Cooperation for malaria control and elimination in the Guiana Shield

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The Guiana Shield, a small region of South America, is currently one of the main hotspots of malaria transmission on the continent. This Amazonian area is characterised by remarkable socioeconomic, cultural, health, and political heterogeneity and a high degree of regional and cross-border population mobility, which has contributed to the increase of malaria in the region in the past few years. In this context, regional cooperation to control malaria represents both a challenge and an indispensable initiative. This Viewpoint advocates for the creation of a regional cooperative mechanism for the elimination of malaria in the Guiana Shield. This strategy would help address operational and political obstacles to successful technical cooperation in the region and could contribute to reversing the regional upsurge in malaria incidence through creating a functional international control and elimination partnership.

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Introduction

Malaria incidence and mortality have rebounded over the past decade in the Americas, a cause for concern given the global stagnation of key malaria control indicators since 2015.[1] This rise is the result of several factors, including national-level difficulties, political instability, financial restrictions, turnover of health-care professionals, and difficulties in successful implementation of decentralised programmes.[2]

Although the current epidemiological situation in Venezuela is taking a dominant role in this situation, complex transmission dynamics are involved in the Guiana Shield, a remote region of South America[3] located between the Orinoco (Venezuela) and Amazon (Brazil) rivers. In 2018, approximately 47% of the 753 000 cases detected on the entire continent were concentrated in this region, which represents less than 4% of the population at risk of malaria in the Americas.[4–8]

The relatively small population living in the Guiana Shield spans seven political territories: Guyana (formerly British Guiana), Suriname (formerly Dutch Guiana), French Guiana (an administrative region of France), the Bolivar and Amazonas states in Venezuela, and the Amapá and Roraima states in Brazil. Each of these countries has its own distinct malaria control programme but hard-to-reach and mobile populations are a common challenge.

Regional-scale cooperation could help overcome local limitations and address shared problems.[9] However, in such a heterogeneous context, health cooperation is particularly complex unless adequate support is provided.

This Viewpoint describes the characteristics and challenges of the region and proposes the creation of a regional mechanism for malaria elimination in the Guiana Shield.

Remote and mobile populations: a common challenge

The Guiana Shield is made up essentially of a mountainous massif with a mineral-rich subsoil and is characterised by a dense hydrological network that flows into the Atlantic Ocean and the Caribbean Sea.[3] The climate is hot and humid, and land is typically covered by tropical rainforest or savannah. The human population is mainly concentrated in urban areas. The road system is generally sparse and frequently of poor quality, especially in the forested areas, and part of the population lives in small and remote settlements accessible only by river or air.

In this context, a fundamental and common challenge in reducing malaria incidence is the extreme remoteness of the most affected populations. The scarcity of health facilities, the logistical difficulties and cost associated with the procurement and transportation of consumable supplies, and the challenge of maintaining quality interventions by isolated health workers (associated in some territories with a high turnover of human resources) are operational obstacles that can hamper the smooth implementation of effective interventions. In practical terms, these issues mean that the areas most affected by malaria often struggle with inadequate or non-existent access to health care and to malaria diagnosis and treatment, as well as to preventive measures—eg, vector control.

Another important challenge in the Guiana Shield is the high cross-border and regional population mobility. Migration (ie, linear mobility) can lead to outbreaks, since it moves people who are infected into regions that have otherwise low-level transmission.[10] This challenge is illustrated by the transnational spread of malaria and other communicable diseases following the recent migratory flow of refugees from Venezuela to Brazil.[11] In an even more frequent and substantial manner, the region has considerable circular mobility of some communities due to short-term and medium-term pendular movements.[12] The presence of large cross-border ethnic groups makes this phenomenon widespread in the Guiana Shield, related to family or religious gatherings or driven by economic reasons.[13] Another very common pattern of circular

