

# Epidemiological Behavior of Malaria on the Pacific Coast of the Department of Nariño, Colombia, 2003–2017\*

Comportamiento epidemiológico de la malaria en la costa pacífica del departamento de Nariño, Colombia, 2003-2017

Comportamento epidemiológico da malária na costa pacífica do departamento de Nariño, Colômbia, 2003-2017

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## Abstract

**Introduction:** The Pacific Coast of the department of Nariño is one of the Colombian regions most affected by malaria. Therefore, to understand more about the situation of the disease in the region, this study aimed to describe the epidemiological behavior of this disease in said region during the period of 2003–2017. **Materials and methods:** The study was a descriptive epidemiological research. Secondary information was sourced from Public Health Surveillance System. The study variables consisted of cases and deaths due to malaria, which was distributed by sex and age, between the years of 2003–2017. Student's t-test was used

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to evaluate the disease's behavior. *Results:* During the study period, there were 84,600 cases of malaria, with an annual average of 5,640; 57.9% (95% ci: 57.6–58.3) in men and 42.1% (95% ci: 41.7–42.4) in women. The prevalence presented marked variability. During the years of 2007, 2016, and 2017, rates were higher with 29.9, 31.1, and 39.5 cases per 1,000 inhabitants, respectively. *Conclusions:* The municipalities where the majority of the cases were concentrated were Tumaco, Roberto Payan, and Olaya Herrera. Moreover, the origin of the cases were located in low variability micro-territories that share typical eco-epidemiological conditions for the circulation of the vector. During the study period, 41 deaths were recorded, with an annual average of 3 cases, of which 75.6% (95% ci: 62.5–88.8) were male and 24.4% (95% ci: 11.2–37.5) were female, with cases being distributed without a statistical significance ( $t$  Student = 1.66;  $p = 0.10$ ).

*Keywords:* *Anopheles*; mortality; morbidity; *Plasmodium*; prevalence.

## Resumen

*Introducción:* la costa pacífica del departamento de Nariño es una de las regiones colombianas más afectadas por la malaria; por ello, con el fin de conocer detalladamente la situación de la enfermedad, este estudio se planteó como objetivo describir su comportamiento epidemiológico en la región mencionada, para el periodo 2003-2017. *Materiales y métodos:* estudio epidemiológico de tipo descriptivo con fuente de información secundaria proveniente del Sivigila. Las variables del estudio fueron casos y muertes debidas a malaria distribuidas por sexo y edad, entre los años 2003 y 2017. Se utilizó el estadístico  $t$  de Student para evaluar el comportamiento de la enfermedad. *Resultados:* durante el periodo de estudio hubo 84 600 casos de malaria, con un promedio anual de 5640, el 57.9 % (ic95 %: 57.6-58.3) en hombres y el 42.1 % (ic95 %: 41.7-42.4) en mujeres. La prevalencia presentó marcada variabilidad, aun cuando en los años 2007, 2016 y 2017 las tasas fueron mayores con 29,9; 31,1 y 39,5 casos por cada 1000 habitantes, respectivamente. *Conclusiones:* los municipios donde se concentró la mayoría de los casos fueron Tumaco, Roberto Payán y Olaya Herrera, además que la procedencia de los casos estuvo ubicada en microterritorios con poca variabilidad y que comparten condiciones ecoepidemiológicas típicas para la circulación del vector. En el periodo de estudio se registraron 41 defunciones, con promedio anual de 3 casos, de los cuales el 75.6 % (ic95 %: 62.5-88.8) fue en hombres y el 24.4 % (ic95 %: 11.2-37.5) en mujeres. La distribución no tuvo significancia estadística ( $t$  de Student = 1.66;  $p = 0.10$ ).

*Palabras clave:* *Anopheles*; mortalidad; morbilidad; *Plasmodium*; prevalencia.

