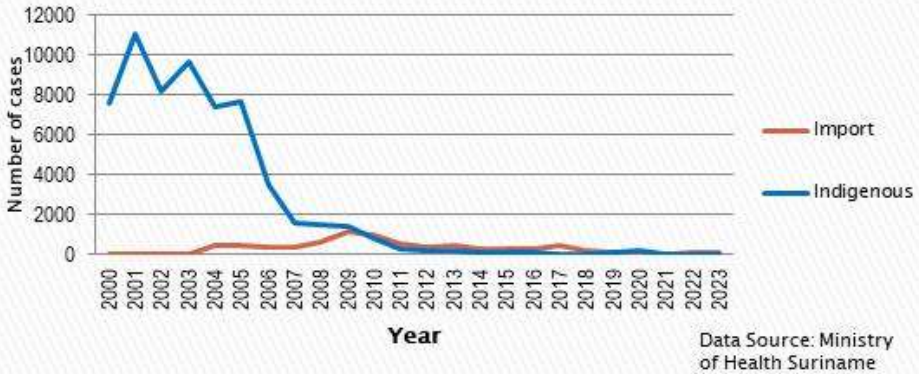
National Strategic Plan for Malaria Elimination Suriname 2023-2027

Eliminating Malaria through the avoidance of its re-establishment

Ministry of Health Suriname

Number of malaria cases by classification 2000-2023



Data Source: Ministry of Health Suriname

Ministerie van Volksgezondheid

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1 Introduction

1.1 Rationale

The current document aims to extend Suriname's National Malaria Strategic Plan for the Elimination of Malaria (NMSPEM) from 2023 to 2027. Despite the current low number of cases, maintaining Suriname free of malaria is not simple or easy. The Malaria Program has designed the new "National Strategic Plan for Malaria Elimination to carry on the successful impact on the incidence of malaria in the country.

Suriname has a history of success with malaria control. This NMSPEM reasserts the need to maintain free access to malaria services, irrespective of race, ethnicity, sex, and legal status. It also emphasizes regional aspects of malaria in Suriname and the need to reach regional elimination through the avoidance of re-establishment. The core strategy of the plan is to sustain the efforts that have successfully avoided the re-introduction of malaria. It adds new tactics to speed up the elimination of *P. vivax* and a renewed, increased effort to work towards the improvement of the proper delivery of malaria services in the other Guyana Shield countries.

Malaria was eliminated in the coastal area with quinine treatment and spraying with DDT in the nineteen sixties. And in the last decade, with a focus on prompt diagnosis and treatment, malaria has been quasi-eliminated in the interior. Suriname has had no indigenous cases of *P. falciparum* malaria since 2019.

In addition, Suriname took advantage of a network of Primary Care Clinics in all the areas occupied by stable local communities, both Indigenous and Maroons. They support the general public health preventive activities and provide early diagnosis and treatment for malaria. Other countries in the region do not have a similar comprehensive structure, nor are they provide malaria services to all in remote areas. This epidemiological conjuncture generates the actual pattern of malaria in Suriname. There is a constant arrival of imported cases coming mainly from French Guiana

It was not an easy task. Suriname's interior is vast and sparsely populated. Access to the interior is difficult and expensive. Malaria in the country has been part of the regional epidemiological conjuncture of the Guyana Shield; the northern part of the Amazon Region; covering Colombia, Venezuela, Guyana, Suriname, French Guyana, and Brazil. The countries of the Guyana Shield are responsible for more than 80% of Malaria in the Americas. Malaria in the Shield is strongly related to mining, logging, and illegal activities such as smuggling and drug trafficking. This always focused in the remote forested areas of the interior. The population density is low, but mobility is high, especially amongst the miners. The mining communities in Suriname are multiethnic. Besides the multiethnicity, there is also an international presence in these areas, a predominance of Brazilians followed by Guyanese, French, Venezuelans, Cubans, Chinese, Colombian, and Caribbean. The problem is compounded by the difficulties if providing health services in these areas. They have little or no access to health services, sometimes not even access to simple malaria diagnosis and control.

There are two different types of external influence in the epidemiology of malaria in Suriname.

The first one is local and contiguous, along the eastern border with French Guiana, along the Marowijne river. Both sides of the border sustain mining areas, and the miners move from one side to the other to take advantage of the peculiarities of each side of the border. In Suriname, they are legally mining, and on the French side, they are illegal, but the amounts of gold seem superior.

The southern border with Brazil and the western border with Guyana were never areas of importance regarding malaria risk. Currently, there is no malaria along these orders.

The second one is regional, long distance. It is the result of long-distance migration from Brazilian mining districts, Venezuelan mining districts, and mining districts in the western border of Guyana, along Venezuela. It is also important to consider the miners from areas within the center and eastern part of French Guiana that travel to Surinamese mining sites.

The current achievements of Suriname in controlling malaria in the interior were based on a combination of tactics to support the strategy to deliver early treatment and diagnosis free of charge to all. It was accompanied by continuous surveillance and rapid reaction to new indigenous cases to avoid re-establishment. Malaria in Suriname is predominantly imported due to a seesaw movement of small-scale gold miners back and forth between Brazil, French Guyana, Guyana, Venezuela, and Suriname. In summary, the main difficulty for the final elimination of malaria in Suriname is its vulnerability, and the continuous arrival of imported cases, in areas of the interior that are highly receptive due to the presence of *A. darlingi*, the most efficient malaria vector in the Americas.

The relatively high rate of arrival of individuals with malaria (high vulnerability) into Surinamese territory has the potential to reintroduce malaria both in the villages and mining sites with high receptivity and vulnerability. It justifies the maintenance of the current system of early case detection and prompt treatment spread across the country, both in the villages, in the mining areas, and in the places on the coast where the miners supply themselves to avoid re-introduction and for early containment of outbreaks. Any re-introduction can potentially lead to the re-establishment of malaria. Introducing a single case in Suriname can have the following possible outcomes: Early treatment leading to containment or delays in diagnosis and treatment leading to re-establishment. In addition, *P. vivax* cases can lead to relapses, which can again leas to re-establishment of malaria if not treated in a timely manner.

In the last five years, there were no cases of *P. falciparum malaria* but there have been cases of re-establishment of *P. vivax* in Indigenous villages. The lack of a simple high-impact strategy to contain *P. vivax* outbreaks has led to exploring new approaches. The target established by the Surinamese Government to achieve and maintain the elimination of malaria in the country in 2025 requires a thorough understanding of the epidemiology of malaria in the country; and, if possible, in the region and dedicated investment in effective critical interventions supported by new tactics to manage *P. vivax*. The

regional aspects that explain the persistence of malaria in Suriname require a political and geographical perspective of pursuing the aim of elimination on a regional level.

In the annexes, a selection of publications about the peculiar epidemiology of malaria in Suriname and its dependency on the regional malaria epidemiological conjuncture in the Guyana Shield is listed in detail by topic. It offers insight into the problem and can be used to increase the knowledge about the epidemiology of malaria in Suriname and its current determinants.

1.2 Malaria Worldwide

Malaria is preventable and treatable. It is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes. Increased malaria prevention and control measures with new diagnostic tests and treatment combinations dramatically reduce the malaria burden in many places. In December 2022, the World Health Organization (WHO,2022) estimated that in 2021, 247 million malaria cases occurred worldwide, an increase from 227 million in 2019 compared with 251 million cases in 2010 and 228 million cases in 2018.

Most malaria cases in 2022 were in the African Region, 95%.
Malaria case incidence (i.e., cases per 1000 population at risk) was reduced from 81 in 2000 to 59 in 2015 and 56 in 2019 before increasing again to 59 in 2020 and 2021. The increase in 2020 was associated with service disruption during the COVID-19 pandemic. Malaria, in all its scales, tends to be concentrated in some areas. Twenty-nine countries accounted for 96% of malaria cases globally, and four countries – Nigeria (27%), the Democratic Republic of the Congo (12%), and Mozambique (4%) accounted for almost half of all cases globally.

In 2020, there were an estimated 627 000 deaths from malaria globally, compared with 558 000 estimated deaths in 2019. Africa concentrated 96% of the deaths. Between 2015 and 2020, mortality reduction was 0% in Africa, with a slight decrease in 2021. Children aged under five years are the most vulnerable group affected by malaria. Nige-

ria accounts for 31% of adult mortality and 38% under-fives mortality. The percentage of malaria deaths under five decreased by only 10% between 2000 and 2020. In 2020, they accounted for 77%.

Plasmodium falciparum is the most prevalent malaria parasite in the African Region, accounting for almost all of the estimated malaria cases in South-East Asia. *P. vivax* is the predominant parasite in the Region of the Americas.

1.3 Malaria in the Americas

Malaria transmission in the Americas has always been lower than in sub-Saharan Africa, with the highest incidence. Immunity to malaria in these low-malaria endemic areas of the Americas is usually not acquired during childhood. All age groups can be at risk of disease. Still, frequently, malaria is an occupational disease related to activities in forested, remote areas, such as small-scale mining, logging, and slash-and-burn expansion of the agricultural frontier. It is also influenced by illegal activities such as smuggling across borders, drug plantations, land grabbing, illegal occupation of national parks, or armed conflict. In the past, Malaria was prevalent in most of the Americas. It was limited mainly by climate, in the extremes of latitudes and altitude, or lack of rainfall. Large control programs locally eliminated malaria in the first half of the twentieth century. Malaria was then mainly restricted to tropical areas and areas with a severe deficiency of health services. Malaria resurged in the seventies and eighties with the boom of land occupation of the Amazon region and the sequential resistance to first-line treatments against

P. falciparum, and also the resistance to DDT. Currently, in the Americas, malaria is a disease occurring mainly in neglected, poor populations with little or no health care services. The global malaria landscape has changed significantly since the beginning of the 21st century. The combined use of Artemisinin combination therapies (ACTs) and Rapid Tests for malaria diagnosis (RDTs) was adopted by most countries with an increasing impact on the mortality and incidence of malaria caused by P. falciparum.

In the Americas, malaria cases were reduced by 60% (from 1.5 million to 0.60 million) and case incidence by 70% (from 14 to 4) between 2000 and 2021. The region's progress in recent years has suffered from the significant increase in malaria in the Bolivarian Republic of Venezuela, which had about 35 500 cases in 2000 and more than 467 000 cases by 2019. In 2020, cases reduced by more than half compared with 2019, to 232 000, owing to restrictions on movement during the COVID-19 pandemic and a shortage of fuel that affected the mining industry, which is the main contributor to the recent increase in malaria in the country. These restrictions may also have affected access to care, reducing cases reported from health facilities. Countries that experienced substantial increases in the region in 2020 compared with 2019 were Haiti, Honduras, Nicaragua, Panama, and the Plurinational State of Bolivia. Over the same period, malaria deaths and the mortality rate reduced by 64% (from 919 to 334) and 73%. The Bolivarian Republic of Venezuela, Brazil, and Colombia accounted for 79% of all cases in this region. Most of the cases in this region are due to *P. vivax* (71.5% in 2021).

First-line treatment for *P. falciparum* in the Americas includes artesunate-lumefantrine, artesunate plus mefloquine (ASMQ), and chloroquine (CQ). Test of ACTs conducted between 2015 and 2020 in Brazil and Colombia demonstrated high efficacy. There has been no increase in the prevalence of the C580Y mutation described in Guyana.

1.4 Regional Context

Suriname is a Latin American country, situated in the Guyana Shield, bordering Guyana in the west, French Guiana (territory of France) in the east and Brazil in the south. Until the last two decades of the 20th century, Suriname was considered the area with the highest malaria transmission rates in the Americas. (Rosendaal,1990).

Malaria in Suriname can only be understood in the regional context of the Guyana shield. The countries of the Guyana Shield, Colombia, Venezuela, Brazil, Guyana, and French Guyana are responsible for more than 80% of Malaria in the Americas. Brazil has the

most considerable number of cases, followed by Venezuela and Colombia, with Guyana in fourth place.

Currently, there are two types of regional influence in the epidemiology of malaria in Suriname, one immediate, contiguous, the influx of gold miners from French Guiana along the eastern border, and the other indirect, the arrival of long-distance travelers coming from areas with high malaria incidence in Brazil, Venezuela and the eastern part of Guyana.

Until around 2004, Malaria was a significant public health problem outside the coastal fringe, with high morbidity and mortality. In the past, the villages of Indigenouss and Maroons living in the forested interior had a high incidence f malaria. Incidence was also high in the gold mining camps carried out by Brazilians. Malaria incidence was equally high in French Guyana, especially in the French villages along the Marowijne river, the border with Suriname, and the French illegal mining sites. Since 2004, with an increase in internal and external financial support; particularly from the Global Fund; Suriname has created a high-impact program based on improving the delivery of diagnosis, treatment, and prevention with LLINs.

There were no barriers to access to services, and they were free to all, even to undocumented migrants working in the mines. The program was implemented trough an existing network of primary health care clinics and workers of the Medische Zending (Medical Mission , MZ), [1] ; in the villages of the interior and by the newly created network of malaria service deliverers (MSDs) of the Ministry of Health Malaria Program in the mining areas. The impact was rapid and consistent, both in the villages and in the Surinamese mining areas. The effect was also felt across the border within French Guyana. The villages in the border areas, both sides of the border, benefited from the introduc-

[1] (www.medischezending.sr/program/malaria/)

tion of artemisinin combination therapy (ACT) and the distribution of LLINs. The decline in cases was swift and maintained.

Since 2009 the number of indigenous cases has declined to the point that currently, most of the cases are being imported from the French Department of la Guyane. The French department has been under the pressure of continuously fluctuating migration of thousands of Brazilian small-scale gold miners. They are known in South America as “garimpeiros.

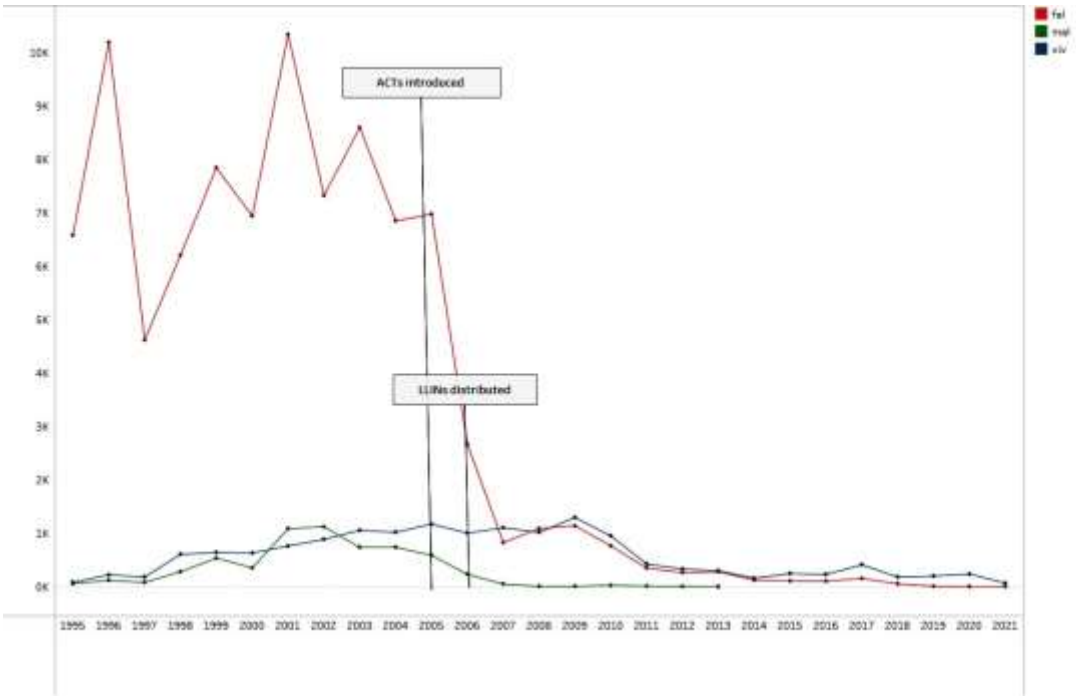


Figure 1: • Impact of ACTs and LLINs in malaria cases, Suriname 1995-2020, falciparum in red, vivax in blue, and malarie in green.

They are experts in small-scale mining in the most difficult conditions peculiar to the Amazon. Most of the Brazilian miners on the French side work illegally. Some of the mining sites are inside protected areas of the Parc Amazonien de Guyane

(2020), France's largest national park, covers around 40% of the French Guiana territory. There are no malaria services in French illegal mining areas for different legal reasons.

Due to their illegal status, miners are under constant vigilance from the French legal authorities. There are regular joint operations of the French police and Army, aiming to destroy the logistical chain and the miners' supplies. Due to the large number of miners and the difficulties of access in the remote mining sites, most miners escape or are free to go. Some Brazilian miners move back to Brazil, but a substantial number move to the nearest place across the border with Suriname. They stay at the edge or sometimes in the capital, Paramaribo, until the police and military operations are finished and then return to re-initiate another mining cycle. This pattern of constant movement between the two countries explains the importance of imported malaria in the current epidemiological situation in Suriname. In addition to the cases imported from French Guyana, lately, some cases have come from Venezuela and Guyana. These two countries are suffering a sharp regional increase in cases similarly related to gold mining in forested areas with low or no access to malaria services. Currently, the main difficulty for the final elimination of malaria in Suriname is the continuous inflow of imported cases.

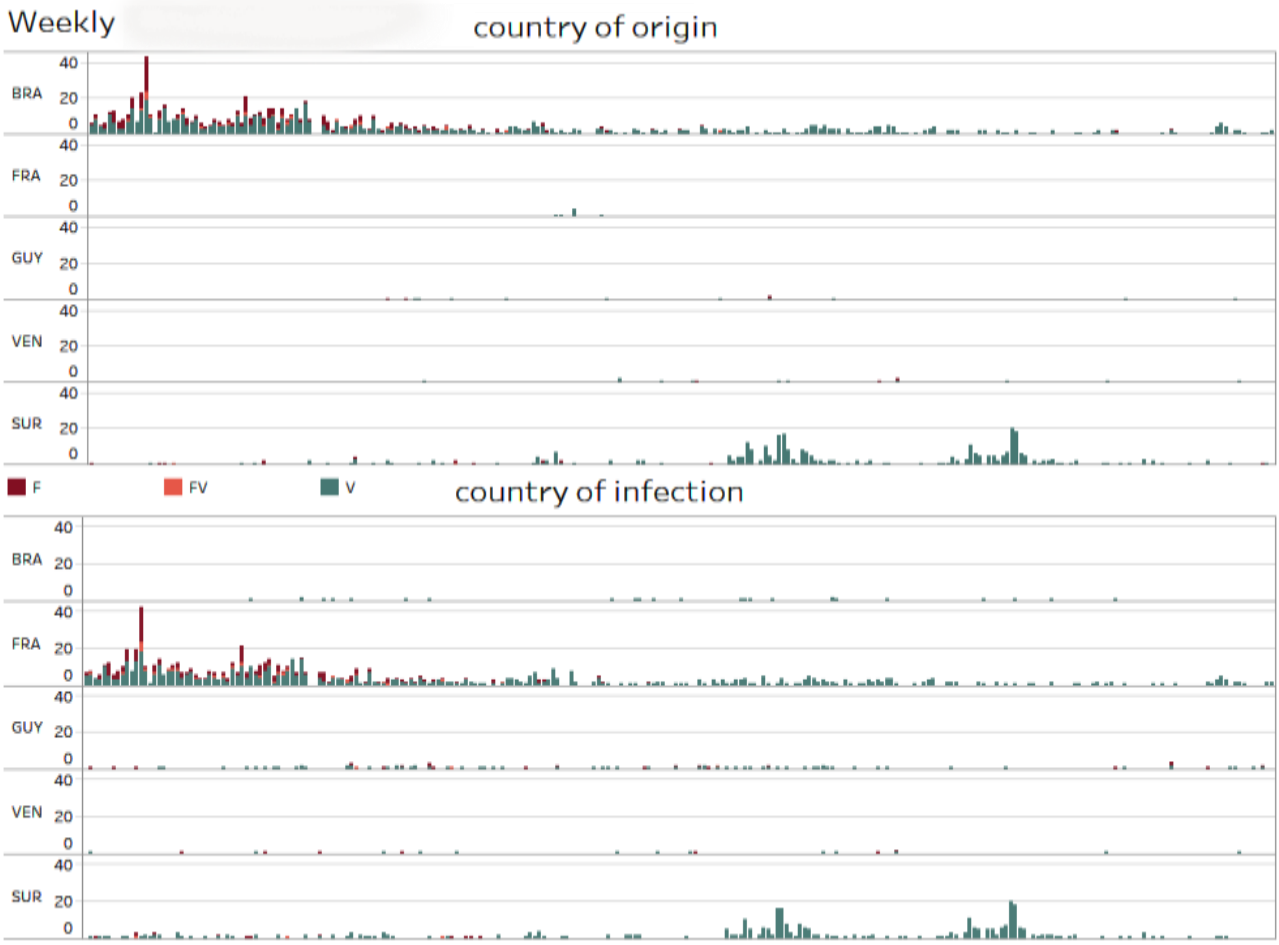


Figure 2: Number of malaria cases by country of origin and country infection from 2017 to 2020, falciparum in red, vivax in blue, mixed pink.

In summary, Suriname has to deal with a constant influx of cases of malaria imported from French territory, mostly Brazilian, working in gold mining areas in French Guiana and, more recently, with

Guianese and Venezuelan miners who are coming through the western border. The importation of these cases into Surinamese territory could reintroduce malaria in the villages and Surinamese mining sites. It necessitates the maintenance of a system of early case detection and prompt treatment spread across the country, both in the villages, the mining areas, and the places on the coast where the miners supply themselves to avoid re-introduction and contain possible outbreaks. The gold miners self-medicate using ACTs bought illegally over the counter in areas of difficult access. There is a high risk of the development of drug resistance in *P. falciparum* parasites.. The World Health Organ-

ization (WHO) has categorized countries regarding artemisinin resistance, based on pfk13 mutant prevalence and the clinical response to artemisinin derivatives (World Health Organization, 2017). The threshold of 5% of pfk13 mutants has been met in Guyana, first in 2010 (Chenet et al., 2016), then in 2016–2017 (Mathieu, 2020). The public health significance of the presence of these mutations on the therapeutic efficacy of artemisinin-based combination therapies in Guyana is unknown. The risk of emerging resistance could defeat *P. falciparum* elimination strategies in this region.

