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# Ressurgence of Malaria in Portugal: Myth or actual threat?

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ACADEMIA DAS CIÊNCIAS
DE LISBOA

LISBOA • 2025

*Título:* Ressurgence of Malaria in Portugal: Myth or actual threat?
*Edição:* Academia das Ciências de Lisboa
*Data de edição:* 2025
*DOI:* https://doi.org/10.58164/z9nt-da34

# Ressurgence of Malaria in Portugal: Myth or actual threat?

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**ABSTRACT**

Malaria, a life-threatening disease caused by *Plasmodium* parasites and transmitted by *Anopheles* mosquitoes, was endemic in Portugal for centuries, particularly in low-lying coastal and riverine areas. Intensive control measures, including vector control and effective antimalarial treatments, led to the elimination of malaria in Portugal by 1960. However, concerns about malaria resurgence due to global warming often emerge in the media, as rising temperatures and changing climatic conditions could favor mosquito populations. This paper examines the potential for malaria re-establishment in Portugal by analyzing the three essential elements of the "malaria triangle": the human host, the mosquito vector, and the parasite. While *Anopheles atroparvus*, a competent malaria vector, remains present in Portugal, imported malaria cases are effectively managed, preventing the establishment of a parasite reservoir. A critical review of climate models and epidemiological data suggests that the threat of malaria resurgence in Portugal remains minimal, given the country's robust healthcare system, vigilant vector monitoring, and effective treatments. The paper concludes that global warming alone is unlikely to trigger a malaria resurgence in Portugal unless accompanied by failures in healthcare, vector control, and antimalarial resistance. Ensuring sustained efforts in these areas is essential to prevent the re-establishment of malaria in the future.

**RESUMO**

A malária, doença potencialmente fatal causada por parasitas do género *Plasmodium* e transmitida por mosquitos *Anopheles*, foi endémica em Portugal durante séculos, sobretudo em zonas costeiras e ribeirinhas de baixa altitude. A aplicação sistemática de medidas de controlo — incluindo intervenções antivetoriais e terapêuticas antimaláricas eficazes — permitiu eliminar a doença no país em 1960. Apesar disso, surgem frequentemente preocupações sobre um possível ressurgimento associado ao aquecimento global, uma vez que o aumento das temperaturas e as alterações climáticas podem favorecer a expansão e a atividade dos mosquitos vetores. Analisa-se o potencial de restabelecimento da malária em Portugal considerando os três elementos fundamentais do "triângulo da malária": o hospedeiro humano, o vetor e o parasita. Embora *Anopheles atroparvus*, vetor historicamente competente, permaneça presente em Portugal, os casos importados são rapidamente identificados e tratados, impedindo a formação de um reservatório parasitário. A revisão crítica de modelos climáticos e de dados epidemiológicos indica que o risco de reaparecimento da malária em Portugal continua a ser muito reduzido, sustentado pela robustez do sistema de saúde, pela vigilância entomológica contínua e pelos tratamentos eficazes. Conclui-se que é improvável que o aquecimento global, isoladamente, provoque um ressurgimento da malária, exceto se ocorrerem falhas significativas no controlo vetorial e na resposta em saúde pública.

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## INTRODUCTION

Malaria is a potentially fatal disease caused by *Plasmodium* parasites, transmitted to humans through the bites of infected female *Anopheles* mosquitoes. Of the five species that infect humans — *Plasmodium falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi* – *P. falciparum* and *P. vivax* are the most clinically significant.

*P. falciparum* is the most virulent species, responsible for most malaria-related deaths. It thrives predominantly in sub-Saharan Africa, where environmental conditions are ideal for mosquito breeding and transmission, whereas *P. vivax* is the most geographically widespread species, commonly found in Asia, Latin America, and parts of Africa (Figure 1). Although infections are typically less severe than those caused by *P. falciparum*, *P. vivax* can form dormant liver stages (hypnozoites) that reactivate months or even years after the initial infection, causing recurrent illness. This characteristic complicates elimination efforts and leads to ongoing health and economic burdens.