## Resumo

*Introdução:* a costa pacífica do departamento de Nariño é uma das regiões colombianas mais afetadas pela malária; por isso, com o propósito de conhecer mais em detalhe a situação da doença, este estudo se apresentou como objetivo descrever o comportamento epidemiológico desta doença na região mencionada, para o período 2003-2017. *Materiais e métodos:* estudo epidemiológico de tipo descritivo. Fonte de informação secundária proveniente do Sivigila, as variáveis do estudo foram casos e mortes causadas pela malária distribuídas por sexo e idade, entre os anos 2003-2017. Utilizou-se o estatístico  $t$  de Student para avaliar o comportamento da doença. *Resultados:* durante o período de estudo houve 84.600 casos de malária, uma média anual de 5640, o 57,9% (ic95%: 57,6-58,3) em homens e o 42,1% (ic95%: 41,7-42,4) em mulheres. A prevalência apresentou marcada variabilidade, sendo os anos 2007, 2016 e 2017 quando as taxas foram maiores com 29,9; 31,1 e 39,5 casos por 1000 habitantes, respectivamente. *Conclusões:* os municípios onde se concentrara a maioria dos casos foram Tumaco, Roberto Payán e Olaya Herrera, para além que a procedência dos casos esteve localizada em microterritórios com pouca variabilidade e que compartilham condições eco-epidemiológicas típicas para a circulação do vector. No período de estudo se registraram 41 óbitos, com média anual de 3 casos, dos quais o 75,6% (ic95%: 62,5-88,8) foram homens e o 24,4% (ic95%: 11,2-37,5) foram mulheres, distribuição sem significância estatística ( $t$  Student = 1,66;  $p = 0,10$ ).

*Palavras-chave:* *Anopheles*; mortalidade; morbilidade; *Plasmodium*; prevalência.

## Introduction

Malaria is caused by *Plasmodium* parasites and transmitted by the female *Anopheles*. There are five different species of plasmodium that infect humans (*P. falciparum*, *P. vivax*, *P. malariae*, *P. knowlesi* and *P. ovale*). The most severe infections are caused by *P. falciparum* and *P. vivax* (1,2).

The Pan American Health Organization estimates that more than 50 million cases occur annually; 500,000 people are hospitalized, and 20,000 people die of the disease. Control of the disease is expensive, and epidemics have a negative impact on the socioeconomic development of the countries affected (3). Venezuela, Brazil, and Colombia are the Latin American countries with the highest incidences of malaria (4,5).

As inferred, Colombia is considered to be one of the countries with the highest risk for contracting malaria at the global and regional levels. Therefore, malaria in Colombia continues to be a challenge for public health. It is important to understand its intimate relationship with structural processes such as armed conflicts, poverty, and the health reforms under Law 10 of 1990 and Law 60 and 100 of 1993, which regulated the administrative decentralization of health-care in Colombia. With these reforms, responsibility regarding malaria control was assigned to the departmental and municipal entities without the capacity to provide a technical response, which increased malaria rates throughout the country, making decentralization a risk factor for malaria in Colombian municipalities (6).

Intervention strategies for the control of cases have been based on diagnosis and treatment, which to date has not shown a significant reduction in results (7), and it has had even less impact on improving the quality of life of those affected.

The aforementioned, despite the fact that malaria is an event of public health interest and international surveillance, is part of the international treaties that Colombia has signed; among which it is relevant to mention the United Nation's Sustainable Development Goals, which are aimed at reducing inequality and at the transformation toward a new world. Thus, in its third objective called: Good Health and Well-Being, it establishes criteria to guarantee a healthy life and to promote people's well-being at any age, with the goal of ending the epidemics of AIDS, tuberculosis, malaria, hepatitis, and neglected tropical and vector-borne infectious diseases by 2030 (8).

However, despite the commitments subscribed by Colombia, malaria cases increased between 2012 and 2017, though they had witnessed a decline in previous periods (9). According to the estimates from the Instituto Nacional de Salud (INS), the cases were concentrated mainly in the departments of Chocó, Nariño, Antioquia, Amazonas, Valle del Cauca, and Córdoba (10).

Specifically, the Pacific Coast of the Department of Nariño (Costa Pacífica del Departamento de Nariño [CPDN]) is a region in which the presence of malaria is favored due to factors such as: its geographic location; eco-epidemiological conditions that allow for the proliferation of anopheline vectors; the vulnerability of the population due to poverty and displacement associated with public order problems; the irregularity of the operational actions of a clinical and control nature; the increased resistance of malaria parasites to drugs and insecticides and; the low impact of social engagement (11).