The problem of self-medication in areas without access to diagnosis and treatment is being addressed tentatively in a joint project with the French and Brazilian health authorities. It is related to using a kit, Malakit, for self-diagnosis and treatment in places with no access to health services. (www.malakit-project.org).

Recent re-introduction of *P. vivax* in some Indigenous villages, the lack of a high-impact strategy to contain *P. vivax* outbreaks, extended by the seemly high relapse rate of *vivax* (Lacerda, 2019 and Llanos Cuenta, 2019), leads to the search of new approaches. The target established by the Surinamese Government to achieve and maintain the elimination of malaria in the country by 2025 requires a thorough understanding of the epidemiology of malaria in the country and dedicated investment in key effective interventions supported by novel tactics to manage *P. vivax*. Finally, the regional aspects that explain the persistence of malaria in Suriname require a political and geographical perspective of pursuing the aim of elimination on a regional level.

1.4.1 Analysis of the Effort of Diagnosis in the Guyana Shield Countries

Diagnosis and treatment are crucial aspects for the elimination of Malaria in the Guyana Shield that is responsible for more than 80% of the Malaria in the Americas. Control of malaria starts with the provision of early diagnosis. Without a diagnosis, no data, information, or proper treatment exists. Countries and provinces with a high number of cases border Suriname. In addition, most of its cases come from French Guyana, an area with

limited data. Data from the World Malaria Report 2021 table H is used in this section to analyze the offer of services.

The tables below show the trends of the effort to diagnose malaria and the positivity of the two main methods used, RDTs and microscopy, in the countries of the Guyana Shield. WHO guidelines state that RDTs are as adequate as Microscopy for diagnosing malaria. Despite this and the regional priority; promoted by PAHO, the use of RDTs in the Americas region is still low. The remoteness of many malaria sites and the lack of capillarity of the health services presupposes the need to use RDTs by a trained local individual. In the forested areas of the Guyana Shield, RDTs are the most efficient way to deliver a diagnosis in the areas with malaria transmission. Suriname is the only country making the widespread use of RDTs for diagnosis as part of its core strategy.

RDTs in relation to microscopy

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil		9.0%	155.7%	111.7%	86.3%	95.8%	154.3%	263.5%	368.7%	435.4%	505.6%
Colombia	0.0%	0.9%	3.0%	2.3%	4.5%	0.8%	4.0%	0.6%	0.8%	0.8%	0.8%
Venezuela	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	34.5%
Guyana	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.8%	1.7%	4.1%
French Guiana	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Suriname	9.5%	7.1%	34.2%	27.1%	105.7%	118.2%	90.1%				225.1%

Figure 3: Percent of RDTS to Microscopy.

The positivity rate of microscopy and RDTs (see tables below) are low in Suriname due to the current intensity of the surveillance of suspected cases. In the other countries of the region, the rates are much higher. Higher positivity rates usually imply a delay in diagnosis or insufficient access. In addition, the different surveillance systems seem not to cover the whole of their territories due to the low capillarity of the health services. French Guiana is a case apart. Most of the current cases come from the southern part of French Guyana. The French surveillance system is very limited in this area and does not cover high risk gold mining communities. The authorities consider the mining activities illegal in that region. To provide any support would be a promotion of such activities. Notwithstanding, it is the area of origin of most cases currently being diagnosed in Suriname.

RDTs % positivity

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil		29.1%	20.3%	19.1%	11.7%	19.7%	21.6%	24.2%	27.3%	20.6%	25.7%
Colombia		19.8%	13.2%	17.3%	5.9%	29.5%	10.6%	52.4%	25.7%	31.0%	36.6%
Venezuela											100.0%
Guyana		100.0%					26.2%	119.2%	66.6%	27.5%	37.0%
French Guiana											
Suriname	13.9%	2.0%	5.3%	3.3%	2.0%	0.2%	0.1%	1.6%	0.2%	0.1%	0.0%

Figure 4: Percent of RDTS positive per country and year.

% positivity of microscopy

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Brazil	12.34%	10.77%	10.23%	9.29%	8.18%	8.89%	9.26%	11.16%	10.37%	9.54%	10.95%
Colombia	22.56%	15.15%	14.70%	15.58%	11.10%	15.19%	23.67%	15.67%	21.92%	16.86%	19.81%
Venezuela	11.27%	11.99%	12.86%	16.85%	17.59%	22.07%	35.36%	45.94%	57.92%	38.27%	30.11%
Guyana	10.77%	14.61%	16.07%	15.29%	8.65%	7.51%	9.83%	13.72%	16.26%	16.14%	18.05%
French Guiana	7.55%	4.99%	3.83%	1.44%	1.65%	2.57%	1.83%				1.92%
Suriname	9.52%	4.96%	1.75%	3.87%	0.56%	2.29%	2.11%	3.29%	1.85%	1.53%	1.72%

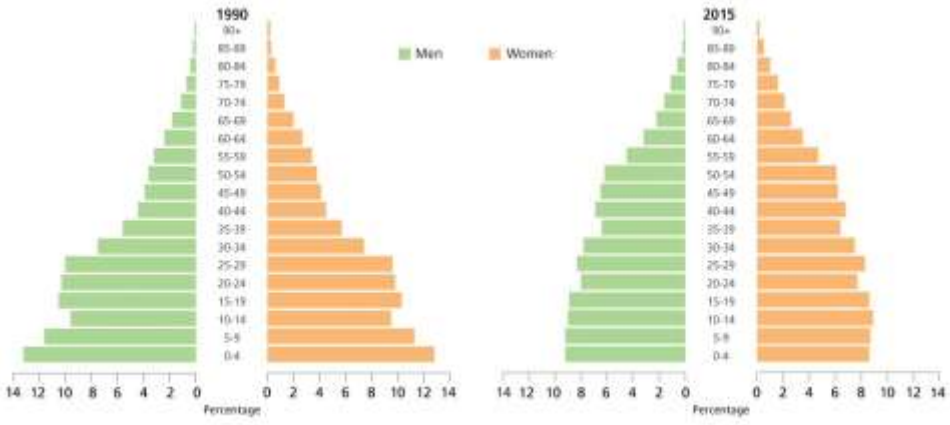
Figure 5: Percent of microscopic slides positive per country and year.

2 Background Information on Suriname

2.1 Geography and Demography

The Republic of Suriname is on South America's northeast coast. Guyana borders it to the west, French Guiana (territory of France) to the east, and Brazil to the south. Most of the population lives in the narrow coastal plain to the country's north. Approximately 90% of Suriname's total land area is classified as forest. The country's economy relies on the exploitation of mineral resources and there is a potential for new income derived from offshore oil in the next few years.

Suriname gained its independence from the Netherlands in 1975. It is a constitutional democracy based on the 1987 Constitution. The Head of State is the President, who the National Assembly elects. The urban districts occupy only 0.5% of the country's territory and are inhabited by 70% of the population. Demographics According to the most recent census in 2012, the total population was 541,638, with a male to female ratio of almost



1:1. Relative growth of the population since 2004 was 9.9%, the result of an average annual growth of 1.1%.

Figure 6: Suriname population pyramid last census

2.2 The Health System

The first level of care in Suriname's health system comprises two networks of government-subsidized primary health care facilities. The Regional Health Services (RGD) receives public funds to operate 43 primary health clinics in the coastal area. In addition, some 150 private primary care clinics are accessible to the population in the coastal area. In the interior, Medical Mission (MZ), a faith-based organization, receives government funding to manage currently about 52 primary health clinics in Maroon and Indigenous villages. Six more clinics in the country's West, the border with Guyana, that are now under the administration of Mungra Medical Centre in Nieuw-Nickerie expected to be re-assigned to MZ. MZ has extensive experience working with the traditional systems of the different ethnic groups of the interior. Is model could be used in neighboring countries that do not have similar systems.

Figure 7: Primary health clinics of MZ in Suriname

There is also a network of primary care physicians that work within a defined area and are paid via the insurance system or privately. In Suriname, there are eight hospitals, four of which are in the capital, Paramaribo, one on the eastern border, in the Marowijne

district, close to Albina, one in the district of Nickerie at the western border, and one in the Wanica district.

In the city and the main entry points in the borders, there are small clinics run by the malaria program to deliver malaria services. In addition to the miner's neighborhood in Paramaribo, the Trop Clinic offers expanded services. It does include not only diagnosis, treatment, and linkage to care but also prevention through awareness and education on malaria, HIV, leprosy, COVID 19 and leishmaniosis.

In Suriname, the Bureau of Public Health (BOG) is responsible for public health programs, including environmental health, sanitation, and the public health laboratory. Access to specialized and emergency care for those living in the interior remains challenging due to the difficulties and high transportation costs, either by air, road, or boat to a hospital in the coastal area or the capital. Access to secondary care occurs through referrals by primary care physicians. There is a simple form of Health Insurance designed to cover the poorest sector of the population and a network of private doctors working as General Practitioners. A recent new threat to the health system has been the emigration of health professionals to other countries.

2.2.1 Summary of the structure of Malaria control in Suriname

. In the cartogram below, a summary of the geographical distribution of the strata and malaria delivery services

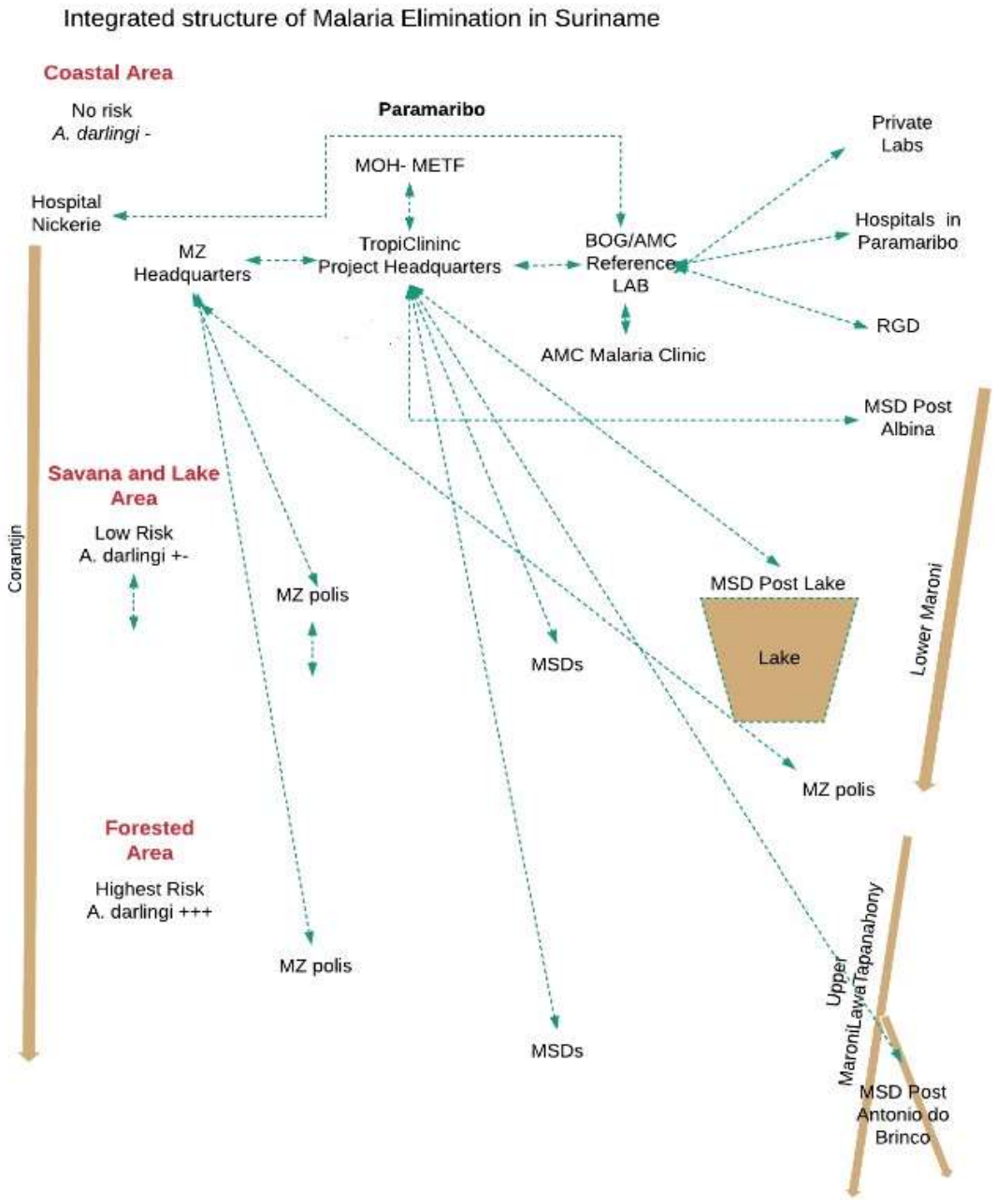


Figure 2 Structure of the Program in Suriname.

3.Historical Aspects of Malaria in Suriname

Malaria in Suriname is related to regional epidemiology. The history of malaria control in Suriname shows a similar process to that of other countries of the Amazon region, with two phases of successful interventions separated by a gap. During the interval, the resistance of *P. falciparum* to several drugs, Chloroquine, Quinine, Sulfa-Pirimetamine combination, and Mefloquine, spread across the region.

The first phase, in Suriname, was the elimination of malaria in the coastal area in the nineteen-fifties and sixties, using household spraying with DDT and treatment with quinine. The Bureau of Public Health (BOG) carried out the program.

The second phase of control was preceded by a regional and local increase in *P. falciparum* due to drug resistance and the occupation of the Brazilian Amazon by migrants and in Suriname by the post-independence conflicts destabilizing the country. It started in 2005 and was the result of the collective impact of the financial support of the Global Fund to fight AIDS, Tuberculosis and Malaria (The Global Fund) that has supported the sequential projects of the Country Coordination Mechanism (CCM) and the technical support of the AMI/RAVREDA project in Suriname. They led to improvements in access to rapid diagnosis and prompt treatment. The diagnosis was expanded with both slides in areas of the settled population and RDTs in the more remote areas for the mobile groups. In parallel, using ACTs plus PQ for the treatment led to a rapid decrease in malaria incidence by P. falciparum. The decline of *P. vivax* was slower and consistent, and the few cases *of P. malariae* disappeared. (Breeveld, 2012 and Hiwat et al, 2018). LLINS were distributed to the whole population of the interior. Also, besides the strong support from the Global Fund, Suriname benefited from a grant from the Inter-American Development Bank and bilateral initiatives in infectious diseases, including malaria, with Brazil and France.

Domestically the government of Suriname has committed to a loan covering the period 2020-2024 with the IDB for the Health Sector. It includes a substantial commitment to

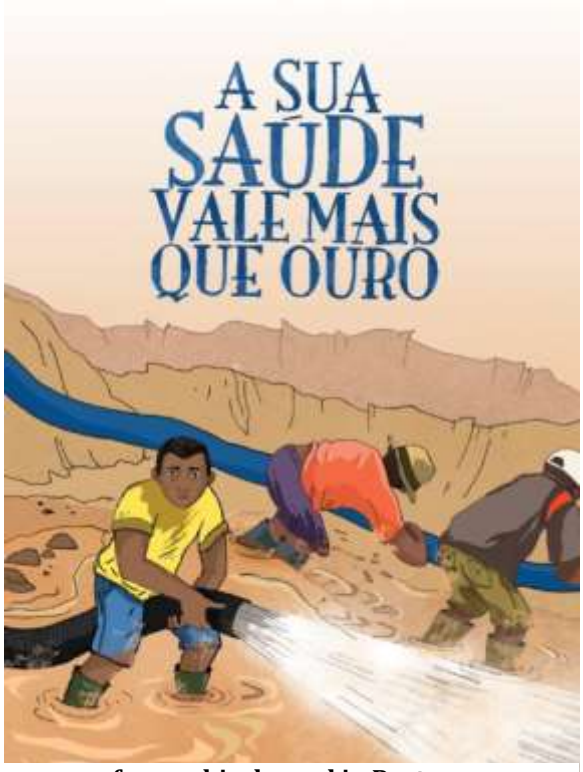
malaria control. It also covers the introduction of the District Health Information System (DHIS2). The AMI/RAVREDA Project, coordinated by PAHO and USAID and funded by USAID, was an important building block for the success of the control of malaria in Suriname. It provided a forum for exchanging experiences, for the standardization of research protocols, for the testing of new strategies, and for the training of staff of malaria control and scientists. Starting with RAVREDA, Suriname has benefited from PAHO technical assistance through the presence of a Malaria Technical Officer in its Surinamese representation since 2004.

Crucial for the process of improving malaria control was the coordination by the National Malaria Board. The Board was established by the Ministry of Health and composed of members of the different ministries, academy, Malaria service providers, national malaria experts, international organizations, non-governmental agencies, and affected populations. The board coordinated all aspects of the implementation of the control of malaria in the country. The result was a more than 95 % reduction in the number of malaria cases in four years. (Hiwat, 2018). The Malaria Board has evolved into the Malaria Elimination Task Force to provide focus on the elimination effort. More information about the malaria program in Suriname can be accessed on the home page of the program (www.malariasuriname.com)

The interior of Suriname has traditionally been inhabited by many ethnic groups, 6 Maroon groups, and a larger number of Indigenous groups (Carlin, 2002). Elimination in the villages was rapid. Plasmodium falciparum was the main parasite due to the Maroons, African genetic background. Treatment with ACT had an almost immediate impact. It is important to emphasize that in this near elimination of malaria in the residential communities, the existence of MZ, a decentralized system of community polyclinics covering all the areas with villages in the interior, was crucial. Medical Mission, MZ, a government-subsidized NGO, delivers primary health care through a network of polyclinics staffed by well-trained health assistants in the use of specific protocols for different types of syndromes (Aldighieri, 2000)

In Suriname, there are no fewer than twenty languages spoken. Most Surinamese are multilingual. In terms of the number of speakers, the main languages in Suriname, successively the Dutch language, Sranan Tongo (Surinamese Creole), English, Sarnami (Surinamese Hindustani), Javanese, and different Maroon languages (especially Saramaccan and Ndyuka). Language is a critical issue for the staff that works with the interior populations and the Brazilian miners, most of whom speak only Portuguese. The staff of the clinics is fluent in the different local languages. The preexistence of this network of primary health care clinics of MZ allowed the rapid implementation and impact of the new malaria services in the villages of the interior (van Eer, 2018). Communication material is also always produced in several languages.

Below is an example of the cover graphic novel produced by the malaria program about the health risks associated with mining, malaria, leishmaniasis, and mercury poisoning, called: *Your health values more than gold.*



Poster cover of a graphical novel in Portuguese

The work towards eliminating malaria was always done in concertation with the local native authorities. Women's associations also have been involved, especially in the implementation of LLINs.

4 Stratification of Malaria in Suriname

Stratification is used in this NMSPEM as a tool to discriminate areas in areas of similar epidemiological characteristics. The aim is to increase the impact of the program on the control and elimination of malaria control in each stratum. It is not a goal, but a means to guide interventions and increase the impact program. Stratification has a long history in the country. Suriname has been traditionally classified into three main ecological zones (macro stratification) related to ecology, transmission characteristics, and malaria risk: (Rosendaal,1990).

1. The coastal area where malaria is transmitted by *A. aquasalis* and where malaria was controlled with DDT spraying and treatment;
2. The savanna belt is a transition zone; the savanna belt with low transmission and sporadic outbreaks,
3. The forested interior, south of the limit of the rivers' tidal influence, has high transmission.

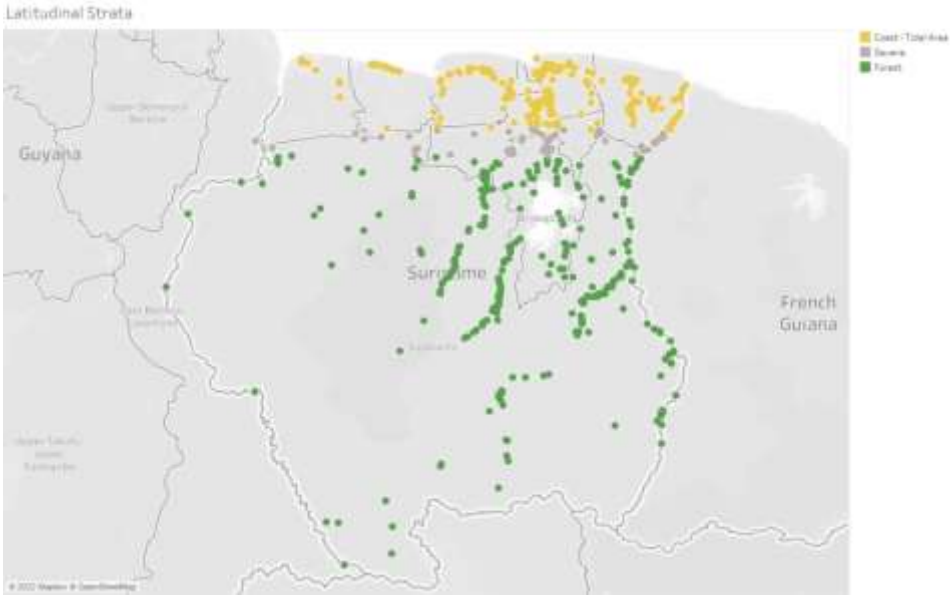


Figure 9: Stratification of Suriname, Coast, Savanna and Forest.

