YANGON UNIVERSITY OF ECONOMICS

DEPARTMENT OF STATISTICS

MASTER OF APPLIED STATISTICS PROGRAMME

ANALYSIS OF MALARIA CASES IN TOUNGUP TOWNSHIP OF RAKHINE STATE

ZAW TUN WIN

MAS - 80

MAS 3rd BATCH

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BY

ZAW TUN WIN
Master of Applied Statistics
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This thesis is submitted as a partial fulfilment towards the Degree of Master of Applied Statistics

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YANGON UNIVERSITY OF ECONOMICS
DEPARTMENT OF STATISTICS
MASTER OF APPLIED STATISTICS

ANALYSIS OF MALARIA CASES IN TOUNGUP TOWNSHIP OF RAKHINE STATE

This thesis is submitted to the Board of Examination as partial fulfillment of the requirement for the Degree of Master of Applied Statistics

Approved by the Board of Examiners

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ABSTRACT

This study analyses malaria cases in Toungup Township, Southern Rakhine State.A random sample of 240 malaria cases were chosen from 602 malaria positive cases among 85,076 tested people who lived in Toungup Township from 2019 to 2021. Descriptive statistics, Fisher's Exact Test, Phi Coefficient, and logistic regression model are used for the analysis of malaria cases. Two kinds of positive cases were combined as one variable due to the same treatment and clinical characteristic i.e., Plasmodium falciparum and mixed infected cases were combined as same category and coded as Pf and Plasmodium vivax infected cases were another variable coded as not Pf in this study. According to the descriptive statistics, the Plasmodium falciparum cases was 89.20% and not Plasmodium falciparum was 10.8%. The results of Fisher's Exact Test showed that population type, test methods, and origin of infection are associated to the malaria positive cases. And then, the results of Phi Coefficient showed that age group, occupation and case classification are also significant associated to the malaria positive cases. The results from logistic regression analysis showed that age group, population type (migration), occupation, and origin of infection (inside Township) are significantly related to the malaria positive cases in Toungup Township.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABER	Annual Blood Examination Rate
ACT	Artemisinin-based Combination Therapy
API	Annual Parasite Incidence
CART	Combination of Multivariate Analysis and Classification and Regression Tree
CIFI	Case Identification and Foci Investigation
CoD	Cause of Death
COVID-19	Coronavirus Disease 2019
GAD	Government Administrative Department
GMS	Greater Mekong Sub Regional
GTS	Global Technical Strategy
ITNs	Insecticide-treated Nets
IPTp	Intermittent Preventive Treatment of Malaria in Pregnancy
IPTsc	Intermittent Preventive Treatment of School-aged Children
IRS	Indoor Residual Spraying
MD	Malaria Deaths
MDA	Mass Drug Administration
NMCP	National Malaria Control Programme
PDMC	Post-discharge Malaria Chemoprevention
Pf	*Plasmodium falciparum*
Pv	*Plasmodium vivax*
PMC	Perennial Malaria Chemoprevention
S. E	Standard Error
SMC	Seasonal Malaria Chemoprevention
TPR	Test Positivity Rate
URC	University Research Company, Co. LLC
VBDC	Vector Borne Disease Control
WHO	World Health Organization

CHAPTER I
INTRODUCTION

Malaria is caused by the plasmodium parasite. That is transmitted between human by genus anopheles' mosquitoes. These malaria victims are in the poorest and generally most remote parts of the world, increase the issue in findings support to cope with the disease. Curable and preventable with medication, medical care but a vaccine is not out there. According to World Health Organization (2004), there were about 207 million cases of malaria leading to 627,000 deaths. In 2020, there were an estimated 241 million cases of malaria worldwide. The overwhelming majority is 90% of the cases happen in Africa (medical research council,2001) most of the death occur in youngsters. However, the speed of deaths in youngsters has been reduced by 54% since 2000 (WHO,2014) but malaria remains a serious health challenge to humanity over the world.

1.1 Rationale of the Study

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected female Anopheles mosquitoes. It is preventable and curable. The African Region carries a disproportionately high share of the global malaria burden. In 2020, the region was home to 95% of malaria cases and 96% of malaria deaths. Children under 5 accounted for about 80% of all malaria deaths in the Region Globally, there were an estimated 241 million malaria cases in 2020 in 85 malaria endemics countries (including the territory of French Guiana), increasing from 227 million in 2019, with most of this increase coming from countries in the African Region. There were 224 million estimated malaria cases in 2015 (WHO,2021).

Malaria case incidence (i.e., cases per 1000 population at risk) reduced from 81 in 2000 to 59 in 2015 and 56 in 2019 but increasing again to 59 in 2020. The increase in 2020 was associated due to services during the COVID-19 pandemic (WHO,2021)

Between 2000 and 2019, case incidence in the WHO African Region reduced from 368 to 222 per 1000 population at risk, but increased to 232 in 2020, mainly because of disruptions to services during the COVID-19 pandemic. The WHO South-East Asia Region accounted for about 2% of the burden of malaria cases globally. Malaria cases reduced by 78%, from 23 million in 2000 to about 5 million in 2020. Malaria case incidence in this region reduced by 83%, from about 18 cases per 1000 population at risk in 2000 to about three cases in 2020 (3). India accounted for 83% of cases in the region. Sri Lanka was certified malaria-free in 2016 and remains malaria-free. In 2019, the WHO updated the distribution of mortality in children aged under 5 years by cause of death (CoD). This affected the malaria CoD fraction, raising the point estimate of malaria mortality from 2000; however, this change has had little effect on trends in malaria mortality (WHO,2021).

Globally, malaria deaths reduced steadily over the period 2000–2019, from 896 000 in 2000 to 562 000 in 2015 and to 558 000 in 2019. In 2020, malaria deaths increased by 12% compared with 2019, to an estimated 627 000; an estimated 47 000 (68%) of the additional 69 000 deaths were due to service disruptions during the COVID-19 pandemic .The percentage of total malaria deaths in children aged under 5 years reduced from 87% in 2000 to 77% in 2020 (3).Globally, the malaria mortality rate (i.e., deaths per 100,000 population at risk) halved from about 30 in 2000 to 15 in 2015 and then continued to decrease but at a slower rate, falling to 13 in 2019. In 2020, the mortality rate increased again, to 15 (WHO,2021).

India accounted for about 82% of all malaria deaths in the WHO South-East Asia Region. Sri Lanka was declared malaria-free in 2016, becoming only the second country in Southeast Asia, after the Maldives, to successfully eliminate malaria. Apart from India, Indonesia, Myanmar, and Thailand, malaria-endemic countries have reported reductions in malaria incidence of more than 75% since 2000 (Theingi Aye, 2019).

In Myanmar, currently, 291 townships (out of 330) are malaria endemic (i.e., malaria is normally occurring there). The burden of malaria has declined dramatically during the last six years in Myanmar. There is an 82% reduction in malaria cases between 2012 and 2017 (i.e., from 481,204 in 2012 to 85,019 in 2017). A decade ago, Myanmar had more than 1 million malaria cases every year; today the country has slashed this number to 108,000. With continued investments in prevention, treatment, and education programs, including supporting the country’s thousands of healthy volunteers, Myanmar continues to make great strides forward in its efforts to address artemisinin resistance and eliminate the disease. Myanmar's National Strategic Plan for Intensifying Malaria Control and Accelerating Progress Towards Malaria Elimination (2016-2020) has set a vision of a malaria-free Myanmar by 2030, consistent with the Greater Mekong Sub Regional (GMS) commitment made by all Asia Pacific Leaders at the 9th East Asia Summit in November 2014. Myanmar's plan includes reducing the incidence of malaria to less than one case per 1,000 population at risk in all states/regions by 2020; interrupting transmission of and eliminating indigenous P. falciparum by 2025; eliminating all indigenous malaria of four human malaria parasites in the whole nation by 2030 and preventing the re-establishment of local malaria transmission where it has been eliminated due to importation of parasites (Saw Lwin,2018).

Chin State had the highest reported malaria incidence and mortality (35.23/1000 pop), Kayin (12.82/1000pop), and Rakhine (5.32/1000pop). In 2018, there was an 84% reduction in malaria cases (2012 total cases- 481,204 and 2018 total cases-76,518) and a 95% reduction in malaria deaths (in 2012 total malaria deaths-403 and in 2018 total malaria deaths- 30) compared to 2012. Out of the 76,518 cases, 31% were reported by the National Malaria Control Programme and 69% were reported by the partners. The drastic fall in the reported number of malaria cases and deaths pointed out a major improvement in access to early diagnosis, appropriate treatment including referral, and appropriate prevention. The malaria mortality rate in 2018 was 0.04 per 100,000 population. A total of 19 malaria deaths were reported from 8 States/Regions with the highest reported from Rakhine State, total deaths were 7 (7). According to the VBDC annual report, the total population of Rakhine state is about 2.2 million, and 357,951 were tested for malaria, and test positive cases 11,631 (VBDC,2018). University Research Company, Co. LLC. (URC) has conducted pilot elimination activities in three townships in Rakhine State namely Toungup Township, Ramree Township, and Munaung Township since 2018 and till now.

In this study, all positive malaria cases for three years were selected and analyzed by using appropriate statistical methods. In which, two kinds of positive cases were combined as one variable due to the same treatment and clinical characteristic i.e., Plasmodium falciparum and mixed infected cases were combined as same category and Plasmodium vivax infected cases were another variable.

Therefore, this study sought to investigate the differences and factors related to those positive cases in Toungup Township. Up to now, the malaria elimination plan is still ongoing, and the project activities are conducted in those townships. But there was no overall analysis of the malaria case situation trend and forecasting for coming years in those townships by project aspect. And there was no township with data-based research for malaria elimination project in Myanmar. This study will support and help to develop the changing strategy for the malaria elimination plan in Myanmar not only at the township base but also at State/Region wise up to the national level.

1.2 Objectives of the Study

The objectives of this study are:

i. To describe the current malaria cases and corresponding measures in Toungup Township

ii. To investigate the association between the demographic, socioeconomic and other characteristics, and malaria cases in Toungup Township

iii. To explore the influencing demographic and socioeconomic factors of malaria cases in Toungup Township

1.3 Method of Study

Reviewing and analyzing the secondary data and information from the submitted timely reports i.e., monthly reports from the Toungup Township. Firstly, descriptive statistics are used to display the current malaria cases and corresponding measures in Toungup Township. Secondly, Fisher's Exact Test and Phi Coefficient are used to investigate the association between the demographic, socioeconomic and other associated factors and malaria cases in Toungup Township. Finally, binary logistic regression model is used to explore the factors related to malaria cases in Toungup Township.

1.4 Scope and Limitations of the Study

The study is mainly based on secondary data and records from Toungup Township in Southern Rakhine State for the period from January 1, 2019, to December 31, 2021. In this study, age, sex, occupation, type of population, test method, test result, type of malaria case, previous history of malaria, and the origin of infection of positive patients are used for analysis.

1.5 Organization of the Study

This study comprises five chapters. Chapter I describes the introduction which is comprised of five sub-headings: Rationale of the Study, Objectives of the Study, Method of Study, Scope and limitations of the Study, and Organization of the Study. Chapter II expresses the literature review. Chapter III presents the research methodology. The analysis of malaria cases is described in Chapter IV. Chapter V reveals the conclusions, findings, and discussions, recommendation and needs for further study.

CHAPTER II
LITERATURE REVIEW

A literature review is a content body that points to the key places of modern knowledge, as well as good results, and conceptual and analytical contributions to content. This is not primary data and discusses only secondary data sources. This study is divided into four sections. Overview of malaria, malaria situation in Myanmar, malaria situation in Rakhine State, and review of related studies concerning associated characteristic of positive cases and their effect on malaria disease.

2.1 Overview of Malaria

Malaria is an acute febrile illness caused by *Plasmodium* parasites, which are spread to people through the bites of infected female *Anopheles* mosquitoes. 5 parasite species cause malaria in humans, and 2 of these species – *P. falciparum and P. vivax* – pose the greatest threat. *P. falciparum* is the deadliest malaria parasite and the most prevalent on the African continent. *P. vivax* is the dominant malaria parasite in most countries outside of sub-Saharan Africa.

The first symptoms – fever, headache, and chills – usually appear 10–15 days after the infective mosquito bite and may be mild and difficult to recognize as malaria. Left untreated, *P. falciparum* malaria can progress to severe illness and death within a period of 24 hours. In 2020, nearly half of the world's population was at risk of malaria. Some population groups are at considerably higher risk of contracting malaria and developing the severe disease: infants, children under 5 years of age, pregnant women, and patients with HIV/AIDS, as well as people with low immunity moving to areas with intense malaria transmissions such as migrant workers, mobile populations, and travelers (WHO,2021).

According to the latest World Malaria report, there were 241 million cases of malaria in 2020 compared to 227 million cases in 2019. The estimated number of malaria deaths stood at 627 000 in 2020 – an increase of 69 000 deaths over the previous year. While about two-thirds of these deaths (47 000) were due to disruptions during the COVID-19 pandemic, the remaining one-third of deaths (22 000) reflect a recent change in WHO's methodology for calculating malaria mortality (irrespective of COVID-19 disruptions). The new cause-of-death methodology was applied to 32 countries in sub-Saharan Africa that shoulder about 93% of all malaria deaths globally. Applying the methodology revealed that malaria has taken a considerably higher toll on African children every year since 2000 than previously thought .

The WHO African Region continues to carry a disproportionately high share of the global malaria burden. In 2020 the Region was home to 95% of all malaria cases and 96% of deaths. Children under 5 years of age accounted for about 80% of all malaria deaths in the Region. Four African countries accounted for just over half of all malaria deaths worldwide: Nigeria (31.9%), the Democratic Republic of the Congo (13.2%), the United Republic of Tanzania (4.1%), and Mozambique (3.8%). Every year, more than 1 billion people are infected and more than 1 million die from vector-borne diseases. World Health Organization (WHO) has highlighted the serious and increasing threat of vector-borne diseases with the theme "Preventing vector-borne diseases" and also with the slogan "Small bite, big threat" for the year 2014. Among vector-borne diseases, malaria poses the biggest threat with about 40% of the world's population at risk of infection. In 2013, 97 countries had an ongoing transmission of malaria. Malaria decreases economic growth by more than one percentage point per year in endemic countries. Malaria transmission season generally coincides with the harvesting season and brief periods of illness exact a high cost on the world's poorest regions (Varun Kumar,2014). Over the last 2 decades, expanded access to World Health Organization (WHO)-recommended malaria prevention tools and strategies – including effective vector control and the use of preventive antimalarial drugs – has had a major impact in reducing the global burden of this disease.

Vector control is a vital component of malaria control and elimination strategies as it is highly effective in preventing infection and reducing disease transmission. The 2 core interventions are insecticide-treated nets (ITNs) and indoor residual spraying (IRS). The global control efforts have achieved a 37% decrease in malaria incidence and a 60% decline in mortality between 2000 and 2015 by applying effective prevention through the indoor residual spray, the use of Insecticide-treated bed nets (ITNs), and source reduction). Ethiopia has reduced the number of malaria cases by 50–75%.

Progress in global malaria control is threatened by emerging resistance to insecticides among *Anopheles* mosquitoes. According to the latest World Malaria Report, 78 countries reported mosquito resistance to at least 1 of the 4 commonly-used insecticide classes in the period 2010–2019. In 29 countries, mosquito resistance was reported to all main insecticide classes (WHO,2021).

