October and November). These seasonal occurrences indicate the real malaria transmission for the study area.

6. Conclusions and Recommendations

6.1 Conclusions

From 2012 to 2018 prevalence malaria were decreasing, the variation were statically significant, and 2019 Six months no malaria cases confirmed. Generally, the following investigations in study area were:-

1. In terms of *Plasmodium* species were *P. falciparum* more than *P. vivax.*
2. More males were malaria confirmed than females
3. In seasonal pattern of malaria confirmed cases were high in spring (September, October, December), and low in winter (March, April, May).
4. In terms of age, < 5 years were the highest malaria confirmed age groups whereas 15 and above years were the lowest malaria confirmed age groups.

6.2 Recommendations

1. The study gives a hint that planning for elimination of the disease in the locality may be achievable in the near coming. Nevertheless, Malaria control interventions must be maintained and scaled-up to sustainably reduce its risk and possibly decrease from the locality.
2. Controlled activity should be continued in the strengthened manner in the study area.
3. Communities should be maintenance under five children's because unable to protect themselves from *Anopheles* mosquitoes.
4. The laboratory technicians must have license and more experienced to examine febrile persons
5. Further studies should be conducted to determine the status of malaria based on yearly patterns

References

Abebe TN (2014). Compiled body of works in field epidemiology. MPH Thesis. School of Public health, Ethiopia field epidemiology training program, Addis Ababa University, Addis Ababa, Ethiopia.

Alemu A, Fuehrer HP, Getnet G, Tessema B, Noed H (2013). *P. ovale curtisi* and *P. ovale wallikeri* in North-West Ethiopia. *Malar J* **12**:346.

Aregawi M, Lynch M, Bekele W, Kebede H, Jima D, Taffese HS, Yenehun AM, Lilay A, Williams R, Thomson M, Nafo-Traore F, Admasu K, Gebreyesus AT, Coosemans M (2014). Time series analysis of trends in malaria cases and deaths at hospitals and the effect of antimalarial interventions, 2001-2011,Ethiopia. Armstrong JC 1969. *P.ovale* endemic in Ethiopia. *Trans R Soc Trop Med Hyg* **63**:287-88.

Baired JK (1998). Age-dependent characteristics of protection, Susceptibility to *P. falciparum*. *Ann.Trop.med paranital* **92** (4), 367-390

Baird JK (2013). Evidence and implications of mortality associated with acute *P.vivax* malaria. *Clin Microbiol Rev*.; **26**:36–57.

Balkew M, Ibrahim M, Koekemoer LL, Brooke DB, Engers W, Aseffa A, Gebre-Michael T, Elhassen I (2010). Insecticide resistance in *An. arabiensis (Diptera: Culicidae)* from villages in central, northern and south west Ethiopia and detection of mutation. *Parasit Vector* **3**:40.

Breman TG (2001). The eras of the hippopramus: manifestations, determinants, and estimates of the malaria burden. *AM.J.Trop.med.Hyg.* **64** (1-2 suppl.).1-11

Carneiro I, Roca-Feltrer A, Griffin JT (2010). Age-patterns of malaria vary with severity, transmission intensity and seasonality in sub-Saharan Africa: a systematic review and pooled analysis. *PLoS One* **5**, e8988.

Clark HC (1915). The diagnostic value of the placental blood film in aestivo-autumnal *malar. J Exp Med;* **22**: 427–45.

Cot, Deloron (2003). Malaria prevention strategies: Pregnancy-Associated Malaria (PAM). *Br Med Bull* **67**(1):137-48.

Cox-Singh J (2008). *P. knowlesi* malaria in humans is widely distributed and potentially life threatening. *Clin. Infect. Dis*. **46**: 165-171.

Escalante AA, Freeland DE, Collins WE and Lal AA (1998). The evolution of primate malaria parasites based on the gene encoding cytochrome-b from the linear mitochondrial genome. Proceedings of the National Academy of Sciences of the United States of America **95**:8124-8129.

Ethiopian WFD (2015). Addis ababa. Ethiopia.

FMoH (2015). HSDP IV annual performance report 2014/2015. Addis Ababa: Ministry of Health.

Fischer PR. (2003). Malaria and newborns. Journal of *Tropical Paediatrics* **49**: 132–134.

FMoH (2015). Annual Performance Report 2015 (HSDP IV) for EFY 2007 (2014/15) version 1, Addis Ababa, Ethiopia.