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mobility in this Amazonian area is urban–rural mobility, which is linked to the use of natural resources in rural or forested areas (eg, fishing, agriculture, logging, or mining).[14–17] Overall, mobility is associated with spillover effects and thus fuels malaria circulation and outbreaks.[18–20] In the Guiana Shield, the mobility pattern of malaria parasites (and their human hosts) seems to follow two main axes: in the north, they spread between Venezuela, Roraima, and Guyana (and Colombia), in the south between Suriname, French Guiana, and Amapá.[21,22]

Gold mining activities, often artisanal and at small or medium scale, are a major socioeconomic pursuit throughout the Guiana Shield.[23,24] These activities combine remoteness, migration, and pendular mobility between mining sites and their logistical hubs (which can be cross-border or urban, or both).[25–27] Additionally, gold mining exposes individuals to unfavourable environmental conditions generated by the clearing of intact forest areas.[28] Due to the frequently informal or even illegal nature of these activities, the political and administrative environment can be unpropitious to the delivery of health services on site by the public authorities. Even if they are not systematically present, the insecurity and violence associated with illegal gold mining are additional obstacles to the local provision of health care and preventive services.[29,30] The combination of these features makes gold mining by far the largest contributor to malaria transmission in the Guiana Shield,[24–26,31] with an obvious regional impact.

Indigenous communities are another key population group greatly affected by malaria transmission in the Guiana Shield: several of these ethnic groups are also characterised by extreme geographical isolation, the obstacles to health-care access, and, when traditional territories straddle borders, by mobility that ignores national boundaries. Moreover, it is often necessary to design tailored tools and strategies, adapted to their specific ways of life, perceptions, and representations, to effectively tackle malaria transmission. Sharing these tools for cross-border ethnic groups would be highly beneficial.[13,32–34]

Epidemiological landscape of malaria in the Guiana Shield

Despite the geographical and ecological proximity of the Guiana Shield territories, malaria epidemiology varies