The main, and most efficient vector, *A. darlingi*, can be found in most parts of the interior and sometimes in the savanna. Its presence, distribution, and relative abundance; were related to the occurrence of malaria during high transmission. The interior of Suriname had the highest transmission rates of *P. falciparum* in the Americas until the first decade of the 21 century

(Rosendaal, 1990). This initial macro ecological stratification has been refined by adding epidemiological and socio-economic information in four main strata. The more detailed stratification (Meso stratification) was also designed to be useful for control purposes and has guided the control program's implementation since 2004. It is composed of five strata. It has been the base for the design of the last NMSPEMs and the current one. There is little or no geographical superimposition of the different strata, but there are socio-economic connections between them. Not only between them but also with the mining areas in the interior of French Guyana. The population groups from each stratum interact in the gold mining areas on both sides of the borders. In a way, French Guiana functions as an awkward stratum since it is the source of most cases diagnosed in Suriname in the last decade. The interaction of the population is also extensive in the places that are part of the logistical chain of small-scale mining in the interior. It connects the coast and savanna, and interior. The main strata with their substrata are:

1. **The coastal area**, with no transmission and the absence of A. darlingi, the main vector in the Amazon region: Is a strategic place for early detection of cases coming into Suriname by land from Guiana and the interior by road, boat and plane to supply themselves in Paramaribo. In strategic places on the coast, the NMP has fixed posts for malaria services.
    1.1. Sub stratum Paramaribo. Capital of Suriname, point of entry of miners coming by plane. It has a large Brazilian community centered in some neighborhoods—the main node supplying the mining in the interior with equipment, food, and labor.
    1.2. Sub stratum Albina, point of entry from the coastal area of French Guiana by road.
    1.3. Sub stratum Nickerie, point of entry from Guiana by road.
2. **Gold mining areas in the savanna and lake region** that are covered with malaria service deliverers with easier access to the coastal area:
    2.1. Sub stratum with access by road in the Savanna.
    2.2. Sub stratum with access by boat in the lake area.
3. **Gold mining areas in the interior** that are covered with malaria service deliverers and posts in the supply chain's main node in French Guiana border. Access to the area by boat or small planes:
    3.1. Sub-stratum supply area – along the river in front of the French town of Maripasoula. A site where miners gather during periods of intensification of control of illegal activities in French Guiana.
    3.2. Sub-stratum scattered mining sites in the forested area.
4. **Stable, traditional communities of Indigenous and Maroons** that are covered by the Primary Health Care network of 52 policlinics of MZ. In the Maroon area, due to their genetic composition, P. vivax is rare.
    4.1. Sub stratum Maroon villages can be subdivided by riverine system/ Marowijne , Tapanahony, Suriname, Saramaca, Lawa/ and ethnicity.
    4.2. Sub-stratum Indigenous villages. River system/Lawa can also subdivide itTapanahony, Sipaliwini, Coeroeni/ and by ethnicity.

    4.3 Sub stratum of the upper Suriname river and Gran and Pikien creeks. A. darlingi was present in abundance in the two creeks but was found in low densities in the Suriname river. Transmission was sustained in the creeks and had a periodical epidemic characteristic in the Suriname river. (Rosendaal, 1987,1991)

    4.4 Sub stratum West Suriname, under increasing pressure of logging and presence of loggers from Guiana and Malaysia.

When stratifying, it is a must to emphasize that the major source of cases is across the border in French Guyana or from other mining sites in Brazil, Venezuela and Western part of Guyana. There is also a risk that the situation in the Guyana-Venezuela mining areas might lead to the future exportation of cases to Suriname. In the French Guianese publication map of 2016 (de Santi, 2016) a proxy of the risk is shown by the number of

cases in the army and police generated in each area, the different areas. Two large clusters one in the eastern border with Brazil another near the western border with Suriname. Most of the cases in Suriname come from the western cluster around Sophie. Both clusters are in areas where it is illegal to mining and therefore there are no access to malaria services (Mathieu, 2013).

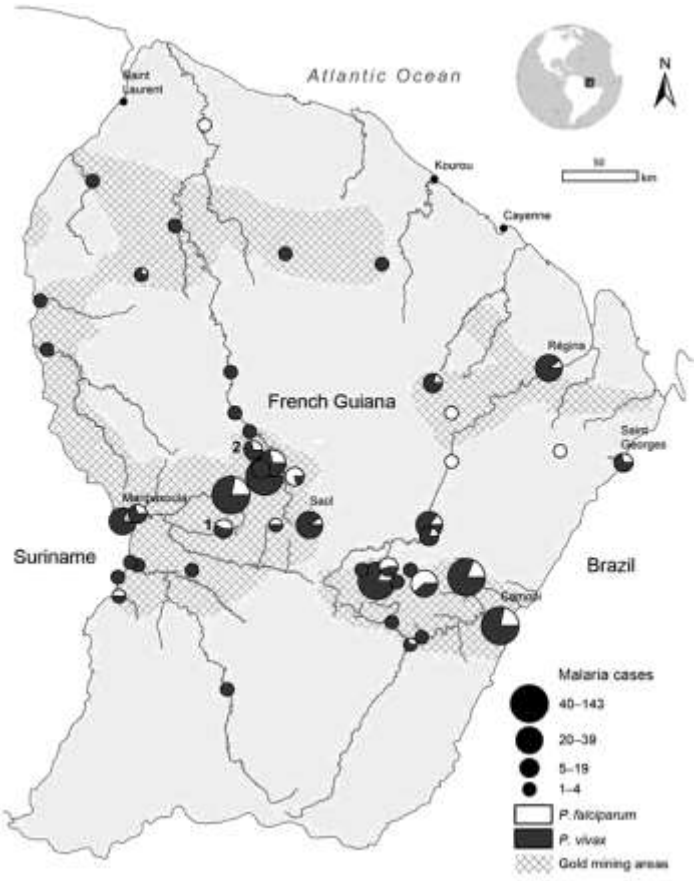


Figure 10: Sites generating cases in the Army and Police personnel in French Guiana.

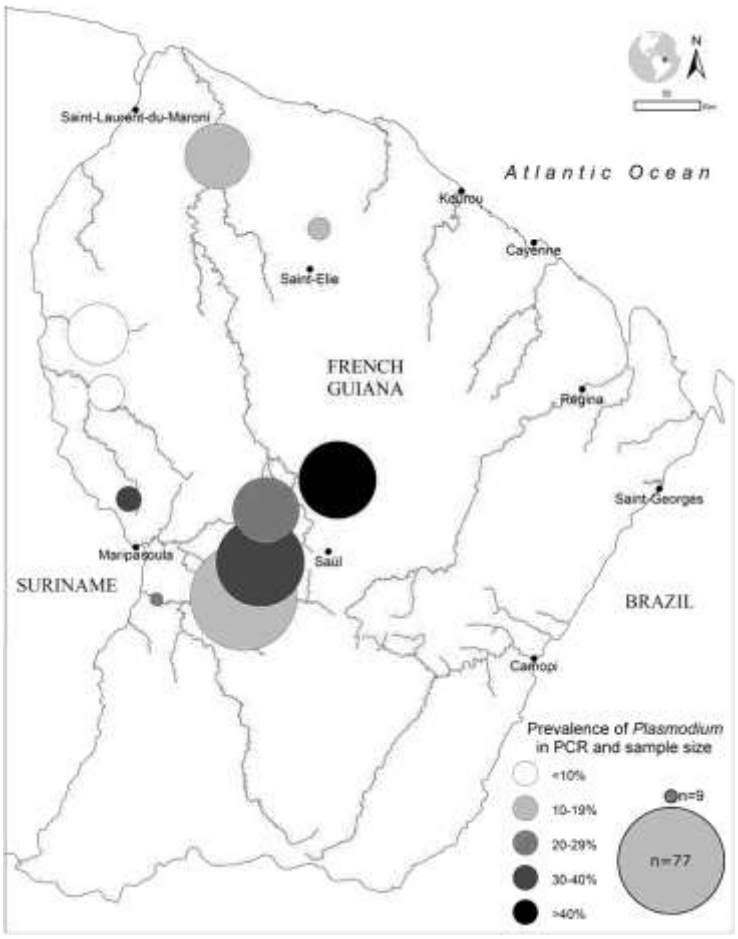


Figure 11 Heterogeneity of* Plasmodium *spp. carriage between the different illegal gold mining zones in French Guiana, 2015

The intensity of malaria in the sites near Suriname is also detected in the data from Douine, 2016, PCR was used to detect *P. falciparum* malaria in gold miners in French Guianese mining sites. The results are summarized in the map from the publication.

5 Current Status of Malaria Control in Suriname

5.1 Malaria, Gold Mining I: Imported Malaria

With the initial decrease of malaria in the villages, the attention was centered on the most important risk area, the small-scale gold mining areas known as Garimpos (de Theije,2009). Most of the garimpeiros working in Suriname and French Guiana are Brazilian, with a minority of French Guyanese, Surinamese, Guyanese, and a few from other nationalities from Latin America and the Caribbean as well as a growing presence of Chinese citizens. The Brazilian garimpeiros have specialized in the different and complex aspects of small-scale gold mining in the remote areas of the Amazon region. They have adapted effortlessly to the mining in the Guyana Shield, with its porous borders and relatively large superficial, alluvial reserves of gold. This peculiar community has its traditions, habits, and rules. The most common technique used to extract gold is amalgamation with mercury, and even sometimes cyanide, leading to high levels of heavy metal in the food chain. The cost of living in the mining areas is quite high due to the difficulties in transporting merchandise. The local prices are indexed in gold.

The local populations of the interior, both Maroon and Indigenous, are frequently involved with different aspects of the mining economy in Suriname. They cater to the needs of the miners, supplying them with transport, fuel, food, tools, etc.

The presence of women in the mines is common. They are mainly Brazilian, but like the men, there are women from other Latin American and Caribbean countries and even from mainland China. Some local women can also be involved in mining activities. Women work as cooks, cleaners, and sellers of cosmetics and medicines. Commercial sex exists in parallel with mining activities. Children are not commonly found in the mining areas but can be present in more stable places in the supply sites. It has been important for the success of malaria control in Suriname to adapt strategies to their socioeconomic peculiarities. The conjuncture of malaria-related to illegal and legal small-scale gold mining also creates the challenge of dealing with malaria from a regional, beyond-the-

border perspective. Borders are not respected as limits and can be seen as an opportunity for business.

The maps below summarize the dynamic connections between Brazil, France, and Surinam. It is important to emphasize that in the areas where gold is exploited, it is estimated that several thousand Brazilians are working in illegal mining (Piantoni,2011). Most of the miners come to Suriname from the Brazilian states of Para, Maranhao, and Roraima. The southern part of French Guiana is a National Park where mining should be allowed. Currently, there are no malaria services in those areas inside the National Park

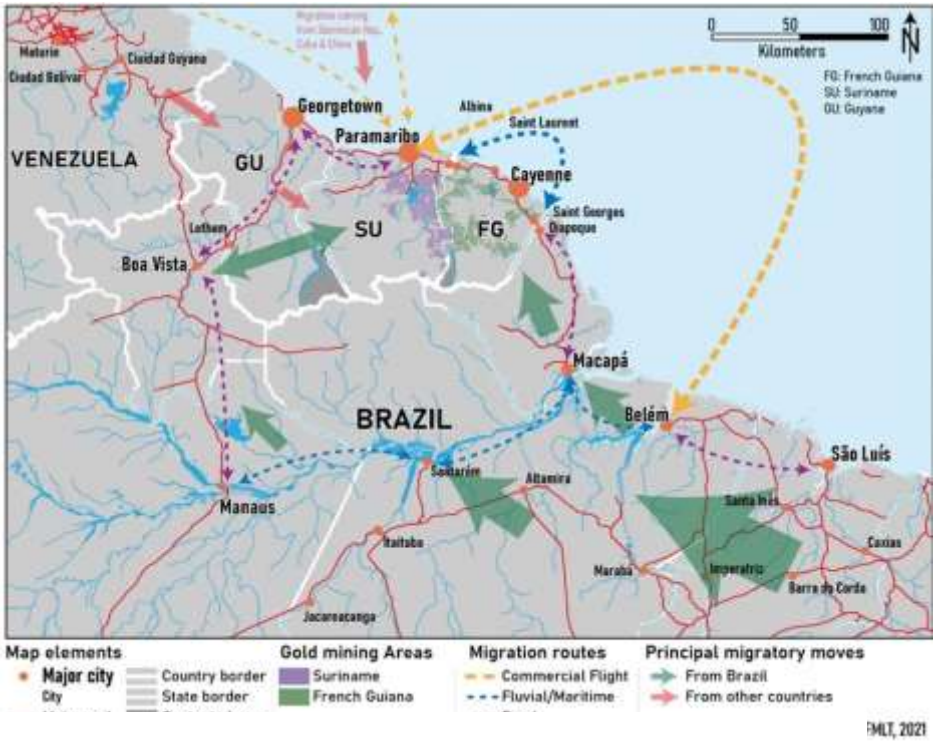


Figure *12*: Regional connections

that occupies the southern part of French Guyana, except for a small health post in Saul. The epidemic of Malaria in Venezuela and a large number of cases in Guyana are a growing concern for the Malaria Program, which has started to refocus the strategy on the border Suriname-Guyana with an increase of MSDs in the region. The new Brazilian government is increasing the containment of illegal mining in the Brazilian Amazon. It might lead to larger numbers of Brazilian garimpeiros traveling to Suriname.

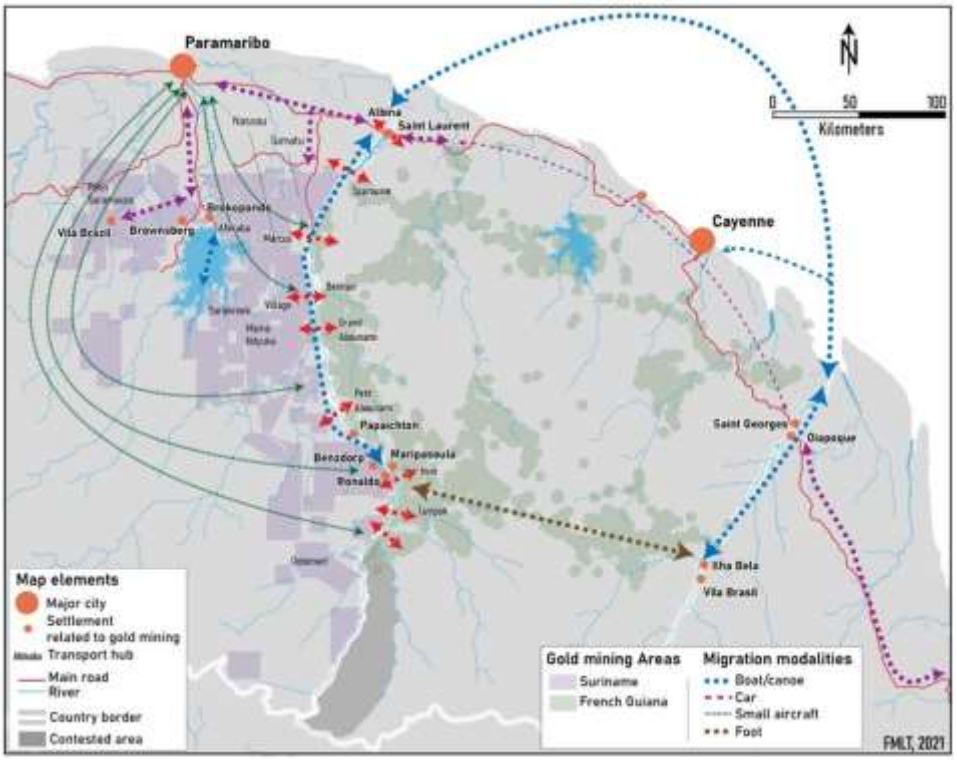


Figure 13: Local connections Suriname – French Guyana*2*

5.2 Malaria and gold mining II: The tactics to deliver services.

Since Malaria transmission in the gold mining communities has specific epidemiological characteristics (Douine,2017), we will devote this subsection to it. One of the main points is that gold miners tend not to complete the treatment schemes. It is one point addressed by the increase the awareness approach of the program.

The lack of adherence seems to be related to difficulties in access to diagnosis and treatment. Especially so, when access is difficult due to distances or costs (Nacher,2013, Heemskerk, 2014), self-medication is common. Surveys in Suriname (Heemskerk, 2014, 2018, 2021) have shown that about half of migrant workers self-medicate. Of those who

[2] The maps summarize the spatial dynamic are from a KIT NL publication (Heemskerk 2021)

self-medicate, only 40% complete the treatment. It has also been shown that if they have access to diagnosis and treatment, their adherence to full treatment increases (Hemmkeerk,2014). To impact malaria in the mining areas, the Malaria Program of the Ministry of Health has targeted specific interventions with three interconnected main lines of work. The implementation both static, with labs at the border areas, and dynamic, with MSDs, uses the spatial logic of gold mining in the region as a basis for planning activities.

1. Provision of free malaria services in clinics in strategic places.
2. Malaria Service Deliverers (MSDs).
3. Self-diagnosis and treatment kit.

Prevention is approached through the use of LLINs. Unfortunately, the mobility of the miners leads to a high loss of distributed LLINs. Furthermore, the type of net is related to adherence to its use. The nets must be adequate for use in both beds and hammocks (Heemskerk,2014). Miners prefer the same type of net designed by the Maroon.

5.2.1 Provision of free malaria services in clinics

The first is providing free malaria services (diagnosis and treatment) in fixed strategic places with a concentration or influx of garimpeiros. There are two larger free clinics in Paramaribo. The Malaria Program has one clinic, in the miner's neighborhood, the Trop Clinic, and one central in the Bureau of Public Health. There are small posts functioning in the interior.

The health services offered in the Trop Clinic were expanded. It includes not only diagnosis, treatment, and linkage to care but also prevention through awareness and education on malaria, HIV, leprosy, and leishmaniosis. Since 2020 Covid 19 was include The Trop Clinic's employees are conscious of the vulnerability of the migrant population, their limitations in getting access to health care, and the risks and constraints related to commercial sex. They can interact with the target population in several languages, such as English, Dutch, Surinamese, Portuguese and Maroon Languages.

The staff has been trained in the consequences of stigmatization and the ways of recognizing and reporting (suspected) human trafficking. The posts in the interior are localized in the strategic places for the supply of the Garimpos and the population movement across the border; these are small malaria screening and treatment posts. They are mainly situated along the border with French Guiana and in the access to the lake area.

Figure 3: Trop Clinic Logo

5.2.2 Malaria Service Deliverers

The second line of work, a unique feature of the malaria program in Suriname, is the so-called Malaria Service Delivers (MSDs) Network. MSDs are lay people from the target migrant population communities trained to provide malaria diagnosis and treatment to their peers under the supervision of the Malaria Program. Based on their reports to the Malaria Program, when cases are detected in one area, they are analyzed. If needed, an active case detection (ACD) coupled with an outbreak contention activity is launched (Hiwat,2012). Another innovation is the expansion of the coverage of the MSDs by the provision of vehicles. Due to difficulties and the extremely high cost of traveling in the mining areas, the Malaria Program in Suriname supports the mobility of some MSDs in large mining areas with All-Terrain Vehicles (ATM) and a boat. The program also guarantees fuel and maintenance. The malaria program also facilitates communication between MSDs and the Program. Despite the remoteness of the interior, contact by phone is adequate in most of the high-risk areas by phone. Most of the imported malaria cases

in Suriname are diagnosed by these MSDs. Due to the gold mining dynamics, training new MSDs is a continuous process. There is a high turnover due to the back-and-forth migration and the constant movement in search of more productive mining sites, which is inherent to gold mining activities. Usually, the MSD network consists of 8 full-timers and 24 volunteers, of which the latter are trained and able to provide services when necessary. The numbers of MSDs and their stations might need adjustment according to the epidemiological situation.

5.2.3 A System to Improve the Quality of Self-treatment

Joint discussions with France and Brazil led to the evaluation and implementation of a novel approach for areas without services: self-diagnosis and self-treatment, with the main focus in French Guiana. The Malakit project (PAHO, 2017). It relies on the information generated by previous studies on mobility, knowledge, attitudes, and behavior among the miner population (Douine, 2014). Miners haphazardly use antimalarial drugs. If they think they might have malaria, they start a short incomplete treatment (Nacher, 2013). Since a higher percentage of miners finish their medicines with a positive diagnosis, the kit might improve adherence to full treatment (Heemskerk, 2015). It targets the groups of highest risk, the miners working in French Guyana. The approach is based on distributing kits for self-diagnosis and self-treatment against malaria in

Figure 4: Malakit promotion material

cross-border areas of French Guianawith Brazil and Suriname. The project's main objective was to evaluate if the use of the RDT in the kit

increases the completion of treatment. The kit contains an ACT combination plus a single dose of Primaquine.

The evaluation of the Malakit pilot initiative has been published (Douine, 2021; Lambert, 2021). The project was implemented in the Surinamese and Brazilian borders with French Guiana. The third and first longest international borders of France. It aimed at determining the effectiveness of distributed kits, from Suriname and Brasil, for self-diagnosis and self-treatment of illegal gold miners in the French mining sites without access to malaria services. The evaluation relied on questionnaires at inclusion and follow-up visits and pre/post-intervention surveys. The proportion of patients reporting the use of certified ACT after a positive diagnosis increased after the intervention (OR 1.8, 95%CI [1.1-3.0]). From April 2018 to March 2020, 3,733 persons participated in the intervention. The kit was used correctly by 71.7% [65.8-77.7] of the 223 persons reporting having used a malakit during the follow-up visits. No serious adverse events related to the misuse of malakit have been reported (Douine, 2021). The intervention possibly worked toward the decline in malaria incidence in the region. Given the results, the user will be continued and expanded to include specific treatment for *Plasmodium vivax* in a new project called Curema (Sanna, 2021). The collaborative group also discusses the possibility of using a rapid test to identify previous *P. vivax* infections. One of the weaknesses of the project is the inability, due to legal constraints, to distribute the kits in French territory.