Preventive chemotherapies are the use of medicines, either alone or in combination, to prevent malaria infections and their consequences. It requires giving a full treatment course of an antimalarial medicine to vulnerable populations (generally infants, children under 5 years of age, and pregnant women) at designated time points during the period of greatest malarial risk, regardless of whether the recipients are infected with malaria. Preventive chemotherapy includes perennial malaria chemoprevention (PMC), seasonal malaria chemoprevention (SMC), intermittent preventive treatment of malaria in pregnancy (IPTp) and school-aged children (IPTsc), post-discharge malaria chemoprevention (PDMC) and mass drug administration (MDA). These safe and cost-effective strategies are intended to complement ongoing malaria control activities, including vector control measures, prompt diagnosis of suspected malaria, and treatment of confirmed cases with antimalarial medicines (WHO,2021).

Since October 2021, WHO also recommends the broad use of the RTS, S/AS01 malaria vaccine among children living in regions with moderate to high *P. falciparum* malaria transmission. The vaccine has been shown to significantly reduce malaria, and deadly severe malaria, among young children. Early diagnosis and treatment of malaria reduce disease, prevents deaths, and contribute to reducing transmission. WHO recommends that all suspected cases of malaria be confirmed using parasite-based diagnostic testing (through either microscopy or a rapid diagnostic test. Diagnostic testing enables health providers to swiftly distinguish between malarial and non-malarial fevers, facilitating appropriate treatment.

The best available treatment particularly for *P. falciparum* malaria is the primary objective of treatment is to ensure the rapid and full elimination of *Plasmodium* parasites to prevent an uncomplicated case of malaria from progressing to severe disease or death. Malaria elimination is defined as the interruption of local transmission of a specified malaria parasite species in a defined geographical artemisinin-based combination therapy (ACT). area as a result of deliberate activities. Continued measures to prevent the re-establishment of transmission are required.

In 2020, 26 countries reported fewer than 100 indigenous cases of the disease, up from 6 countries in 2000. Countries that have achieved at least 3 consecutive years of zero indigenous cases of malaria are eligible to apply for the WHO certification of malaria elimination. Since 2015, 9 countries have been certified by the WHO Director-General as malaria-free, including Maldives (2015), Sri Lanka (2016), Kyrgyzstan (2016), Paraguay (2018), Uzbekistan (2018), Argentina (2019), Algeria (2019), China (2021) and El Salvador (2021) (WHO, 2021).

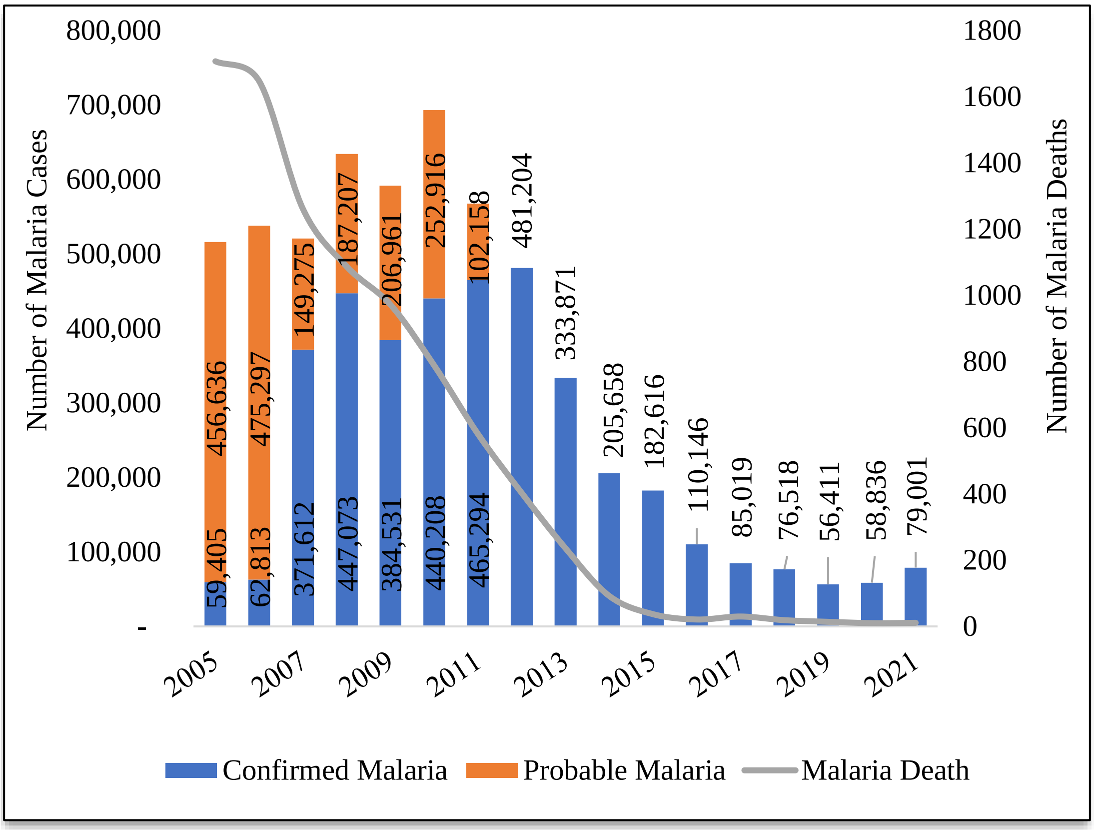
Malaria surveillance is the continuous and systematic collection, analysis, and interpretation of malaria-related data, and the use of that data in the planning, implementation, and evaluation of public health practice. Improved surveillance of malaria cases and deaths helps ministries of health determine which areas or population groups are most affected and enables countries to monitor changing disease patterns. Strong malaria surveillance systems also help countries design effective health interventions and evaluate the impact of their malaria control programs (WHO, 2021).

The WHO Global technical strategy for malaria 2016–2030, updated in 2021, provides a technical framework for all malaria-endemic countries. It is intended to guide and support regional and country programs as they work toward malaria control and elimination. The strategy sets ambitious but achievable global targets, including:

- reducing malaria case incidence by at least 90% by 2030
- reducing malaria mortality rates by at least 90% by 2030
- eliminating malaria in at least 35 countries by 2030
- preventing a resurgence of malaria in all countries that are malaria-free (WHO, 2021).

2.2 Malaria Situation in Myanmar

In Myanmar, currently, 291 townships (out of 330) are malaria endemic (i.e., malaria is normally occurring there). The burden of malaria has declined dramatically during the last six years in Myanmar. There is an 82% reduction in malaria cases between 2012 and 2017 (i.e., from 481,204 in 2012 to 85,019 in 2017). A decade ago, Myanmar had more than 1 million malaria cases every year; today the country has slashed this number to 108,000.



Source: VBDC Annual Review Meeting 2020-2021

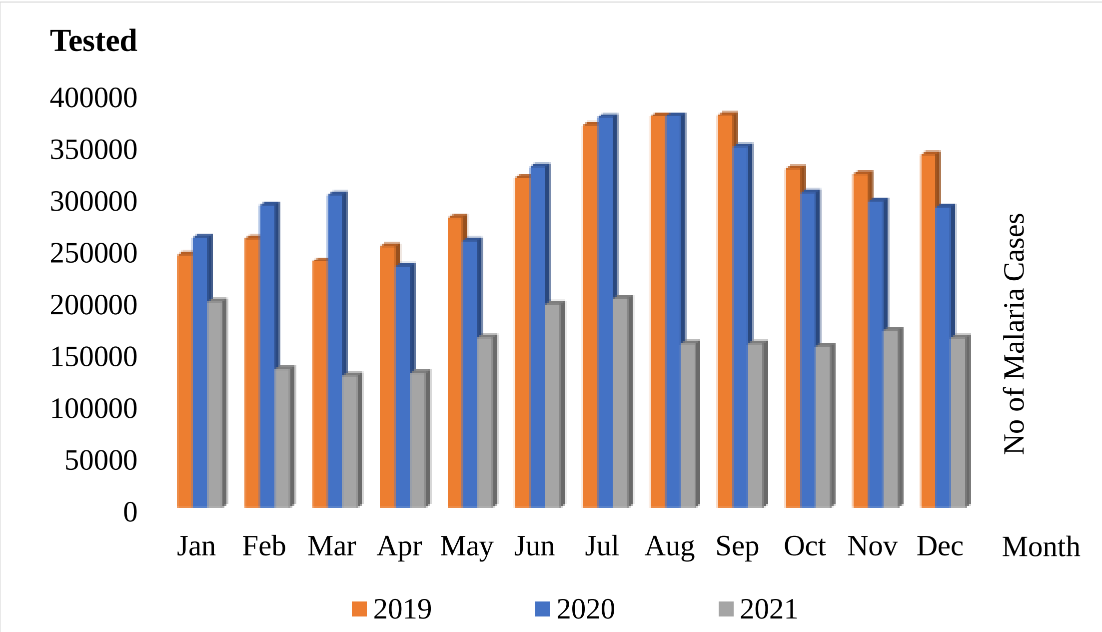
Figure (2.1) Malaria Morbidity and Mortality in Myanmar (2005-2021)

The Figure (2.1) shows the morbidity and mortality of malaria in Myanmar (2005 to 2021). The disease burden gradually decreased from 456,636 to 79,001 positive cases and the mortality cases also declined from 1,707 to 11 within 16 years. And then, malaria morbidity and mortality of outpatients and in patients are shown in Table (2.1). Due to the comprehensive approaches including early diagnosis and prompt treatment to all malaria positive cases i.e., confirmed and probable cases by effective antimalaria drugs, the morbidity and mortality of malaria are decrease in country wise.

Table (2.1) Malaria Morbidity and Mortality of Out-patients and In-patients (2019-2021)

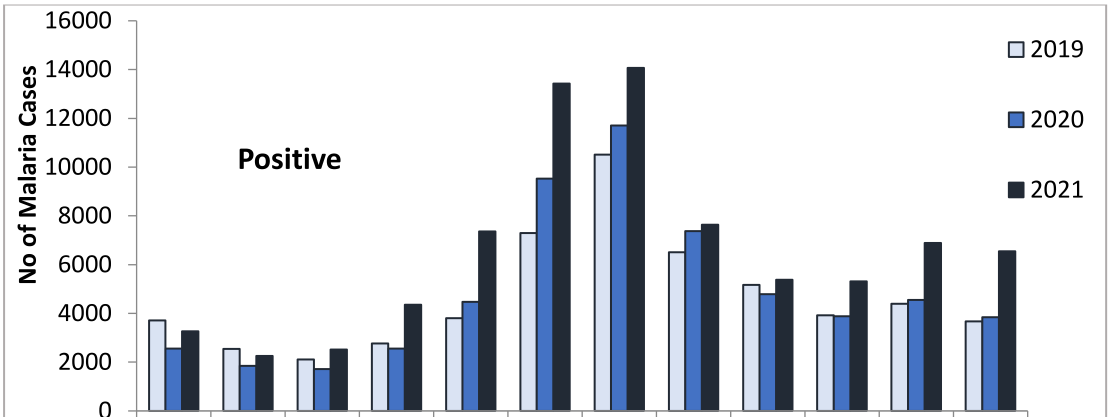
Year	Out-patient		In-patient						
	Total Attendance (Out-patient)	Out-patient confirmed malaria cases	Total Admission	In-patient confirmed malaria	Cerebral Malaria	Other Severe complicated malaria	In-patient Deaths	In-patient Malaria Deaths	CFR
2019	13,588,313	187,390	1,682,153	1,361	42	47	17,108	4	0.023
2020	12,111,246	14,411	1,282,122	1,051	14	23	9,810	4	0.381
2021	4,311,072	12,877	298,769	291	9	10	5,079	2	0.687

In this table, the outpatient confirmed malaria cases dramatically decreased from 187,390 to 12,788 within 3 years. The case fatality rate due to malaria was 0.023,0.381 and 0.687 respectively. Moreover, monthly tested and positive cases are showed in Figures (2.2) and (2.3).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.2) Monthly Tested (2019-2021)

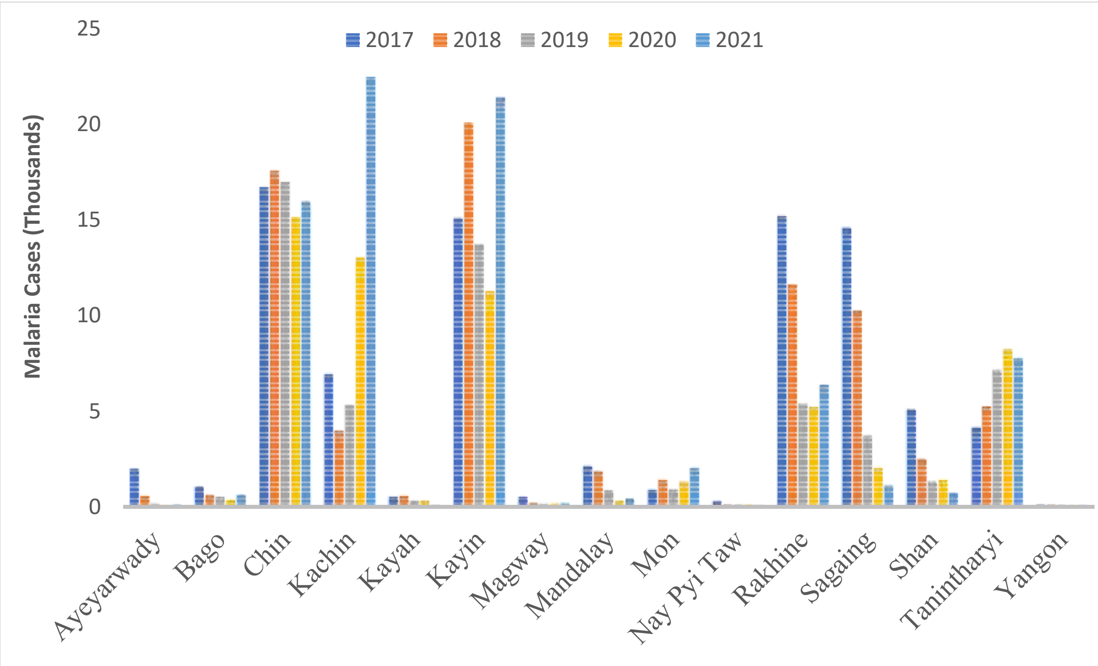


Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	3709	2549	2107	2761	3805	7296	10518	6513	5167	3918	4401	3667
2020	2558	1855	1716	2552	4479	9523	11709	7372	4794	3885	4551	3842
2021	3260	2252	2521	4355	7357	13428	14069	7636	5380	5315	6884	6544

Source: VBDC Annual Review Meeting 2020-2021

Figure (2.3) Monthly Positive Cases (2019-2021)