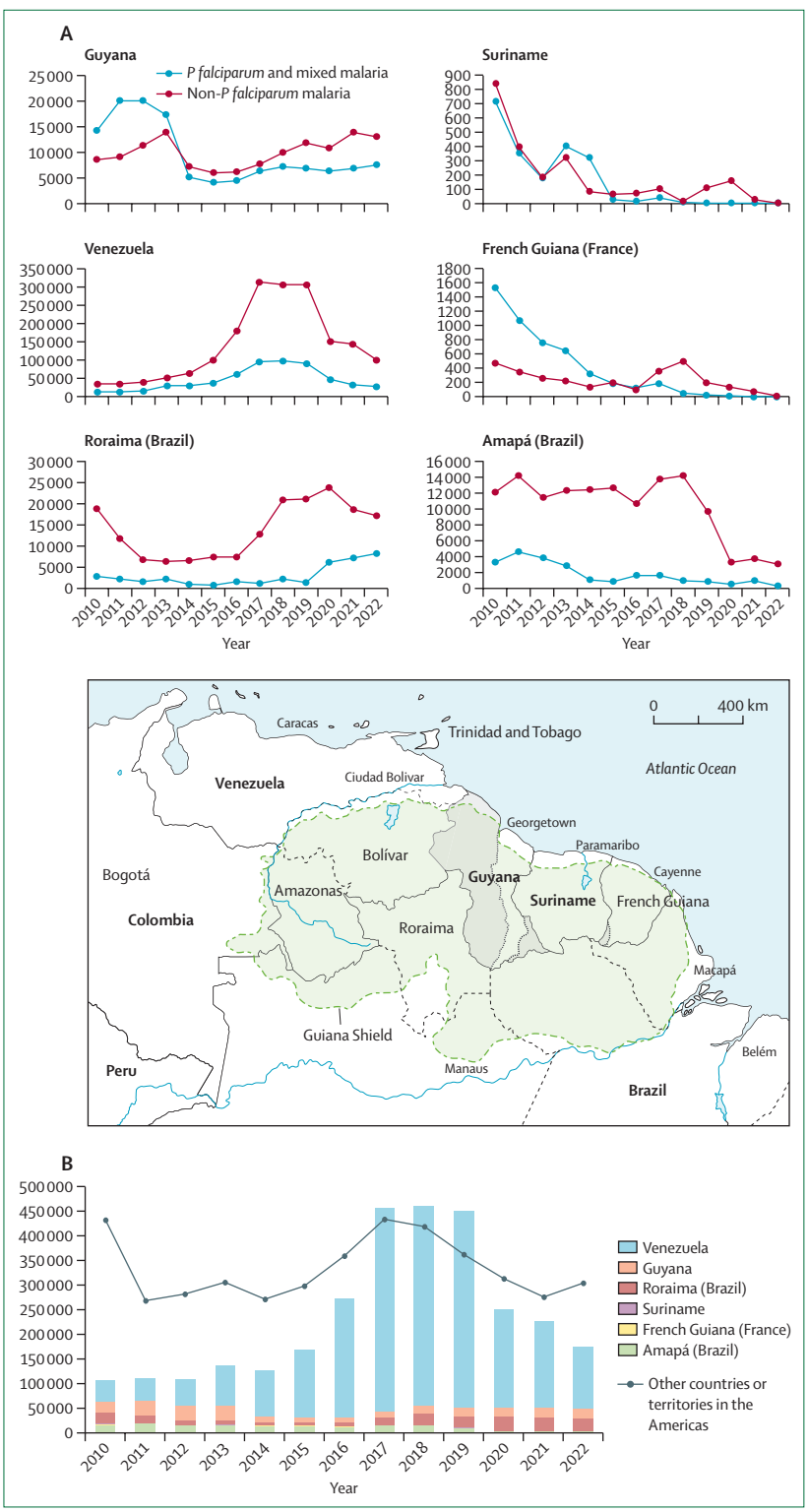

Figure: **Annual numbers of reported malaria cases in each territory of the Guiana Shield (A) and the cumulative numbers across the Guiana Shield (B)**
(A) Map of the Guiana Shield (adapted from https://d-maps.com/carte.php?num_car=284548&lang=en) and curves representing the annual number of confirmed cases of malaria in each territory of the Guiana Shield from 2010 to 2021: in blue, *P falciparum* (including mixed infection) cases; in red, non-*P falciparum* cases. Data were obtained from 2010 to 2022 from the World Malaria Report 2023 for Guyana, Venezuela, Suriname, and French Guiana (indigenous cases)[1] and from the Brazilian Ministry of Health epidemiological surveillance system for Amapá and Roraima states in Brazil (indigenous and imported reported malaria cases).[8] (B) Histogram representing the cumulative annual number of confirmed malaria cases (indigenous and imported) in the Guiana Shield, together with a curve representing the annual number of malaria cases (presumed and confirmed) reported in the rest of the continent, from 2010 to 2022. Note that scales on y axes differ between plots.

drastically between them (figure). The epidemiology also varies substantially over time and remains particularly unstable.

Suriname and French Guiana have had a considerable reduction in the number of cases over the past decade, with zero indigenous cases reported in Suriname in 2022 and 21 in French Guiana according to WHO data, and both have been selected for the WHO E-2025 initiative.[1] The elimination of malaria in Suriname in particular seems within reach, given that by the end of 2023 there had been 2 years with no indigenous cases reported in the country.[35]

In Brazil, the epidemiological situation shows notable local variations: almost all cases are concentrated in the Amazon region, and just 37 of Brazil's 5570 municipalities (among which 426 reported malaria cases in the past 3 years) account for 80% of cases.[36] The number of reported cases has fallen considerably in the state of Amapá, which borders French Guiana, from 13 657 cases in 2015 to 3320 in 2022.[8] Conversely, Roraima (which shares borders with Venezuela and Guyana) has seen a sharp increase in malaria incidence over the past 5 years, initially in line with the Venezuelan epidemic and subsequently with the explosion of illegal gold mining in the region's Indigenous territories.[8,22,27,32] In 2022, Roraima reported 25 725 cases (*vs* 8001 in 2015), accounting for 20% of cases reported in Brazil, with a proportion of 32% of *Plasmodium falciparum* or mixed infections in people with malaria.[8]