5.3 Quality Control of Diagnosis

Suriname has a structure of quality control for the diagnosis of malaria in place. It was evaluated by PAHO in 2019 and has been improved by adopting the recommendations. The current network comprises one central laboratory in the Bureau of Public Health

(BOG). It receives slides for primary diagnosis and cross-checking from the Blood Bank, private labs, hospital labs, MZ, and Malaria Programs. Two other labs provide quality control; the malaria program laboratory receives slides from cross-checking from the MSD, and the MZ lab receives slides from 17 clinics in the interior, with current malaria microscopy diagnosis capacity. The country already has two certified microscopists level 1 by WHO, with certification valid for three years. One is located at the BOG Central Laboratory, and the other is at the Ministry of Health, Malaria Program laboratory. The recommendations of the PAHO evaluation that will be incorporated in the current NMSPEMM implementation have as major points the following: The need to produce standard guidelines to be used by all the laboratories working with malaria microscopy. The guidelines should address the diverse labs' role and their hierarchy and indicate the BOG as the central laboratory. It should also include the standardization of the indirect quality control and reporting process. The quality assurance (QA) and quality control (QC) manuals have been developed. Since the number of positive cases is quite small, it is necessary to regularly re-train the current microscopists and health workers. High turnover also creates the need to train new personnel continuously. Individual proficiency testing is done using panels. The evaluation of proficiency is to be followed by retraining the microscopists without optimal performance.

5.4 Equity assessment

As discussed above in the introduction, the high-risk population in Suriname that is key for controlling and eliminating malaria are the native, indigenous populations of the interior and the predominantly Brazilian garimpeiros (artisanal miners). Since the reorganization and expansion of the Malaria program with the support from the Global Fund, special attention has been devoted to eliminating barriers involving the risk groups in the decision-making and planning of the program and the daily activities.

Using the malaria toolbox, we have listed the conceptual framework of the various determinants and how each of them was addressed:

1. Risk Factors

- Biological factors
- Low immunity to parasites is a common factor for all in Suriname due to low incidence.

2. Socio-economic and cultural factors

- Poverty - The link between poverty and malaria in Suriname is currently through mining work, the control program's main focus.
- Social exclusion - Social exclusion will be discussed below in the item undocumented workers.

3. Gender inequalities –

- The risk of malaria in Suriname is higher in males, which is related to the main determinant of malaria, work in mining areas, the main focus of the program.

4. Financial barriers

- Financial barriers were important before the scaling up of the program in the year 2005. Tests and treatment were expensive. They are free of charge to all, independent of any status.

5. Cultural norms

- The use of tests and drugs to treat malaria has a long history in the region, amongst the different ethnic groups, nationalities, and religions.

6. Complex emergencies

- During periods of floods, which were the only complex emergency, malaria control was expanded and strengthened.

7. Populations most impacted

- Pregnant women receive special attention from the program and are provided with LLINs in the villages, maroon, Indigenous, Surinamese, or Brazilian of the interior and mining areas.
- Infants - Same as above.
- Children under 5 - Save as above.

- People living with HIV - The program has been expanding its activities to provide counseling and services for HIV; also leprosy and leishmaniasis.
- Nonimmune - Most of the population is nonimmune.
- Mobile populations - One of the main risk factors since gold mining is associated with mobility and taken care of with the focus of the program in mining areas since the decrease of malaria in the villages.
- Travelers - Travelers are advised to use prophylaxis if they go to the interior's malariogenous areas. The program has advised the travel agencies who sell trips to the interior.

8. Underserved populations

- Populations impacted by conflict, including refugees and internally displaced persons - The population with the highest risk of malaria are Brazilian miners working illegally in French Guyana. They are the priority of the program. Portuguese is spoken at the labs and by the malaria service deliverers. All materials are translated into Portuguese.
- Populations living in remote areas face geographical barriers to services - The main geographical barrier to services is the nonexistence of malaria services in the main mining areas on the French side of the border. It has led to an intense effort of the Surinamese Program to impact malaria across the border. This is explained in the section about the Malakit self-treatment kit that is distributed from Suriname to individuals, mainly Brazilian, working across the border in French Guiana, French territory.
- Women and children from poor settings - Covered above.
- Undocumented workers - Services are offered to all in Suriname, as discussed above.
- Indigenous populations - Indigenous populations are covered by a comprehensive package of Public Health that includes malaria treatment and prevention. Health workers speak the local languages, and the materials are translated. Drawings are used for the nonliterate population. In the last three years, two

outbreaks of *P.vivax* in Indigenous villages have led to a re orientation of the program to deal with the issue of relapses.

- Ethnic minorities - Same as above.

5.4.1 Breaking the barriers to access the malaria services

The main concept that led to the success of the malaria program in Suriname has been the free delivery of free services, irrespective of the status of the individuals. Careful attention was given to the needs of the main risk groups, Brazilian miners and ethnic groups of the interior, to provide them with the appropriate services. Several KAP studies were done, and the knowledge accumulated by the public health services of the interior was used. In the Guyana Shield, barriers to access are one of the crucial issues in eliminating malaria, and Suriname has focused on solving them since 2005. The difficulties of access, remoteness, and low coverage of health services are common challenges. Also, gold mining activity is illegal in areas where it is strictly forbidden. Part of the interior of Guyana, Venezuela, and some parts of northern Brazil do not have proper access to malaria diagnosis and treatment. In French Guyana, illegal mining does not respect the National Parks. The French authorities mounted regular missions to expel gold miners, with results limited to their physical presence in the areas. The current policy is centered on decreasing the capacity of the miners to work by interrupting their supply chain.

The French police and army entered the camps and destroyed all the equipment and supply of the miners. They also build and man-check posts in the rivers to hamper mining activities. During those operations, part of the miners is caught by the police and but most of them scape. They return to the closest border, Brazil or Suriname. They stay near the border with French Guiana waiting for the operation to end. The costs of working in the mining areas are also a challenge. Prices get higher as the distance from the coastal area increases and access becomes more difficult. All prices are indexed in gold. Payments in the interior have to be made in foreign currency or gold.

The population in the mining has difficulties accessing general health care. The multi-ethnic character of the population vulnerable to malaria in Suriname can be a barrier. Suriname is a land of many languages, and the staff of the control program must speak the languages needed to interact with the target populations. It is important to have staff fluent in Portuguese since most cases are in Brazilian individuals speaking only Portuguese, sometimes with a rudimentary comprehension of Saranantongo. There are no specific gender or age barriers. Men comprise the most vulnerable population in the mining areas. Women working there share the same conditions. Children are rare in mining areas. In the villages, services are offered to all. Women and children who stay in the village longer than men have easier access to malaria services. Despite the existing partner public-private partnerships, the current NMSPEM proposes an expansion. It is objective is to minimize the future impact of government financial difficulties. The economic crisis tends to be accompanied by increases in the value of gold. The expansion of large-scale gold mining in Suriname opens the opportunity for further support from the sector to the elimination effort. Since the breaking down of the barriers has been a most important tactic of the Malaria Control Program in Suriname it is worth summarizing the activities:

Barrier	Solution Implemented
The high price of drugs in the legal and illegal markets, especially in the gold mines.	Free access to diagnosis and treatment for all
Difficulties in access to malaria services, diagnosis, and treatment, in town and the routes to the mining areas.	Local malaria service deliverers are trained, and labs provide diagnosis and treatment in the supply nodes and the miners' neighborhood in the Paramaribo
Difficulties in access to health services in the gold mining areas	Expand the activities of the MSDs

Marron and Indigenous villages are scattered over the forested interior.	A network of 52 Public Health Clinics (MZ) covering the area occupied by the native population. Expand the work with the local associations, Indigenous and Marron.
Miners staying on the Surinamese side of the border during French operations	Posts are the strategic places providing diagnosis and treatment plus ACDs
High cost of treatment of severe malaria.	The cost of the treatment of severe malaria is covered by MOH
Miners travel back and forth to Paramaribo to rest, buy supplies, and travel back and forth to Brazil.	Malaria Program Trop Clinic is open to all, offering malaria services with multi-ethnic staff. The staff is trained in the consequences of stigmatization and how to recognize and report (suspected) human trafficking.
High risk of malaria in the illegal mining areas of French Guyana.	Distribution of LLINs to miners in border areas and piloting the use of a self-diagnosis self-treatment kit (MALA-KIT).
Different languages are spoken by the vulnerable group.	Recruit locals or individuals fluent in the local languages and materials translated.

5.4.2 Engagement of the high-risk groups and vulnerable populations in the Malaria Program

It is a priority of the Malaria Program to engage the communities that have been suffering the burden of malaria. We will divide this section into two parts, native populations, and garimpeiros. In Suriname, the native people of the interior are composed of two main groups, Maroons and Indigenouss. The Maroons, that are descendent of Africans who fought against slavery can be further subdivided into ethnic groups that have their language and customs. Likewise, the Indigenous can also be subdivided. They live in the

interior of the country, along the main rivers. There is a spacial public health structure to care for them, Medische Zending (MZ). MZ works closely with the communities and their traditional networks. All decisions are discussed in public meetings called Kutrus with the local authorities. The Malaria Program has been working with MZ and participates in the Kutrus when malaria is an issue. In addition, the staff of MZ is selected locally from the ethnic groups of the interior. The ability to speak the different local languages is a must.

The garimpeiros are offered malaria services from the Malaria Service Deliverers, MSDs. They are selected within and in the community by the MSD supervisors. MSDs are also chosen locally, in mining areas where malaria has occurred in the past, or in strategic places that receive many individuals coming into Suriname trough the neighboring countries. Portuguese fluency is essential for using diagnostic tools, delivering treatment, and collecting the necessary data to be transmitted to the program.

Increasing the awareness of the communities.

The focus of the activities to increase the awareness of the communities has been on discussing the importance of early diagnosis and prompt full treatment for the elimination of malaria. In addition, in targeted groups the importance of prevention using nets is discussed.

5.4.3 Selection of LLINs and Design of the Malakit

The proper selection of the type of long-lasting mosquito net is essential for their impact. The nets used in Suriname resulted from a survey to see the preferred net. It included shape, size, color, and type of cloth. According to the native populations, the net had to be capable of dual use; in a bed or a hammock should be a large, dark color; green was preferred. Using nets designed by Maroon women, Suriname came up with a model duplicated by the manufacturer. When presented with all the different options in the market of LLINs the garimpeiros also preferred the local nets.

The malaria awareness activities at the village level and in the gold mining areas are done using materials designed with the communities and written or video in adequate local languages. A similar strategy was used when designing the Malakit. Several options were presented to focus groups of garimpeiros until a model was selected.

5.5 Public-Private Partnership

The Surinamese Program has benefitted from Public-Private Partnerships with partners from different sectors. It works with the private labs in the coastal area, building their capacity and creating channels for the exchange of data and information. It also controls the quality of their diagnosis. With the large-scale mining sector, the relationship led to the donation by the Newmont company of the structure of the Tropclinic, where, besides the clinic, the laboratory and the malaria program offices are located. There is also an agreement with Newmont for the distribution of LLINs and the screening of cases in their mining area. The characteristic fragmentation of the Garimpo, with hundreds of groups that work as independent units, makes it difficult to build any form of a public-private partnership with the mining sector with the highest risk for malaria. Perhaps the consolidation of the mining areas under enterprises being entertained by the government will allow an extension of the arrangements.

Logging concessions are also being approached to provide a malaria-free environment to their workers. The program works with two large companies, Green Heart and Palmeiras. They bring Guyanese and Malaysian workers, respectively, to Suriname. Difficulties in recognizing interlocutors in the Brazilian gold mining garimpeiro community. The program trains

MSDs work in their areas, screen workers for malaria, and distribute LLINs for prevention. ACDs are executed if cases are detected in their areas.

Also, with the Tourism sector, the program is working closely due to their joint interest in keeping the interior of Suriname free of Malaria. In the containment of the outbreak in Palumeu, the program cooperates with METS, a tour operator that works with the Indigenous community.

5.6 Malaria in the villages, preventing re-introduction

The villages in the interior need to be closely monitored due to the high risk of re-establishment of Malaria. The population has high mobility moving both between villages, to and from gold mines, to and from agricultural fields, to and from the urban areas on the coast, or even in other countries. Different Indigenous and Maroon ethnic groups are spread across both sides of the border. The Trios have villages in Brazil and the Wayanas in French Guiana. The Djucas and Boni Maroons live on both sides of the Marowijne river. They frequently travel to visit relatives do business or to participate in religious and cultural gatherings

Maroons and Indigenous also work in the mines and can potentially reintroduce malaria back to the villages. The risk is higher, especially in the interior areas where *A. darlingi* is present most of the year. The map below presents the decline in malaria in the interior with the improvement of diagnosis and treatment. The Maroon villages with only *P. falciparum* due to their resistance to *P. vivax* and the Indigenouss with both *falciparum* and *vivax*.

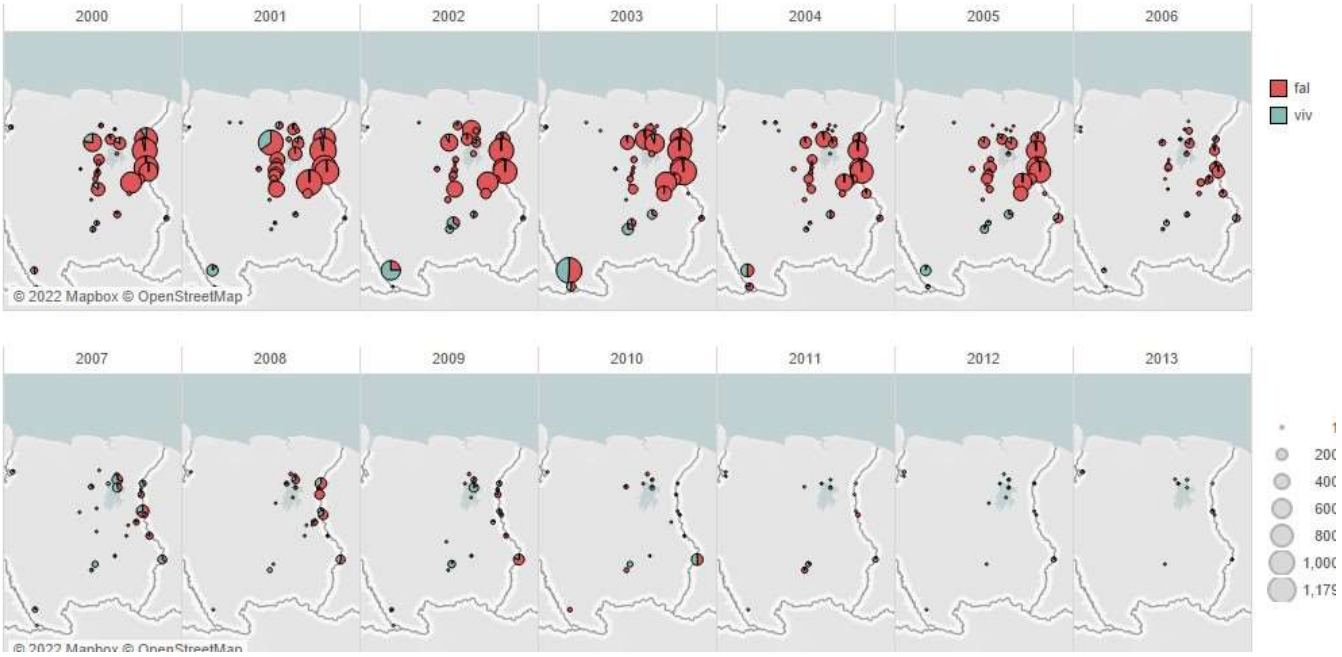


Figure 16: : Malaria in the villages 2000-2013, falciparum cases in red, vivax in blue.

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Also, the relapses of *P. vivax*, acquired elsewhere, can occur in the villages months after the initial episode and start an outbreak. The continuous work of MZ clinics is essential to avoid the reintroduction of malaria in the villages of the stable population of the interior.

Jointly with MZ the program has a strong commitment to involve the community in all the activities. Not only of awareness and health promotion but also in the discussions on how to implement the interventions.

5.6.1 Control of outbreaks

As in other settings in tropical areas, the high relapse rate slows down the control of *Plasmodium vivax* outbreaks. Data on relapse rates of *P. vivax* in Brazil and Peru have shown that patients with full 14 days of treatment with Chloroquine plus Primaquine or Tafenoquine have a relapse rate of 20% in six months. Incomplete treatments led to much higher relapse rates (Llanos Cuentas, 2019). In 2019 there was an outbreak in two Indigenous villages in the south of Suriname in the Tapanahony river, Palumeu, and the larger nearby village of Tepu. Malaria has been eliminated in Palumeu since 2014. There were initially 45 cases of *P. vivax* in Palumeu. Five more cases were detected in the nearby village of Tepu. The outbreak was resilient and lasted for more than a year due to frequent relapses.

The common malaria outbreak in two Indigenous villages in Suriname was rather resilient, lasting more than a year. It was contained using five concomitant tactics:

increasing malaria diagnostic and treatment through the 1-3-7 method using rapid diagnostic testing (RDT) and active and reactive case detection (ACD/RCD),

1. Increasing malaria diagnostic and treatment through the 1-3-7 method using rapid diagnostic testing (RDT) and active and reactive case detection (ACD/RCD),
2. Distribution and promotion of the use of long-lasting insecticide-treated bed nets,
3. Mass drug administration (MDA),

4. Increasing awareness through health promotion,
5. Increasing surveillance.

The molecular epidemiology of the outbreak was studied, and it was reported that all isolates from the first and second Palumeu outbreaks shared a distinctive haplotype presuming a single clonal lineage. An imported case probably triggered the first outbreak, while a relapse was suggested as a source of the second outbreak. A diverging variant was demonstrated in Alalaparoe, implicating an infection from a different source. (Labadie-Bracho, 2021) Suriname is planning to use molecular and serological tests to identify the previous and current cases of *P. vivax*. The identification could serve as a guide for interventions with Focused Mass Drug Treatment.

5.7 Entomological Activities

In the past, during the DDT spraying years, the BOG had a large entomological and mosquito control unit. After a period of relative neglect, entomological studies were done in the interior of Suriname by a group of entomologists in the late eighties. The publications compiled in the book of Rosendaal, 1990, describe the importance of vector *A. darlingi* in the transmission of malaria in the interior. The investigators also evaluated the IRS's impact and impregnated nets' use. The conclusion was that there were advantages of the nets over the IRS due to the mobility of the interior populations and the openness of their houses. Entomological activities were resumed with the support of the GFATM projects after 2005. Unfortunately, this was again stalled in 2017 due to the loss of technical staff.

The current NMSPEM will strengthen the entomological component of the malaria program to provide better support for the elimination effort as required by WHO. The rapid decline of malaria in Suriname was parallel to the collapse. darlingi, the main vector of population collapse (Hiwat,2012). Monitoring the dynamics of the darlingi population is important for the estimation of the susceptibility of the interior.

Three sentinel sites were planned for strategic places in the interior that represent risk areas for future malaria reintroduction and have different socioeconomic and environmental characteristics. One is in Stoelmans island in east Suriname, along the border with French Guyana, the second is in the lake area, and the third one is in the west of Suriname. Entomological activities are needed to maintain the regular study of insecticide resistance to guide the selection of nets. The information is important for selecting the types of nets to use. Also, the duration of their protective efficacy needs to be monitored. Different ethnic groups have other washing traditions. It leads to different duration of insecticide presence in the nets. In the case of outbreaks, the epidemiological analysis has to be complemented by the appropriate entomological investigations to judge if vector control is applicable as part of the containment strategy.

The use of LLINs in high risk or in highly vulnerable populations has been a preventive strategy used in Suriname. With decrease of the incidence the use of nets is being focused in the highest risk groups. One of the challenges has been the distribution of nets to miners who frequently move across the border to French Guyana. There is both a high turnover of the population as well as losses of nets due to the action of the police and army in the mining camps of French Guyana. Efforts were made and will be made to exclude the nets from the destruction of illegal mining sites.

5.8 Monitoring and Evaluation of Malaria in Suriname

Suriname has built a reliable system to monitor the epidemiology of malaria. The Malaria Program in a national database aggregates the malaria data. It allows detailed epidemiological analysis monitoring and information generation for planning and improving control. Reports are produced weekly. The malaria information system is based on data from other parts of the Health Sector, hospitals, laboratories, and private clinics. It compiles data from the Malaria Service Deliverers, Malaria Laboratories in the border area, Malaria Laboratory BOG, Malaria Program TropClinic, Hospitals, and MZ Primary Health Care

Clinics. The data is checked and entered into an access database.

6 Analysis of Epidemiological Data

Suriname's comprehensive malaria surveillance system feeds into a database and produces weekly, monthly, and annual regular reports. The information discussed here is derived from the periodic report and analysis made using the national database. Most cases of malaria diagnosed in Suriname are currently of *Plasmodium vivax.* The last indigenous case of *Plasmodium falciparum* occurred in 2018.