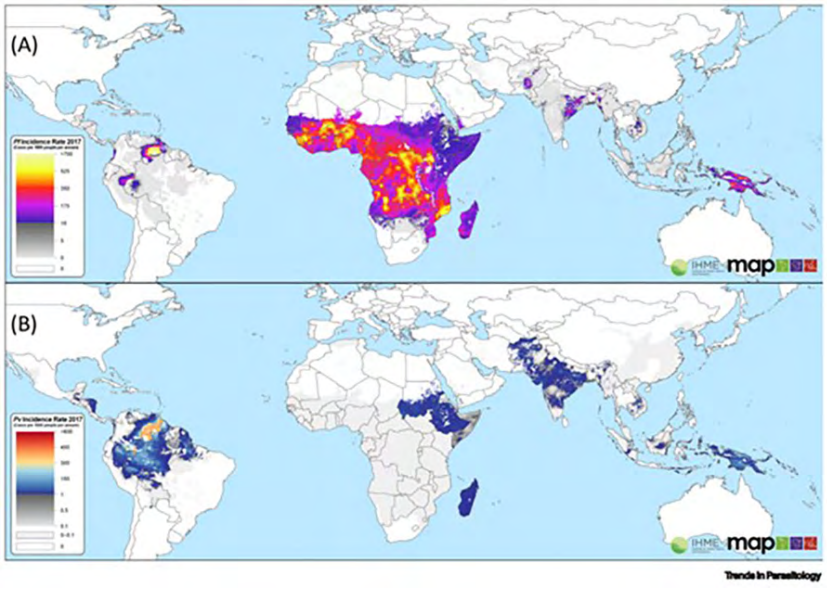


Figure 1. The incidence of *P. falciparum* and *P. vivax malaria* in 2017. Adapted from Price *et al.* (2020).

Malaria symptoms can range from mild to severe and typically appear 10 to 15 days after an infected mosquito bite. Mild symptoms include fever, chills, headache, muscle aches, fatigue, nausea, vomiting, and diarrhea. These symptoms often resemble those of a flu-like illness and can recur in cycles every two to three days, corresponding to the parasite's life cycle.

Severe malaria, primarily caused by *P. falciparum*, can lead to life-threatening complications, including cerebral malaria (seizures, confusion, and coma), severe anemia, acute respiratory distress syndrome (ARDS), low blood sugar, kidney failure, and multi-organ failure. If untreated, severe malaria can rapidly progress and result in death, particularly in young children, pregnant women, and immunocompromised individuals. Prompt diagnosis and treatment are crucial to prevent complications and reduce mortality. The parasite's ability to adhere to blood vessel walls can obstruct blood flow to vital organs, causing complications like cerebral malaria, severe anemia, and multi-organ failure. These severe manifestations are often fatal if untreated, particularly in young children and pregnant women.

Malaria remains a major global health challenge, with over 240 million cases and more than 600,000 deaths estimated yearly. The disease disproportionately affects sub-Saharan Africa, which accounts for about 95% of global malaria cases and deaths. Tragically, children under five years old are the most vulnerable, representing approximately 80% of malaria-related deaths in this region. These children often suffer repeated infections that impair growth, cognitive development, and overall well-being. Malaria also contributes to maternal anemia and adverse pregnancy outcomes, including low birth weight and stillbirths.

Efforts to combat malaria focus on prevention, control, and treatment. Key interventions include insecticide-treated mosquito nets (ITNs), indoor residual spraying (IRS), and preventive therapies for vulnerable populations. Effective antimalarial medications, such as artemisinin-based combination therapies (ACTs), are crucial for treating infections and reducing transmission. However, challenges like drug and insecticide resistance, inadequate healthcare access, and socio-economic factors continue to hinder malaria control and elimination. Strengthening surveillance, scaling up interventions, and investing in research are essential to achieving global malaria eradication.