This has led to an increase in the reported cases of malaria in this area of Colombia (10), which can be related to the previously mentioned factors. From a geographical point of view, in particular, the transmission of malaria in the CPDN occurs in the 10 coastal municipalities that it is comprised of, which are: Barbacoas, El Charco, Francisco Pizarro, La Tola, Magüi Payán, Mosquera, Olaya Herrera, Roberto Payán, Santa Bárbara, and Tumaco (Figure 1) (11). Malaria data for the CPDN shows that for the period of 2003–2017, there was a continuous epidemic situation that required immediate control actions by state entities, with interventions coming both from the clinical and socio-community sectors (11). Based on what has been stated so far, coupled with the purpose of deepening the knowledge of the disease's dynamics, this study aims to describe the epidemiological behavior of malaria in the CPDN population during the period of 2003–2017.



**Figure 1.** The geographic location of the CPDN

**Source:** Designs owned by the estudio *La malaria as a result of the articulation of both the history and the social conditions that affect the inhabitants of the Pacific coast of the department of Nariño, Colombia* (12).

## Materials and methods

Following a quantitative approach, a descriptive epidemiological study was conducted, along with a secondary source of information, in which the general characteristics of the population under study were analyzed (13). Then, an analysis of malaria's morbidity and mortality in the CPDN population during the period of 2003–2017 was conducted. The sources of data used were resourced from Public Health Surveillance System (Sivigila) and also from records regarding the vital mortality statistics and population projections from the National Administrative Department of Statistics, as well as from the Individual Health Care Service Records from the Ministry of Health and Social Protection, containing information on the morbidity within the country (10,14–16). The information was managed using the Integrated Social Protection Information System (17).

The variables analyzed were confirmed cases of and deaths from malaria, distributed by sex and age. Place variables included rural areas, which is the population that is susceptible to becoming ill or dying from this disease, and time variables were the years 2003–2017.

The data reported by the INS on the presence of malaria in the studied region was used as a starting point. The study was conducted in two stages of temporal analysis, the first one between 2003 and 2006 and the second one between 2007 and 2017. The MSPS Decree 3518 of 2006 regulating the country's Sivigila, which activated the surveillance of events of interest in public health, including malaria, and making it a factor in reducing the possibility of underreporting the disease, was taken as a reference point (18).

The selection of malaria cases was made using the diagnostic codes from the International Classification of Diseases - Tenth Revision as references, and the list of codes used by the WHO to register causes of death, which identify malaria by the codes B50-B54 (19,20). This, in turn, were compared to the codes from the Registro Único de Afiliados al Sistema de la Protección Social's death module, which identifies the malaria event's terminal condition by code 465 (21,22).

The information was tabulated in a database using sex, five-year age groups, and the geographic location of the cases as references. The data that did not report the distribution of cases by sex (male-female) was adjusted using proportional allocation methodology, which consists of distributing the data and applying a weighted percentage to each variable of interest, thus distributing proportionally the amount of data that applies to each variable (23).

The calculations were done using a data matrix prepared for this purpose with parameters for estimating prevalence and mortality rates. Rate adjustments were made using the direct method with the Epidat 4.2 software (24). The rural population of the 10 municipalities that make up the CPDN in 2005 was used as the standard. This study was approved by the

Ethics Committee of the Universidad Jorge Tadeo Lozano, in accordance with Law 001 of February 6, 2019.