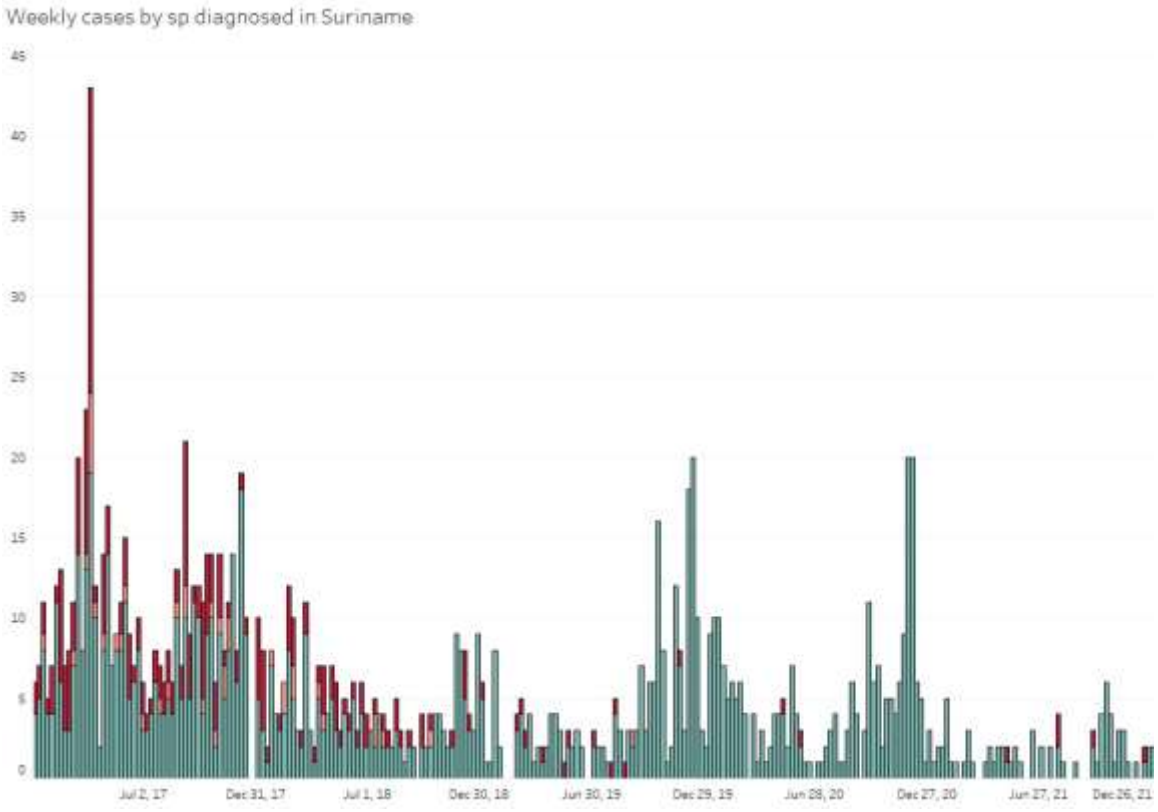

Figure17: : Malaria in Suriname 2017-2020, falciparum in red, vivax in blue, and mixed in pink

The epidemiological trend has been a decrease in cases accompanied by a few small outbreaks of *Plasmodium vivax* in Indigenous villages. Monthly series show a slight tendency of malaria to peak late in the year. The late outbreaks of Plasmodium influence this peak *vivax* in Indigenous villages in the Tapanahony river.

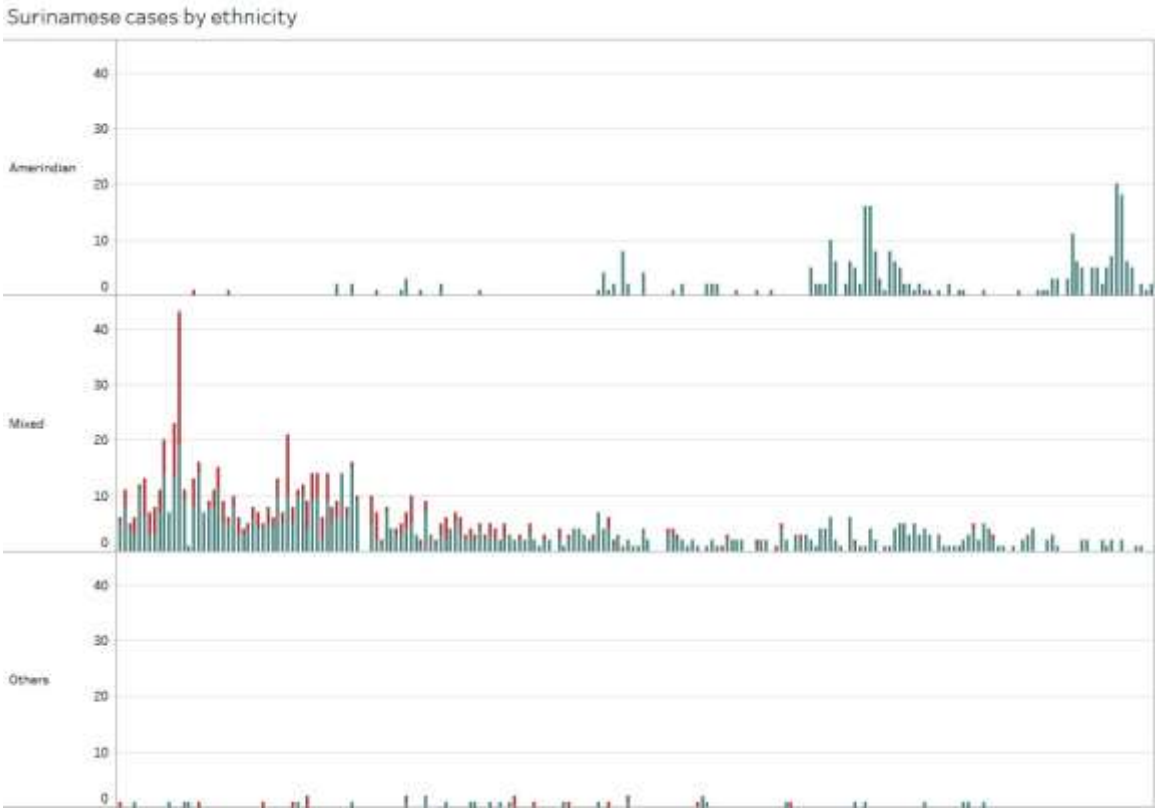

Figure 5: Malaria in Suriname Ethnicity 2017-2020.

The populations with higher risk are the Brazilian gold miners. Interestingly, most of the cases in Suriname are in Brazilian that were infected in the French department of French Guyana. As in the past decade, Suriname malaria is highly concentrated among Brazilians working, mostly illegally, in areas of France with little access to malaria services on any other type of private or governmental health services. Indigenouss of the headwaters of the Tapanahony river also have had a higher incidence of malaria.

Looking at the data by locality, there are two main clusters of cases diagnosed in Suriname:

1. Inside Suriname, the Indigenous villages of the Tapanahony,
2. Outside of Suriname, the illegal mining sites around Sophie in French Guyana.

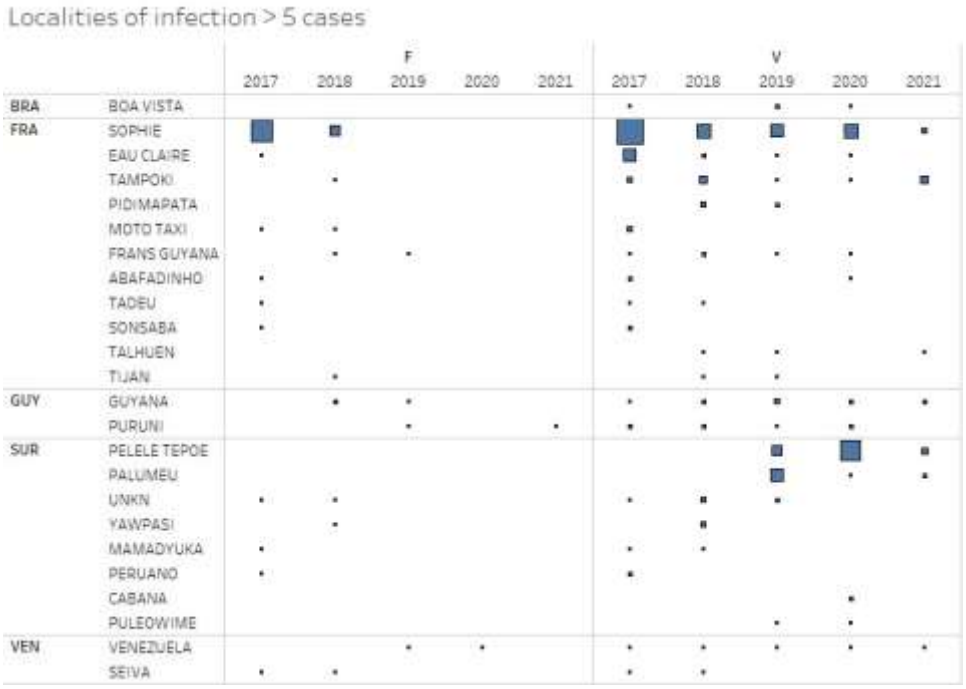

Figure 69: Malaria by locality with more than 5 cases

Malaria in the Indigenous villages shows a different pattern from malaria in the gold mines, with a higher percentage of women and cases in small children. The cases labeled as mixed are in the vast majority of Brazilian miners. Two Indigenous villages had outbreaks. The Maroon interior population is mainly Duffy-negative and protected from *P. vivax*.

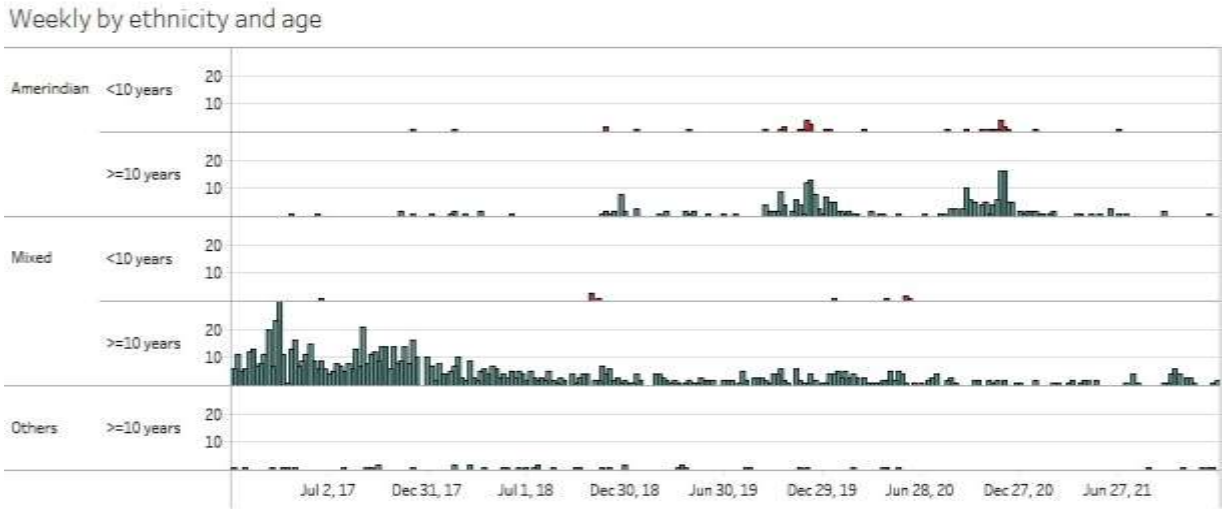

Figure 7 : Cases by ethnicity and age, falciparum in red, vivax in blue.

Palumeu, a Trio village, had an outbreak starting in 2019. The cases spread to the nearby village of Tepu. No deaths have occurred, and all cases reported were *P. vivax* malaria. Palumeu and Tepu are tribal Indigenous villages in the south of Suriname, in the Tapanahony river. To reach the villages, one must charter a flight or travel by boat for several days through a network of rapids. The registered population of both Palumeu and Tepu is around 400 individuals. Currently, there are about 250-300 individuals in each village. Entomological conditions for the transmission of malaria are excellent. There are high densities of vectors in the villages, resulting from the surrounding swampy areas serving as mosquito breeding sites. During the dry season, the river bed can provide breeding places for mosquitoes. (Rosendaal,1990)

The mobility of the population is high, they travel for work, for hunting, to acquire goods in the coastal areas and to join family members and religious groups. They are not limited by international borders. Additionally, the living conditions/habits of the populations, which include living in very open structured houses and being active late at night and early in the morning during mosquito biting times, contribute to the transmission risk. The outbreaks were contained by a mix of mass drug treatment interventions and distribution of LLINs, followed by an increased effort to strengthen the activities of diagnosis, treatment, and follow-up at the local level.

6.1 Epidemiological Summary 2022

2022 is the first year since cases are counted without indigenous malaria cases in Suriname. The table below, extracted from the year report, summarizes the current situation. All cases were imported or introduced.

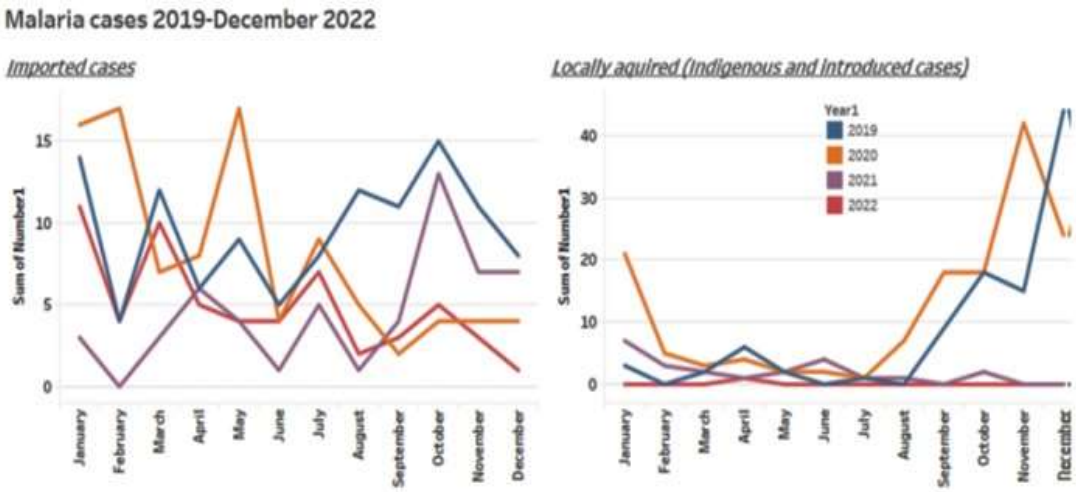

Table: Number of cases

Classification1	Year1	January	February	March	April	May	June	July	August	Septemb..	October	November	December	Grand Total
Indigenous	2019	3	0	2	6	2	0	1	0	9	18	15	44	100
	2020	21	5	3	4	2	2	1	7	18	18	42	24	147
	2021	7	3	2	1	2	4	1	1	0	0	0	0	21
	2022	0	0	0	0	0	0	0	0	0	0	0	0	0
Introduced	2021	0	0	0	0	0	0	0	0	0	2	0	0	2
	2022	0	0	0	1	0	0	0	0	0	0	0	0	1
Imported	2019	14	4	12	6	9	5	8	12	11	15	11	8	115
	2020	16	17	7	8	17	4	9	5	2	4	4	4	97
	2021	3	0	3	6	4	1	5	1	4	13	7	7	54
	2022	11	4	10	5	4	4	7	2	3	5	3	1	60

Figure 8 Figure 23: Printout of the weekly report aggregated for 2022

7. Information on Laboratory-Based Malaria Studies in Suriname

7.1 Surveillance and Monitoring of Emerging Antimalarial drug resistance

The threat of emerging antimalarial drug resistance in Suriname has been investigated in the past decade through various laboratory/clinical studies conducted within Suriname or with international collaborators.

7.1.1 Investigations of susceptibility of *P. falciparum* to antimalarial drugs:

Clinical Efficacy studies

Prevalence of day three parasitemia after artemether-lumefantrine treatment was studied ac-ˆ cording to WHO protocols in 2005/2006 and again in 2011. Parasite persistence on day three significantly increased from 2% in 2005/2006 to 31% in 2011, indicating possible emerging resistance to artemether (Vreden, 2013).

The most recent efficacy study in 2013/2014 with artesunate monotherapy demonstrated a day three parasitemia of 10% and at least 17% of the samples with an extended parasite half-life[2], supporting the earlier observation of the possible presence of artemisinin resistance.

Although the susceptibility of *P. falciparum* to antimalarial drugs is conventionally investigated in efficacy studies through therapeutic responses, the declining malaria numbers rendered *in vivo* studies in Suriname are no longer feasible due to inadequate study power for the sample size.

Molecular markers or drug-associated markers have been utilized as alternative methods to monitor the extent of resistance to antimalarial drugs in *P. falciparum* strains circulating in Suriname.

Characterization of single nucleotide polymorphisms (molecular markers)

Various studies have focused on the characterization of molecular markers in the *pfdhfr* gene (amino acids 16, 51, 59, 108, and 164), linked to Fansidar (pyrimethamine/sulfadoxine), markers in the *pfcrt* gene (amino acids 76 and 350), associated with Chloroquine and Piperaquine resistance respectively, in the *pfATP6* gene and in the *pfmdr1* gene (amino acids 86, 184, 1034, 1042 and 1246), possibly influencing parasite response to mefloquine, lumefantrine, and even artemisinin.

The molecular characterization of the *dhfr* gene revealed the wildtype nucleotide at the codons at the positions 16, 59, and 164, while the fixed Ser to Asn mutation at codon 108, as well as the Asn to Ile mutation at codon 51(Adhin, M. R. , 2013) correlated well with Suriname's historically high Fansidar (pyrimethamine/sulfadoxine) treatment failure

The molecular characterization of the *pfmdr1* gene revealed the existence of a uniformly distributed genotype in Suriname(Adhin, M. R. , 2013), corresponding with the full mefloquine-sensitive 7G8-like genotype [Y184F, S1034C, N1042D, D1246Y](Zalis M. et al, 1998). Also, the studied isolates for single nucleotide polymorphisms (L263E; A623E; S769N) in the *pfATP6* gene harbored an identical wildtype *pfATP6* genotype(Adhin M.R, 2012), while a steady 100% prevalence of the hallmark K76T mutation in the *pfcrt* gene provided molecular validation of Chloroquine resistance in Suriname.

Similar to French Guiana and Guyana, a high prevalence (80.6%) could be demonstrated for the *pfcrt* C350R mutation, associated with piperaquine resistance in isolates from Suriname (*not yet published*).

Molecular markers were also investigated in isolates from miners as a high-risk group to assess the extent and the role of mining areas as reservoirs of malaria resistance in Suriname (Adhin M.R, 2013).

Extremely limited genetic diversity in the *Plasmodium falciparum* isolates was observed throughout the country, despite geographic, population, and economic differences (Adhin M.R, 2014).

DNA sequencing

In collaboration with the Malaria branch of the CDC, Atlanta, *Plasmodium falciparum* isolates from Suriname were genotyped to gain insight into the status of mutations designated as confirmed Artemisinin resistance markers (WHO, 2015) in the kelch propeller domain of the ***PfK13*** gene.

Within the investigated isolates, none of the mutations in the K13 gene associated with artemisinin resistance in Southeast Asia were detected in the isolates from Suriname, not even mutation C580Y (Chenet S.M. et al, 2017).

Quantitative Real-Time PCR

pfmdr1 copy number was determined for a cohort since increased ***pfmdr1*** copy number is considered an important determinant for *in vivo* resistance to Mefloquine and reduced sensitivity *in vitro* for Artesunate and Lumefantrine. Increased copy number was revealed in 11% of these *P. falciparum* samples, although none of the multicopy isolates exceeded two copies of the ***pfmdr1*** gene (Labadie-Bracho, 2013).

With elimination as a target and an ongoing search for new markers, Suriname must continue the molecular surveillance monitoring system, especially for K13 mutations in the imported samples.

The established national malaria gene bank, as characterized Plasmodium gene repository for Suriname, needs to be maintained to safeguard future malaria research and enable the study of strains' evolution through comparative analysis of isolates from different periods.

7.1.2 Investigations of susceptibility of *P. vivax* to antimalarial drugs

With the growing importance of containing and eliminating *P. vivax* malaria, Suriname should be prepared to screen for potentially reduced susceptibility of *P. vivax* to Chloroquine, Primaquine, or even Tafenoquine in the future. Efforts should be made to establish molecular assays for markers as soon as these are available.

7.2. Differentiation between new infections and recrudesce or relapse

The use of molecular techniques in paired isolates should be continued for *P. falciparum* and *P. vivax* in case of recurrent malaria.

7.3. Use of PCR-RFLP profiling for molecular outbreak reconstruction

PCR-RFLP was successfully used to reconstruct recent *P.vivax* outbreaks in Palumeu (Labadie-Bracho, 2021) and Pelele Tepoe (*not yet published*). RFLP-profiling revealed that outbreak samples from the three indigenous villages Palumeu, Pelele Tepoe, and Apetina almost exclusively harbored a single clonal type, matching the lineage previously described in 2019, despite multiple relapses and drug pressure exerted by mass drug administration events, suggesting a limited *P. vivax* hypnozoite reservoir in Suriname.

In contrast, isolates originating from Sophie, a mining area in neighboring French Guiana, displayed a highly heterogeneous parasite population consistent with its endemic malaria status, demonstrating the differentiating capacity and, thus, the usefulness of PCR-RFLP for *P. vivax* genetic diversity

studies.

Continued future use of this affordable molecular surveillance tool is highly recommended, even as a guide for the roll-out of targeted interventions to contain the outbreak.

In addition, this tool can also be applied to gain insight into *P.vivax* genetic diversity and identify imported cases or potential foci.

7.4. Early detection of cases

The sensitive Real-Time PCR assay can not only aid in the early detection of cases during an outbreak, thereby improving the possibilities for containment of the outbreak but can also resolve ambiguous microscopic determination or identify persons with persisting low parasitemia after drug treatment.

7.5. Serology

Next to molecular strategies, Suriname has started to utilize a serological approach as a possible new malaria elimination strategy tool. Results from the first study provided malaria seroprevalence data for the three circulating *Plasmodium* species in Suriname in isolates from a mining area (Benzdorp) and a Maroon village (Stoelmanseiland). The overall seroprevalence reached a rather high 78%, considering our low transmission in the past decade and the frequency of antibodies for more than one *Plasmodium* species even reached 47.5% (Labadie-Bracho, 2020).

The high antibody response for the three tested long-lasting antibodies indicated an earlier antibody saturation, which will hamper the detection of significant recent transmission shifts.

Follow-up studies are required to gather sufficient data to select the best-suited antigens and target populations, such as young children or Indigenouss, so that serology can become a useful stratification tool in regions without malaria and a lower historical burden. Country-customized cut-off values have already been determined for antibodies against seven common Plasmodium antigens in a reference population of Surinamese with no malaria history, enabling the generation of a true representation of the actual "negative sero-distribution in our setting for future studies.

Additional efforts should focus on the use of serology as a possible novel strategy to detect a recent infection, especially for *P.vivax*, which could guide decision-making on re-treatment or focal mass therapy.