FMoH (2000). Malaria control profile. Ministry of Health, Addis Ababa, Ethiopia, pp1-10.

FMoH (2004). Malaria Diagnosis and Treatment. Guidelines for Health Workers in Ethiopia 2nd Edition. Federal Ministry of Health, Addis Ababa, Ethiopia.

Gebremariam N (1988). The ecology of health and disease in Ethiopia. In Malaria. Edited by Kloos H, Zein AZ. *Boul Westview Press*; 136-150.

Gething PW, Patil AP, Smith DL (2011). A new world malaria map: *P.falciparum* endemicity in 2010.*Malar J* **10**:378.

Ghebreyesus TA, Derressa Witten KH, Getachew A, Seboxa T (2006). The epidemiology and ecology of health and disease in Ethiopia. *In Malar Edited*, 556-576.

Greenwood BM., Bojang K,, Whitty CJ and Targett GT (2005). *Malar Lancet*, **365** (9469), 1487–98.

Griffin JT, Hollingsworth TD, Okell LC, Churcher TS, White M, Hinsley W,Bousema T, Drakeley CJ, Ferguson NM, Basáñez MG, Ghani AC (2010). Reducing *P. falciparum* malaria transmission in Africa: a model-based evaluation of intervention strategies. *Med*, **7**:e1000324.

Guthmann PJ, Bonnet M, Ahoua L, Dantoine F, Balkan S, van Herp M, Tamrat A, Legros D, Brown V, Checchi F (2007). Death Rates from Malaria Epidemics, Burundi and Ethiopia. *Emerg Infect Dis* **13**(1):140-43.

http://www.who.int/mediacentre/factsheets/fs094/en (accessed on 5 March 2019)..

https://commons.wikimedia.org/wiki/File:Life_Cycle_of_the_Malaria_Parasite.svg (Accessed on August 10).

Jamison D, Mosley WH, Measham A, and Bobadilla JL (1993). Disease control priorities in Developing countries. Oxford University Press. New York Pp 12–48.

Karl NP, Kumar A, Singh OP, Carlton JM, Nanda N (2014*)*. A review of malaria transmission dynamics in forest ecosystems. *Parasite Vectors*, **7:**265.

Kateera F, Ingabire CM, Hakizimana E, Rulisa A, Karinda P, Grobusch MP (2015). Long‐lasting insecticidal net source, ownership and use in the context of universal coverage: a household survey in eastern Rwanda. *Malar J*.; **14**:390.

Krogstad DJ (1996). Malaria as a re-emerging disease, Prevalence and Epidemiology of Malaria in Nigeria: A Review, *In J of Res in Ph and Bio,* **8**(4) pp.10-12, 2017.

Legesse Y, Tegegn A, Belachew T (2007). Knowledge, Attitude and Practice about Malaria Transmission and Its Preventive Measures among Households in Urban Areas of Assossa Zone, Western.Ethiopian *J of Heal Deve,* **21**: 157-165.

Lengeler, Christian (2004). Insecticide-Treated Bed Nets and Curtains for Preventing Malaria. Cochrane Database Systematic Reviews 2. No **2**:CD000363

Lindsay SW, Martens WJM (1998). Malaria in the African highlands: Past, present and future. *Bull World Health Organ*; **76**(1):33–45.

Lopez AD, Mathers CD, Ezatti M (2001). Global and regional burdens of disease and risk factors,: Systematic analysis of population health data. *Lancet* **367**(9524), 1747-1757 (2006).

May RM, Anderson RM (1990). Parasite-host co-evolution. Review [50 refs].]*Para 100Supp* **l**:S89-101.

Markus MB (2011). Malaria: origin of the term "hypnozoite". *J of the hist of bio,* **44** (4), 781–6.

McGregor JA (1984). Epidemiology, malaria and pregnancy. *Am J Trop Med Hyg **33:**517-525.*

Mekonnen, SK, Aseffa A, Berhe N, Teklehaymanot T, Clouse RM., Gebru T, Medhin G, Velavan TP(2014). Return of chloroquine-sensitive *P. falciparum* parasites and emergence of chloroquine-resistant *P.vivax* in Ethiopia. *Malar. J.* **13**: 244.

Mendis K, Rietveld A, Warsame M, Bosman A, Greenwood B, Wernsdorfer Bull.World health organ (2009). From malaria control to eradication: The WHO perspective. *Trop Med Int Heal*.;**14**(7):802–9.