## Results

### Population features

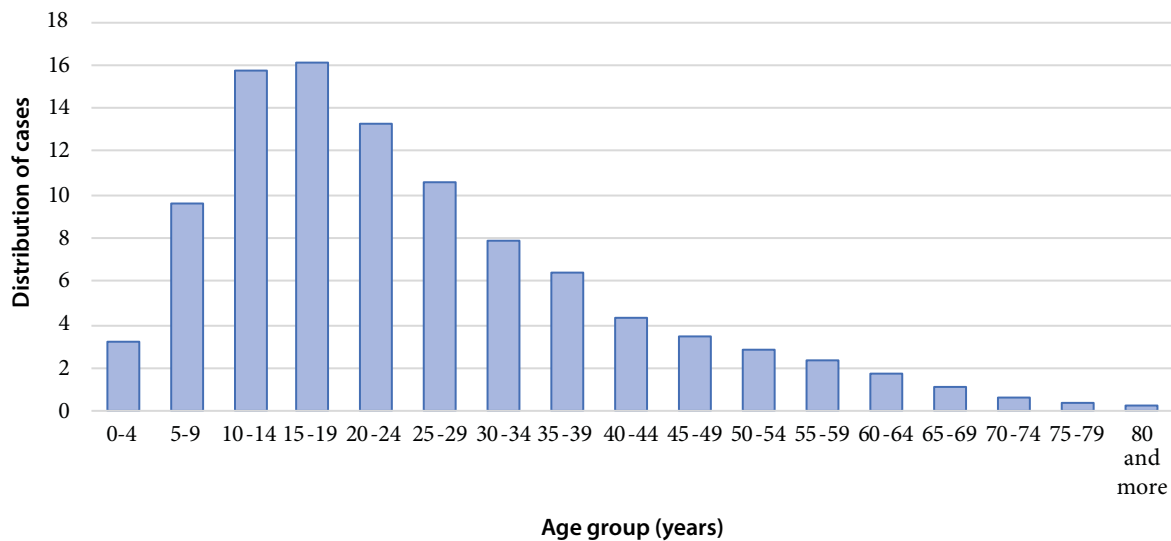
The rural population of the CPDN presents certain particular characteristics; the population structure is mostly made up of adults (15 to 64 years old), followed by children (0 to 14 years old) and senior citizens (65 years and over). Regarding the population pyramid, this presents a regressive trend that can be related to a decrease in birth rates and displacement, which would engender an aging population in this region of the department.

During the period of 2003–2017, the rural population of the CPDN registered an annual average demographic growth rate of 1.37%, which suggests a population growth of approximately 21% during the study period. Whereas for Colombia in this same period, the annual average population growth rate was 1.25%, which equates to approximately a 15% total increase, indicating that in this Colombian region the growth was slightly higher, which may be associated with the boom of illicit crops and illegal mining in the region.

### Malaria morbidity

During 2003–2017, there were 84,600 malaria cases and an annual average of 5,640 cases, of which 57.9% (95% CI: 57.6–58.3) were men and 42.1% (95% CI: 41.7–42.4) were women, a distribution that was not statistically significant ( $t$  Student = 1.23;  $p$  = 0.22). This situation may be associated with men's occupations, who mainly perform mining and agricultural tasks in the region, among which are illegal mining and illicit crops.

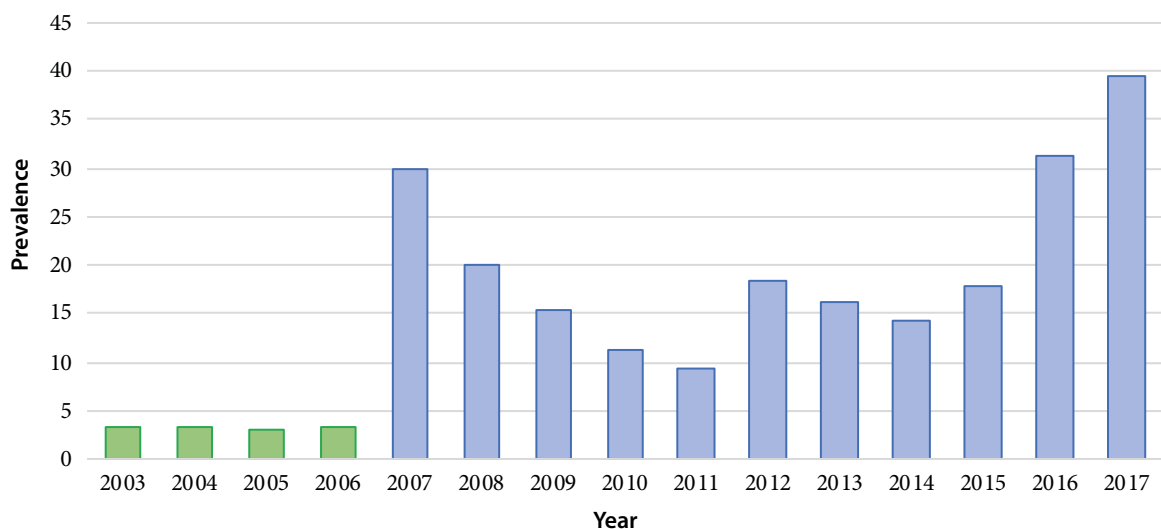
Regarding the distribution of cases by age group, malaria cases were concentrated in the population group that ranges from 10 to 24 years old, which represents 45.1% (95% CI: 44.8–45.4) of the reported cases. When the data is analyzed by five-year age groups, the most affected population group was the 15 to 19-year-old (16.2%) group, followed by the 10 to 14-year-old (15.7%) group, which is related to the demographic behavior evidenced in this Colombian region (Figure 2).