## LIFE CYCLE OF MALARIA PARASITES

The life cycle of *Plasmodium* parasites, the causative agents of malaria, involves two hosts, humans and *Anopheles* mosquitoes, and consists of several crucial stages, each critical for transmission and disease progression. The cycle begins when an infected female *Anopheles* mosquito bites a human, injecting saliva

containing *Plasmodium* sporozoites into the bloodstream. These sporozoites travel quickly to the liver, where they infect liver cells (hepatocytes) inside which they multiply asexually, producing thousands of merozoites. Once matured, merozoites are released into the bloodstream, where they invade red blood cells (RBCs), inside which they mature through ring, trophozoite, and schizont stages. Each schizont releases more merozoites, which infect new RBCs, causing cycles of fever and chills as red blood cells burst. Some merozoites develop into sexual forms called gametocytes, which circulate in the bloodstream. When another *Anopheles* mosquito bites an infected person, it ingests gametocytes. Inside the mosquito's gut, gametocytes develop into male and female gametes, fuse to form a zygote, and develop into motile ookinetes. Ookinetes penetrate the mosquito's gut lining and form oocysts, where sporozoites develop. The oocysts eventually rupture, releasing sporozoites that migrate to the mosquito's salivary glands, ready to infect another human host (Figure 2).

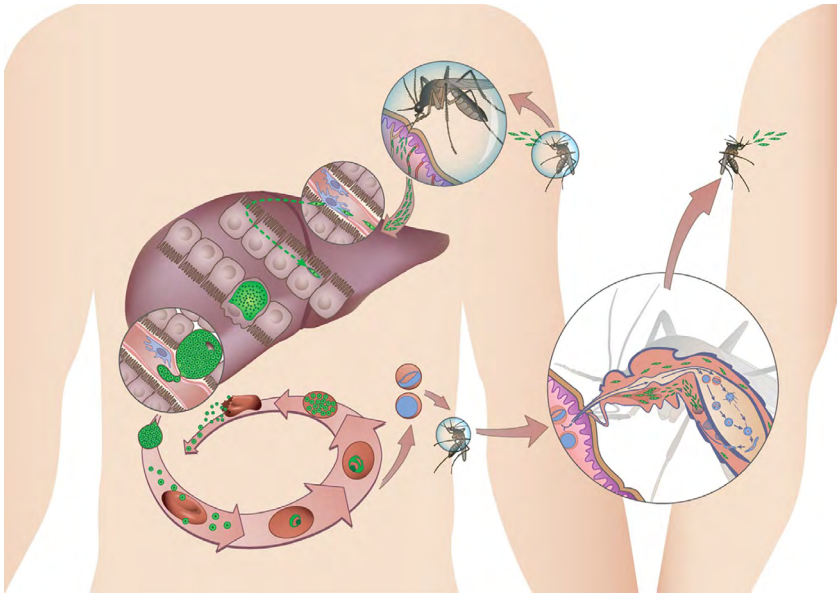

Figure 2. The life cycle of *Plasmodium* parasites.

## PREVALENCE AND ELIMINATION OF MALARIA IN PORTUGAL

Malaria was historically endemic in Portugal, particularly in low-lying coastal and riverine areas where conditions favoured mosquito breeding. The disease was most prevalent in the Tejo, Mondego, Águeda and Sado river valleys

(Figure 3), which provided ideal habitats for *Anopheles atroparvus*, the primary mosquito vector responsible for malaria transmission in Portugal. Malaria cases in Portugal were common for centuries, with recurring outbreaks affecting rural populations. The disease burden varied over time, often linked to socio-economic conditions, agricultural practices, and changes in mosquito habitats. A significant turning point came with the global malaria eradication campaigns of the 1950s, supported by the World Health Organization (WHO). Intensive vector control measures, particularly indoor residual spraying with DDT and widespread use of antimalarial drugs, drastically reduced transmission. These efforts led to the interruption of autochthonous (locally transmitted) malaria in the late 1950s. The last recorded case of malaria acquired in Portugal dates from 1959, and, in 1960, the country was officially declared malaria-free, marking the end of endemic transmission. Since then, malaria cases in Portugal have been exclusively imported, primarily from travellers returning from malaria-endemic regions in Africa, Asia, and Latin America. Surveillance and prompt treatment have kept imported cases under control, preventing re-establishment of transmission.