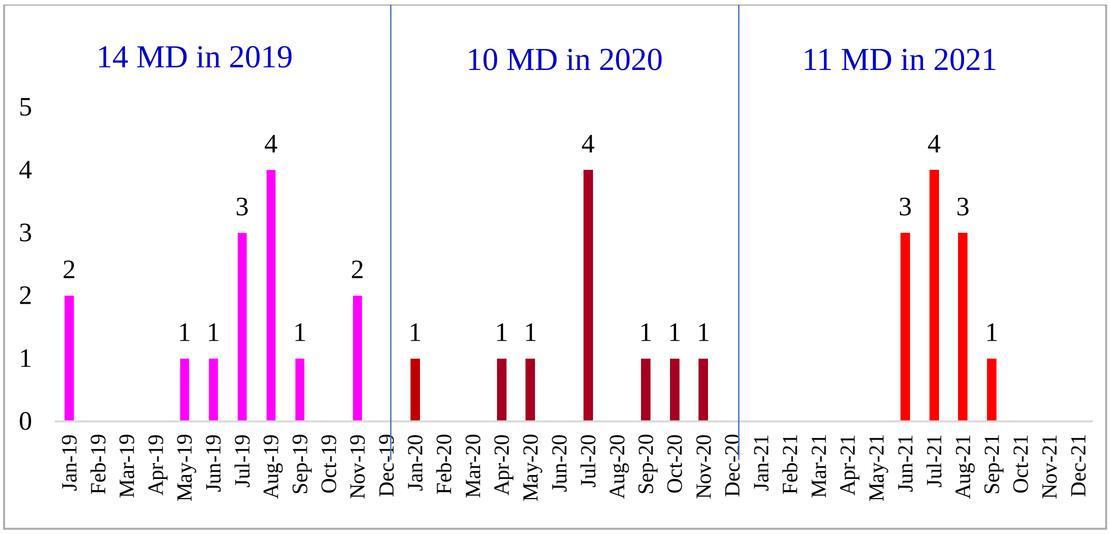
According to Figures (2.2 and 2.3), the total number of tested and positive cases of malaria was shown from 2019 January to 2021 December (36 months) by monthly based data. The positive number of cases tends to increase in 2021 by comparing with 2020 and 2019 monthly data. And malaria situation in State/Regions are described in Figure (2.4).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.4) Malaria Situation in States/Regions (2017 to 2021)

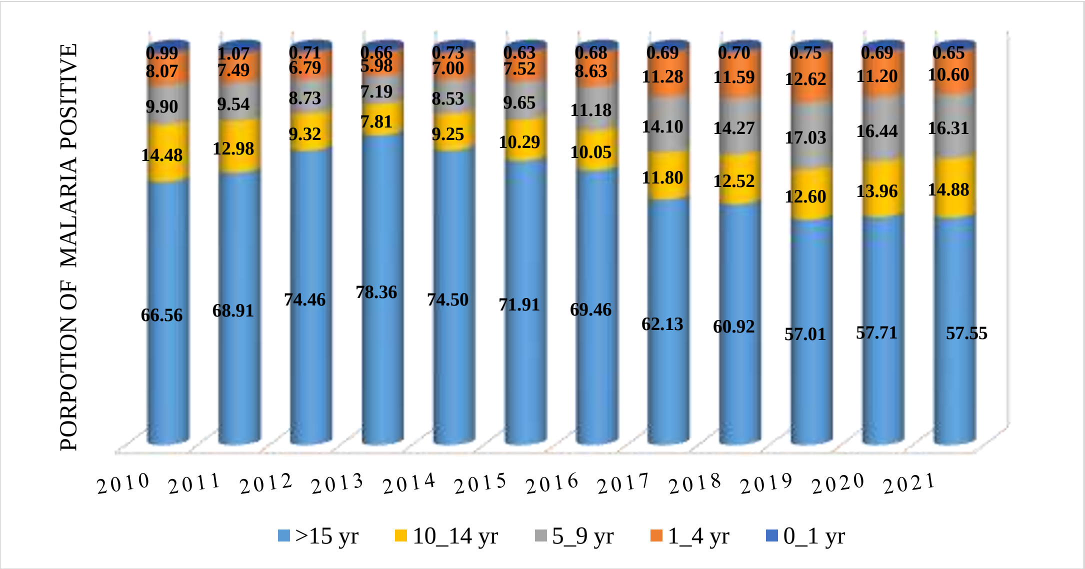
In the figure, the malaria cases in states and regions of Myanmar from 2017 to 2021 showed that some states significantly still increased in five years compared with other states and regions including Rakhine State. Furthermore, monthly malaria deaths are presented in Figure (2.5).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.5) Monthly Malaria Deaths (2019-2020 to 2021-2022 Apr)

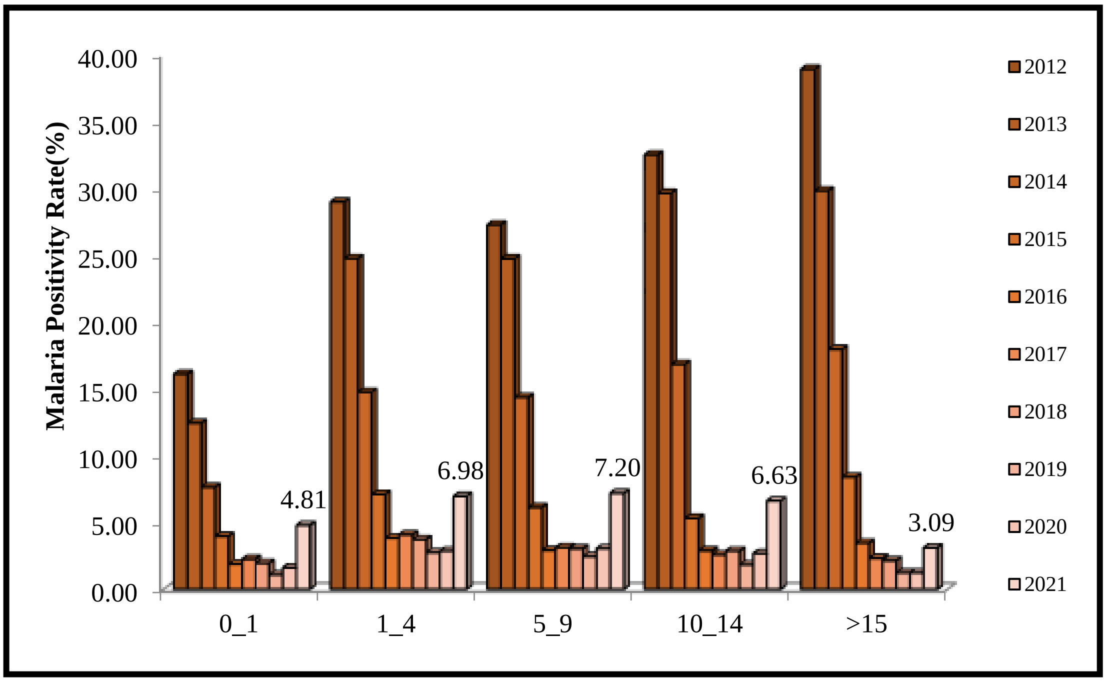
Malaria deaths (MD) were seen in May, June, and July of every year as a seasonal appearance. In below figure, the confirmed malaria cases by age group are also described.



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.6) Proportion of Confirmed Malaria Cases by Age Group (2010-2021)

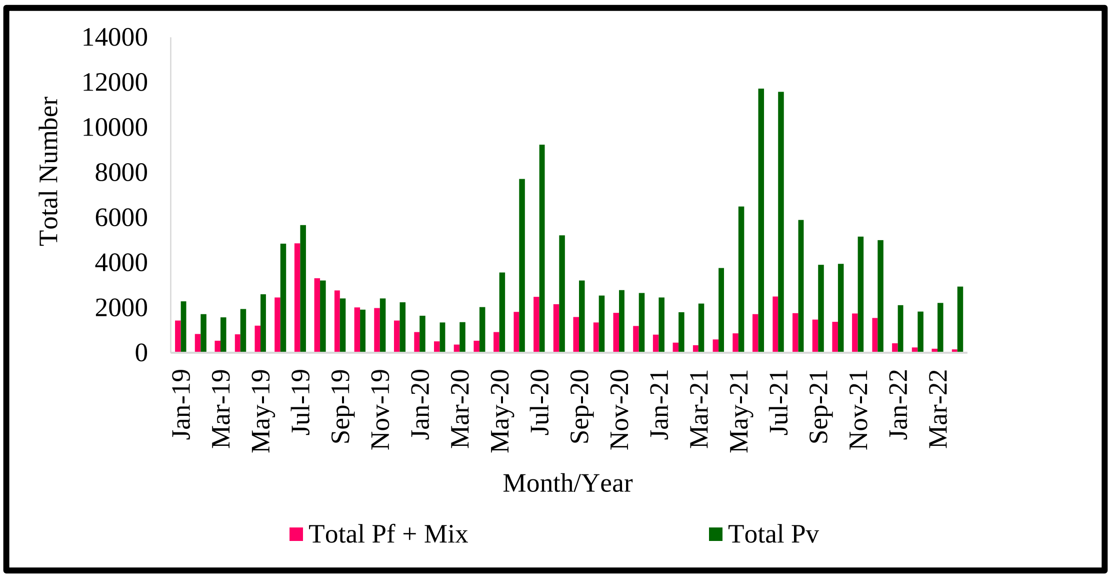
In proportion of confirmed malaria cases by age group, the majority of cases were above 15 years of age range 78-57 percent for 5 years. The test positivity rate by age group were also described in Figure (2.7).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.7) Malaria Positivity Rate by Age Group (2012-2021)

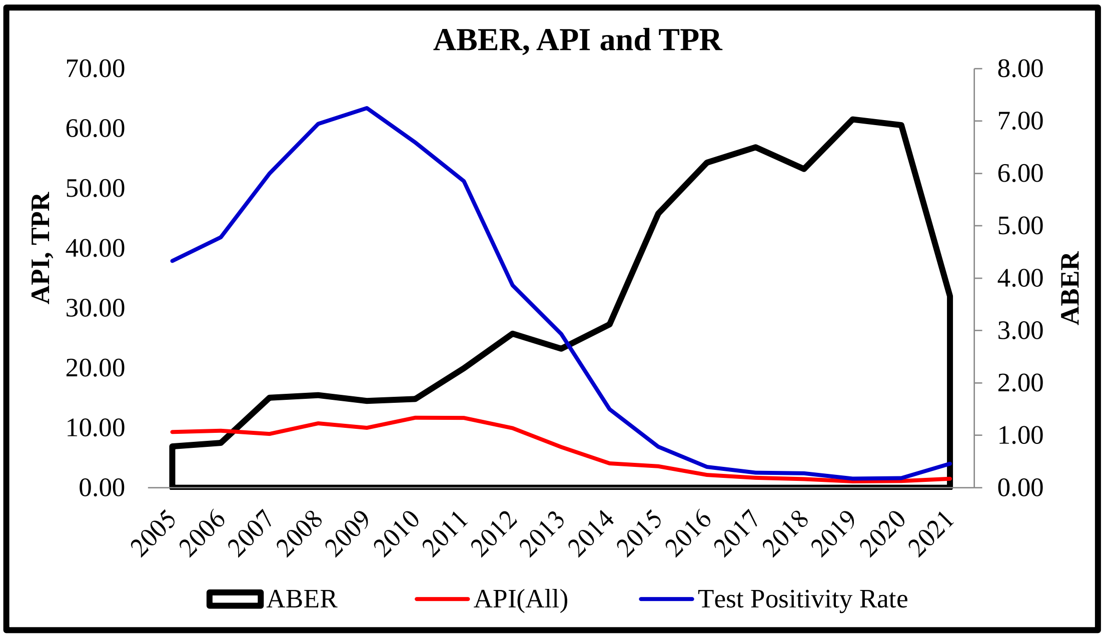
In Figure (2.7), the test positivity rate of malaria cases by age group by 10 years, in which the positive rate was slightly increase in last three years in all age groups. The monthly malaria cases and proportion by species were shown in figure (2.8).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.8) Monthly Malaria Cases and Proportion by Species (2019-2022 Apr)

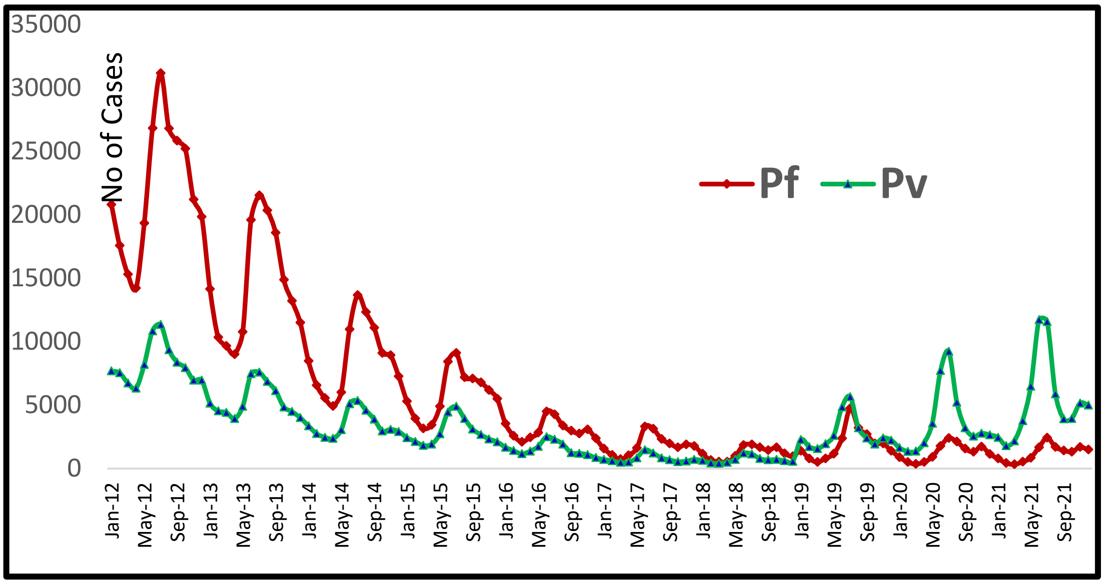
The malaria case ratio by species was changing i.e., Pv percent was gradually increasing than that of PfMix percent starting from mid-2019 to 2022 April. The case ratio trend was gradually increase. The annual blood examination rate, the annual parasite incidence, and test positivity rate were also shown in Figure (2.9).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.9) Annual Blood Examination Rate (ABER), Annual Parasite Incidence (API), Test Positivity Rate (TPR) (2005-2021), Pf/Pv Ratio (2012-2021)

The annual blood examination rate was gradually increased by testing blood examination more year by year, and the annual parasite incidence (API), and test positivity rate (TPR) decreased showing the decreasing trend of malaria cases. The ratio of Pf and Pv cases were also shown in below Figure (2.10).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.10) Annual Blood Examination Rate, Annual Parasite Incidence, Test Positivity Rate (2005-2021), Pf/Pv Ratio (2012-2021)

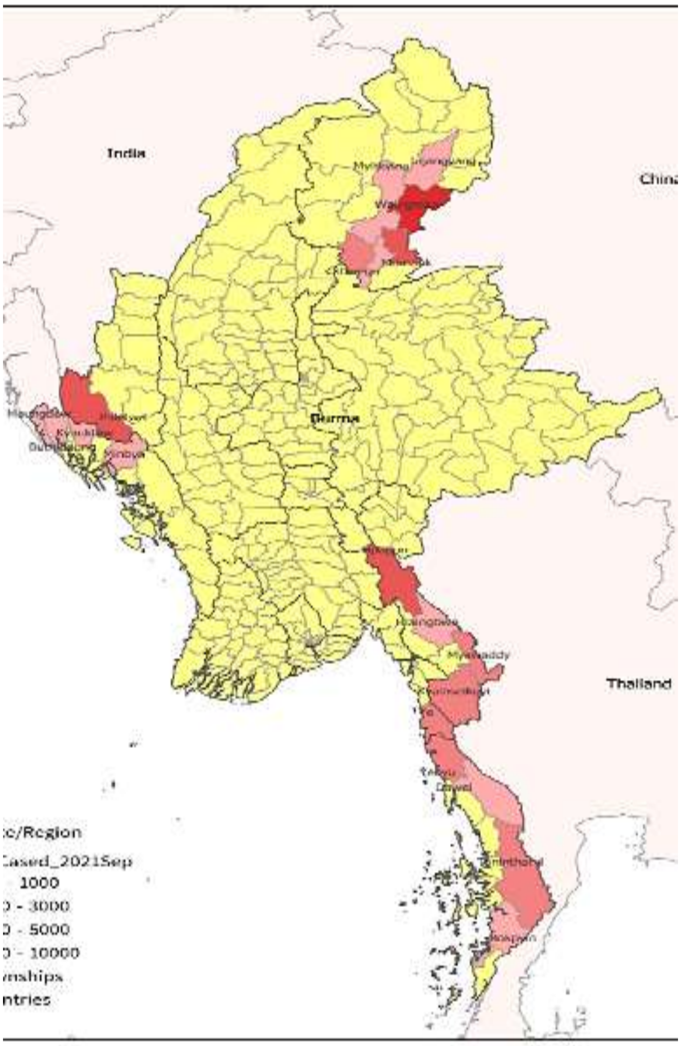
The Pv cases were more detected and significantly higher than Pf cases starting from the early month of 2019 till September 2021.