Mockenhaupt FB, Ulmen U, von Gaertner C, Bedu-Addo G, Bienzle U (2002). Diagnosis of placental *malar.J C lin Microbiol*.; 40:306–malariology. 4th ed. London: Arnold; 2002. p. 85–106.

Mohammed H, Tedla M, Meseret B, Moges K, Daddi A, Mekonnen T, Adugna W, Tesfaye M, Amha K (2015). Genetic diversity of Plasmodium falciparum isolates based on MSP-1 and MSP-2 genes from Kolla-Shele area, Arbaminch Zuria District, southwest Ethiopia. *Malar J* **14**: 73.

Murphy SC, Breman JG (2001). Gaps in the childhood malaria burden in Africa: cerebral malaria, neurological sequelae, anemia, respiratory distress, hypoglycemia, and complications of pregnancy. *Am J of Trop Med and Hyg*, **64** (1,2 S):57–67.

Murray CJ (2012). Global malaria mortality between 1980 and 2010: systematic analysis. *Lancet* **379** : 413-431.

Nega D, Assefa A, Mohamed H, Solomon H, Woyessa A, Assefa Y, Kebede A, Kassa M (2016). Therapeutic efficacy of artemether-lumefantrine (Coartem®) in treating uncomplicated *P. falciparum* Malaria in Methahara, Estern Ethiopia. *Reg cli sty. PLoS One* **11(**4): e0154618

Negash K, Kebede A, Medhin A, Argaw D, Babaniyi O, Guintran JO, Delacollette C (2005). Malaria epidemics in the highlands of Ethiopia. *East Africa Med J*, **82**:186-192.

Newton CR, Taylor TE, Whitten RO (1998). Patophysiology of fatal *falciparum* malaria in Africa children. *AM,J. Trop.med Hyg.***58**(5),673-683.

O'connor (1967). The distribution of anopheline mosquitoes in Ethiopia. Mosquito News **27**(1): 42-54.

Orish NV, Ansong YJ, Onyeabor SO, Sanyaolu OA, Oyibo AW, Iriemenam CN 2016.Over diagnosis and overtreatment of malaria in children in a secondary healthcare centre in Sekondi-Takoradi, Ghana. *Trop Doct* **46** (4):191-198.

Paaijmans KP, Read AF, Thomas MB (2009). Understanding the link between malaria risk and climate.*Proc. Natl. Acad. Sci*. USA, **106 :**13844.

PMI (2018). President's Malaria Initiative Ethiopia Malaria Operational Plan FY 2018.

Quiñones ML, Norris DE, Conn JE, Moreno M, Burkot TR, Bugoro H, (2015). Insecticide resistance in areas malaria control and elimination. *Am J Trop Med Hyg.;* **93** (3 *Suppl*):69–78.

Samba E (2001). Preface: The malaria burden and Africa. The American Journal of Tropical Medicine and Hygiene 64: ii (Supplement). See also Greenwood 1999 (Greenwood, B.M. 1999. Malaria mortality and morbidity in Africa. *Bull.World health organ* ,**77**: 617–618.

Smith DL, Noor AM, Hay SI, Snow RW (2009). Predicting changing malaria risk after expanded insecticide treated net coverage in Africa. *Trends Parasitol.;***25**:511–6.

SNNPR (2005).Southern Nations, Nationalities and People's Region Health Bureau Malaria Annual Report 2005 (EFY 1997); Hawassa, Ethiopia.

SNNPR (2015a). Southern Nations, Nationalities and People's Region Health Bureau Malaria Annual Report (EFY 2007), Hawassa, Ethiopia.

SNNPR (2015b). Health Bureau Second Round Health Sector Growth and Transformation Plan HSTP 2008-2012 EC, Sept 2015; Hawassa, Ethiopia.

SNNPR (2016). Health Bureau Public Health Emergency Management (PHEM) Core Proces weekly PHEM bulletin Epidemiological Week 33, 2016 (09/12/08-15/12/2008 E.C); Hawassa, Ethiopia

Snow RW, Craig M, Dechman (1999). Estimating mortality, morbidity and disability due to malaria among Africas non pregnant population. *Bull.World health organ*.**77(**8),624-640.

Snow RW, Guerra CA, Noor AM (2005). The global distribution of clinical episodes of *P. falciparum malaria*.Natyre.; **434:**214-217.

Snow RW and Marsh K (2002). The consequences of reducing transmission of *P. falciparumin* Africa. *Adv in Para***. 52:** 235–264.