8. Key Points of the Epidemiological Situation that Guide the NMSP.

In 2022 Suriname had no indigenous cases of Malaria. No cases of *P. falciparum* since 2018. To maintain this situation, the key points are:

- There is high vulnerability and receptivity to malaria.
- There is high mobility of the population, both miners and local populations of the interior.
- The cost of living and traveling in Gold mine areas is very high.
- There is high risk of development of resistance.
- There is a need to sustain the current financial support in the interior of Suriname
- There is a need to sustain and expand the current efforts to deliver malaria services in the interior of Suriname.
- There is a need to improve the provision of treatment through the use of self-diagnosis and treatment kits.
- The need to implement new tactics for the elimination and outbreaks containment P. vivax.
- There is a need to develop use of molecular and serological tests to identify targets for focal treatment.
- There is a need to entertain the use of re-treatment schemes for individuals that had P. vivax.
- There is a need to improve data exchange between the countries in the region.
- There is a need to improve the surveillance of resistance across the region.
- Large areas in the neighboring countries are without access to malaria services.
- Work together with neighboring countries toward regional improvement of DTIR.

9. Brief SWOT Analysis

This brief SWOT analysis focuses on the most important issues for the elimination of malaria transmission in Suriname.

9.1. Strengths

The main strengths are related to the currently existing structure and resources of malaria surveillance and control in the country. They must be maintained and strengthened by this NMSPEMM:

- Coordination by the Malaria Board and Elimination Task Force.
- Country Coordination Mechanism capable of approving a sequence of proposals to the Global Fund.
- Dedicated Technical Officer from PAHO/WHO to assist with Malaria elimination.
- Joint work with institutions from French Guiana and Brazil to expand the use of self-treatment kits.
- Progressively integrated approach of service delivery.
- Maintained financial support of the Global Fund.
- Free malaria diagnosis and treatment to all.
- The existence of a network of polyclinics of MZ, working with the traditional village structures covering the different Maroon and Indigenous ethnic groups of the interior with the diagnosis and treatment for malaria.
- The successful use of malaria service deliverers in the gold mining areas.
- Malaria laboratories in strategic places.
- A body of knowledge developed not only locally in Suriname by the malaria program, Bureau of Public Health, BOG, Faculty of Medicine (MWI), and local Public Health NGO (SWOS) but also regionally with PAHO, CDC, Pasteur, French Guianese health authorities, Guianese health authorities, and Brazilian health authorities that is the base for evidence-based decision making.

- Public-Private Relationships with mining companies, logging companies, tourism, and private labs.
- Experienced personnel working and advising the control program.

9.2. Weaknesses

The main weakness is the continuous flow of patients from the French side of the border, where services are lacking in many active, illegal mining sites. Patients with *P. vivax* are not treated with Primaquine in French Guyana, leading to a higher frequency of relapses that can occur when they are in Suriname. This weakness is compounded by the lack of results in the innumerous tentative of working towards a solution for the delivery of malaria services in French territory. Be it by French health authorities in French Guiana or by MSDs send from the Surinamese side of the border.

Currently in the Surinamese mining areas, the adherence to the use of LLINs is low in part due to the gold miners' lack of interest in their use, in part due to the low risk of malaria in Suriname but also due to the difficulties related to the acquisition of the model preferred by them that is more expensive than the normal nets. The distribution of nets for the population of miners at highest risk, the ones who cross the border to French Guiana is also problematic. The turnover and movement of the illegal miners is high, creating a demand for renewed the distribution of nets at short periods of time. In addition, the destruction of the illegal miners equipment by the French authorities frequently include the nets.

The peculiar socio-economic situation of the Brazilian garimpeiros makes it difficult to engage their community in a partnership to work towards malaria elimination. Their mobility and the high turnover of the MSDs, also hamper the sustainability of the outreach activities. Finally, at the moment, there are no strategies of high impact for the rapid containment of *P. vivax* outbreaks. Therefore, the main weaknesses are:

- Large areas of illegal gold mining in French Guiana with no malaria services.
- Low adherence to the use of LLINs by the gold miners.

- High turnover of MSDs.
- Difficulties in recognizing interlocutors in the Brazilian gold mining community.
- Low impact of the current strategy for *P. vivax* outbreak containment.

9.3 Opportunities

At the regional level, the interest in the elimination of malaria in the Guyana Shield, which is responsible for more than 80% of Malaria in the Americas, opens an opportunity for Suriname to consolidate the elimination in its territory. There is evidence that malaria in Suriname, French Guyana, and the Brazilian state of Amapa is at a rather low level. Especially malaria caused by P. falciparum. It is an opportunity for a sub-regional elimination in this eastern part of the

Guyana Shield. It could be achieved with an expanded effort to reach the gold mining areas in French Guiana with malaria services. Good relationships and ongoing cooperation with neighboring countries. Also, the success of the combination of the MZ policlinic for the stable villages and the MSDs for the mining areas could be a model to be applied across the Guyana Shield. For Suriname, there is an opportunity to improve the quality and the integration of the malaria data to the national health information system by porting it to the DHIS2 platform with support from WHO and PAHO. The main opportunities are:

- A window for the elimination of Malaria in the Guyana Shield.
- Suriname provides technical support to improve the delivery of malaria services in the Guyana Shield.
- Expansion of the model MSDs + Policlinics of MZ to the neighboring countries with the support of the Global Fund.
- Porting the Information System to the DHIS2 platform.
- Regional integration of surveillance systems.
- Improvement of malaria diagnosis and treatment delivery in the South of French Guyana, West of Guyana, South of Venezuela, and Roraima in Brazil.

9.4 Threats

Similar to other areas where malaria is related to gold mining activities in the Amazon, incomplete treatments of *P. falciparum* are the main threat since they might lead to resistance to ACTs. Changes in the price of gold or economic difficulties in Brazil, French Guyana, Suriname, Guyana, and Venezuela are a threat due to their impact on the migratory flow and the dimension of legal and illegal gold mining. An increase in gold mining will make the control of malaria more difficult. It is already happening in Venezuela. The new government in Brazil is planning to restrict and even ban in some areas small-scale gold mining, the garimpo. Such actions will result in a massive migration of Brazilian garimpeiros to all the Guyana Shield mining sites. The current focus on keeping Suriname free of malaria runs the risk of being lost due paradoxically to the successful impact. This might lead to a discontinuation of local and international funding. There is a need to maintain the malaria control effort as long as the neighboring countries cannot deal with their malaria burden. Therefore, the main threats are:

- Lack of adherence to full treatment leads to resistance to ACTs.
- Changes in the intensity of gold mining activities due to economic difficulties or an increase in gold prices.
- Limitation of the areas available for garimpo in the Brazilian Amazon announced by the newly elected government.
- Increase the already high mobility in the interior with the opening of roads.
- New projects in the interior of the Guyana Shield.
- Increase in the already high costs for implementing malaria control activities in the interior.
- Discontinuation of funding.
- Loss of focus on the need to maintain the current malaria control effort within Suriname.

10 Structure of the Strategic Plan

10.1 Introduction

This plan, as the previous ones, is built on the accumulated capacity in Suriname to control and eliminate large areas and also to contain outbreaks of Malaria to avoid the re-establishment of malaria in the country.

10.2 The Vision

Suriname will be free of malaria transmission within a region free of malaria in 2025.

10.3 The Mission

Provide immediate and free access to malaria diagnosis, treatment, and follow-up to all cases, to avoid the re-establishment of malaria in Suriname while at the same time supporting the expansion of services, across the border areas, with the neighboring countries.

10.4 The Aim

Decrease and contain imported malaria and local outbreaks and prevent the re-establishment of Malaria in Suriname.

10.5 The Objectives

The Suriname government aims to eliminate malaria transmission in the country, decreasing the number of imported malaria to avoid its re-establishment. Since most cases in Suriname are imported, the priority to achieve this vision is focused on breaking the constant influx of imported cases introducing the disease in the country. The operational objectives are centered on early diagnosis and treatment and finding ways to collabo-

rate with the regional effort to improve malaria services in French Guyana, Brazil, Guyana, and Venezuela.

The National Malaria Strategic Plan contains the following main objectives:

- Sustain the required financial resources, national management capacity, and structures to effectively and efficiently deliver the interventions needed to achieve and maintain elimination.
- Decrease the number of imported cases working towards elimination in the Guyana Shield through an active campaign of advocacy with the neighboring countries at the regional and international level to convince the health authorities of the need to provide free malaria diagnosis, treatment, and prevention to all, including the population living in the mining areas.

  Maintain preventive measures; early, free diagnosis, free treatment, and follow-up of all cases to avoid the reintroduction of malaria.

10.6 Priorities

There are five main priorities in this NMSPEMM. Each one is related to the temporal sequence of malaria occurring in Suriname. Cases not treated or partially treated from across the border once in Suriname can reintroduce transmission and outbreaks. There is a need to contain malaria as closely as possible of the sources. Countries with borders with Suriname are generating the majority of cases diagnosed in Suriname since 2010.

In sequence, the first priority is to sustain the current successful program. The second priority is to diagnose and treat the cases when they are entering Suriname to avoid imported cases. The third priority is to diagnose and treat the cases in the country as soon as possible to prevent the re-establishment of malaria transmission. The fourth sequential priority is to prevent and contain outbreaks, if they occur, in the shortest possible time. The fifth priority is the regional and global work towards improving diagnosis and treatment in the areas lacking health services of the Guyana Shield. The five priorities can be stated as follows:

1. Secure the maintenance of the current program.
2. Prevention of imported cases.
3. Prevention of re-establishment of malaria
4. Prevention and containment of outbreaks.
5. Work regionally and globally to improve access to diagnosis and treatment in Guyana Shield.

10.7. Main Strategy of Implementation

The main components of the Strategy are:

1. Intensify the current commitment and the national and regional coordination of the malaria elimination effort in the country and also work with the partners to the extent of the elimination of Malaria to the whole of the Guyana Shield.
2. Maintain an information system adequate for the analysis, monitoring, evaluation, and planning.
3. Expand the T3, Test, Treat, and Track, as DTIR, Diagnosis, Treatment, Investigation, and Response.
4. Maintain the capacity of MZ to deliver malaria services in the villages of the interior.
5. Maintain integrated health services for vulnerable migrant populations.
6. Maintain and expand the clinics and posts for migrants, shifting towards providing more integrated health services.
7. Strengthen the entomological component to improve vector control management.
8. Execute key operational research to generate evidence for accelerating the impact toward elimination.
9. Engagement the high-risk groups and vulnerable populations in the malaria program[3].

[3] A transversal component.

10.8 Principles of implementation that have been incorporated to reach the objectives:

- The strategy is based on the following principles
- Maximize a people-centered integrated system to deliver malaria services.
- Prioritize interventions of high impact.
- Consider the diversity of ethnic origin, language, and socio-economic circumstances described in the introduction.
- Diagnosis and treatment, including the hospitalization of severe cases, are free for all, irrespective of nationality, sex, age, ethnicity, or immigration status.
- Engagement of local traditional authorities and structures in the decision-making process.
- Recruit staff to work in the interior locally.
- Recruit staff with adequate language knowledge for the target population.
- The tactics of implementation will be adapted to incorporate the best practices for the different scenarios derived from the stratified analysis.
- Work with local and regional partners to develop a strategy to the extent of the elimination of Malaria in the Guyana Shield.
- Increase the integration of malaria services with other health services for the vulnerable migrant populations in the mining areas.
- Increase the coordination and integration of activities in the interior to save costs.
- Maintain the operational capacity of the Malaria Service Deliverers Network
- Maintain the operational capacity of the primary health clinics for the vulnerable native populations in the interior villages to diagnose, treat and follow up cases and coordinate the response to outbreaks with the National Program.
- Improve the agility and integration of the information system, the analysis of data, and the response to information, porting it to HIS2.

- Active participation in regional and international efforts for the elimination of malaria.
- Adopt and adapt to the local needs of the international organizations' guidelines for eliminating malaria and the best existing scientific evidence.
- Regionally promote best practices.
- Expand Public-Private partnerships.
- Expand the participation of the local associations in work to raise the awareness of the communities in the early detection of cases and containment of outbreaks.

11. Implementation

The effort's success that led to the decrease of Malaria in Suriname was due to the focus on diagnosis and treatment, prioritization of high-impact interventions, adaptation to local needs, and integration of the implementation strategies. The implementation will be described in separate tables to guide the planning and budget. Their actual implementation is dynamic and integrated.

11.1. Intensify the current commitment and the national and regional coordination of the malaria elimination effort in the country and also work with the partners to the extent of the elimination of Malaria to the whole of the Guyana Shield.

The strategy is related to priority number one: to maintain the current program to reach elimination in Suriname, and in parallel also strive for regional elimination. For Suriname, the commitment to elimination includes active participation in the regional efforts for elimination in the Americas and the advocacy for an expanded regional approach to the problem. Suriname considers that a joint project, built upon the extremely successful model of the RAVREDA-Amazon Malaria Initiative (PAHO,2012); a low-cost initiative with an enormous impact; if focused on the elimination of Malaria would provide a solid ground for a joint effort in the Americas and most particularly at the Guyana Shield.

Suriname is planning to work with Guyana in order to support their program and possibly to write a joint proposal for the elimination of malaria in Guyana.

An effort will be made to keep the current trained staff to avoid high turnover and constant training of newcomers.

Tactics	Activities	Indicators	Outputs	Impact
1.1 Maintain and expand the level of financing for the elimination of Malaria.	Incorporate the diverse funds (MZ, BOG, Malaria Program) needed for malaria elimination in the multiannual development plan and the annual budget of the MOH.	Funds are allocated to the Malaria Program yearly.	A yearly Financial Report of the National Malaria Budget.	Sustained financial support for the Malaria Program.
1.2 Maintain the gratuity of the malaria diagnosis and treatment.	Free diagnosis and treatment are included in the budget.	Funds are allocated yearly.	A yearly budget covers the gratuity of services.	Sustained financial support for the gratuity.
1.3 Maintain and expand, as needed, the staff of the program.	Prepare the human resources plan for the execution of the NSP.	Positions described in the HR plan filled.	The human resources plan for the period of the NSP is updated annually.	The program is fully staffed to execute the plan.
1.4 Policies and technical decisions defined by the Malaria Elimination Task Force	Bi-monthly review of Malaria and readjustment of elimination policies, guidelines, SOPs, and other technical decisions implemented nationwide.	The number of meetings.	Agenda of the meetings. Bi-monthly integrated reports on the progress of Malaria elimination.	Program following the guidance of the Malaria Elimination Task Force.
1.5 Expand bilateral and multilateral cooperation to eliminate Malaria with France, Guyana, and Brazil.	Advocate through international organizations (GF through the CCM, PAHO-WHO), the foreign office, the Ministry of Health, and the local embassies.	Number and list of bilateral cooperation meetings, projects, and initiatives	Agreements signed.	Decrease of Malaria in the region.

1.6 Engage the Country Coordinating Mechanism (CCM) in preparing a joint project to eliminate Malaria in the **Guyana Shield in addition to the Suriname proposal.** .	CCM coordination through the Global Fund of the preparation of a multi-country proposal for eliminating the Guyana Shield. MOU with Guyana for cooperation in the elimination of malaria in Guyana. Draft of a project proposal. .	List of the meetings.	The project proposal will be completed in 2024.	Project Proposal presented to the Global Fund.
1.7Facilitate communication among donor organizations and partners.	Regularly share progress and new information with policymakers and partners and at national, global, and regional initiatives for containment of resistance and elimination of Malaria	List of meetings.	Active participation in global and regional initiatives for the containment of resistance and elimination of Malaria.	Decrease of Malaria in the region.
1.8 Advocate for the creation of a Project similar to the RAVREDA-Amazon Malaria Initiative (USAID) II will focus on the elimination of Malaria in the Americas.	Contact the countries of the region to draft a solicitation for a renewed regional effort, with a structure similar to the RAVREDA-AMI project but with a new focus on eliminating Malaria in the Americas.	Draft letter of intent for the creation of a new network focused on the elimination of Malaria in the Americas.	Presentation of the idea to the partners and international agencies, particularly PAHO and USAID Malaria initiative.	Letter of intent the countries of the region to create a new network for the elimination of Malaria in the Americas.

11.2. Maintain and strengthen the information system needed for early detection and the containment of re-establishment.

Data and information derived from it are key for elimination. This strategy is crucial to comply with WHO recommendation in the World Malaria Report 2022 related to the prevention of re-establishment is stated below:

" Once countries have eliminated Malaria, they should sustain the minimum activities necessary to prevent re-establishment in areas with malariogenic potential (i.e., risk of importation in areas receptive to transmission). Malaria-free countries should maintain vigilance to detect imported cases that might occur anytime and anywhere rapidly. Detection of introduced or indigenous cases should trigger a rapid response and a thorough investigation to prevent further transmission."

Suriname has a database aggregating different data sets with information about malaria cases. It started with an ingenious system of data transmission from the interior via radio and currently uses near real-time communication via cell phone. Malaria Service Deliverers receive cell phones to maintain contact with the program. The first steps to implement the DHIS2 system have been completed, and the country will be implementing it. A database with geographically referenced localities of infection was updated and will be used as the basis of microstratification. MZ also has an information system that links the village polis to the central office in Paramaribo. Due to its commitment towards regional elimination, Suriname is proposing a regular effort to jointly analyze and report the malaria situation with all the countries of the Guyana Shield that are adopting DHIS2. A regional weakness is the absence of data from the southern part of French Guyana.

Tactics	Activities	Indicators	Outputs	Impact
2.1 Maintain and improve the capacity of the information system.	Training for the use of the DHIS2 system. Annual training on the use of standard templates to analyze malaria occurrence.	List of the trainees	Monthly reports produced with the DHIS2.	DHIS2 was implemented and used in the Malaria Program data management system.
2.2 Improve the data on the follow-up and the localization of the localities generating cases.	Creating a georeferenced list of localities to map the cases in the interior and gold mining areas integrated into the DHSI2. Stratification of Malaria based on the georeferenced cases.	100 % of the malaria cases geo referenced to the area of probable transmission.	List of georeferenced localities completed and updated semiannually included in the DHSI2. Annual stratification of Malaria using the data.	Improved malaria stratification.
2.3 Maintain and expand the exchange of information with the countries of the Guyana Shield.	Monthly exchange of data through PAHO, through bilateral agreements, and by the publication of data online.	List of monthly reports published.	Monthly report online	Improved regional surveillance. Improved containment of outbreaks.
2.4 Monitoring insecticide resistance (part of the entomological activities described in table 7).	Bottle and WHO paper tests.	Results of the tests.	Trips to the interior for mosquito capture. Online meetings to share the data regionally. Contract of entomologist for the activity.	Early detection of insecticide resistance.

2.5 Monitoring of resistance of parasites to antimalarial drugs is part of the operational research activities described in table 8).	Molecular resistance study.	Results of the molecular studies of resistance.	Collection and storage of strains of parasites in the MWI laboratory. Molecular markers for *P. falciparum* resistance analyzed. Online meetings to share the data regionally.	Early detection of antimalarial resistance.

11.3. Maintain the focus on diagnosis, treatment, investigation, and response (DTIR) to avoid local cases and re-establishment.

The main focus of the Suriname program has always been on prompt diagnosis and treatment, followed by investigation and response, as it is currently being proposed as the main priority of PAHO for the elimination of Malaria in the Americas. With the reduction in the number of cases diagnosed in Suriname, the intensity of the investigation and response to individual cases has been increased and is more detailed. Each case or conglomerate of cases will be analyzed to plan the response. Localities generating cases have been mapped. Early treatment is especially important for the cases of *P. vivax* due to the early appearance of gametocytes leading to the early transmission before clinical symptoms. Some operational research priorities described in item 8 are related to improving DTIR. More emphasis will be placed on the participation of local MSDs in the detection and containment of outbreaks. Tafenoquine will be piloted along with G6PD testing in Indigenous villages. Financial support for the Program and MZ staff to travel as soon as possible to the interior for the investigation and containment of Malaria is essential to avoid re-establishment.

Tactics	Activities	Indicators	Outputs	Impact
3.1 Maintain the localization, investigation, and follow-up of the localities generating cases.	Follow up on the full treatment and control of the cure of the cases. Use phone contact with patients that do not stay in the city.	Percent of suspect cases of Malaria diagnosed and treated within 48 hours. Percent of localities with cases that were investigated and followed.	Monthly report of the percentages with epidemiological analysis.	Prevention of re-establishment.
3.2 Support for the follow-up in near real-time the occurrence of cases in the interior villages.	Compilation of data weekly with MZ.	Percentage of outbreaks in the villages detect in less than one week.	Weekly reports of cumulative cases highlighting possible outbreak areas and localities. Annual report of the percentage of outbreaks detected in one week.	Prevention of re-establishment.
3.3 Clear communication of the cases diagnosed by MZ and the MSDs to the central level.	All cases informed by phone to the central level and compiled in 24 hours.	Percentage of cases that were informed in 24 hours.	List of regular contacts with MZ three times a week to keep track of the national distribution of cases. List of contacts with MSDs weekly.	Prevention of re-establishment.
3.4 Support for trips to investigate cases and possible outbreaks.	Trips to the villages of the interior of the national program staff and MZ staff to investigate reports of cases and possible outbreaks.	Percentage of outbreaks that were investigated in the first week.	Reports of the investigation of outbreaks.	Prevention of re-establishment.
3.5 Support the activities of outbreak containment.	Trips to the interior of staff of the national program and or MZ to contain outbreaks.	Percentage of outbreaks contained within ten days.	Reports of the activities of outbreak containment.	Prevention of re-establishment.

3.6 Promote increased patient adherence to full treatment.	EIC material is distributed when treatment is prescribed, distributed, and broadcasted. Expand the initial focus to the treatment of *P. vivax*.	90% of cases completed the treatment scheme.	Follow up of previous KAP study to evaluate changes in the pattern of adherence to diagnosis and treatment and its determinants.	Increased adherence to full treatment.

11.4. Maintain the capacity of the network of primary health care clinics to deliver malaria services to the vulnerable native populations in the villages of the interior to avoid re-establishment in the villages.