The National Malaria Control Programme planned to conduct intensification and acceleration of malaria in 24 Townships of Myanmar as in Table (2.2).

Table (2.2) High Malaria Burden Townships in Myanmar for Implementing Intensification Plan & Acceleration Plan

Sr. No.	State/ Region	Township	Sr. No.	State/ Region	Township
1	Chin	Paletwa	13	Mon	Ye
2	Kachin	Waingmaw	14	Rakhine	Buthidaung
3	Kachin	Momauk	15	Rakhine	Kyauktaw
4	Kachin	Shwegu	16	Rakhine	Maungdaw
5	Kachin	Injangyang	17	Rakhine	Minbya
6	Kachin	Mansi	18	Rakhine	Mrauk U
7	Kachin	Sumprabum	19	Sagaing	Banmauk
8	Kachin	Myitkyina	20	Sagaing	Pinlebu
9	Kachin	Bhamo	21	Tanintharyi	Yebyu
10	Kayin	Hpapun	22	Tanintharyi	Tanintharyi
11	Kayin	Kyainseikgyi	23	Tanintharyi	Dawei
12	Kayin	Myawaddy	24	Tanintharyi	Palaw

There are 24 Townships in 7 States/Regions of High malaria burden townships in Myanmar for implementing the Intensification Plan and Acceleration Plan.



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.11) High Malaria Burden Townships in Myanmar for Implementing Intensification Plan & Acceleration Plan

The planned townships are placed in border areas of Myanmar and the neighboring countries i.e., Thailand, People Republic of China, India, and Bangladesh.

According to VBDC annual review meeting, NMCP can conduct the following activities concerning with malaria disease elimination activities in overall country.

Table (2.3) Achievements of Case Identification and Investigation (CIFI) in Myanmar (2019 – 2021)

	2019	**2020**	**2021**
No. of malaria cases	2732	4131	2047
No. of malaria cases notified	2114	3274	706
No. notified within 24 hours	1742	3002	626
No. of case investigations done	2062	3171	479
No. of cases classified	2062	3171	479
No. of indigenous cases	511	1306	202
No. of imported cases	1414	1652	256
No. of introduced cases	19	25	1
No. of induced cases	11	9	1
No. of relapse cases	81	140	18
No. of recrudescent cases	3	3	0
No. of cryptic cases	23	36	1
No. of foci investigation done	493	592	33
No. of foci classified	484	577	33
No. of active foci	174	248	8
No. of residual non-active foci	271	265	25
No. of cleared foci	39	64	0

Source:(Nay Yi Yi Lin, 2022)

2.3 Malaria Situation in Rakhine State

In Rakhine State, there are 7 Districts, 17 Townships, 11 Sub-townships, 191 quarters, 1,125 village tracts, and 3,604 villages. The total number of houses is 573,606 and the total population is 2,914,547. Population density is 92.8 persons/ sq.km. **(**Zaw Zaw Aung, 2022)

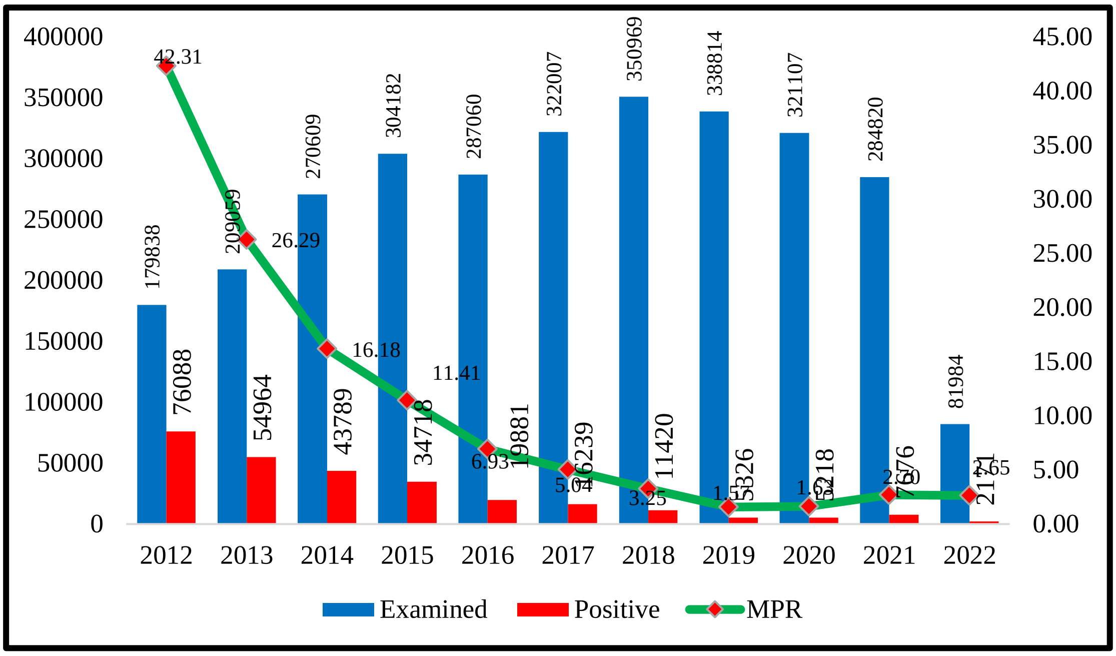
Health facilities and Manpower in Rakhine State are as follow:

There is one 500-bedded hospital, two 200-bedded hospitals, four 100-bedded hospitals, seven 50-bedded hospitals, four 25-bedded hospitals, 54 Station Health Units, one Urban Health Center, 131 Rural Health Centers, 594 Rural Health Sub Centers, 18 Maternal and Child Health and 18 VBDC teams, one at State level and the other 17 at Township level. **(**Zaw Zaw Aung, 2022)

Source: VBDC Annual Review Meeting 2020-2021

Figure (2.12) Health Centers of Rakhine State

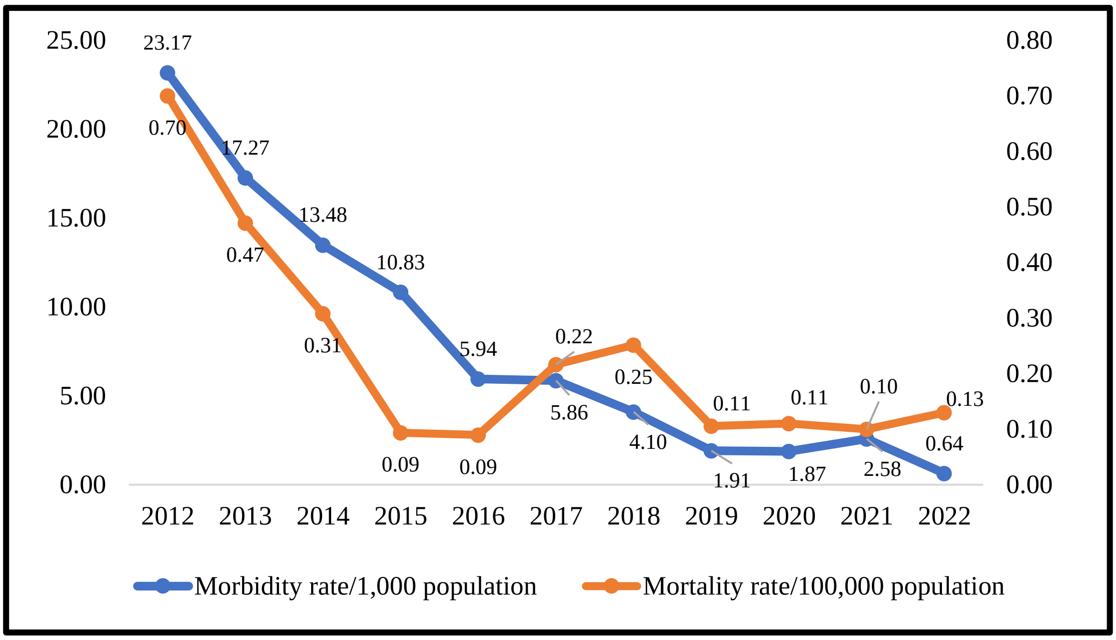
In Figure (2.12), the overall location and distribution of health centers of Rakhine State are shown. In Figure (2.13), the yearly examines, positive cases, malaria positive rate in Rakhine State (2012 - 2022 June).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.13) Yearly Examine, Positive Cases, Malaria Positive Rate in Rakhine State (2012 - 2022 June)

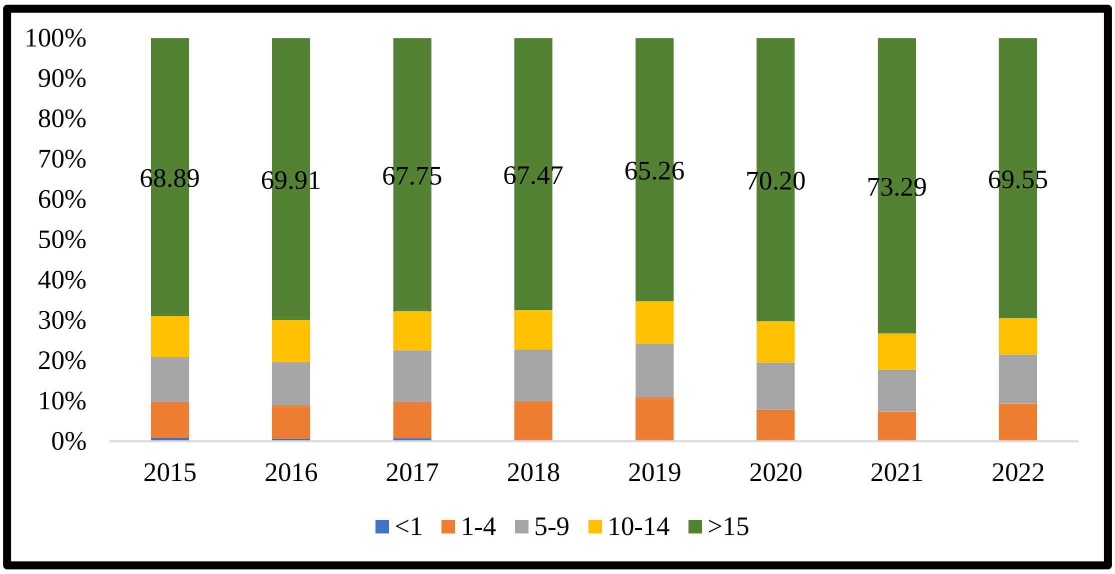
According to Figure (2.13) the positive case-finding rate was gradually decrease yearly. In Figure (2.14) the morbidity and mortality rates are shown. In which, the morbidity rate is significantly decrease but the mortality rate per 100,000 population are slightly increase in year 2022 and year 2017 and 2018.



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.14) Malaria Morbidity and Mortality Rates (2012 – 2022 Up to June) in Rakhine State

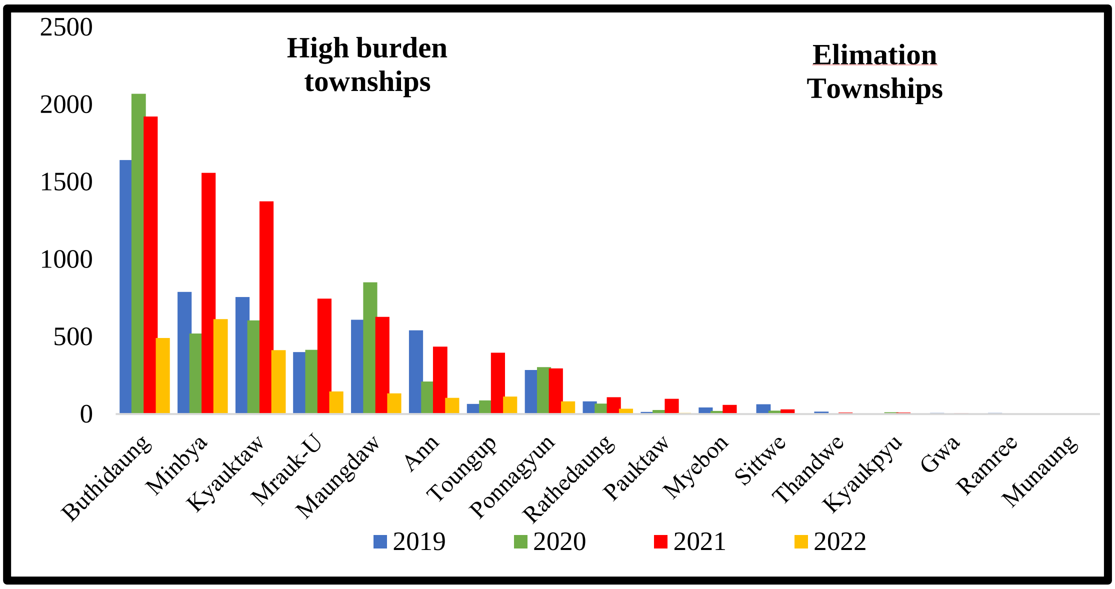
In 2015, the total positive cases were 34,718, total death were 3; in 2020, the total positive were 5,326, total death were 3; in 2021, total positive were 7,676, total death were 3; in 2022 up to June, total positive were 2,171, total death were 4. The distribution of malaria cases by age group were shown in below figure (2.15).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.15) Age Distribution (%) of Malaria Cases (2012 - 2022 up to June) in Rakhine State

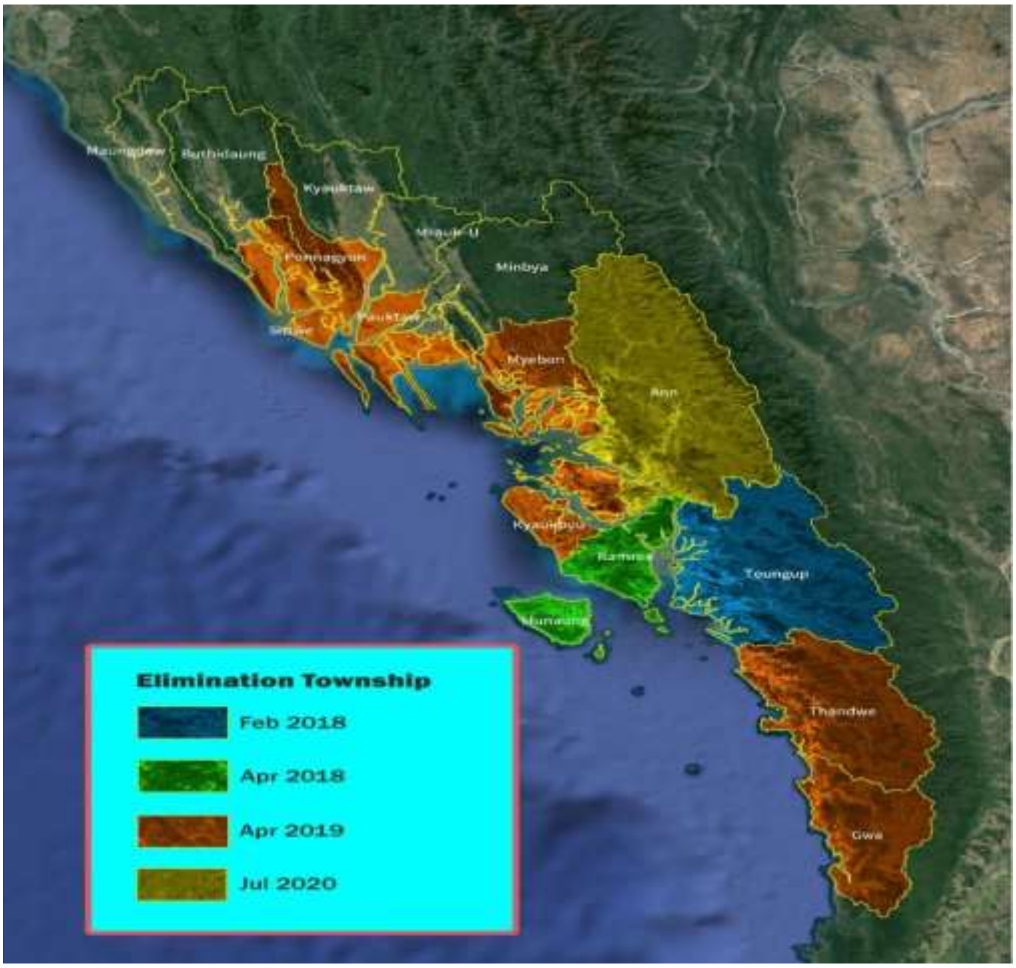
In figure (2.15), in the proportion of confirmed malaria cases by case group, the majority of cases are above 15 years of age range 65-73 percent for 8 years.