**Figure 2.** Proportion of malaria cases in the CPDN according to age group, 2003–2017

**Source:** INS-Sivigila malaria cases 2003–2017 (10,14).

The prevalence of the disease presented marked variability, with the years of 2007, 2016, and 2017 showing the highest rates of infection with 29.9, 31.1, and 39.5 cases per 1,000 inhabitants, respectively (Figure 3). When analyzing the event's behavior from the beginning to the end of the study period, it could be found that between 2003 and 2017, the prevalence of infection showed an increase of 1.042%, a statistically significant result ( $t$  Student = 5.63;  $p = 0.030$ ).



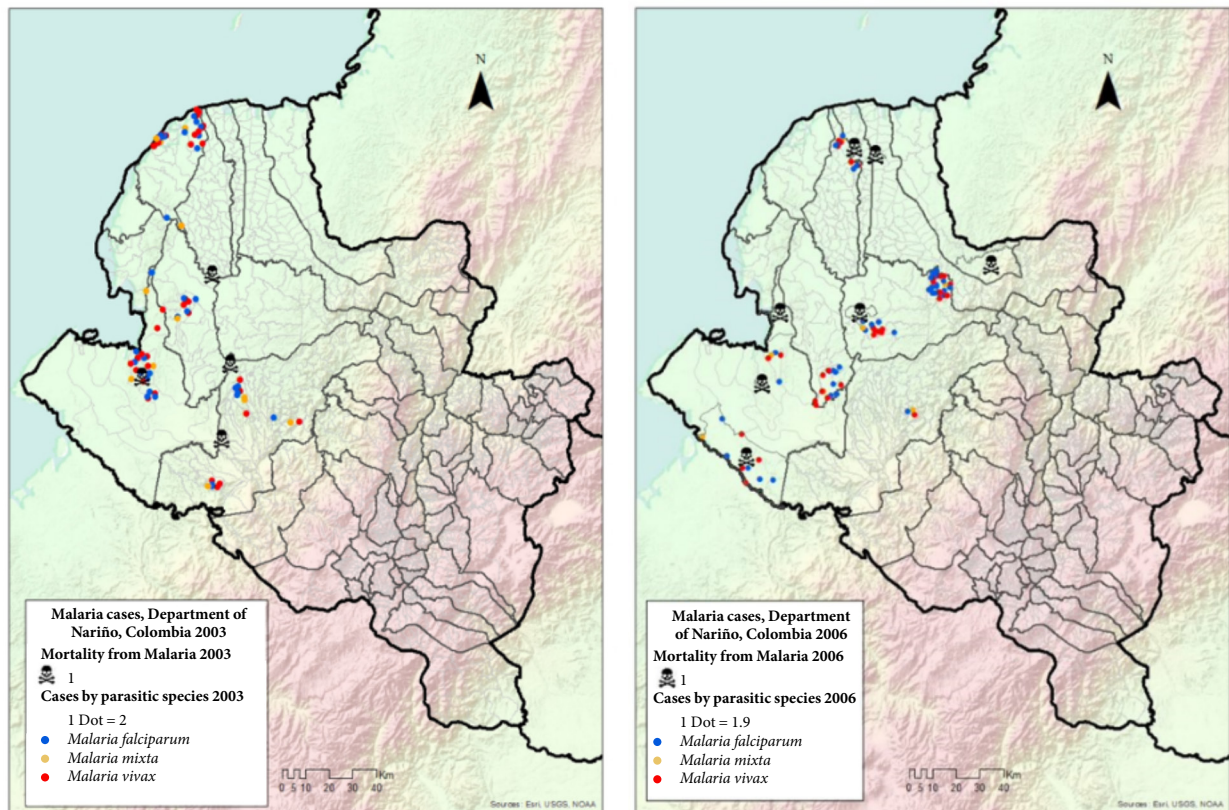
**Figure 3.** CPDN malaria infection prevalence, 2003–2017

**Source:** INS-Sivigila malaria 2003–2017 (10,14).



We can infer that Decree 3518 of 2006 activated the mandatory notification of events of interest in public health in Colombia, including malaria, which is done through Siviigila, something that became evident from 2007. Taking into account this situation and our study period, we conducted an analysis of two periods, the first one from 2003 to 2006 and the second one from 2007 to 2017.