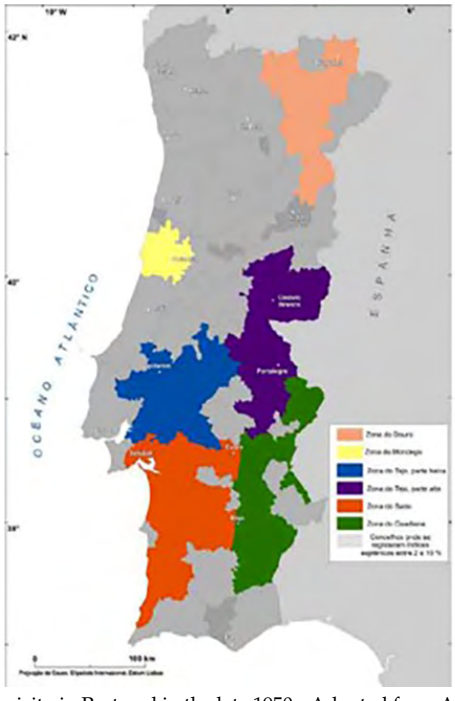


Figure 3. Areas of malaria endemicity in Portugal in the late 1950s. Adapted from Associação Bandeira Azul (2015).

The WHO's malaria eradication campaigns led to the successful elimination of malaria in parts of Europe and North America, as well as the Caribbean, and

Taiwan. However, the campaign struggled in sub-Saharan Africa and other regions with intense transmission, weak health systems, and logistical challenges. Problems such as insecticide resistance, parasite resistance to chloroquine, insufficient funding, and lack of community engagement hindered the long-term success of the campaign. By the late 1960s, it became clear that global eradication was unachievable with the existing tools and strategies, and, in 1969, the WHO shifted its focus from eradication to malaria control, aiming to reduce the disease burden rather than eliminate it entirely.

## THE "MALARIA TRIANGLE"

The Malaria Triangle refers to the interplay of three essential factors required for malaria transmission: the parasite, the mosquito vector, and the human host (Figure 4). Understanding the relationships within this "triangle" is crucial for effective malaria control and elimination strategies. Malaria transmission requires all three components of the triangle to interact. Breaking any side of the triangle — such as eliminating the parasite from humans, controlling mosquito populations, or preventing bites — can disrupt the cycle and reduce transmission. A fourth element may be added to this equation, in the form of environmental factors that may favour transmission (Figure 4). Global warming may play a prominent role among such factors given widespread suggestions that it may lead to resurgence of malaria in areas where the disease has been eliminated.

We will analyze the likelihood of persistence of each of the three main corners of this triangle in Portugal, as well as the possible impact of the fourth.

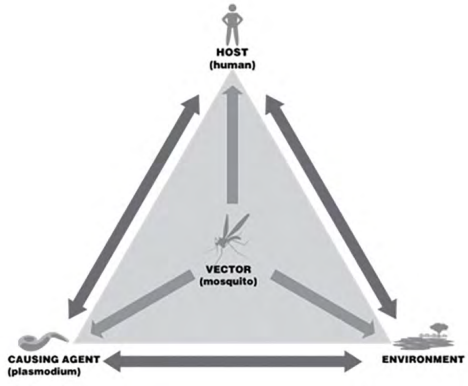


Figure 4. The "malaria triangle".

### Humans

There can be little doubt that humans are present throughout the Portuguese territory, in numbers totalling more than 10 million. The population is concentrated along the coast, particularly in urban areas like Lisbon and Porto and, despite a declining growth rate due to low birth rates and an aging population, the presence of this angle of the "malaria triangle" in Portugal seems assured.