The existence of MZ policlinics with a cadre of well-trained professionals was and is one of the keys to the success of the elimination effort. With the declining virtual elimination of transmission in most villages, the need to maintain awareness of the possible reintroduction of Malaria and the essential capacity for diagnosis and treatment is high. It is also important that the community is aware of how Malaria can be reintroduced and that they are actively engaged in avoiding it. This can be facilitated by the traditional local authorities and by the local associations. Since new tests will be piloted, such as new RDTs, new Hemozoin-based tests, and G6PD tests, if they are approved for regular use, it will be necessary to train the staff to use them. Due to the high turnover of staff working in remote areas, continuous training is needed for the staff of MZ primary health care clinics. The staff training is being integrated with the training to deal with other parasitological diseases, especially the emerging problem of Chagas in the Amazon, Leishmaniasis, and other vector-borne diseases such as the arboviruses, and the use of microscopy for the diagnosis of Leprosy. MZ needs support for the renewal and maintenance of equipment due to the high wear caused by the conditions in the interior. The needs related to the investigation and containment of Malaria in the villages are listed in table 3.

Tactics	Activities	Indicators	Outputs	Impact
4.1 Maintain and expand the current staffing of Malaria in the border labs and the polyclinics.	Trained staff available in all the policlinics.	Percent of sites without staff.	Human resources contracted with competitive salaries.	No interruption in work.
4.2 Clinics supplied to provide diagnosis and treatment.	Acquisition of supplies for diagnosis and treatment. Distribution of supplies. Stock control.	The number of stockouts of diagnosis or treatment.	Stock control database.	No stockouts.
4.3 Staff trained and evaluated in microscopy, diagnosis, treatment, and new tests when available.	Annual training. Updated material for the training as needed.	Percent of policlinics with staff trained annually.	List of training and trainees. Educational material used in training.	Staff trained.
4.4 Evaluation of the performance of microscopists in both public and private labs.	Evaluate the individual competence of microscopists using PAHO protocol. Retrain the failed.	Percent of microscopists evaluated.	Results of the evaluation. Lab certification. Retraining of staff not competent.	Competent microscopists. Labs certified.
4.4 Staff trained in the microscopic diagnosis of other parasitic diseases.	Annual refreshment training in series with the malaria training.	Percent of selected policlinics (the ones with microscopists) with trained staff	List of training and trainees. Educational material used in training.	Microscopists are capable of diagnosing other parasitic diseases.
4.5 Staff trained to recognize and do initial treatment of severe Malaria.	Annual refreshment training. Analysis of determinants of severe cases	Percent of policlinics that were selected with trained staff. Malaria mortality.	List of training and trainees. Educational material used in training.	Reach zero malaria mortality related to inadequate management.
4.6 Staff trained to start in DTIR.	Annual training for all the staff in cascade.	Percent of the total number of policlinics with local training.	List of training and trainees. Educational material used in training.	Prevention of re-establishment.

4.8 Increased community participation and awareness.	Annual meetings in all the villages and localities with risk of reintroduction according to stratification of cases. Take advantage of Kutrus organized by MZ.	Percent of localities in the high risk for re-establishment strata covered per year.	Involve local MZ, NGOs, community leaders, mining cooperatives, companies, and associations. Educational material used in the awareness campaigns. Sequential KAP studies.	Prevention of re-establishment.
4.9 Material produced for awareness campaigns.	Development and translations of awareness Materials.	List and numbers of materials used.	Educational materials produced.	Increased knowledge, attitude and practices.
4.10 Staff trained in outreach/BC communication with the target population.	Annual training for MSD and GZA (MZ).	The number of staff trained.	List of training and trainees. Handouts/training materials.	Increased knowledge, attitude and practices.
4.11 Renewal and maintenance of equipment for diagnosis.	Training in the maintenance of microscopes. Revision of the equipment in the public and private labs (BOG). Entertain the possible contact with Brazil, in Fiocruz, for the training.	Number of trainees in the maintenance of the equipment.	Report on the condition of the equipment.	Lab certification.

11.5. Maintain and expand the integrated health services for vulnerable migrant populations.

The malaria service deliverers network is crucial for the program. MSDs is a core strategy created in Suriname to deliver malaria services in the barren and remote areas of the small-scale gold mining in the Amazon region.

It involves recruiting local individuals to use rapid diagnostic tests and deliver treatment. Treatment is followed up, and the cases are reported to the main level of the program. It is an important part of epidemiological intelligence. It allows the early detection of possible outbreaks in the mining areas. The supervisors of the MSDs in the interior are provided with phone cards to call the main level for reporting. MSDs are a mix of volunteers working in smaller areas and individuals who receive some financial and travel support to cover larger areas. MSDs have an impact even across the border in French Guiana since some of them travel across the border.

MSDs are regularly supervised. Due to the high costs of traveling to and through the interior, supervision should be integrated with other activities, especially the ones related to increasing the awareness of communities. The MSDs are involved in passive and active case detection and the distribution of LLINs. In some sites, they are provided with an All-Terrain Vehicle (ATV) and or a boat to increase their coverage area. Similar to what is happening in the villages, with the declining, virtual elimination of transmission, the need to maintain awareness of the possible reintroduction of Malaria and the essential. Therefore, the community must be aware of how Malaria can be reintroduced and that they are actively engaged in avoiding it.

The expansion of other health services to the Brazilian community of the mining areas is being discussed with Brazilian authorities. The matter will be pursued with the embassy and the new Brazilian government. There is also a possibility of further IDB funds for this matter.

Tactics	Activities	Indicators	Outputs	Impact
5.1 Maintain and expand the current staffing levels of MSD in the gold mining areas, depending on need.	Diagnosis and treatment are made available in strategic mining areas. Expand activities in the western part of the country and in the future anywhere where there is a high risk of re-establishment.	Percent of MSD coverage in the high-risk areas.	List and map MSDs working in malaria high-risk mining sites and supply areas vis a vis the occurrence of Malaria.	Prevention of re-establishment in mining and supply areas.
5.2 Maintain the MSDs supplied to provide diagnosis and treatment.	Supply the MSDs regularly. Schedule of supply in coordination with the bi-monthly supervision.	Percent of MSDs with stock outs. Duration of the stock outs.	Schedule of supply in coordination with the bi-monthly supervision. System for accountability of supply management.	No stock outs.
5.3 MSDs trained in the use of RDTs and malaria treatment.	Semiannual refreshment training and training of new MSDs. Evaluation of the performance of the MSDs.	Percent of MSDs trained of the core number of MSDs working for the program.	List of training and trainees. Educational material used in training.	Improved adherence to guidelines of diagnosis and treatment increased.
5.4 Supervision visits to the MSDs areas.	Bimonthly supervision. Schedule supervision trips to the interior in coordination with the supply of the MSDs.	MSDs follow guidelines for treatment and diagnosis.	Report with the analysis of the findings of the supervision. Remediation of the problems found.	Improved adherence to guidelines of diagnosis and treatment increased.
5.5 Increased community participation.	Meetings with representatives of the local communities parallel to the supervision.	Percentage of MSDs with meetings in their area of coverage.	List of meetings and attendees. Material for the awareness campaigns.	Increased insight into the needs of the community's health.
5.6 MSDs reporting in near real-time the cases of Malaria.	Regular reporting by cell-phone.	Percentage of positive cases reported within 48 hours.	Analysis of MSDs reporting.	Reporting component of DTIR sped up.

5.7 Maintenance of vehicles and cabins functioning as posts.	Use the system to control the use of vehicles. Maintenance of boats and ATMs. Schedule of maintenance of the equipment.	Percent of vehicles with regular maintenance.	Vehicle use and maintenance database. Report on the use of the vehicles.	Expansion of the area covered by the MSDs.
5.8 Plan and implement the integration of services for Malaria and other possible health priorities of the gold miners that can be implemented by the MSDs.	Meetings with the mining community and Brazilian embassy. Bilateral and IDB discussion for the integration of services.	List of meetings and Agreements.	Report of the activities implemented concerning the agreements.	Improvement of some aspects of the health of the mining community

11.6. Maintain and expand the clinics and posts for free malaria diagnosis and treatment in sites that facilitate the access of high-risk migrants.

As discussed in the epidemiology analysis, the current main risk group and vulnerable population in Suriname are small-scale miners who travel mainly from Brazil to mine in the French Department of French Guianaand Suriname. They arrive mainly overland, by bus or even walking but also by boat and by plane from Brazil to Guyana.

There are important points of entry and points where the miners working in Suriname supply themselves for their activities inland. The knowledge of the entry and supply routes has been used by the Malaria Program to establish in these strategic places the capacity to provide prevention, diagnosis, and treatment of Malaria. They are situated along the border with French Guiana(border screening posts) and in Paramaribo in the neighborhood (TropClinic) favored by the miners and in the periods of higher incidence in the past.

Due to the decrease in the number of cases of Malaria, the sites are being integrated with the health system to provide other preventive and diagnostic services such as HIV testing and counseling, and condom distribution. They are being expanded to include Leishmaniasis and Leprosy. With the growing numbers of individuals coming through Guyana, new posts will be established on the western border both at legal and illegal points of entry. Training of the staff in the health clinics and private labs will continue to maintain the quality and the speed of the diagnosis and treatment as well as the communication of the cases for surveillance and follow-up.

There are bilateral efforts with Brazil to expand those services. Since most of the users of the clinic and border posts are Portuguese speaking, all the labs include personnel fluent in Portuguese as their mother tongue. The head lab is at TropiClinic, in Paramaribo, and it is where the Malaria Program has its office. The Information System is consolidated in the Malaria Program office.

The Malaria Laboratory in the Central Laboratory of the BOG is the national reference lab responsible for quality control and training. It is accreditated by WHO every two years. It has two microscopists that are certified by WHO. All the laboratories send their slides for re-check. The new guidelines for quality control of diagnosis recommended by a PAHO mission in 2019 were implemented.

Tactics	Activities	Indicators	Outputs	Impact
6.1 Maintain and expand the current structure of strategically located labs.	Provide prevention, diagnosis, and treatment. Expand services on the western border.	Maintenance of the number of sites providing services. Numbers of new sites opened.	List and map the sites.	Expansion of the delivery of services. Prevention of re-establishment.

6.2 Maintain the existing integration of services.	Expansion of the current scope of services, HIV, TB, Leprosy, Covid19.	Percent of strategic labs providing HIV counseling and testing. Percentage of strategic labs providing other services.	Semestrial report with the services provided.	Improvement of HIV management and some other aspects of infectious diseases in the mining community
6.3 Staff of the labs trained in counseling, microscopy, diagnosis, and treatment of the expanded diseases	Annual training that includes the new disease guidelines.	Percent of the staff trained.	List of trainees and meetings. Materials used in training.	Improvement of HIV management and other aspects of infectious diseases in the mining community.
6.6 Maintain the Parasitology-Malaria Lab in the BOG.	Quality control of diagnosis and labs. Microscopy training. Control of slides from the blood bank. Contract a parasitologist.	The number of cases diagnosed and the number of slides reads. List of activities.	Report on the quality control of Blood Bank. List of training and trainees.	Diagnosis improved in the country.
6.8 Maintain the training and supervision of the Private Labs	Certification and quality control of the labs by the Bureau of Public Health (BOG) Guarantee prompt diagnosis in the private lab in real-time.	Percent of labs supervised per year. Percent of diagnosis done in real-time.	Annual report of the BOG central lab about the private labs.	Improved diagnostic capacity in the private labs.

11.7. Strengthen the entomological component to improve vector management.

WHO urges malaria-endemic countries to invest in public health entomology capacity to support the control and elimination of Malaria. In Suriname, due to the loss of personnel, the capacity for implementing diverse entomological activities was decreased and is being strengthened. An entomologist works on the project to coordinate the activities and train field workers to execute the entomological activities. Monitoring the resistance to insecticides is a top priority since Suriname uses LLINs to prevent Malaria in high-risk groups. The level of adherence to the use of

nets varies in the different interior populations. According to WHO, guidelines nets must be selected according to local preferences. In Suriname, there is a clear preference for a type of net, dark, large, adequate for a mobile population, that can be used for both hammocks and beds. The different populations at risk prefer this type of net. Some Indigenous prefer thick nets made of cloth that cannot be impregnated with insecticides. They are used in their homes and camps, hunting, slashing, and burning agricultural huts. Standard nets have low acceptability. The traditional cloth nets could, however, be used under LLINs. The preferred nets have a higher price that is justified by adherence.

Standard LLINs have low acceptability. LLINs will be prioritized in high-risk areas with a history of adherence to LLINs, such as villages with cases. The distribution of nets to gold miners needs a similar strategy to increase adherence to their use and needs re-evaluation. The dynamics of the population of An. darlingi was strongly related to the incidence of Malaria in Suriname. Monitoring this dynamic is important for evaluating the susceptibility of Malaria and the risk of reintroduction. Three sentinel sites in strategic places are established. The entomological aspects of persistent outbreaks (indigenous cases for more than two weeks) will also be investigated.

Tactics	Activities	Indicators	Outputs	Impact
7.1 Maintain the contract of an entomologist.	Coordination of entomological activities.	Entomology under a contract.	Entomological report.	Allow WHO entomological requirements for elimination to be achieved.
7.2 Capacity building activities in the entomology lab of the Bureau of Public Health.	Train the team of BOG technicians for entomological activities.	The number of technicians trained.	Reports of the training and material used.	Allow WHO entomological requirements for elimination to be achieved.

7.3 Monitoring of insecticide resistance.	Bottle and WHO paper tests.	Results of the tests.	A regular report is published and shared with the network shared with partners (neighbor countries and WHO).	Allow WHO entomological requirements for elimination to be achieved.
7.4 Implementation of vector studies in persistent outbreaks.	Implementation of vector studies in areas with outbreaks.	Percent of outbreaks detected with an entomological report.	Guideline for entomological studies in outbreaks developed.	Allow WHO entomological requirements for elimination to be achieved.
7.5 Sentinel sites studies.	Regular studies of population dynamics and behavior.	Percentage of the planned studies executed.	Report of the studies.	Detection of possible changes in the entomological scenario.
7.7 Acquisition of the preferred nets.	Acquisition of the nets that were selected in the KAP studies.	Percent of nets acquired of the good type.	Definition of the type of net acquired according to the preferred types.	Improved adherence to the use of nets.
7.8 Focused use of LLINs in groups with a high risk of transmission that adheres to the use of nets.	Identify the groups based on the epidemiological data of the last five years and the previous KAP studies.	90 % possession of LLINs among the target populations.	Report on selecting groups/areas to be targeted by the LLINs distribution. KAP's study on the target groups' ownership and use of nets.	Prevention of Malaria in target groups.
7.9 Promotion of adherence to the use of nets.	Installation of nets in the target area. Community meetings to explain the use of nets.	80 % of individuals in the targeted group slept under a net the night before.	Guidelines for the installation. Material for community meetings.	Increased adherence to the use of nets in target populations.

11.8. Execute key operational research to generate evidence to avoid re-establishment and acceleration of the impact towards elimination.

Suriname has the installed capacity to execute the necessary molecular and serological studies in the MWI laboratory. The objective of the investigations is to test, evaluate, and select strategies of impact. The rationale for testing novel strategies is threefold: to find ways to impact Malaria in the gold miners in the French areas, to improve the early detection of imported cases, and to contain outbreaks. Especially the outbreaks caused by *P. vivax* that have a longer duration due to the relapses. The use of serology to identify past infections of *P. vivax* to focus on the treatment of potential hypnozoite carriers will also be investigated as one of the tools to contain the outbreaks caused by relapses. Expansion of the use of Malakit, a tool for self-testing and treating Malaria in the areas with no access to malaria services in the French Department of French Guianacurrently being evaluated. Since the number of *P. falciparum* cases is quite small, molecular studies of the presence of genes related to resistance and molecular epidemiology are a must, part of the elimination effort according to WHO guidelines.

Tactics	Activities	Indicators	Outputs	Impact
8.1 Expand and continue evaluating the use of the Malakit, self-test, and self-treatment kit.	In coordination with the French and Brazilian health authorities, design an expansion of the test distribution with an extra effort to distribute the test in French territory. Follow up on the evaluation of the impact of the kits	Percent of increase in the number of Kits distributed per year.	Evaluation of the impact.	Increased access to diagnosis and treatment in areas without easy access, emphasizing the South of French Guyana.

8.2 Identification of all Malaria cases for molecular epidemiology.	Maintaining and Quality Control of the national malaria gene bank. Molecular typing of strains.	Percent of cases with strains analyzed.	A regular report published and shared with partners	Allow WHO epidemiological requirements for elimination to be achieved.
8.3 Introduction of g6pd tests previous to combination Cq+Tafenoquine for *P. vivax* treatment.	Use of WHO-recommended g6pd tests in the population using the new combination. Evaluate the impact on the relapse rate.	Percent of vivax cases tested and treated with the new protocol.	Design of the protocol for the testing Results of the evaluation published.	Decrease in the relapse rate in vivax outbreaks.
8.4 Re-treatment of *P. vivax* cases in outbreaks to minimize the impact of relapses.	Treatment and follow-up in villages with outbreaks by MZ and Malaria Program.	Percent of relapses after the re-treatment.	Report of the impact of re-treatment.	Decrease in the relapse rate in vivax outbreaks.
8.5 Serology as means to detect a relatively recent infection to guide decision-making for re-treatment or focal mass therapy.	Collection of blood samples.	Design and implementation of the protocol.	Results of the detection of past infections used in focused MDA.	Decrease in the relapse rate in vivax outbreaks.
8.6 Continued monitoring of molecular resistance markers in all Falciparum cases.	Samples from all P.falciparum cas Molecular studies of resistance in MWI.	Percent of *P. falciparum* cases studied.	The results of the molecular studies were published and shared with partners.	Allow WHO epidemiological requirements for elimination to be achieved.
8.7 Preparing molecular assays for screening for potential markers for reduced susceptibility to Chloroquine, Primaquine, and/or Tafenoquine.	Samples from cases.	Molecular Studies in MWI.	The results of the molecular studies were published and shared with partners.	Allow WHO epidemiological requirements for elimination to be achieved. Early detection of resistance to first-line antimalarials.

8.8 Serology as a stratification tool for regions without Malaria and a low malaria historical burden.	Selection of technique to use.	Design and implementation of the protocol.	Published results.	Prevention of re-establishment.
8.9 PCR-RFLP during *P.vivax* outbreaks. (molecular outbreak reconstruction or as support for decisions on the selection of a type of interventions	Samples from outbreaks.	Molecular outbreak reconstruction or as support for selecting a type of intervention.	Design and implementation of PCR.	Prevention of re-establishment.
8.10 Molecular analysis of paired samples for all recurrent malaria cases *P.falciparum* and *P.vivax*.	Samples from recurrent cases suspected of relapses.	Percent of vivax recurrent cases analyzed.	Publication of results.	Allow WHO epidemiological requirements for elimination to be achieved.

11.9. Activities Related to the Engagement of the High-Risk Groups and Vulnerable Populations in the Malaria Program

Most of the activities described in table 9 have already been included in the previous tables and discussed in section 5.4. Since they are key for the impact of a program that, at its core, is centered on the delivery of diagnosis and treatment to vulnerable populations, it was decided that they should be presented in a separate table. They are transversal to all the activities with the communities.

Tactics	Activities	Indicators	Links with other tables
9.1 Free delivery of malaria services	No barriers to access to the free services.	Diagnosis and treatment are free in all public services.	1.2 Maintain the gratuity of the malaria diagnosis and treatment.
9.2 Geographical distribution of the services determined by the needs of the vulnerable population	Stratification and map of the distribution of services	Map with the distribution of cases and services.	5.1 Maintain and expand the current staffing levels of MSD in the gold mining areas, depending on need.
9.3 Selection of staff locally with the communities taking into consideration language skills.	Process of selection with the communities	List of MSDs	
9.4 Traditional authorities and communities involved in the decision making	The selection of strategies and planning is influenced by the participation of communities.	KAP studies and meetings with the communities	4.8
9.5 KAP studies on the adequacy, acceptance, and evaluation of the program by the communities.	Follow-up of KAP studies	KAP studies analyzed	7.7, 7.8, 4.8, 3.6

11.10. Addition: Health System Strengthening as part of acceleration of the impact towards elimination.

Recognizing that malaria interventions are closely dependent on the Health System Strength in general, especially on having the infrastructure and trained human resources, as well as the necessary technology i.e. for data management in place, this section of the National Malaria Elimination Plan was added to highlight some of the activities identified necessary at this point. The Health System has been severely impacted by consecutive periods of economic downfall and the pressure of the COVID pandemic. Maintenance of capacities has suffered, resulting in the need of 'catch-up' or restorative interventions. A budget addendum for this section has been established.

Tactics	Activities	Indicators	Comments
National HR capacities for Malaria (outside MP), Integrated health service provision and RSSH	Ensure salaries and subsidies for malaria and integrated health services	HR in place for all key positions at all key localities	Payment of salaries/subsidies is done by the MoH to ensure full HR capacities.
Guiana Shield commitment to Malaria Elimination	Suriname-Guyana (regional)workshops on collaboration and alignment of strategies (including field visits to assess best practices)	Agreement on collaboration toward malaria elimination in the Guiana Shield and aligned strategies	One MoU is already in place between the MoHs of Guyana and Suriname, more elaborate MoUs on collaborative interventions, aligned strategies are needed
Sustainable health care in the hinterland of Suriname	MZ capacity building ; infrastructure, equipment, HR training	up to date and adequate facilities, equipment and HR for integrated service provision in the Interior of Suriname	Infrastructure renovated/build, equipment purchased, people trained. This activity is aligned with the MZ capacity building plan.
Capacities for radical treatment of Pv malaria for mobile migrant context	French Guiana, Brazil, and Suriname pilot on Radical Treatment (CURE-MA- co-funding)	Research data on the potential and challenges for introduction of radical Treatment in the mobile migrant context	Curema details available on the www.malakit-project.org website. Ongoing activity.