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.16) Number of Cases by the Township in 2019- 2022 up to June in Rakhine State

Due to the number of malaria case findings per year, the township was categorized into high-burden and elimination townships as in the figure. Toungup Township was one of the malaria high burden townships in Rakhine State. The trend of changing from high burden to elimination township by year are shown in Figure (2.17).



Source: VBDC Annual Review Meeting 2020-2021

Figure (2.17) Elimination Townships in Rakhine State (2018-2022 June)

The malaria positive cases finding in elimination townships in Rakhine State are shown in Table (2.4) and Figure (2.18).

Table (2.4) Malaria Positive Cases in Elimination Townships in Rakhine State (2018-2021)

No.	Township	2018	2019	2020	2021
1	Toungup	262	66	99	437
2	Ramree	7	7	4	0
3	Munaung	0	1	0	0
4	Thandwe	30	16	1	10
5	Gwa	117	7	1	6
6	Kyaukpyu	37	4	11	9
7	Sittwe	477	63	22	30
8	Rathedaung	220	82	68	92
9	Pauktaw	23	13	27	97
10	Myaebon	135	43	21	60
11	Ponnagyun	866	285	304	295
12	Ann	729	542	210	436
	Total	**2,911**	**1,136**	**768**	**1,472**

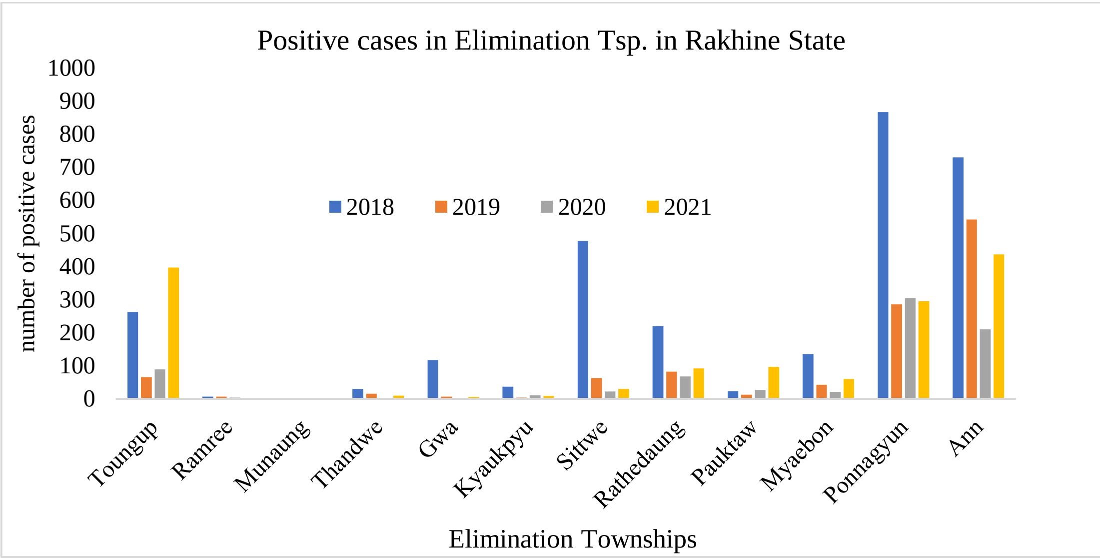


Figure (2.18) Malaria Case Finding in Elimination Townships in Rakhine State (2018-2021)

2.4 Review on Related Studies

Duc et al. (2008) studied by using the combination of multivariate analysis and classification and regression tree (CART) method provided an accurate and dynamic picture of the main risk factors for malaria infection. The results showed that the control of forest malaria remains an extremely complex task that has to address poverty-related risk factors such as education, ethnicity, and housing conditions.

Kumar et al. (2014) studied that with the various recent advancements in diagnostic and treatment modalities, malaria remains a public health problem in developing countries, and changing environmental and climatic conditions are considered the biggest challenge in fighting against the scourge of malaria. Malaria is an entirely preventable and treatable illness caused by parasites of Plasmodium species and transmitted exclusively by the bites of the Anopheles mosquito. Although preventable and treatable, malaria causes significant morbidity and mortality, particularly in resource-poor regions.

Ayele et al. (2016) studied that individuals with poor socio-economic conditions are positively associated with malaria infection. Improving the housing condition of the household is one of the means of reducing the risk of malaria. The result found that children and female household members are the most vulnerable to the risk of malaria.

Yang et al. (2017) showed that there was an association between malaria and environmental factors, and occupational structure was revealed; individuals and disease prevention and control departments should implement more stringent preventative strategies in places with hot and humid environmental conditions, to control and eliminate malaria in their research of spatiotemporal epidemic characteristics and risk factor analysis of malaria in Yunnan Province, China.

Vygen-Bonnet and Stark (2018) stated in their research of changes in malaria epidemiology in Germany showed that the steep rise in vivax malaria notifications in 2014 and 2015 was mainly due to newly arriving refugees from Eritrea but also due to refugees from other countries of the Horn of Africa and South Asia, predominantly young men. Clinicians should include malaria in their differential diagnosis in case of a febrile illness in this population even if arrival to Germany dates back several months.

Ibrahim et al. (2018) investigated the effect of malaria predictors on some malaria related diseases using logistic regression model. Their findings indicated significant relationship between malaria predictors and some malaria related diseases such as malaria plus typhoid, malaria plus anaemia, malaria plus urinary tract infection etc. It was found that the predictor: age, vomiting and cough were not predictors of malaria as well as its related diseases and that male patients had more malaria plus and other related diseases than female patients. Also the results indicated that patients aged 40 years and above tend to have malaria plus other related diseases than those in other categories of age.

DePina et al. (2019) stated that measures on the effect of environmental factors on malaria showed a strong positive correlation with temperature and relative humidity, a moderately positive correlation with the pluviometry, and a strong negative correlation with wind speed.

Essendi et al. (2019) stated that their study confirmed that educational status, occupation, and house structure were important risk factors for malaria infection, and their findings were consistent with previous reports in East Africa.

Habyarimana and Ramroop (2020) stated that the results significant factors associated with malaria were: the gender of the child, the number of household members, whether the household had mosquito bed nets for sleeping, whether the dwelling had undergone indoor residual spraying in the 12 months before the survey, the location of the household's source of drinking water, the main wall materials of the dwelling, and the age of the head of the household. The prevalence of malaria was also high among children living in houses with walls built from poorly suited materials; this suggests the need for intervention in construction materials.

Mosha et al. *(*2020) stated that three years after the universal coverage campaign LLIN usage had decreased considerably despite the distribution of new LLINs in the interim. Children living in households with full access to LLINs per sleeping place were at lower risk of malaria; however, malaria prevalence in this group remained high. Standard pyrethroid-only LLINs were no longer sufficiently protective even when in good condition and relatively new. More efforts should be made to maintain high coverage of more effective types of LLIN between campaigns.

Gallalee et al. (2021) stated that the quantitative and qualitative findings in their study suggest there have been a decline in malaria transmission in Myanmar's Ayeyarwady region that coincides with the implementation of the government's multi-pronged malaria elimination strategy and with a period of deforestation. Although it is difficult to measure the impact of changes in malaria control guidelines and interventions, a large increase in malaria control funding has led to increased investment in training, case management practices, and commodities such as LLINs and RDTs.

Kumar et al. (2022) studied that meteorological variables are the driving forces of malaria transmission, and it has been suggested that the spread of Vector-Borne Diseases (VBDs) to developing nations is due to globalization. However, malaria is also associated with poverty and the socioeconomic status of the place. Weather factors (temperature, rainfall, humidity, atmospheric pressure, wind, and cloud) play vital roles in transmitting VBDs. The temperature, rain, humidity, and wind conditions of any location play a crucial role in the life cycle of mosquitoes.

This study mentioned that changing climate patterns impact sectors such as agriculture, hydrology, health, and others. Malaria is a vector-borne disease significantly associated with changing climate, rampant in Bihar State, India. Hence, the current study aimed to analyze the status and trends of malaria in Bihar (India).

2.5 Analytical Framework

Based on the previous studies, the following analytical framework was constructed (Figure 2.19). This framework was adopted to explain the factors related to malaria cases in Toungup Township of Rakhine State. It describes how socio-economic, demographic, and other associated variables effected malaria cases. This framework posits that socio-economic, demographic and the other associated variables such as gender, age, test method, disease outcome (severe or uncomplicated), type of disease, previous history of malaria, type of malaria case, type of population, occupation, and origin of infection have an influence on malaria cases Pf.

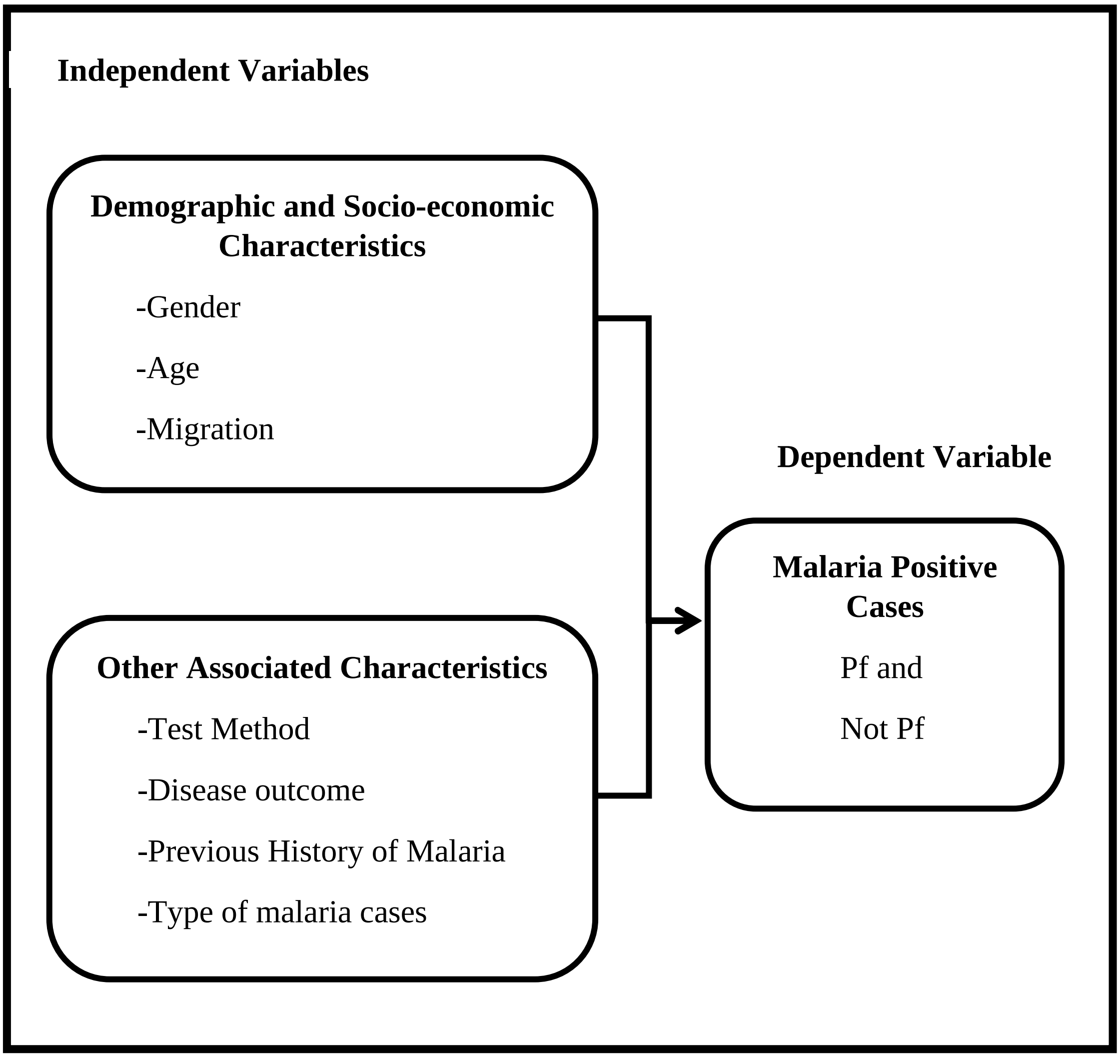


Figure (2.19) Analytical Framework of Positive Malaria Cases

Two kinds of positive cases were combined as one variable due to the same treatment and clinical characteristic i.e., *Plasmodium falciparum* and mixed infected cases were combined as same category and coded as Pf and *Plasmodium vivax* infected cases were another variable coded as not Pf.

CHAPTER III
RESEARCH METHODOLOGY

In this chapter, data sources, profile of Taungup Township, one-way analysis of variance, the binary logistic regression model, the likelihood ratio test, Chi-square goodness of fit tests, Hosmer-Lemeshow test, Cox and Snell R-square, Wald Statistic, Pearson's Chi-squared test Evaluation of Logistic Regression Model and Definition of Selected Variables and variables description are presented.

3.1 Data Source

In this study, the secondary data on three years cumulative malaria positive cases of Taungup Township were obtained from the 2019 to 2021 township malaria data base. There were 85,076 tested patients in Toungup township for three years. 602 malaria positive cases were recorded and select a random sample of 240 cases among them for this study. Total positive cases for Pf were 202, mixed 13, Pv 25 and mixed infection were 13. Due to the same treatment regimen for positive cases, the study combined Pf and mixed cases as Pf cases and analyzed.