Despite a long history of success in reducing the incidence of malaria, Venezuela has had a large-scale epidemic, which peaked between 2017 and 2019. In 2018, an estimated 522 059 presumed and confirmed cases of malaria were reported in Venezuela, which represented 56% of cases and 72% of deaths in the Americas.[1] The latest officially published subnational figures also date back to 2018 and report prominent circulation of malaria in the states of Bolivar and Amazonas (part of the Guiana Shield), accounting for 73% of total nation-wide cases, and in the state of Sucre.[7,37] This situation has improved considerably in the past few years, following a national response to the epidemic backed by international funding and support and reduced population mobility due to COVID-19 pandemic restrictions, with approximately 151 458 cases reported to have occurred in the country in 2022. Despite these advances, Venezuela still accounts for the highest malaria burden in the region, with more than 31% of all presumed and confirmed malaria cases in the Americas.[1]

In Guyana, reducing malaria burden faces difficulties in controlling transmission, particularly in remote areas bordering Venezuela and Roraima that have high levels of mining activity. In recent years, the country has seen an increase in the number of cases, with 20 730 reported in 2022, 36% of which were *P falciparum* or mixed infections.[1]

As is the case in the rest of Latin America, *Plasmodium vivax* is the most prevalent species in the countries of the Guiana Shield (75% in 2022)[1,8] and is associated with relapses.[38] Nevertheless, *P falciparum* still circulates in the region, and the use of smuggled artemisinin-based drugs for self-treatment by hard-to-reach populations has been implicated as a cause of the emergence of the C580Y mutation in the *P falciparum* Kelch 13 gene in northern Guyana in the 2010s. This mutation is associated with in vitro reduced sensitivity to artemisinin compounds, raising serious concerns about the risk of emergence of resistance and resurgence of *P falciparum*.[21,39]

An area of overlapping cultures

Although the Guiana Shield was already populated by several Indigenous Peoples in the pre-Columbian era, modern history contributed to even broader ethnic and cultural diversity through colonisation from Europe, the transatlantic slave trade from Africa, and the influx of labourers of Asian origin. In the past few decades, the region has been experiencing migrations from the Caribbean (eg, Haiti), South America (eg, Colombia and Venezuela), and the Middle East (eg, Syria and Afghanistan) due to political, economic, and environmental situations. Overall, the inhabitants of the Guiana Shield speak five different official languages and dozens of ethnic mother tongues, and are subject to social, legal, administrative, and political systems influenced by their different colonial heritages. International political and commercial relations are highly fragmented across the region, illustrated by these countries belonging to three different economic and political communities (ie, the Southern Common Market, the Caribbean Community, and the EU). Border disputes over remote and mineral-rich territories continue to cause cyclical diplomatic tensions between the countries, as illustrated by the recent territorial dispute between Venezuela and Guyana, which will probably make cooperation between those two countries particularly difficult.[40]

These differences have also influenced the responses of the countries to the health-related challenges. Malaria control and elimination efforts (and thus results) are directly affected by the overall functioning of the health system and the structure of malaria control programmes and their financing (table). Moreover, some of these territories are part of large states whose central governments are very distant in geographical and political terms. The autonomy these territories have could, at times, be insufficient to provide appropriate responses to local situations.