### Anopheles mosquitoes

Portugal is home to several species of *Anopheles* mosquitoes, the vectors responsible for transmitting malaria. Historically, the most significant species was, a member of the *Anopheles maculipennis* complex, which was the primary vector for malaria transmission in the country. *Anopheles atroparvus* is well-adapted to temperate climates and is found in low-lying, humid areas such as coastal regions, river valleys, and marshlands — especially in the Tagus Valley, Alentejo, and Algarve regions. Although malaria was eliminated in Portugal in 1960, *Anopheles* mosquitoes remain present, particularly in rural and semi-rural areas where breeding sites like stagnant water, rice paddies, and wetlands exist.

Continued entomological surveillance and vector control measures are essential to monitor mosquito populations. The Rede de Vigilância de Vetores (REVIVE) plays a crucial role in this regard, by continuously monitoring and reporting on these populations, particularly those of *Anopheles atroparvus*. Importantly, the latest data from REVIVE indicate a decreasing trend in the prevalence of this species in Portugal (Figure 5).

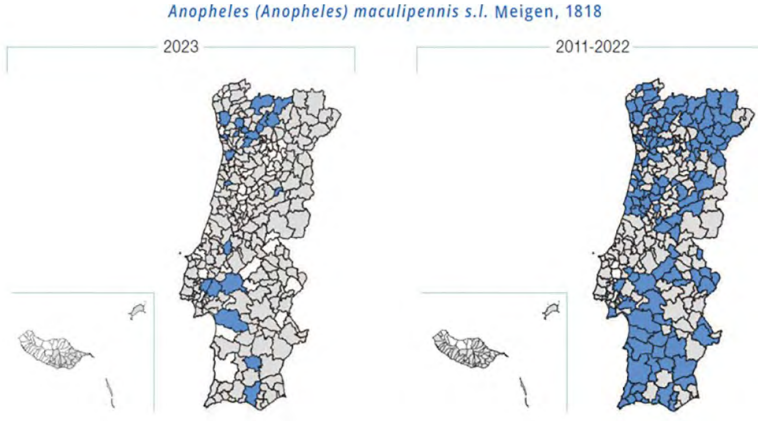


Figure 5. Geographic distribution of *Anopheles maculipennis* in Portugal. In INSA (2024).

Nevertheless, mathematical models predict that *Anopheles atroparvus* will continue to prevail in Europe over the next few decades (Hertig, 2019), making it a safe assumption that this angle of the "malaria triangle" will also remain present in the country for the foreseeable future.

## The parasite

Although the disease was declared eliminated from Europe, every year several cases of imported malaria are reported by European countries, including Portugal (Figure 6). However, when such cases are identified and diagnosed, patients are treated with existing effective antimalarials, abrogating parasite transmission. As such, a reservoir of Plasmodium parasites is not formed, as long as adequate diagnosis and treatment are available.

Thus, despite the presence of humans and mosquitoes, the third angle of the "malaria triangle" remains absent. This is well-illustrated by the fact that, despite the arrival of hundreds of thousands of people in Portugal coming from malaria-endemic regions in 1974–1976, no outbursts of malaria have been documented.