3.2 Profile of Taungup Township

Toungup Township is situated in Thandwe District with a total area of 1173.39 square miles at 18 feet above the sea level. From 2010 and 2017, the highest temperature recorded was 36.4 Ċ (2013 and 2014) and the lowest temperature recorded was 11.7 Ċ (2011). The average rainfall was 186.87 inches with the highest record at 241.33 inches in 2011. There are 39,042 households with a population of 157,058 (under both the Government Administrative Department (GAD)) and non-GAD. There are 8 wards, 52 village tracts and 207 villages. On-the-ground, there are 241 recorded villages/worksites. Some are not included in the GAD list, but Defeat Malaria covered them for elimination activities.

3.3 Fisher's Exact Test

Fisher's Exact test is used to determine whether or not there is a significant association between two dichotomous variables. It is typically used as an alternative to the Chi-square test of Independence when one or more of the cells counts in a 2x2 table is less than 5.

Fisher's Exact Test uses the following null and alternative hypothesis:

H_0: (Null hypothesis) The two variables are independent.

H_1 :(Alternative hypothesis) The two variables are not independent.

Suppose it has the following 2x2 table:

	Group 1	Group 2	Row Total
Category 1	a	b	a+b
Category 2	c	d	c+d
Column Total	a+c	b+d	a+b+c+d = n

This produces the same p value as the CDF of the hypergeometric distribution with the following parameters.

Population size =n

Population "successes" = a+b

Sample size = a+c

Sample "successes" = a

(Fisher, R.A.,1954)

3.4 Phi Coefficient

A Phi Coefficient (sometimes called a mean square contingency coefficient) is a measure of the association between two binary variables. For a given 2x2 table for two random variables x and y:

	y=0	y=1
x=0	a	b
x=1	c	d

The Phi Coefficient can be calculated as:

phi Φ = (bc-1d)/sqrt((a+b) (c+d)(a+c)(b+d))

$$\phi = \frac{bc - ad}{\sqrt{(a+b)(a+c)(b+d)(c+d)}}$$

A Phi Coefficient takes on values between -1 and 1 where:

-1 indicates a perfectly negative relationship between the two variables.

0 indicates no association between the two variables.

1 indicates a perfectly positive relationship between the two variables.

(Yule, B. W. (1912))

3.5 Binary Logistic Regression Model

Binary logistic regression is a type of regression analysis that is used to estimate the relationship between a dichotomous dependent variable and dichotomous-, interval-, and ratio-level independent variables. The dependent variable in logistic regression is usually dichotomous, that is the dependent variable can take value 1 with a probability of success, P(Y=1) = π, or the value 0 with the probability of failure P(Y=0) $= 1 - \pi$. The use of linear regression model for categorical variables was considered as inappropriate because the response values are not measured (ratio scale or quantitative values) and the error terms are not normally distributed (Rastogi & Singh, 2019). The major limitation of linear regression is that it cannot fit with the dependent variables that are categorical or dichotomous. Logistic regression assesses the impact of multiple independent variables simultaneously at a time on the categorical dependent variable.

The binary logistic regression model in the usual form is

$$Y_i = E(Y_i) + \varepsilon_i \qquad (3.1)$$

For a binary dependent or response variable 'Y' and an independent or predictor variable 'X', the probability for the distribution of 'Y' can be written as:

$$P(Y = 1) = \pi$$

$$P(Y = 0) = 1 - \pi$$

The logistic regression model is therefore given as,

$$\pi_i = \frac{\exp(\sum_{j=1}^{p} \beta_j X_{ij})}{1 + \exp(\sum_{j=1}^{p} \beta_j X_{ij})} \qquad (3.2)$$

Therefore, Equation (3.5) can be written as

$$\pi(X) = \frac{e^{\beta_0+\beta_1 X}}{1+e^{\beta_0+\beta_1 X}} \tag{3.3}$$

Equation (3.6) determines the binary logistic regression for a single independent variable. Here, the two regression constraints viz. the intercept, β_0, and the regression parameter for X, β_1, set the basis of the above-mentioned model.

For a binary response variable 'Y', having 'k' number of independent variables ($X_1, X_2,\ldots, X_k$); π(X) is used to represent the probability that Y=1 for having event and 1- π(X) to represent the probability of not having event (Y=0).

These probabilities are written as

$\pi(X) = P(Y = 1|\, X_1\,, X_2\,, \ldots, X_k\,)$

$1 - \pi(X) = P(Y = 0|\, X_1\,, X_2\,, \ldots, X_k\,)$

Since the distribution of the error term ε_i depends on the Bernoulli distribution of the response Y_i. The expected value of each Y_i is

$$E(Y_i) = \pi_i = \frac{\exp(\beta_0 + \beta_1 X_1 + \cdots + \beta_i X_i)}{1 + \exp(\beta_0 + \beta_1 X_1 + \cdots + \beta_i X_i)} \tag{3.4}$$

where, $E(Y_i)$ = conditional mean given the value of X_i

β_0 = the constant of the equation

β_i = the coefficient if the predictor variable i

An alternative form of the logistic regression equation is:

$$\log[\,\pi(X)] = \log\left[\frac{\pi_i}{1-\pi_i}\right] = \beta_0 + \beta_1 X_1 + \cdots + \beta_i X_i \tag{3.5}$$

Odds Ratio

An Odds Ratio (OR) is a measure of association between a certain property A and a second property B in a population. Specifically, it tells how the presence or absence of property A has an effect on the presence or absence of property B. The OR is also used to figure out if a particular exposure (like eating processed meat) is a risk factor for a particular outcome (such as colon cancer), and to compare the various risk factors for that outcome.

The formula of odd ratio can be written as

$$OR = \frac{odds(A)}{odds(B)} = \frac{\frac{P_A}{(1-P_A)}}{\frac{P_B}{(1-P_B)}} \tag{3.6}$$

The regression coefficient is the estimated increase in the log odds of the outcome per unit increase in the value of the exposure. An odds ratio > 1 suggests an increasing probability of being in a higher level on the dependent variable as values on an independent variable increases, whereas a ratio < 1 suggests a decreasing probability with increasing values on an independent variable. An odds ratio = 1 suggests no predicted change in the likelihood of being in a higher category as values on an independent variable increase. A multiple logistic regression model can be fitted with a binary response variable (Y) and a binary predictor variable (X), and in addition other predictor variables $Z_1,\ldots,Z_k$ that may or may not be binary. If a multiple logistic regression was used to regress Y on X, $Z_1,\ldots,Z_k$, then the estimated coefficient β_x for X is related to a conditional OR. Specifically, at the population level

$$e^{\hat{\beta}_x} = \frac{P(Y=1 \mid X=1, Z_1,\ldots,Z_k) / P(Y=0 \mid X=1, Z_1,\ldots,Z_k)}{P(Y=1 \mid X=0, Z_1,\ldots,Z_k) / P(Y=0 \mid X=0, Z_1,\ldots,Z_k)} \tag{3.7}$$

where, $e^{\widehat{\beta}_x}$ is an estimate of this conditional odds ratio. The interpretation of $e^{\widehat{\beta}_x}$ is as an estimate of the OR between Y and X when the values of $Z_1, \ldots, Z_k$ are held fixed.

3.6 Evaluation of Logistic Regression Model

After estimating the coefficients, there are various evaluation parameters or test need to be conducted for assessing the appropriateness, usefulness and adequacy of the developed logistic regression model. These evaluation parameters are the statistical test of each predictor variable and goodness-of-fit statistics.

3.6.1 The Likelihood Ratio Test

Overall fit of a model shows how strong a relationship between all of the independent variables, taken together, and dependent variables. It can be assessed by comparing the fit of the two models with and without the independent variables. A logistic regression model with the k independent variables (the given model) is said to provide a better fit to the data if it demonstrates an improvement over the model with no independent variables (the null model). The overall fit of the model with k coefficients can be examined via a likelihood ratio test which tests the null hypothesis.

$$H_0 = \beta_1 = \beta_2 = ... = \beta_k = 0.$$

To do this, the deviance with just the intercept (-2 log likelihood of the null model) is compared to the deviance when the k independent variables have been added (-2 log likelihood of the given model). Likelihood of the null model is the likelihood of obtaining the observation if the independent variables had no effect on the outcome. Likelihood of the given model is the likelihood of obtaining the observations with all independent variables incorporated in the model.

The difference of these two yields a goodness of fit index G = χ^2 statistic with k degrees of freedom (Bewick et al., 2005). This is a measure of how well all of the independent variables affect the outcome or dependent variable.

G = χ^2 = (-2 log likelihood of null model) - (-2 log likelihood of given model)

An equivalent formula sometimes presented in the literature is

$$= -2\log \frac{likelihood\ of\ the\ null\ \text{mod}\ el}{likelihood\ of\ the\ given\ \text{mod}\ el}$$

Where; the ratio of the maximum likelihood is calculated before taking the natural logarithm and multiplying by -2. The term ‘likelihood ratio test’ is used to describe this test. If the p-value for the overall model fit statistic is less than the conventional 0.05, then reject H_0 with the conclusion.

3.6.2 Chi-Square Goodness of Fit Test

With logistic regression, instead of R^2 as the statistics for overall fit of the linear regression model, deviance between observed values from the expected values is used. In linear regression, residuals can be defined as $y_i - \hat{y}_i$ where y_i is the observed dependent variable for the i^th^ subject, and $\hat{y}_i$ the corresponding prediction from the model. The same concept applies to logistic regression, where y_i is equal to either 1 or 0, and the corresponding prediction from the model is as

$$\hat{y}_i = \frac{e^{\alpha + \beta_1\chi_1 + \ldots + \beta_k\chi_k}}{1 + e^{\alpha + \beta_1\chi_1 + \ldots + \beta_k\chi_k}}$$

Chi-square test can be based on the residuals, $y_i - \hat{y}_i$ (Peng & So, 2002).

A standardized residual can be defined as

$$r_i = \frac{y_i - \hat{y}_i}{\sqrt{\hat{y}_i(1-\hat{y}_i)}}$$

One can then form a χ^2 statistic as $\chi^2 = \sum_{i=1}^{n} r_i^2$

This statistic follows a χ^2 distribution with n - (k+1) degrees of freedom, so that p-values can be calculated.

3.6.3 Hosmer-Lemeshow Test

The Hosmer-Lemeshow test is to examine whether the observed proportions of events are similar to the predicted probabilities of occurrence in subgroups of the model population. The Hosmer-Lemeshow test is performed by dividing the predicted probabilities into deciles (10 groups based on percentile ranks) and then computing a Pearson Chi-square that compares the predicted to the observed frequencies in a 2-by-10 table. The value of the test statistic is

$$H = \sum_{g=1}^{10} \frac{(O_g - E_g)^2}{E_g}$$

Where Og and Eg denote the observed events and expected events for the g^th^ risk decile group. The test statistic asymptotically follows a χ^2 distribution with 8 (number of groups -2) degrees of freedom. Small values (with large p-value closer to 1) indicate a good fit to the data, therefore, good overall model fit. Large values (with p <0.05) indicate a poor fit to the data (Hosmer & Lemeshow, 2000).

3.6.4 Cox and Snell R-Square

The ratio of the likelihoods reflects the improvement of the full model over the intercept model (the smaller the ratio, the greater the improvement). L(M) is the conditional probability of the dependent variable given the independent variables. If there are N observations in the dataset, then L(M) is the product of N such probabilities. Thus, taking the n^{th} root of the product L(M) provides an estimate of the likelihood of each Y value. Cox & Snell's presents the R-squared as a transformation of the –2ln[L(MIntercept)/L(MFull)] statistic that is used to determine the convergence of a logistic regression. Note that Cox & Snell's pseudo-R-squared has a maximum value that is not 1: if the full model predicts the outcome perfectly and has a likelihood of 1, Cox & Snell's is then $1 - L(M\ Intercept)^{2/N}$, which is less than one. The Cox and Snell R square is:

$$R^2 = 1 - [\frac{L(M_{Intercept})}{L(M_{Full})}]^{2/N}$$

3.6.5 Wald Statistic

The Wald statistic is the ratio of the square of the regression coefficient to the square of the standard error of the coefficient. The Wald statistic is asymptotically distributed as a Chi-square distribution. Wald test is used as a test of significance for the coefficients in the logistic regression.

$$W_j = \frac{\beta_j^2}{SE_{\beta_j^2}}$$

Each Wald statistic is compared with a Chi-square with 1 degree of freedom. Wald statistics are easy to calculate but their reliability is questionable (Bewick et al., 2005).

3.7 Definition of Selected Variables

In this study, dependent variable was focuses on malaria positive cases Pf and mixed infection were combined and coded as 1 and the Pv cases were coded as 2. These cases were be affected by the demographic, socio-economic and other associated characteristics such as age, gender, test method, test result, previous history of malaria, type of malaria case, type of population, occupation, and origin of infection of positive patients.

Malaria Case: Individual who was infected with malaria parasite and test positive. It is divided into two groups as Pf (*Plasmodium falciparum* plus mixed infection) and coded as 1 and Pv cases were coded as 2. (Occurrence of malaria illness or disease in a person in whom the presence of malaria parasites in the blood has been confirmed by parasitological testing.) (WHO,2022)

Age of Malaria Case: It includes malaria positive cases at age groups less than or equal 20 years, 21 to 40 years of age and more than 40 years.

Gender of Malaria Case: It refers to the characteristics of malaria positive case by male coded as 1 and female coded as 2.

Migration: The patient who lived in Toungup Township was resident and coded as 1 and the patient who replaced, relocated, or stayed at Toungup township was migrant and coded as 2.

Type of Occupation of Malaria Case: The occupational of status of malaria case is classified as six categories based on the type of works and coded 1 to 6.

Type of Work	**Code**
Causal worker	**1**
Machine/mechanic/car/boat works	**2**
Farm/paddy field/upland work	**3**
Dependent/staff/students	**4**
Timber/forest related works	**5**
Chain saw worker	**6**

Test Method: All suspected patients have to test by rapid diagnostic test (RDT) or under microscope. For RDT code was 1 and for microscopy code was 2.

Disease outcome: The disease outcomes were severe case or uncomplicated case which were coded for severe case was 1 and uncomplicated for 2.

Previous History of Malaria: All positive patients enquired whether they have any experience of malaria infection. If they had coded as 1 and if not coded as 2.

Type of malaria cases: The positive cases were investigated and classified as imported, indigenous, induced, introduced and unclassified according to case classification definition.

Imported case: Malaria case or infection in which the infection was acquired outside the area in which it is diagnosed and coded as 1.

Indigenous case: A case contracted locally with no evidence of importation and no direct link to transmission from an imported case and coded as 2.

Induced case: A case the origin of which can be traced to a blood transfusion or other form of parenteral inoculation of the parasite but not to transmission by a natural mosquito-borne inoculation and coded as 3.

Introduced case: A case contracted locally, with strong epidemiological evidence linking it directly to a known imported case (first-generation local transmission) and coded as 4.

Unclassified case: A case could not be traced and have no evidence of linkage with above cases by case investigation method and coded as 5.

Types of Case	**Code**
Imported	**1**
Indigenous	**2**
Induced/ Introduced	**3**
Unclassified	**4**

Origin of infection: The positive case contracted malaria infection inside Toungup Township was coded as 1 and outside of Toungup was coded as 2.

Origin of Infection	**Code**
Inside Toungup Township	**1**
Outside Toungup Township	**2**

3.8 Description of Variables

This study used a binary logistic model because of the outcome dependent variable, malaria case has binary responses. The explanatory independent variables are age, gender, type of population, test method, test result, type of cases, occupation of case, previous history of malaria, and place of infection.