Serwanga A, Sears D, Kapella BK, Kigozi R, Rubahika D, Staedke SG, Kamya M, Yoon SS, Chang MA, Dorsey G, Mpimbaza A (2015). Anti-malarial prescription practices among children admitted to six public hospitals in Uganda from 2011 to 2013. *Malar J* **14**:331.

Steketee RW, Nahlen, BL, Parise ME, Menendez C (2001). The burden of malaria in pregnancy in malaria endemic areas. *Am J Trop Med and Hyg.* **64**, S28–S35.

Tora TFO (2018). Tora town population Affaires Directorate Report, Tora, Ethiopia.

Tora TAO (2018).Tora town admnistration Agriculture Office Repor, Tora, Ethiopia.

Tulu AN (1996). Determinants of malaria transmission in the highlands of Ethiopia: the impact of global warming on morbidity and mortality ascribed to malaria. PhD Thesis, London School of Hygiene and Tropical Medicine.

Tulu NA (1993). The ecology of health and disease in Ethiopia, in Malaria. Edited by Kloos H, Zein AZ. *Boul West view Pre*; 341-352.

Verhoeff F, Brabin B, Chinsulku L, Kazembe P, Broad head R (1999). Malaria in pregnancy and its consequences for the infant in rural Malawi. *Annals Trop Med and Para,* **93,** S25–S33.

White NJ, Pukrittayakamee S, Hien T, Faiz MA, Mokuolu O, Dondorp AM (2013). *Malar. Lancet, 6736 (13).85*.

WHO (2005).The World Malaria Report. Geneva Switzerland . Accessed date April 20 2019

WHO (2010*).* Guidelines for the treatment of malaria. Second edition. Available from: http://www.who.int/malaria/publications/atoz/9789241547925/en/. Accessed date April 20, 2019

WHO (2013). World Malaria Report. Geneva Switzerland Available from: http://www.who.int/malaria/publications/world_malaria_report_2013/en/. Accessed date April 20 2019

WHO (2014). The World Malaria Report. Geneva Switzerland Fact sheet Available from: http://www.who.int/mediacentre/factsheets/fs094/en/ Accessed date April 20 2019

WHO (2015).From MDG to SDG. Geneva Switzerland: http://apps.who.int/iris/bitstream/10665/200009/1/9789241565110_eng.pdf?ua=1. Accessed on Jan 19, 2019.

WHO (2016). World Malaria Report 2016. Geneva: .Available from:http://apps.who.int/iris/bitstream/10665/252038/1/9789241511711-eng.pdf. Accessed on July 10, 2019.

Yewhalaw D, Wassie F, Steurbaut W, Spanoghe P, Bortel VW, Denis L, Tessema AD, Getachew Y, Coosemans M, Duchateau L, Speybroeck N (2011). Multiple insecticide resistance: an impediment to insecticide-based malaria vector control program**.** *PLoS One* **6** (1):e 16066.

Yimer F, Animut A, Erko B, Mamo H (2015). Past five-year trend, current prevalence and household knowledge, attitude and practice of malaria in Abeshge, South central Ethiopia *Malar J* **14**:230.

Zerihun, Afework TH and Kolaczinski JH (2007). Potential for integrated control of neglected tropical diseases in Ethiopia. *Trans Roy Sci Trop Med and Hyg,* **102:** 213-214.

Zhou G, Afrane YA, Malla S, Githeko AK, Yan G (2015*).* Active case surveillance, passive case surveillance and asymptomatic malaria parasite screening illustrate different age distribution, spatial clustering and seasonality in western Kenya. *Malar J*.;**14**:41

Appendix

ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES

DEPARTMENT OF ZOOLOGICAL SCIENCES

Data collecting format

Region: SNNPR, Name of Health office _____ Zone: Silte Zone

Wored/Town _____ Date of data collection: _____ The purpose of this data collecting format is to gather information on the Assessment of the prevalence and incidence of malaria in Tora Town and child hood malria in Tora Primary hospitals ,Silte Zone. This data is used to write Msc thesis in Biology in AAU. Therefore, you are kindly requested to fill this format with the correct information. Your accurate and reliable information are appreciated for the achievement of the objectives of the research.

Appendix I Retrospective data collecting format

Table 1 Tora Town health office yearly (2012-2018) Total examined and species distribution collecting format.

Year	Total Examined no.	P. *falciparum*, no.	P. *vivax*, no.	Total slide negative, no.
2012				
2013				
2014				
2015				
2016				
2017				
2018				
Total				

Table 2 Seasonal patterns (2012-2018), species distribution and gender distribution at Tora town health office data collecting format.