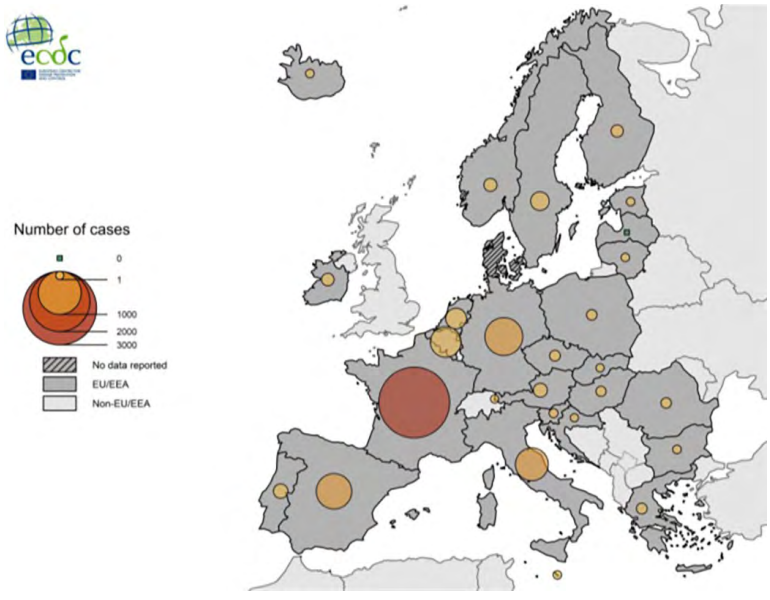


Figure 6. Confirmed malaria cases by country, EU/EEA, 2022. In ECDC (2024).

## THE IMPACT OF GLOBAL WARMING

Global warming refers to the long-term increase in Earth's average surface temperature due to the buildup of greenhouse gases like carbon dioxide, methane, and nitrous oxide in the atmosphere (Figure 7). These gases trap heat from the sun, leading to changes in climate patterns, rising sea levels, and more frequent extreme weather events. Human activities, particularly fossil fuel combustion, deforestation, and industrial processes, are the primary drivers of global warming. Its impacts include melting ice caps, shifting ecosystems, and threats to biodiversity. Global warming is a reality that cannot and should not be ignored.

Media reports often highlight concerns that global warming could lead to a resurgence of malaria in regions where it was previously eradicated, including parts of Southern Europe and the Mediterranean. Rising temperatures, increased humidity, and changing rainfall patterns create more favorable conditions for *Anopheles* mosquitoes to thrive and expand their range. This could enable malaria transmission in areas where cooler climates once limited mosquito populations.

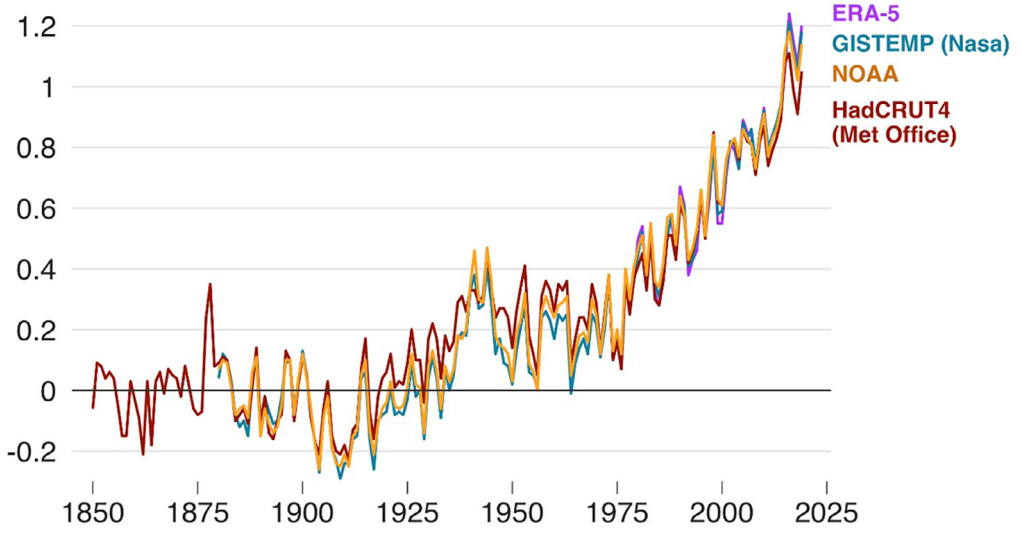


Figure 7. Temperature rise since 1850. Global mean temperature change from pre-industrial levels, $^{O}$C. Adapted from BBC News (2020, January 15).

However, what is the actual evidence for this risk? Not much, and not strong. In fact, despite scattered reports of detection of hitherto absent *Anopheles* mosquitoes in European countries (Raele *et al.*, 2024) and data suggesting a possible spread of malaria to African regions where it is currently not present (Zong *et al.*, 2024), when present-day global distribution of *P. falciparum* malaria was used to establish the current multivariate climatic constraints and these results were applied to future climate scenarios to predict future distributions, remarkably few changes were projected, even under the most extreme scenarios (Rogers & Randolph, 2000) (Figure 8).