Y = Malaria case

= 1, if case is Pf

= 2, if case is not Pf

X_1 = Age

= 1, age (less than or equal 20 years)

= 2, age (21 to 40 years of age)

= 3, age (more than 40 years)

X_2 = Gender

= 1, male

= 2, female

X_3 = Migration

= 1, Resident

= 2, Migrant

X_4 = Occupation

= 1, Causal worker

= 2, Machine/mechanic/car/boat works

= 3, Farm/paddy field/upland works

= 4, Dependent/staff/students

= 5, Timber/forest related works

= 6, chain saw worker

X_5 = Test method

=1, RDT

=2, Microscopy

X_6 =Disease outcome

=1, Severe

=2, Uncomplicated

X_7 = Type of cases (Classification)

= 1, Imported

= 2, Indigenous

= 3, Induced/ Introduced

= 4, Unclassified

X_8 = Previous history of malaria

= 1, Yes

= 2, No

X_9 = Origin of infection

= 1, Inside of Township

= 2, Outside of Township

CHAPTER IV
RESULTS AND FINDINGS

In this chapter, the results of descriptive statistics are presented for all 602 malaria positive cases who lived in Toungup Township from 2019 to 2021 for three successive years. Then construction of the positive cases as dependent variable and Fisher's Exact Test, Phi Coefficient and logistic regression are used to analyze the demographic and socio-economic and other related variables and malaria disease.

4.1 Sample Size Determination

To determine the size of sample, formula developed by Yamane (1973) for categorical data is as follows.

$$n = \frac{N}{1 + N(e)^2}$$

To be more accurate Yamane (1973) adjusted calculation formula was used by increasing π = population variance from Dichotomous Variable equal to 0.50 and z= 2 score at significance level α =0.05.

$$n = \frac{(z)^2(\pi)(1 - \pi)(N)}{(z)^2(\pi)(1 - \pi) + (N)(e)^2}$$

where, n= sample size

N= population size

e = error (0.05) reliability level 95%

$$n = \frac{(2)^2(0.5)(0.5)\ 602)}{(2)^2(0.5)(0.5) + (602)(0.05)^2}$$

=240

The required sample size is obtained as at least 240.Therefore, 240 respondents are randomly chosen from malaria positive cases 602 in Toungup Township for this study.

4.1 Background Characteristic of Malaria Cases

In Toungup Township, there are 39,042 households with a population of 157,058 (under both the Government Administrative Department (GAD) and non-GAD. There are 8 wards, 52 village tracts and 207 villages. There were 85,076 tested patients in Toungup township for three years (2019-2021). A random sample of 240 malaria cases were chosen from 602 malaria positive cases among 85,076 tested people who lived in Toungup Township from 2019 to 2021. Among them, there were 240 malaria positive cases in this township was studied. Total positive cases for Pf were 202, Pv 25 and mixed infection were 13 respectively. Due to the same treatment regimen for positive cases, the study combined Pf and mixed cases as Pf cases and analyzed. Table (4.1) displays distribution of malaria cases in Toungup Township.

Table (4.1) Distribution of Malaria Cases in Toungup Township

Malaria Cases	Frequency	Percent (%)
Pf	215	**89.58**
Not Pf	25	**10.42**
Total	240	**100**

Source: Combine positive malaria case register 2019-2021Toungup Township

In Table (4.1), the Pf cases was 215 (89.58%) among 240 cases and not Pf (Pv) was 25 (10.42%).

The characteristic of Age, Gender, Type of Population, Test Method, Test Result, Type of Cases, Occupation of case, Previous history of malaria, and origin of Infection were shown in Table (4.2).

Table (4.2) Distribution of Demographics and Socioeconomic Characteristics and Other Associated Factors of Malaria Cases

Gender	Number	Percent (%)
Male	222	92.5
Female	18	7.5
Age Group	**Number**	**Percent (%)**

≤ 20 years	70	29.17
21 to 40 years	126	52.5
≥ 41 years	44	18.33
Population Type	**Number**	**Percent (%)**
Resident	175	72.92
Migrant	65	27.08
Previous History of Malaria	**Number**	**Percent (%)**
Yes	24	10.0
No	216	90.0
Test Method	**Number**	**Percent (%)**
RDT	231	96.25
Microscopy	9	3.75
Disease Outcome	**Number**	**Percent (%)**
Severe	8	3.33
Uncomplicated	232	96.67

Table (4.2) Distribution of Demographics and Socioeconomic Characteristics and Other Associated Factors of Malaria Cases (Continued)

Occupation	Number	Percent (%)
Causal worker	59	24.58
Machine/mechanic/car/boat works	11	4.58
Farm/paddy field/upland works	51	21.25
Dependent/staff/students	27	11.25
Timber/forest related works	26	10.83

Chain saw worker	66	27.6
Case Classification	**Number**	**Percent (%)**
Imported	197	85.9
Indigenous	13	4.8
Induced/ Introduced	7	2.92
Unclassified	23	9.58
Origin of infection	**Number**	**Percent (%)**
Inside Township	222	92.5
Outside Township	18	7.5

Source: Combine positive malaria case register 2019-2021Toungup Township

According to Table (4.2), there are 222 (92.5%) male positive cases and 18(7.5%) female positive cases. The percentage of positive cases with age between 21-40 years is more than fifty percent 126 (52.5%). The majority of population type is resident 175(72.92%) followed by migrant population 65 (27.08%). The positive cases who had previous history of malaria are 24 (10.0%) and most 217(90.0%) did not have the previous history of malaria. Nearly all positive cases were detected by rapid diagnostic test (RDT) 231 (96.25%) and 9 (3.75%) of positive cases were tested by microscope. Fortunately, most positive cases were uncomplicated malaria patients 232 (96.67%) and the rest 8(3.33%) were severe malaria cases. The occupation of positive cases was categorized into six groups, and there were three main groups were appeared such as category 1,3 and 6 as 59 (24.58%), 51 (21.25%) and 66(27.6%) respectively. According to case classification, the majority of cases were imported cases 197(82.08%), the indigenous cases 13(5.42%), the induced and introduced cases 7(2.9%), and unclassified cases were 23 (9.58%) respectively. They were mainly related to forest related works. Most positive cases were infected from inside Toungup Township 222(92.5%) and outside township were 18 (7.5%).

4.3 Association of Malaria Positive Cases and Demographic and Socioeconomic and other Related Factors

The relationship between malaria positive cases and socio-demographic and other associated factors such as age, gender, migration, test method, test result, type of cases, occupation of case, previous history of malaria, and place of infection are described in Table (4.3).

Table (4.3) Association of Malaria Positive Cases and Demographic and Socioeconomic and other Related Factors

Variable	Fisher's Exact Test (p value)	Phi Coefficient
Gender	0.115	-
Age group	-	0.248***
Migration	0.099*	-
Previous History of Malaria	0.243	-
Test Method	0.000***	-
Disease Outcome	0.620	-
Occupation	-	0.237**
Case Classification	-	0.204**
Origin of Infection	0.003**	-

Source: Combine positive malaria case register 2019-2021Toungup Township
***denotes significant at 1% level, **denotes significant at 5% level and * denotes significant at 10% level

Table (4.3) showed the relationship between malaria positive cases and socio-demographic and other associated factors. The Fisher's Exact Test was carried out to examine the significance of association between malaria positive cases and gender, migration, previous history of malaria, test method, disease outcome and origin of infection. The Phi Coefficient was carried out to examine the significance of association between malaria positive cases and age group, occupation, and case classification.

The study showed that the p value of population type(migration) is 0.099. Since this p value is less than α=0.1, reject the null hypothesis. This means that there is a significant association between population type and malaria positive cases at 10% level. The study also showed that the p value of test methods and origin of infection are 0.000 and 0.003. Since the p value is less than α=0.1 and α=0.05 respectively. This means that there is any statistically significant between test method and origin of infection and malaria positive cases at 1% and 5% level. And then, the p value of other associated factors such as gender, previous history of malaria and disease outcome are greater than 5% level, therefore we do not have sufficient evidence to say that there is any significance association between gender. Previous history of malaria and disease outcome and malaria positive cases.

According to the Phi coefficient, age group, occupation and case classification are statistically significance at 5% level. The results showed that the Phi coefficient value of age group is 0.248, this mean that the correlation or relationship between the age group and malaria positive cases is 0.248. And then, the results of Phi coefficient value for occupation is 0.237, which is similar to say that the correlation or relationship between the variables is 0.237. The study also showed that the Phi coefficient value of case classification is 0.204, this means that the correlation or relationship between the variable is 0.204.

4.4 Results of Binary Logistic Regression Model

Based on the three years malaria positive cases in Toungup Township (2019 to 2021) nine factors are studied by using binary logistic regression. In this study, malaria positive case Pf is considered as dependent variable and it takes the value of 1 when the other factor is related and otherwise. Sex, age, type of population, type of occupation, test method, test result, type of case, previous history of malaria and origin of infection of positive cases are considered as the independent variables. The binary logistic regression model can be written as

$$\log[y] = \log \frac{\pi_i}{1-\pi_i} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

where, Y_i = Malaria Positive cases

= 1, not Pf

= 2, Pf

β_0 = Constant

β_i = Coefficients of the independent variables

X_1 = Age

X_2 = Gender

X_3 = Type of population

X_4 = Type of occupation

X_5 = Test Method

X_6 =Disease outcome

X_7 = Type of cases (Classification)

X_8 = Previous history of Malaria

X_9 = Origin of infection

The overall model fitting information for binary logistic regression model is given in Table (4.4).

Table (4.4) Overall Model Fitting Information

Model Fitting Criteria	Chi-Square Value	df	P-value
Omnibus Test of Model Coefficient	43.111	16	.000***
Hosmer and Lemeshow (H-L) Test	2.398	8	0.966
-2Log Likelihood	121.766[a]		
Cox & Snell R Square	0.164		
Nagelkerke R Square	0.331		

Source: Combine positive malaria case register 2019-2021Toungup Township

In Omnibus test of model coefficient, the inclusion of four explanatory variables yields a chi-square value of 43.111 with 67 degree of freedom, p=0.000. Therefore, the overall model is statistically significant, which means that adding the four explanatory variables to the model have significantly increased ability to predict whether the factors influenced on positive cases.

The Hosmer and Lemeshow test was used to measure the correspondence of the actual and predicted values of the dependent variable. The better model fit is included by a smaller difference in the observed and predicted classification. Hosmer-Lemeshow test statistic gives χ^2value 2.398 with p-value 0.966 and revealed that the test is no significant. Therefore, it can conclude that the fitted model is good.

The -2 log likelihood statistics is 121.766[a]. Table (4.4) provides some approximation of R^2 statistics in logistic regression. Cox and Snell's R^2 attempts to imitate multiple R^2 based on likelihood. The result of Cox and Snell's R^2 and the Nagelkerke R Square are 0.164 and 0.331 which indicate a reasonable fit of the model to the data. This shows that 16.4 % of the variation and 33.1 % of variation in positive cases are explained by the model.

Table (4.5) Results of Binary Logistic Regression Model, Toungup Township

Variable	B	S.E.	Wald	Df	Sig.	Exp(B)
Gender (Sex)						
Male	0.400	0.720	0.308	1	0.579	1.491
Female(ref.)						
Age Group						
≤ 20 years	0.042	0.650	0.004	1	0.948	1.043
21-40 years	1.695**	0.707	5.754	1	0.016	5.447
≥ 41 years(ref.)						
Population Type						
Resident	-1.458**	0.539	7.322	1	0.007	0.297
Migrant(ref.)						
Occupation						
Random/general worker	-1.733*	0.896	3.739	1	0.053	0.177
Machine/mechanic/car/boat works	16.375	11284.197	0.000	1	0.999	12932753.991
Farm/paddy field/upland works	-1.342	0.920	2.129	1	0.144	0.261
Dependent/staff/students	-1.526	1.005	2.309	1	0.129	0.217
Timber/Forest related works	-1.548	1.013	2.335	1	0.127	0.213
Chain-Saw workers (ref.)						
Test Methods						
RDT	0.184	1.217	0.023	1	0.880	1.202
Microscopy(ref.)						
Previous History of Malaria						
Previous History of Malaria(yes)	-0.272	0.758	0.129	1	0.719	0.762
Previous History of Malaria(no)(ref.)						
Disease outcome						
Severe Malaria	21.551	11122.55	0.000	1	0.998	2287650895
Uncomplicated malaria(ref.)						
Case Classification						
Imported case	0.274	0.883	0.097	1	0.756	1.316
Indigenous case	0.801	1.335	0.360	1	0.548	2.228
Introduced and induced case	1.021	1.562	0.427	1	0.514	2.775
Unclassified case(ref.)						
Origin of infection						
Inside Township	-3.270***	0.855	14.622	1	0.000	0.315
Outside Township(ref.)						
Constant	-1.958	2.318	0.714	1	0.398	0.141

Source: Combine positive malaria case register 2019-2021Toungup Township

***denotes significant at 1% level, **denotes significant at 5% level and * denotes significant at 10% level

According to the Table (4.5), the Wald test is used to determined statistical significance for each of the independent variables. The statistical significance of the test is found in the "Sig." column. From these results, it can be seen that population type, age group, general workers, origin of infection and inside Township are statistically significance. But gender, test method, disease outcome, previous history of malaria and case classification are not significance.

According to the age group, the age group is statistically significant and positive effect on Pf disease at 5% level. The result also showed that the odds ratio of age group is 5.447 It can be concluded that the respondent age group of 21 to 40 years was 5.447 times more likely to have Pf disease as compared the age group of over 41years.

And then, the odds ratio of resident is 0. 297.This means that the resident was 0.297 times less likely to have Pf disease as compared to migrant. It was statistically significant at 5% level and negatively effect on Pf disease.

General workers have negative effect and statistically significant at on Pf disease at 10% level. It is found that general workers have about 1.733 times less likely to have Pf disease as compared to chain-saw workers.

Moreover, the origin of disease from inside Township has statistically significant and negative effect on Pf disease at 1% level. It is found that people who lived in inside Township have about 0.315 times less likely to have Pf disease than people who lived in outside Township.

CHAPTER V
CONCLUSION

This chapter provides discussion on findings about relationship between respondent's socio-demographic and other related factors and number of malaria positive cases, conclusion of the study, recommendations, and possible future research.

5.1 Findings and Discussions

In this study, all positive malaria cases for three years (2019 to 2021) in Toungup Township were selected and analyzed by using appropriate statistical method. In which, two kinds of positive cases were combined as one variable due to the same treatment and clinical characteristic i.e., Plasmodium falciparum and mixed infected cases were combined as same category and coded as Pf and Plasmodium vivax infected cases were another variable coded as no Pf. The results of the descriptive statistics found that the Pf cases was 215(89.58%) among 240 cases and not Pf cases was 25(10.42%).

According to the Fisher's Exact Test showed that malaria positive cases were statistically associated by migration, test methods, and origin of infection. And, the Phi Coefficient showed that the malaria positive cases and age group, occupation and case classification are statistically significant associated.

The result from logistic regression analysis showed that age group, population type, general workers, and origin of infection (inside Township) are statistically significant.

According to the age group, the age group is statistically significant and positive effect on Pf disease at 5% level. The younger age group had very little or no immunity for that disease and very prone to get malaria infection.

And then, the resident population type was 0.2973 times less likely to have Pf disease as compared to migrant population. It was statistically significant at 10% level and negatively effect on Pf disease. The migrant people who did not have immunity to resist malaria disease compare with the resident who already lived in that area. So they can get malaria disease more likely than resident people.