For the first study period, 2003–2006, a decrease of 4% in the prevalence of the disease is evident, a result that has no statistical significance ( $t$  Student = 0.12;  $p$  = 0.90) (see Figure 3). A concentration of cases in Tumaco, Roberto Payán, and Olaya Herrera could be observed. The findings in Tumaco evidenced that the places of infection origin were the towns and/or sectors of El Mejicano, Altamira, San Juan, and Corredor de la Espriella. In Roberto Payán, the origin of the cases was concentrated around the towns and/or the micro-territories of Pacora, Hato Grande, and Maque. In Olaya Herrera, the origin of the cases could be located in towns and/or the sectors of Calabazal, Barracoita, and Antequera (Figure 4).



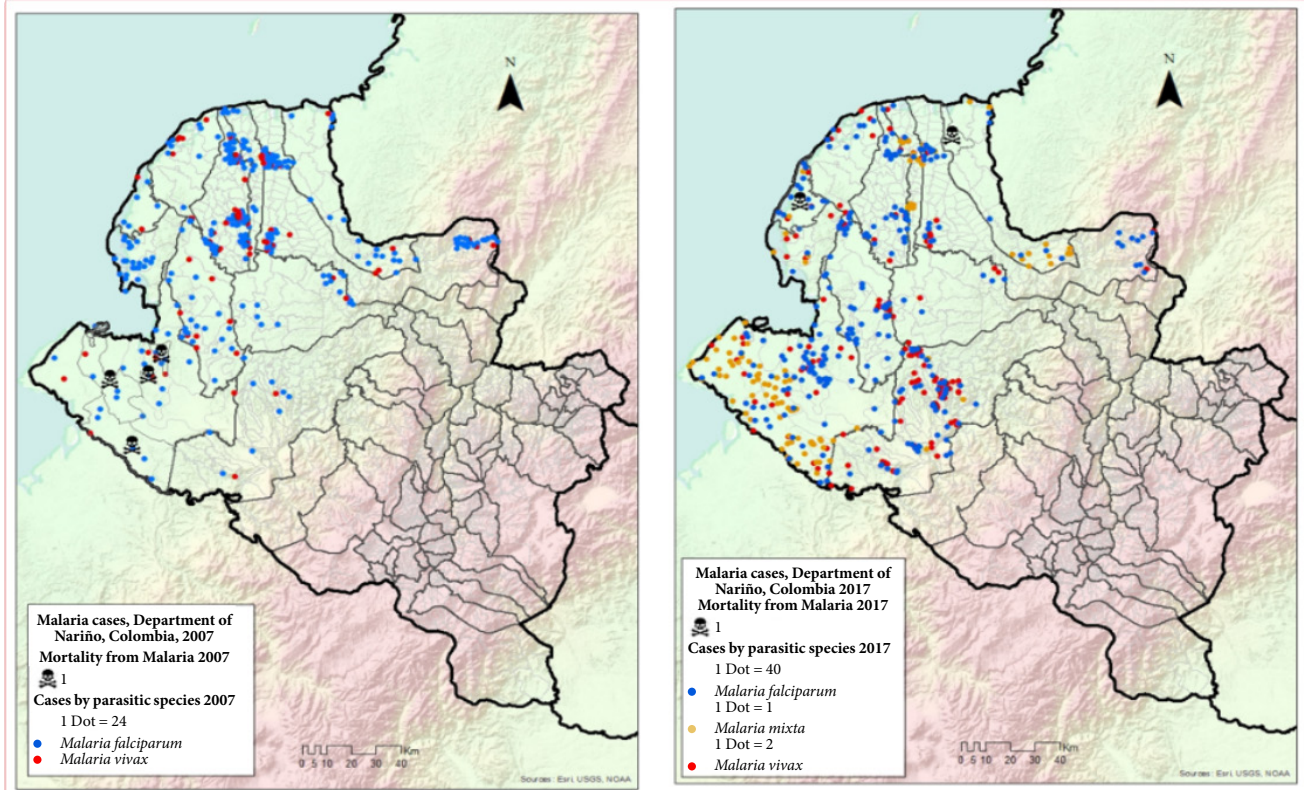
**Figure 4.** Geo-referencing of CPDN malaria cases, 2003–2006

**Source:** INS-Siviigila malaria cases 2003–2006 (10,14).

In the second study period, 2007–2017 the prevalence of malaria presented an increase of 32%, a result that showed no statistical significance ( $t$  Student = 4.3;  $p$  = 0.42). The concentration of cases was in the same municipalities as the first period of study: Tumaco, Roberto



Payán, and Olaya Herrera. We found that the case's origins were also concentrated in the same places, with a significant increase in the number and the appearance of new sectors in small areas, perhaps related to the displacement and migration of a potentially infected population (Figure 5).