These conclusions are further substantiated by those of other reputable studies, which have shown that "Predictions of an intensification of malaria in a warmer world, based on extrapolated empirical relationships or biological mechanisms, must be set against a context of a century of warming that has seen marked global declines in the disease and a substantial weakening of the global correlation between malaria endemicity and climate" (Gething *et al.*, 2010), and it has been claimed that "Simplistic reasoning on the future prevalence of malaria is ill-founded (…) obsessive emphasis on "global warming" as a dominant parameter is indefensible (Reiter, 2008).

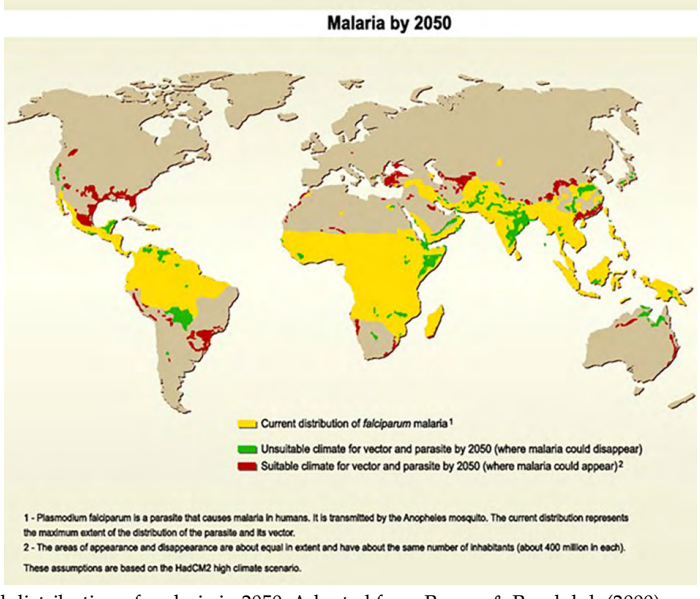


Figure 8. Projected distribution of malaria in 2050. Adapted from Rogers & Randolph (2000).

## CONCLUSION. WHAT WILL THE FUTURE BRING?

It can be safely assumed that "the highly sophisticated European healthcare systems will prevent malaria reestablishment" (Piperaki & Daikos, 2016) and that "the low malariogenic potential of Europe renders resurgence of malaria a remote possibility" (Piperaki & Daikos, 2016). This explains why "despite the substantial number of imported malaria cases and the documented presence of suitable anopheline vectors, autochthonous transmission has not been widely observed in Europe, probably as a result of early diagnosis and treatment, afforded by efficient healthcare systems" (Piperaki & Daikos, 2016).

Therefore, and in conclusion, it seems clear to me that a resurgence of malaria in Portugal is, at best, unlikely, assuming that several conditions remain in place:

- An efficient health system, that ensures prompt diagnosis and treatment of the disease in travellers returning from malaria-endemic regions.
- Adequate and continuous training of healthcare personnel that can appropriately diagnose malaria and provide the most suitable treatment.
- A continued effort on vector monitoring, ensuring that any unexpected alterations in the distribution and prevalence of *Anopheles* mosquitoes is documented and addressed.
- Continued support for research on novel antimalarial therapies that can ensure efficient elimination of the parasite from infected patients, even in the event of the emergence of resistance against currently available drugs.

As eloquently put by Nabi & Qader (2009), "Global warming alone will not be of a great significance in the upsurge of malaria unless it is accompanied by a deterioration in other parameters like public health facilities, resistance to antimalarial drugs and decreased mosquito control measures".

COMUNICAÇÃO APRESENTADA À CLASSE DE CIÊNCIAS
NA SESSÃO DE 20 DE MARÇO DE 2025

COMUNICAÇÃO RECEBIDA A 1 DE ABRIL DE 2025

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