General workers have negative effect and statistically significant at on Pf disease at 10% level. It is found that general workers have about 0.177 times less likely to have Pf disease as compared to chain-saw workers. The chain-saw workers who worked and stayed in that malaria prone places and get lesser health care access compared with general workers.

Moreover, the origin of disease from inside Township has statistically significant and negative effect on Pf disease at 1% level. It is found that people who lived in inside Township have about 0.315 times less likely to have Pf disease than people who lived in outside Township. Malaria is vector borne disease and can get infection at endemic area. Toungup Township is one of the endemic areas of malaria disease. People from outside the endemic areas can get that disease easily when they enter and stay at malaria area like Toungup Township especially forest related works.

5.2 Recommendations

According to the findings, the younger age group had more disease compared to the other age group and the patients may lead to severe disease outcome like dead. Access to health care for treatment of disease in time is important and awareness of disease burden and proper knowledge of prevention of disease is also essential. It is also need for the migrant population who are working in that area. The origin of disease mainly come from outside Toungup Township showed that the disease can transmit from outside township to the whole township. The health personnel from both government and non-government sectors collaborate and communicate each other to prevent and control the spread of disease. The vector borne disease control department of respective Township should conduct intensify the awareness of disease burden to people who live and work in their township and promote health education campaign for prevention and control of malaria disease in their township.

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5.3 Needs for Further Study

This study was conducted based on previous three years secondary data and analyzed by feasible statistical method according to available data source.

The need for further research in the field of malaria cases in Rakhine State is manifested, since not all the factors closely related to malaria cases were available for examination in this thesis. Further study should include the possible associated factors such as the housing condition, use of water, working time and sleeping time, usage of bed-net etc. thus can explain more about which factors influence on malaria disease.

If the malaria case data are based on weekly, monthly, yearly, further study should be used by time series statistical method for forecasting and predicting the malaria cases by township. But there was no overall analysis of the malaria case situation trend and forecasting for coming years in malaria endemic townships. Further studies and research should be conducted in malaria endemic township to support and change the malaria control and elimination strategy of Myanmar.

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APPENDIX

Terminology

A malaria case can be classified as suspected, presumed, or confirmed and as autochthonous, indigenous, induced, introduced, or imported (depending on the origin of infection) or as relapsing.

A malaria case can be classified as autochthonous, indigenous, induced, introduced or imported (depending on the origin of infection) or as relapsing.

Malaria case. Occurrence of malaria infection in a person in whom the presence of malaria parasites in the blood has been confirmed by a diagnostic test

Adherence: Compliance with a regimen (chemoprophylaxis or treatment) or with procedures and practices prescribed by a health care worker

Age group: Subgroup of a population classified by age. The following grouping is usually recommended:

- 0–11 months
- 12–23 months
- 2–4 years
- 5–9 years
- 10–14 years
- 15–19 years
- ≥ 20 years

Age, physiological: Adult female mosquito age in terms of the number of gonotrophic cycles completed: nulliparous, primiparous, 2-parous, 3-parous et seq. Note: Vector age is typically assessed by age grading instead of days.

Annual blood examination rate (ABER): The number of people receiving a parasitological test for malaria per unit population per year

Age-grading, of female adult mosquitoes: Classification of female mosquitoes according to their physiological age (number of gonotrophic cycles) or simply as nulliparous or parous (parity rate)

Anopheles, infected: Female Anopheles mosquitoes with detectable malaria parasites

Anopheles, infective: Female Anopheles mosquitoes with sporozoites in the salivary glands

Artemisinin-based combination therapy: A combination of an artemisinin derivative with a longer-acting antimalarial drug that has a different mode of action

Case, confirmed: Malaria case (or infection) in which the parasite has been detected in a diagnostic test, i.e. microscopy, a rapid diagnostic test or a molecular diagnostic test

Case, fever: The occurrence of fever (current or recent) in a person

Case, imported: Malaria case or infection in which the infection was acquired outside the area in which it is diagnosed

Case, index: A case of which the epidemiological characteristics trigger additional active case or infection detection. The term "index case" is also used to designate the case identified as the origin of infection of one or a number of introduced cases.

Case, indigenous: A case contracted locally with no evidence of importation and no direct link to transmission from an imported case

Case, induced: A case the origin of which can be traced to a blood transfusion or other form of parenteral inoculation of the parasite but not to transmission by a natural mosquito-borne inoculation

Case, introduced: A case contracted locally, with strong epidemiological evidence linking it directly to a known imported case (first-generation local transmission)

Case, locally acquired: A case acquired locally by mosquito-borne transmission

Case, malaria: Occurrence of malaria infection in a person in whom the presence of malaria parasites in the blood has been confirmed by a diagnostic test

Case, recrudescent: Malaria case attributed to the recurrence of asexual parasitemia after antimalarial treatment, due to incomplete clearance of asexual parasitemia of the same genotype(s) that caused the original illness. A recrudescent case must be distinguished from reinfection and relapse, in case of P. vivax and P. ovale.

Case, relapsing: Malaria case attributed to activation of hypnozoites of P. vivax or P. ovale acquired previously

Case, suspected malaria: Illness suspected by a health worker to be due to malaria, generally on the basis of the presence of fever with or without other symptoms

Case detection: One of the activities of surveillance operations, involving a search for malaria cases in a community

Case detection, active: Detection by health workers of malaria cases at community and household levels, sometimes in population groups that are considered at high risk. Active case detection can consist of screening for fever followed by parasitological examination of all febrile patients or as parasitological examination of the target population without prior screening for fever.

Case detection, passive: Detection of malaria cases among patients who, on their own initiative, visit health services for diagnosis and treatment, usually for a febrile illness

Case investigation: Collection of information to allow classification of a malaria case by origin of infection, i.e. imported, indigenous, induced, introduced, relapsing or recrudescent

Case management: Diagnosis, treatment, clinical care, counselling and follow-up of symptomatic malaria infections

Case notification: Compulsory reporting of all malaria cases by medical units and medical practitioners to either the health department or the malaria control programme, as prescribed by national laws or regulations

Certification of malaria-free status: Certification granted by WHO after it has been proved beyond reasonable doubt that local human malaria transmission by Anopheles mosquitoes has been interrupted in an entire country for at least 3 consecutive years and a national surveillance system and a programme for the prevention of reintroduction are in place

Chemoprevention, seasonal malaria: Intermittent administration of full treatment courses of an antimalarial medicine during the malaria season to prevent malarial illness. The objective is to maintain therapeutic concentrations of an antimalarial drug in the blood throughout the period of greatest risk for malaria.

Chemoprophylaxis: Administration of a medicine, at predefined intervals, to prevent either the development of an infection or progression of an infection to manifest disease

Combination therapy: A combination of two or more classes of antimalarial medicine with unrelated mechanisms of action

Cure: Elimination from an infected person of all malaria parasites that caused the infection

Cure, radical: Elimination of both blood-stage and latent liver infection in cases of P. vivax and P. ovale infection, thereby preventing relapses

Diagnosis: The process of establishing the cause of an illness (for example, a febrile episode), including both clinical assessment and diagnostic testing

Diagnosis, molecular: Use of nucleic acid amplification-based tests to detect the presence of malaria parasites

Diagnosis, parasitological: Diagnosis of malaria by detection of malaria parasites or Plasmodium-specific antigens or genes in the blood of an infected individual

Drug efficacy: Capacity of an antimalarial medicine to achieve the therapeutic objective when administered at a recommended dose, which is well tolerated and has minimal toxicity

Drug resistance: The ability of a parasite strain to survive and/or multiply despite the absorption of a medicine given in doses equal to or higher than those usually recommended

Endemic area: An area in which there is an ongoing, measurable incidence of malaria infection and mosquito-borne transmission over a succession of years

Endemicity, level of: Degree of malaria transmission in an area

Epidemic: Occurrence of a number of malaria cases highly in excess of that expected in a given place and time

Erythrocytic cycle: Portion of the life cycle of the malaria parasite from merozoite invasion of red blood cells to schizont rupture. The duration is approximately 24 h in P. knowlesi, 48 h in P. falciparum, P. ovale and P. vivax and 72 h in P. malariae.

Focus, malaria: A defined circumscribed area situated in a currently or formerly malarious area that contains the epidemiological and ecological factors necessary for malaria transmission

Geographical reconnaissance: Censuses and mapping to determine the distribution of the human population and other features relevant for malaria transmission in order to guide interventions

Gonotrophic cycle, mosquito: The period of reproductive development in the female mosquito, including host-seeking, blood feeding, digestion of a blood meal, ovarian development, search for a breeding site and oviposition.

Hibernation: Process in which mosquitoes at one or several stages (eggs, larvae, pupae, adults) survive by means of behavioural or physiological changes during cold periods

House: Any structure other than a tent or mobile shelter in which humans sleep

Household: The ecosystem, including people and animals occupying the same house and the accompanying vectors

Incidence, malaria: Number of newly diagnosed malaria cases during a defined period in a specified population

Indoor residual spraying: Operational procedure and strategy for malaria vector control involving spraying interior surfaces of dwellings with a residual insecticide to kill or repel endophilic mosquitoes

Infection, chronic: Long-term presence of parasitaemia that is not causing acute or obvious illness but could potentially be transmitted

Infection, mixed: Malaria infection with more than one species of Plasmodium

Infection, reservoir of: Any person or animal in which plasmodia live and multiply, such that they can be transmitted to a susceptible host

Infection, submicroscopic: Low-density blood-stage malaria infections that are not detected by conventional microscopy

Infectious: Capable of transmitting infection, a term commonly applied to human hosts

Insecticide: Chemical product (natural or synthetic) that kills insects. Ovicides kill eggs; larvicides (larvacides) kill larvae; pupacides kill pupae; adulticides kill adult mosquitoes. Residual insecticides remain active for an extended period

Insecticide resistance: Property of mosquitoes to survive exposure to a standard dose of insecticide; may be the result of physiological or behavioural adaptation

Integrated vector management: Rational decision-making for optimal use of resources for vector control

Intermittent preventive treatment in infants: A full therapeutic course of sulfadoxine-pyrimethamine delivered to infants in co-administration with DTP2/Penta2, DTP3/Penta3 and measles immunization, regardless of whether the infant is infected with malaria

Intermittent preventive treatment in pregnancy: A full therapeutic course of antimalarial medicine given to pregnant women at routine prenatal visits, regardless of whether the woman is infected with malaria

Long-lasting insecticidal net (LLIN): A factory-treated mosquito net made of material into which insecticide is incorporated or bound around the fibres. The net must retain its effective biological activity for at least 20 WHO standard washes under laboratory conditions and 3 years of recommended use under field conditions.

Malaria case: An occurrence or instance of infection disease. The word is so vague that the type of case should always be specified, as, for instance, a malaria case or a fever case.

Malaria control: Reduction of disease incidence, prevalence, morbidity or mortality to a locally acceptable level as a result of deliberate efforts. Continued interventions are required to sustain control.

Malaria elimination: Interruption of local transmission (reduction to zero incidence of indigenous cases) of a specified malaria parasite in a defined geographical area as a result of deliberate activities. Continued measures to prevent re-establishment of transmission are required.

Malaria eradication: Permanent reduction to zero of the worldwide incidence of infection caused by human malaria parasites as a result of deliberate activities. Interventions are no longer required once eradication has been achieved

Malaria mortality rate: Number of deaths from malaria per unit of population during a defined period

Malaria receptivity: Degree to which an ecosystem in a given area at a given time allows for the transmission of Plasmodium spp. from a human through a vector mosquito to another human.

Malaria reintroduction: Malaria reintroduction is the occurrence of introduced cases (cases of the first-generation local transmission that are epidemiologically linked to a confirmed imported case) in a country or area where the disease had previously been eliminated

Malaria stratification: Classification of geographical areas or localities according to epidemiological, ecological, social and economic determinants for the purpose of guiding malaria interventions

Malaria-free: Describes an area in which there is no continuing local mosquito-borne malaria transmission and the risk for acquiring malaria is limited to infection from introduced cases

Malarious area: Area in which transmission of malaria is occurring or has occurred during the preceding 3 years

Mass drug administration: Administration of antimalarial treatment to all age groups of a defined population or every person living in a defined geographical area (except those for whom the medicine is contraindicated) at approximately the same time and often at repeated intervals

Mass screening: Population-wide assessment of risk factors for malaria infection to identify subgroups for further intervention, such as diagnostic testing, treatment or preventive services

Mass screening, testing and treatment: Screening of an entire population for risk factors, testing individuals at risk and treating those with a positive test result

Mass testing and focal drug administration: Testing a population and treating groups of individuals or entire households in which one or more infections is detected

Mass testing and treatment: Testing an entire population and treating individuals with a positive test result

Net, insecticide- treated: Mosquito net that repels, disables or kills mosquitoes that come into contact with the insecticide on the netting material. Insecticide treated nets (ITNs) include those that require treatment and retreatment (often referred to as conventional nets) and those are “long-lasting” (see definition of long-lasting insecticidal net).

Plasmodium: Genus of protozoan blood parasites of vertebrates that includes the causal agents of malaria. P. falciparum, P. malariae, P. ovale and P. vivax cause malaria in humans. Human infection with the monkey malaria parasite P. knowlesi and very occasionally with other simian malaria species may occur in tropical forest areas.

Population at risk: Population living in a geographical area where locally acquired malaria cases have occurred in the past 3 years

Population, target: An implementation unit targeted for activities or services (e.g.prevention, treatment)

Rapid diagnostic test (RDT): Immunochromatographic lateral flow device for rapid detection of malaria parasite antigens

Rapid diagnostic test, combination: Malaria rapid diagnostic test that can detect a number of different malaria species

Rapid diagnostic test positivity rate: Proportion of positive results among all rapid diagnostic tests performed

Reactive focal screening, testing, treating or drug administration: Screening, testing, treating or administering drugs to a subset of a population in a given area in response to the detection of an infected person

Receptivity: Receptivity of an ecosystem to transmission of malaria

Severe falciparum malaria: Acute falciparum malaria with signs of severe illness and/or evidence of vital organ dysfunction

Surveillance: Continuous, systematic collection, analysis and interpretation of disease-specific data and use in planning, implementing and evaluating public health practice

Testing, malaria: Use of a malaria diagnostic test to determine whether an individual has malaria infection

Transmission season: Period of the year during which most mosquito-borne transmission of malaria infection occurs

Transmission-reestablishment of: Renewed presence of a measurable incidence of locally acquired malaria infection due to repeated cycles of mosquito-borne infections in an area in which transmission had been interrupted

Transmission, interruption of: Cessation of mosquito-borne transmission of malaria in a geographical area as a result of the application of antimalarial measures

Transmission, residual: Persistence of malaria transmission following the implementation in time and space of a widely effective malaria programme

Transmission, seasonal: Transmission that occurs only during some months of the year and is markedly reduced during other months

Transmission, stable: Epidemiological type of malaria transmission characterized by a steady prevalence pattern, with little variation from one year to another except as the result of rapid scaling up of malaria interventions or exceptional environmental changes that affect transmission

Transmission, unstable: Epidemiological type of malaria transmission characterized by large variation in incidence patterns from one year to another

Treatment, directly observed: Treatment administered under the direct observation of a health care worker

Uncomplicated malaria: Symptomatic malaria parasitaemia without signs of severity or evidence of vital organ dysfunction

Vector: In malaria, adult females of any mosquito species in which Plasmodium undergoes its sexual cycle (whereby the mosquito is the definitive host of the parasite) to the infective sporozoite stage (completion of extrinsic development), ready for transmission when a vertebrate host is bitten

Vector control: Measures of any kind against malaria-transmitting mosquitoes, intended to limit their ability to transmit the disease