Integrated health service provision in remote mining context	Extended Pilot on the introduction of integrated health services in the MSD network	Completion of pilot, recommendations for full implementation	Pilot Report, including recommendations. Extension of activity currently funded from MoH/IDB project
Central Data Management Unit at the MoH	RSSH- establishement of Central Data Management Unit at the Mo	CDMU in place	Needs procurement of equipment, supplies, training of HR, establishment of dedicated department
Online LAB information system	RSSH- Establishement of online lab information system at Central Lab (BOG)	OLIS in place	Needs Contract for IT support, equipment procured, all stakeholders on board
Operational Albina Hospital	RSSH finalization and operationalization Albina Hospital	Albina Hospital operational	Infrastructure, equipment, HR in place. Currently being implemented (with delays) from AFD cooperation.
Prevention of Malaria Re-introduction via West border	Establish outreach and essential health services in remote hard to reach (tribal) populations along the West border (including Tigri area)	More elaborate activities to ensure capacities for Malaria cases interception at the western border, and re-introduction prevented	BCC/IEC and ACD/LLIN distribtution mission in remote tribal settlements not currently accessed by the Medical Mission. Following recent outbreak situation (dec 2023) in Tigri area.
Health Services improvement	Capacity building (equipment, infrastructure, training of personnel) Malaria Program and AMC	up to date and adequate facilities, equipment and HR for integrated service provision in the Interior of Suriname	Infrastructure renovated/build, equipment purchased, people trained

12. Databases analyzed for the report:

1. Malaria data of the National Malaria Program Suriname.
2. Data Annexes of the World Malaria Report 2021.
3. Malaria Data 2010-2022 Brazilian Malaria, Tableau Public.

13. Literature used for the report:

1. Adhin, Malti R., et al. Gold mining areas in Suriname: reservoirs of malaria resistance? IDR, vol. 7, 5 May. 2014, pp. 111-6, doi:10.2147/IDR.S60906.
2. Adhin M.R., Labadie-Bracho M. and Bretas G. Am.J. Trop. Med. Hyg. 89 (2): 311–316 (2013)
3. Adhin M.R., Labadie-Bracho M. and Vreden S.G. Malaria Journal 11:322 (2012)
4. Aldighieri, S., et al. Surinam, a key partner in public health regional cooperation in Guyana. Med.Trop.(Mars)., vol. s, no. ., 2000, p. 2000;60, www.ncbi.nlm.nih.gov/pubmed/11436581.
5. Agence Regional de Sante, https://www.guyane.ars.sante.fr/paludisme.
6. Blancodini Patrick. Orpaillage, pollution et problèmes sanitaires : l'exemple de la Guyane française, Geoconfluences. 17 Feb. 2020,
7. Breeveld, Florence JV, et al. History of malaria research and its contribution to the malaria control success in Suriname: a review. Malar. J., vol. 11, no. 1, Dec. 2012, pp. 1-7, doi:10.1186/1475-2875-11-95.
8. Buckee CO, Laxminarayan R, Hay SI, Tatem AJ. 2013 A sticky situation: the unexpected stability of malaria elimination. Phil Trans R Soc B 368: 20120145.
9. Chenet, Stella M., et al. Molecular Profile of Malaria Drug Resistance Markers of Plasmodium falciparum in Suriname. Antimicrob. Agents Chemother., vol. 61, July 2017, p. 7, doi:10.1128/AAC.02655-16.
10. Crowe, V. et al. Can we depend on case management to prevent re-establishment of P. falciparum malaria, after local interruption of transmission? Epidemics, November, 2011.
11. de Santi, Vincent Pommier, et al. Malaria in French Guiana Linked to Illegal Gold Mining. Emerg. Infect. Dis., vol. 22, no. 2, Feb. 2016, p. 344, doi:10.3201/eid2202.151292.
12. de Santi, Vincent Pommier, et al. Malaria Hyperendemicity and Risk for Artemisinin Resistance among Illegal Gold Miners, French Guiana - Volume 22, Number 5—May 2016 Emerging Infectious Diseases journal - CDC. Emerging Infectious Diseases journal, 2020, doi:10.3201/eid2205.151957.
13. de Smet, E., et al. Viver nas corruptelas pan-amazonicas: consumo conspícuo e religião em garimpos transnacionais. Vrije Universiteit Amsterdam, 2012, pp. 37-58, research.vu.nl.
14. de Theije M, Heemskerk M 2009. Moving frontiers in the Amazon: Brazilian small-scale gold miners in Suriname. Eur Rev Latin Am Carib 2009: 5-25.
15. de Theije M, 2010 Flexible migrants. Brazilian gold miners and their quest for human security in Surinam. In A world of insecurity: Anthropological perspectives on human security, ed. Ellen Bal et al. London/Sterling Virginia: Pluto Press.

16. DSDS de Guyane Cire Antilles-Guyane: Surveillance épidémiologique du paludisme en Guyane, Février 2006.
17. Douine, Maylis, et al.. Prevalence of Plasmodium spp. in illegal gold miners in French Guiana in 2015: a hidden but critical malaria reservoir. Malar. J., vol. 15, 2016, doi:10.1186/s12936016-1367-6.
18. Douine, Maylis, et al. .Investigation of a possible malaria epidemic in an illegal gold mine in French Guiana: an original approach in the remote Amazonian forest. Malar. J., vol. 18, 2019, doi:10.1186/s12936-019-2721-2.
19. Douine, Maylis, et al. Malakit: an innovative pilot project to self-diagnose and self-treat malaria among illegal gold miners in the Guiana Shield. Malar. J., vol. 17, no. 1, Dec. 2018, pp. 1-8, doi:10.1186/s12936-018-2306-5.
20. Douine, Maylis. Epidemiologie du paludisme chez les personnes travaillant sur des sites d'orpaillage illégal en Guyane : Quels enjeux pour la santé publique ?. Autre [q-bio.OT]. Université de Guyane, 2017. Français.
21. Douine, Maylis., et al. Self-diagnosis and elf-treatment of malaria in hard-to-reach and mobile populations of the Amazon: results of Malakit, an international multicentric intervention research project. The Lancet Regional Health - Americas 4 (2021).
22. Ejov M. , Davidyants V. , Zvantsov A. Regional framework for prevention of malaria reintroduction and certification of malaria 12014–2020, WHO Europe (2014).
23. Lacerda, Marcus V. G., et al. Single-Dose Tafenoquine to Prevent Relapse of Plasmodium vivax Malaria. N. Engl. J. Med., vol. 380, no. 3, 16 Jan. 2019, pp. 215-28, doi:10.1056/NEJMoa1710775.
24. Llanos-Cuentas, Alejandro, et al. Tafenoquine versus Primaquine to Prevent Relapse of Plasmodium vivax Malaria. N. Engl. J. Med., vol. 380, no. 3, 16 Jan. 2019, pp. 229-41, doi:10.1056/NEJMoa1802537.
25. Leontien Cremers, Judith Kolen and Marjo de Theije (eds Small-Scale Gold Mining in the Amazon. The Cases of Bolivia, Brazil, Colombia, Peru and Surinam.
26. Eersel, Marthelise Gm, et al. Fifty years of primary health care in the rainforest: temporal trends in morbidity and mortality in indigenous Indigenous populations of Suriname. J. Glob. Health, vol. 8, no. 2, Dec. 2018, p. 020403, doi:10.7189/jogh.08.020403.
27. Faway, Emilie, et al. Plasmodium vivax multidrug resistance - 1 gene polymorphism in French Guiana. Malar. J., vol. 15, no. 1, Dec. 2016, pp. 1-7, doi:10.1186/s12936-016-1595-9.
28. Fletcher I. K. et alli. Synergies between environmental degradation and climate variation on malaria re-emergence in southern Venezuela: a spatiotemporal modelling study. Lancet Planet Health 2022; 6: e739–48.

29. Garcia, K.K.S., Abrahao, A.A., Oliveira, A.F.d. et al. Malaria time series in the extra Amazon region of Brazil: epidemiological scenario and a two-year prediction model. Malar J 21, 157 (2022).
30. Hay Simon, David L Smith, Robert W Snow Measuring malaria endemicity from intense to interrupted transmission, Lancet Infect Dis 2008; 8: 369–78
31. Hemskeerk M, Study on the knowledge, attitudes and practices of malaria and malaria treatment in the small-scale gold mining sector in Suriname.
32. Hemskeerk M, Looking for gold, finding malaria Assessment of changes in malaria-related knowledge, attitudes, and practices resulting from the Ministry of Health malaria program in small scale gold mining areas in Suriname.
33. Heemskerk M. , Jacobs E. , Pratley P. , Mobile Migrant population study Suriname: Assessment of mobile migrant population size, demographics, turnover, movement, and priority health needs Royal Tropical Institute, Amsterdam Second final draft, 26 March 2021.
34. Hiwat, Helene, et al. Malaria epidemiology in Suriname from 2000 to 2016: trends, opportunities and challenges for elimination. Malar. J., vol. 17, no. 1, Dec. 2018, pp. 1-13, doi:10.1186/s12936-018-2570-4
35. Hiwat, Helene, et al. Collapse of Anopheles darlingi Populations in Suriname After Introduction of Insecticide-Treated Nets (ITNs); Malaria Down to Near Elimination Level. Am. J. Trop. Med. Hyg., vol. 86, no. 4, 1 Apr. 2012, p. 649, doi:10.4269/ajtmh.2012.11-0414.
36. Hiwat, Helene, et al. Novel strategies lead to pre-elimination of malaria in previously highrisk areas in Suriname, South America. Malar. J., vol. 11, 2012, p. 10, doi:10.1186/14752875-11-10.
37. Hoefte, R., et al. Post-Colonial Trajectories in the Caribbean. Taylor & Francis, 2016.
38. Labadie-Bracho, Mergiory and Malti R. Adhin. Increased pfmdr1 copy number in Plasmodium falciparum isolates from Suriname. Trop. Med. Int. Health, vol. 18, no. 7, 27 Apr. 2013, pp. 796-9, doi:10.1111/tmi.12118.
39. Labadie-Bracho MY, Adhin MR. Reconstruction of Plasmodium vivax outbreaks in a low malaria endemic setting utilizing conventional restriction fragment length polymorphism, Malaria serology data from the Guiana shield: first insight in IgG antibody responses to Plasmodium falciparum, Plasmodium vivax and Plasmodium malariae antigens in Suriname. Malaria Journal 19: 360 (2020).
40. Lambert Y., et alli, Impact of Malakit intervention on perceptions, knowledge, attitudes, and practices related to malaria among workers in clandestine gold mines in French Guiana:results of multicentric crosssectional surveys over time. JMIR Form Res 2022 , vol. 6, iss. 6.
41. Longchamp C., Impact of Malakit intervention on perceptions, knowledge, attitudes, and practices related to malaria among workers in clandestine gold mines

in French Guiana: results of multicentric crosssectional surveys over time, Research Square, February 2022.
42. Mac Donald-Ottevanger, M. Sigrid, et al. Primaquine double dose for 7 days is inferior to single-dose treatment for 14 days in preventing ¡i¿Plasmodium vivax¡/i¿ recurrent episodes in Suriname. Infect. Drug Resist., vol. 11, 20 Dec. 2017, pp. 3-8, doi:10.2147/IDR.S135897.
43. Malaria Program Suriname. Weekly Reports.
44. Malaria Program Suriname 2021 Yearly Report.
45. Malakit Project - https://www.malakit-project.org/fr/le-kit/.
46. Mathieu L. et all´ı Local emergence in Amazonia of Plasmodium falciparum k13 C580Y mutants associated with in vitro artemisinin resistance, Elife, May 2020.
47. Ministry of Health of Guyana, Malaria National Strategic Plan.
48. Musset, Lise, et al. Malaria on the Guiana Shield: a review of the situation in French Guiana. Memórias do Instituto Oswaldo Cruz, vol. 109, no. 5, Aug. 2014, pp. 525-33, doi:10.1590/0074-0276140031.
49. Nacher, Mathieu, et al. Made in Europe: will artemisinin resistance emerge in French Guiana? Malar. J., vol. 12, no. 1, Dec. 2013, pp. 1-4, doi:10.1186/1475-2875-12-152.
50. Nasir et al., Prevention of re-establishment of malaria: historical perspective and future prospects. Malar J (2020) 19:452
51. Piantoni F., 2011, Migrants en Guyane, Arles/Cayenne : Actes Sud/Mus´ee des Cultures guyanaises, 176 p.
52. Pampana E., Malaria Erradication, Oxford University Press, 1968.
53. 54. Retours de l'OMS/OPS Suivi de la r´eunion de concertation - paludisme sites d'orpaillage en Guyane 12 janvier 2015
54. Routledge et alli, Estimating spatiotemporally varying malariareproduction numbers in a near elimination setting. Nature Communications.
55. Rosendaal J A. Epidemiology and control of malaria in Suriname : with special reference to 'Anopheles darling. 1990
56. Smith DL, Cohen JM, Chiyaka C, Johnston G, Gething PW, Gosling R, Buckee CO, Laxminarayan R, Hay SI, Tatem AJ. 2013 A sticky situation: the unexpected stability of malaria elimination. Phil Trans R Soc B 368: 20120145.
57. S. Granger: Territoire en mouvement Revue de g´eographie et am´enagement. Territory in movement Journal of geography and planning 36 (2017)
58. Scully, Jet al. Spatio-Temporal Dynamics of Plasmodium falciparum and Plasmodium vivax in French Guiana:2005–2019. Int. J. Environ. Res. Public Health 2021, 18, 1077.
59. Van Eer, Decr Zalis M., Pang L., Silveira M. et.al. Am. J. Trop. Med. Hyg. 58, (5) 630-637 (1998)

60. eased malaria in Suriname: moving towards elimination. Malar. J., vol. 17, no. 1, Dec. 2018, pp. 1-9, doi:10.1186/s12936-018-2204-x.
61. Tedesco. Let´ıcia da Luz. No trecho dos garimpos: Mobilidade, gênero e modos de viver na garimpagem de ouro amazônica. Part of Transnacionalizacao religiosa.
62. Leticia da LuzVezenegho, Samuel B., et al. High malaria transmission in a forested malaria focus in French Guiana: How can exophagic Anopheles darlingi thwart vector control and prevention measures? Memorias do Instituto Oswaldo Cruz, vol. 111, no. 9, Sept. 2016, pp. 561-9, doi:10.1590/0074-02760160150.
63. Vreden, Stephen GS, et al. Evidence of an increased incidence of day 3 parasitaemia in
64. Suriname: an indicator of the emerging resistance of Plasmodium falciparum to artemether. Memo´rias do Instituto Oswaldo Cruz, vol. 108, no. 8, Dec. 2013, pp. 968-73, doi:10.1590/00740276130167.
65. WHO, Guidelines on the elimination of residual foci of malaria transmission, WHO Regional Office for the Eastern Mediterranean EMRO Technical Publications Seies ; 33.
66. WHO Guidelines for malaria, 3 June 2022. Geneva: World Health Organization; 2022 (WHO/UCN/GMP/2022.01 Rev.2).
67. WHO, Preparing for certification of malaria elimination, second edition. Geneva: World
68. Health Organization; 2022.
69. WHO, Manual para la estratificación según el riesgo de malaria y la eliminación de focos de transmisión. Washington, D.C.: Organización Panamericana de la Salud; 2020.
70. WHO, World Malaria Report 2021.
71. WHO, Strategic Advisory Group on Malaria Eradication. Malaria eradication: benefits, future scenarios and feasibility. A report of the Strategic Advisory Group on Malaria
72. Eradication. Geneva: World Health Organization. 2020.
73. WHO, A framework for malaria elimination. Geneva: World Health Organization; 2017.
74. WHO, ZEROING IN ON MALARIA ELIMINATION: Final report of the E-2020 initiative.
75. WHO, World Malaria Report 2022.
76. Yang et al. The empirical support for the radical cure strategy for eliminating Plasmodium vivax in China BMC Medicine (2022) 20:17.
77. Yan et al. Human-centered design process and solutions to promote malaria testing and treatment seeking behavior in Guyana hinterlands BMC Public Health (2021) 21:2287
78. Zalis M., Pang L., Silveira M. et.al. Am. J. Trop. Med. Hyg. 58, (5) 630-637 (1998)

14 Acronyms

Acronym	Explanation
ABC	Agencia Brasileira de Cooperac¸¨ao
ACT	Artemisinin-based Combination Therapy
AMI	Amazon Malaria Initiative
API	Annual Parasite Incidence
ATM	All Terrain Vehicule
BCC	Behavior Change Communication
BOG	Bureau Openbare Gezondheidszorg (Bureau of Public Health)
CCM	Country Coordinating Mechanism
CDC	Centers for Diseases Control
Cq	Cloroquine
DDT	Dichloro diphenyl trichlorethane
DHIS2	District Health Information Software second version
GFATM	Global Fund to fight AIDS, Tuberculosis and Malaria
GF	Global Fund to fight AIDS, Tuberculosis and Malaria
IEC	Information Education Communication
KAP	Knowledge Attitude and Practice
LLIN	Long Lasting Insecticide treated mosquito Net
MDG	Millennium Development Goal
METF	Malaria Elimination Task Force
MOH	Ministry of Health
MSD	Malaria Service Deliverer
MWI	Medisch Wetenschappelijk Instituut (Medical Science Institute)
MZ	Medische Zending (Medical Mission)
NGO	Non-Governmental Organization
PAHO	Pan American Health Organization

PCR	Polymerase chain reaction
Pq	Primaquine
RAVREDA	Red Amazonica deVigilancia de la Resistencia a los Antimalaricos
RBM	Roll Back Malaria
RDTs	Rapid Tests
SOP	Standard Operating Procedure
T3	Test Treat Track
Tq	Tafenoquine
TWG	Technical Working Group
USAID	United States Agency International Development
WHO	World Health Organization
RDTs	Rapid Tests

15 Annex: publications that give an insight on the control of Malaria in Suriname

This table contain a list of publications about specific aspects of the malaria conjuncture in the eastern part of the Guyana Shield, comprising, three countries, Suriname, Brazil and the French Department of la Guyane. All the listed publications are available on line. Most of the publications were the result of investigations done in the countries by local scientists and published in international journals peer reviewed. If needed they can help to clarify points of the complex conundrum that leads to the persistence of malaria transmission in Suriname.

1. Articles about the epidemiology and control of Malaria in Suriname

J.A. Rozendaal Epidemiology and Control of Malaria in Suriname.

Helene Hiwat Malaria epidemiology in Suriname from 2000 to 2016: trends, opportunities and challenges for elimination.

Florence JV Breeveld History of malaria research and its contribution to the malaria control success in Suriname: a review

Marthelise GM Eersel Fifty years of primary health care in the rainforest: temporal trends in morbidity and mortality in indigenous Indigenous populations of Suriname.

Helene Hiwat Novel strategies lead to pre-elimination of malaria in previously high-risk areas in Suriname, South America.

S. Aldighieri Le Surinam, un partenaire clef pour une cooperation regionale en sante publique dans les Guyanes.

2. New approaches for control of malaria in Suriname

Helene Hiwat Novel strategies lead to pre-elimination of malaria in previously high-risk areas in Suriname, South America.

Maylis Douine Malakit: an innovative pilot project to self-diagnose and self-treat malaria among illegal gold miners in the Guiana Shield.

Edward D. van Eer Decreased endemic malaria in Suriname: moving towards elimination.

Marieke Heemskerk Looking for gold, finding malaria Assessment of changes in malariarelated knowledge, attitudes, and practices resulting from the Ministry of Health malaria program in smallscale gold mining areas in Suriname.

3. In vivo trials in Suriname

Stephen GS Vreden Evidence of an increased incidence of day 3 parasitaemia in Suriname: an indicator of the emerging resistance of Plasmodium falciparum to artemether.

Sigrid Mac Donald-Ottevanger Primaquine double dose for 7 days is inferior to singledose treatment for 14 days in preventing Plasmodium vivax recurrent episodes in Suriname

4. Molecular studies

Stella M. Chenet Molecular Profile of Malaria Drug Resistance Markers of Plasmodium falciparum in Suriname.

Sheila Akinyi Okoth Variation in Plasmodium falciparum Histidine-RichProtein2(Pfhrp2)and Plasmodium falciparum Histidine-Rich Protein 3(Pfhrp3)Gene Deletions in Guyana and Suriname.

Labadie-Bracho MY Reconstruction of Plasmodium vivax outbreaks in a low malaria endemic setting utilizing conventional restriction fragment length polymorphism, Malaria serology data from the Guiana shield: first insight in IgG antibody responses to Plasmodium falciparum, Plasmodium vivax and Plasmodium malariae antigens in Suriname.

Malti Adhin Status of potential PfATP6 molecular markers for artemisinin resistance in Suriname.

Malti Adhin Gold mining areas in Suriname: reservoirs of malaria resistance?

Mathieu L. Local emergence in Amazonia of Plasmodium falciparum k13 C580Y mutants associated with in vitro artemisinin resistance.

5. Epidemiology of Malaria in French Guyana

Mathieu Nacher Made in Europe: will artemisinin resistance emerge in French Guiana?

Vincent Pommier de Santi Malaria in French Guiana Linked to Illegal Gold Mining

Vincent Pommier de Santi Prevalence of Plasmodium spp. in illegal gold miners in French Guiana in 2015: a hidden but critical malaria reservoir.

Maylis Douine Malaria Hyperendemicity and Risk for Artemisinin Resistance among Illegal Gold Miners, French Guiana.

Lise Musset Emergence of Plasmodium vivax Resistance to Chloroquine in French Guiana.

Lise Musset Malaria on the Guiana Shield: a review of the situation in French Guiana.

6. Entomology

Helene Hiwat Ecology of Anopheles darlingi Root with respect to vector.

J. A. Rozendaal Observations on the distribution of anophelines in Suriname with particular reference to the malaria vector Anopheles darlingi.

7. Gold Mining in Suriname and French Guyana

Blancodini Patrick Gold Mining in Suriname and French GuianaOrpaillage, pollution et problemes sanitaires : l'exemple de la Guyane francaise.

De Theije M Moving frontiers in the Amazon: Brazilian small-scale gold miners in Suriname.

Frederic Piantoni Project Gold, Guns and Garimpeiros Pulitzer Center 'immigration br´esilienne aujourd'hui L'immigration br´esilienne aujourd'hui L'immigration br´esilienne aujourd'hui