**Figure 5.** Geo-referencing of CPDN malaria cases, 2007–2017

**Source:** INS-Sivigila malaria cases 2007–2017 (10,14).

Finally, the estimated prevalence of cases for the study period was 231.2 cases per 1,000 inhabitants. However, when an analysis was performed for these same study periods, it was found that the estimated prevalence of cases for the periods of 2003–2006 and 2007–2017 was 13.3 and 209.5 cases per 1,000 inhabitants respectively; This evidenced a marked increase in the morbidity within the last study period.

## Malaria mortality

During the study period, 41 confirmed deaths were registered, with an annual average of 3 cases, of which 75.6% (95% ci: 62.5–88.8) were men and 24.4% (95% ci: 11.2–37.5) were women, a distribution that showed no statistical significance ( $t$  Student = 1.66;  $p = 0.10$ ).

According to the distribution by age group, 43.9% (95% ci: 28.7–59.1) of deaths occurred in the population group aged between 35 and 44 years. Similarly, it could be observed that for

the 2003–2006 period, 65.9% of the total deaths were reported to be from malaria, compared to the 34.1% reported in the years 2007–2017, which proved not to be statistically significant ( $t$  Student = 6.77;  $p$  = 2.16).

## Discussion

The epidemiological behavior of malaria in the CPDN during the study period can be associated to three factors: the first one being the demographic factor, as is the population increase in rural areas, more frequently seen in economically active male individuals, aged 15 to 64 years, with an emphasis on the 15 and 19 year old group; the second factor has to do with the eco-epidemiological characteristics of the region that lead to the cyclical epidemic behavior of the disease occurring between 2 and 7 years, which is associated with the occurrence of the El Niño phenomenon and; the third factor, the natural geographic features of this Colombian region (jungle, humid, warm), which end up favoring the existence and circulation of anopheline vectors. The combination of these three factors makes the area hyperendemic, which maintains an unstable transmission pattern (22,25) to the extent of making it the second highest area of disease burden due to malaria in the country, only after the department of Chocó (10).

However, when the process of the analysis of the data reported on the presence of malaria in the CPDN began, an atypical behavior was observed, since a notable change was observed in the epidemiological reports of the disease when comparing the results for the period of 2003–2006 with those from the years of 2007–2017. This led to a methodological decision that implied that the research needed to be conducted by analyzing each time period separately to avoid bias. A possible explanation for this finding could be the underreporting of malaria cases, which may have been overcome, totally or partially, thanks to the issuance of Resolution 3518 in 2006. This Resolution created and regulated the Sivigila that raised awareness on the notification of cases and contributed to a more accurate visualization of the situation of malaria in the CPDN (18).

However, studies subsequent to the creation of the Sivigila have estimated that in the case of the CPDN the under-registration of cases may still be around 60% (26); a situation that hinders the establishment of the true magnitude of malaria morbidity and mortality in the area (27).

Despite the limitation presented, the findings of this investigation allow for an approach to the epidemiological dynamics of the disease within the territory. In this regard, the first factor that can be stated is that the population between 15 and 64 years of age is the most affected by the disease, with greater emphasis on the population between 15 to 19 years of age, which is consistent with what was reported in a study conducted on cases in Medellín,

which showed that malaria transmission in Colombia has a higher incidence within this population group (28).

Additionally, it was established that, regarding sex, it affects males more than females, although no statistical significance could be found. The explanation for this age group and sex being most affected by malaria may be based on: first, the tendency for urban populations to migrate to rural areas trying to escape situations of risk derived from economic uncertainty or social and/or political conflict; and second, the existence of potentially receptor regions that provide migrants with favorable economic prospects, even though these regions are associated with the proliferation of illicit crops, as well as an increase in illegal mining and the presence of groups operating outside the law, as happens in the CPDN, which causes populations to enter areas of the vector's natural habitat as a way of fulfilling their social and economic needs (25). The combination of these variables enhances the spread and permanence of the disease, which, added to a difficult access to the health system and the nearly total absence of the State in this area, contribute to worsening the situation even more (10,11).