2012-2018 Months	Total examined, no.	Total *P. falciparum*, no.	Total *P. vivax*, no.	Male, no	Female, no
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Over all					

Table 3 Age distribution of Malaria examined and slide-confirmed cases and Plasmodium species at Tora town health office data collecting format.

Year	Total Examined no. (%)	Total slide positive*, no.(%)	Age		
			0-4 years, no.	5-14 years, no.	15 and above years, no
2012					
2013					
2014					
2015					
2016					
2017					
2018					
Overall					

Appendix II Prospective data collecting format

Tora Primary Hospitals

Woreda_____

Health center/Hospital_____

Year _____Quarter_____

Table 4 Seasonal pattern of malaria examined and slide –confirmed children, plasmodium species distribution and gender disterbution in Tora primary hospital, January 2019-July 2009 data collecting format.

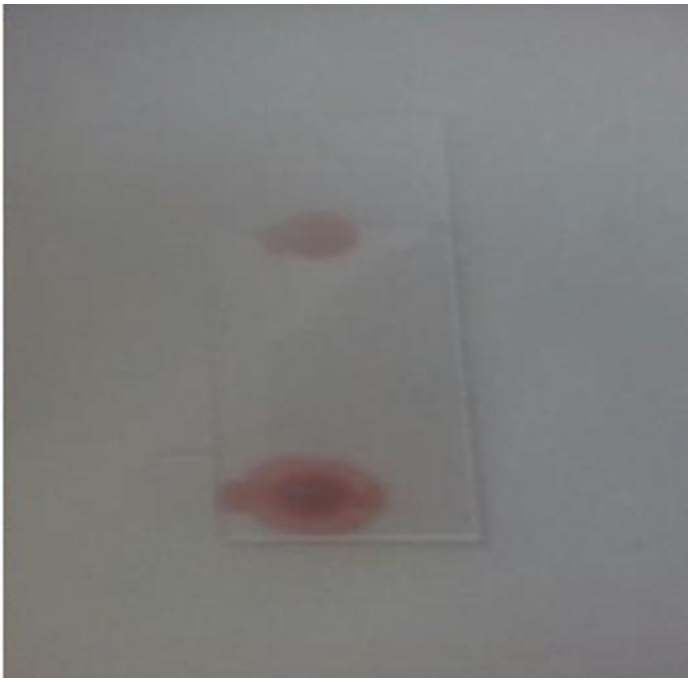
Months	Total Examined no.	*P. falciparum*, no.	*P. vivax*, no.	Male, no	Female, no
January					
February					
March					
April					
June					
July					
Total					

Table 5 Age distribution of malaria examined and slide-confirmed cases in children's at Tora primary hospital, January 2019-June 2019 data collecting format.

Months	Total Examined no.	<1 years ,no	1-4 years,no	5-14 years no
January				
February				
March				
April				
June				
July				
Total				

Completed by_____

Signature_____ Date_____



Appendix III Ethical Clearance

COLLEGE OF NATURAL & COMPUTATIONAL SCIENCES
Addis Ababa University

የተፈጥሮና ኮምፒቲሽናል ሣይንስ ኮሌጅ
አዲስ አበባ ዩኒቨርሲቲ

OFFICE OF THE DEAN
የዲን ጽ/ቤት

Ref. No. ቁጥር CNCSDO/377 /11/2019
Date ቀን February 25,2019

To: **National Research Ethical Review Committee**
Addis Ababa

Subject: **College Research Ethics Review Board Decision**

The College of Natural & Computational Science Institutional Review Board (CNS-IRB) Committee in its meeting held on 20/02/2019 Minute No. IRB/037/2019 has examined the project proposal entitled "**The Prevalence incidence of malaria in Tora primary hospital, Silte Zone**", by Shemsi Shewmolo from Addis Ababa University.

This is, therefore, to request your good office to facilitate his Thesis project proposal

With regards,

Shibru Temesgen /Dr.
Dean, College of Natural & Computational Sciences

ስልክ/Tel.+251-11-123-94-72
ፋክስ/Fax: +251-11-123-94-69
ፖ.ሣ.ቁ/POBox 1176 Addis Ababa, Ethiopia
ኢ.ሜይል/E-mail: dean_cns@aau.edu.et

Please Quote our reference number in you correspondence

"Examine all things; hold fast that which is good"

"ሁሉን መርምሩ መልካሙን ያዙ"