Cross-border movement of patients in such a culturally, politically, and administratively heterogeneous region poses additional obstacles to effective public health action. The legal and operational obstacles to cross-border exchange of patient information usually prevent joint case investigation and management and shared epidemiological surveillance.[43,44] The challenge is all the greater if such mobility is accompanied by illegal

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situations or activities, which inhibits these people from seeking care or sharing reliable information during epidemiological investigations. Mutual understanding between health authorities and professionals is hampered by language and cultural barriers; the diversity of administrative organisations and regulations; the heterogeneity of case management, surveillance, and response protocols; and the turnover of health-care professionals.[43] For these reasons, collaborations are often short-lived.[45]

Global and local examples of regional cooperation

Several international collaborations show that regional-scale initiatives can constitute a partial but necessary response to similar challenges.[9] Elsewhere in the world, positive results in controlling malaria have been achieved through regional cooperation mechanisms, supported by member countries, international organisations, donors, and private sector stakeholders.[9,46] One example is the Asia Pacific Malaria Elimination Network and the Asia Pacific Leaders Malaria Alliance, which bring together national programmes from 22 countries and 54 partners. These two bodies work together to meet the technical needs of malaria control programmes through evidence generation and capacity building (the Elimination Network), strengthening political leadership in malaria control programmes, and facilitating access to the necessary resources (the Malaria Alliance). Another example is the Malaria Elimination 8 concept, an initiative created by the Ministries of Health of eight countries within the Southern African Development Community. This initiative facilitated cross-border collaborations and enabled the creation of malaria health units along strategic borders; it also created a regional situation room to allow shared analysis of epidemiological data and prompt response to outbreaks. The initiative was embedded in a political and economic mechanism that was region-specific and promoted strategic alignment among countries.[47] Several challenges have also been identified during this collaboration, mainly related to internal limitations of the member countries

	Brazil (Amapá and Roraima)	France (French Guiana)	Suriname	Guyana	Venezuela (Bolivar and Amazonas)
First-line treatment for *Plasmodium falciparum* and mixed malaria	Artemether–lumefantrine and single-dose primaquine	Artemether–lumefantrine and single-dose primaquine	Artemether–lumefantrine and single-dose primaquine	Artemether–lumefantrine and single-dose primaquine	Artemether–lumefantrine and single-dose primaquine
First-line treatment for *Plasmodium vivax*	Chloroquine and primaquine (0·50 mg/kg per day for 7 days), no G6PD testing	Chloroquine and primaquine (0·50 mg/kg per day for 14 days) after G6PD testing	Chloroquine and primaquine (0·50 mg/kg per day for 14 days), no G6PD testing	Chloroquine and primaquine (0·25 mg/kg per day for 14 days), no G6PD testing	Chloroquine and primaquine (0·50 mg/kg per day for 14 days) after G6PD testing
Vector control strategy	LLINs, IRS, and health education in active transmission areas	LLINs, IRS, and health education to populations in active transmission areas and clusters	LLINs in populations at high risk of malaria (eg, mobile migrants and border-crossing Indigenous communities)	LLINs (mass and routine distributions); IRS in some areas	LLINs to populations in active transmission areas and clusters
Main current hotspots of malaria transmission	Illegal gold mining areas, Indigenous communities, settlements in the urban periphery, and international border areas in the Amazon region	Illegal gold mining areas in the interior of the region, settlements linked to gold mining activity, unstable transmission in Indigenous communities and border communities	None; no active focus	Hinterland, communities linked to gold mining activities	Illegal gold mining areas in the interior of the region, settlements linked to gold mining activity, unstable transmission in Indigenous communities and some urban areas
Main obstacles to malaria elimination	Ever-changing levels of access to vector control and case management interventions due to the high mobility of the mining population and Indigenous Peoples; difficult access in remote areas; and long geographical distances	Regulatory obstacles to access to drugs, IRS, and LLINs; operational and regulatory obstacles to provision of diagnosis and treatment in remote areas not covered by formal health facilities	Threat of reintroduction through imported cases	Ever-changing levels of access to vector control and case management interventions due to the high mobility of the mining population	Logistical obstacles associated with the deployment of vector control interventions and treatment in mining areas; little regular subnational epidemiological data; and scant research on transmission dynamics in urban areas of the country
Provision of malaria services free of charge	Yes, to everyone in the public sector	Yes, to everyone in the public sector	Yes, to everyone in the public sector	Yes, to everyone in the public sector	Yes, to everyone in the public sector
Sources of financing for malaria control and elimination activities	Domestic funds, PMI, and USAID	Domestic and European funds	Domestic funds and external sources (Global Fund, USAID, etc)	Domestic and external sources (Global Fund, USAID, etc)	Global Fund and PAHO
Malaria elimination strategy	National Malaria Elimination Plan 2022–2035[41]	Regional Malaria Elimination Program 2024–2028 (pending validation)[42]	National Malaria Elimination Plan Suriname 2021–2025 (not published online)	Malaria Elimination Strategy 2020–2025 (not published online)	Comprehensive Plan for the Control of Malaria in the Bolivarian Republic of Venezuela 2021–2026; Master plan for the Strengthening of the Response Against HIV, Malaria and Tuberculosis (not published online)