However, despite the fact that the investigation found that mortality indicators have decreased, morbidity figures have shown an increasing trend. As for the distribution of cases, it was identified that in both study periods, this problem is mainly concentrated in the municipalities of Tumaco, Roberto Payán, and Olaya Herrera. Furthermore, the origin of most cases was usually the same micro-territories located in the interior of the mentioned municipalities (called *veredas* in Colombia), which, in turn, were characterized by typical eco-epidemiological conditions that favored the circulation of the vector. In this regard, the study Frequency and Tendency of Malaria in Colombia, 1990–2011, had pointed out that the spread and permanence of the disease is encouraged in a country with the eco-epidemiological conditions of Colombia, as is the case in the CPDN (29).

The previous findings coincide with the results from other advanced research in the same area. In addition, other studies allow to expand the insight on the impact of the disease on the population. Thus, the study “Complicated malaria in children and adults from three settings of the Colombian Pacific Coast,” identified a high prevalence of complicated malaria in this region, with side effects such as severe anemia, more frequently seen in children (30). The study, Clinical and epidemiological aspects of complicated malaria in Colombia, 2007–2013, also detected an increase in complicated malaria and suggested the creation of policies aimed at avoiding late diagnosis and inadequate disease treatment (31).

In line with the above, a descriptive study of 16 severe cases of *P. vivax* in three municipalities in Colombia between 2009 and 2013 posed a series of questions that should serve to generate new public policies regarding malaria care, such as: i) Does consultation time have an impact on the number of hospitalization days? ii) Are the severity criteria in the WHO guidelines sensitive enough? (32).

On the other hand, Juan Gabriel Piñeros in his study: “Malaria and social health determinants: a new heuristic framework from the perspective of Latin American social medicine,” mentions that in the case of malaria, the area of infection has in itself a particular set of circumstances that is important within its complexity, given that this disease occurs in specific and defined social territories related to unique historical and social dynamics within a defined landscape—the rural territory of tropical areas and the constant construction or deconstruction of its rural characteristics (33). The study: “Evaluación del impacto de las estrategias de promoción, prevención y control de la malaria Nariño-Colombia, 2003–2012,” evidenced that those scenarios that included community participation and education aimed at changing habits saw a greater impact in the decrease of malaria cases (11,34).

In light of the above, it can be deduced that if the epidemiological dynamics of the disease are to be modified, it is necessary to intervene in the prevention and control of malaria under other research paradigms, such as hermeneutics, which can contribute to the exploration of the social determinations and the determinants of health associated with this disease (33).

Therefore, new insights on the problem of malaria are required from the perspective of the challenges posed by the new health policies in Colombia, which should allow for the integration of the Comprehensive Health Care Plan and the Comprehensive Territorial Action Model (35,36). Subsequently, these can then be used under a Comprehensive Health Care Route specific to malaria in a local context with a community approach within the CPDN that manages to harmonize the guarantee of health services, beginning from primary healthcare, planned according to the specific features of the region (37).

The transformation of the epidemiological dynamics of malaria in the CPDN requires a holistic view of the problem, which will help to mitigate the inequity and social injustice historically suffered by the inhabitants of this Colombian region. To do this, public policy makers need to take into account the insights of those affected (the population) to develop plans that will have a significant impact on the social, political, and economic problems of the region. This can be done through actions aimed at the transformation of living conditions and social development, which will provide solutions to the problems associated with the appearance of malaria.

Thus, this work aims to be an input for decision-making that positively impacts this Colombian region. These decisions can be extrapolated, adopted, or adapted to other regions of the country and the world that share similar behaviors in this public health problem called malaria.

## Authors contributions

JG and GJ designed the study. JG gathered the necessary information. JG and RH performed the statistical analysis, interpreted the results, and wrote the article. JG and GJ supervised the statistical analysis and interpreted the results; GJ procured critical revision of the manuscript. RH helped interpret and revise the manuscript. JG and GJ adapted the manuscript for the journal. All of the authors read and approved the final manuscript.

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## Conflict of Interests

None declared.

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