IRS=indoor residual spraying. LLIN=long-lasting insecticidal nets. PAHO=Pan American Health Organization. PMI=US President's Malaria Initiative. USAID=US Agency for International Development.

Table: **Description of the main features of malaria control and elimination policies across the Guiana Shield territories**

that could not be entirely solved by the collaboration (health system weaknesses, limitations in domestic funding, misalignment between political determination and technical implementation, reluctance of field professionals to share data or implement innovations, etc).[47] Numerous other examples are reported in the literature, showing different approaches and variable objectives.[9,48–50] Overall, despite the challenges, and although it is difficult to obtain an evaluation of the effectiveness of these initiatives on malaria transmission, we consider that the synergies produced by these initiatives support joint management of shared phenomena, facilitate collaboration in procurement and staff training, foster innovation and progress, and ultimately promote sustained political commitment from governments.[9]

In the Guiana Shield, regional health cooperation is overall rather scarce, and specifically for malaria. In the past, the countries and territories of the Guiana Shield participated in a larger technical cooperation network, the Amazon Malaria Initiative—Amazon Network for the Surveillance of Antimalarial Drug Resistance. Currently, no formal common health cooperation agreement or regional organisation links all five countries, apart from membership (or collaboration in the case of French Guiana) in the Pan American Health Organisation (PAHO). At a smaller scale, Guyana and Suriname are both members of the Caribbean Public Health Agency. Cross-border bilateral agreements exist, and local meetings among professionals and institutions are held with varying frequency. Regional coordination of malaria control is carried out by PAHO's regional malaria programme through technical meetings and support to the countries. One of WHO's collaborating centres for malaria is located in the Guiana Shield, hosted by the Pasteur Institute in French Guiana, and provides important support to WHO and South American countries through its expertise in diagnosis and anti-malarial drug resistance. These current solutions partly meet the needs for technical cooperation in the region but are confronted with the previously mentioned obstacles and are unfortunately not sufficient to produce structural effects in the implementation of joint strategies.

At an operational level, several cross-border research projects have produced time-limited advances on specific topics. For instance, a shared epidemiological surveillance tool to study cross-border malaria transmission on the border between French Guiana and Amapá was developed thanks to various funding sources within the framework of the activities of the Franco-Brazilian International Joint Laboratory Sentinela and its partners.[51,52] The Malakit project is another example of successful collaboration between scientific, institutional, and civil society stakeholders from Suriname, French Guiana, and Brazil,[53,54] which addressed a specific common problem: malaria among people involved in artisanal and small scale gold mining. The study evaluated an innovative strategy consisting of the provision of free self-testing and self-treatment kits for malaria to gold miners working in remote and illegal sites located in French Guiana, combined with training to use them correctly. The target population was accessed at the cross-border localities where they go to sell gold, purchase goods, and rest.[55] The intervention was very well accepted by the community, with 30% of the target population (estimated at 10 000 people) having received at least one kit over the course of the intervention. The 2-year research project (2018–20) carried out an effectiveness evaluation through a pre-post quasi-experimental design based on a behavioural primary outcome: the intervention was associated with a significant increase in reliance on rapid malaria diagnosis before appropriate treatment by artemisinin-based combination therapy.[55] In terms of the effect on malaria transmission, a significant decrease in malaria prevalence was also described and a 42·9% decline in malaria cases exported from French Guiana to Suriname and Brazil between 2018 and 2020.[55] The scaling-up of this intervention has been implemented by the Malaria Elimination Program of Suriname[56] and is being considered in French Guiana and Brazil.

Benefiting from dedicated human and financial resources and the relative independence offered by the scientific framework, collaborative research is therefore a lever that can enable progress. However, to produce sustainable and long-term results, these innovations must be integrated into health systems and supported by institutional cooperation.

Advocating for a regional initiative to control and eliminate malaria in the Guiana Shield

Malaria elimination in individual countries within the Guiana Shield can only be successful and sustainable if an elimination project for the entire region is considered and designed.

In our opinion, a complex region such as the Guiana Shield could greatly benefit from an operational cooperative mechanism to control and eliminate malaria, which could overcome the previously mentioned obstacles and take advantage of the resources and expertise in the region. As in other similar initiatives elsewhere in the world, the secretariat of this initiative could be provided by PAHO or by a non-governmental organisation (eg, civil society or academia) with sufficient legitimacy and capacity to recruit and support qualified staff who are able to deal with such a multicultural context. One of this initiative's core activities could be the implementation of data sharing activities and the design and management of an integrated surveillance and alert system. The secretariat could be responsible for facilitating regional working groups, which would help capitalise on regional experiences and share relevant tools for common challenges and cross-border populations.

The recruitment of shared ad hoc staff could also enable this initiative to support the training and supervision of field teams involved in malaria care and prevention in the partner countries. This initiative could enable institutional support for cross-border and transnational interventions and projects (eg, carry out joint case investigations, create or maintain transborder malaria testing points, and replicate and scale up the Malakit project's approach), facilitating their implementation and sustainability. In a challenging logistical and economic context, this initiative could also help partner states in procuring commodities and facilitating reciprocal support in the event of stockouts. Moreover, one of the aims of this initiative could be the building of a common, multilateral financing platform that would enable shared actions and overcome the different national funding limitations. As shown by previous collaborations, a regional initiative could also be a key instrument for advocacy, keeping the focus on malaria in the political agenda and catalysing national decisions that could help overcome internal and country-specific obstacles.

The creation of a regional initiative would require a diplomatic, political, and technical process. It seems to us that the first step is inspiring a shared political will, which is one of the objectives of this Viewpoint and of the tireless advocacy of the technical actors involved in malaria elimination. PAHO has a key role to play in this process and will be able to facilitate the emergence of a regional debate by high-level policy makers. Once the political will has been confirmed, the objectives, resources, and governance of this initiative should be defined by a regional forum, involving the region's decision makers and technical and scientific players.

Conclusions

We advocate for the creation of a regional and operational cooperative mechanism for the elimination of malaria in the Guiana Shield that would address the operational, political, and diplomatic obstacles to successful technical cooperation in this region and thus reduce the risk of a malaria upsurge being managed individually by the peripheral, under-resourced, and fragile territories that make up the region.

Although malaria still circulates in the entire Amazon region, one important hotspot for malaria transmission in the Americas is currently located in the Guiana Shield. The ambition and political commitment that will guide the response to this common danger will be the main drivers of the way forward.

Contributors

AS, YL, and MD developed the concept and designed the contents of the Viewpoint. AS drafted the manuscript. AS and MS-M created the graphics. All authors read, corrected, and approved the final manuscript.

Declaration of interests

We declare no competing interests.

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