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Inequitable Access to Healthcare and the Malaria Burden in Colombia: A Value-Based Policy Approach for Sustainable Elimination

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Abstract

Background: Despite broad national health coverage, malaria outcomes in Colombia remain unequal, especially in remote and rural territories. This study assessed disparities in healthcare access influencing malaria burden, severity, and mortality across Colombian municipalities from 2010 to 2023.

Methods: A longitudinal ecological study was conducted using data from the National Public Health Surveillance System, the national statistics agency, and the healthcare provider registry. Municipal indicators included the Potential Access Index for Health Services, Annual Parasite Index (API), and malaria case fatality rate (mCFR). Multivariable logistic and correlation models examined associations with diagnostic delay, travel time to care, age, and sex, adjusting for rainfall and temperature variability.

Results: Municipalities with lower healthcare access had higher mCFR and API. Diagnostic delay >48 hours (aOR, 4.1; 95% CI, 2.24–7.11) and very low access (aOR, 95% CI, 3.5; 1.94–6.37) were the strongest predictors. Extended travel time of >2 hours (aOR, 2.8; 95% CI, 1.62–5.15) and age <5 years (aOR, 1.9; 95% CI, 1.28–3.32) were independently associated with poor outcomes. Only 39.7% of cases were diagnosed within 48 hours. Women showed higher mCFRs across access levels, while men had greater fatality where access was poorest. The average travel time exceeded 3 hours in high-burden zones. Rainfall (aOR, 1.3) and temperature (aOR, 1.2) showed modest effects without altering access-related gradients.

Conclusion: Persistent inequities in diagnostic timeliness and healthcare availability remain significant barriers to malaria elimination in Colombia. Strengthening local diagnostic capacity and expanding community-based services are essential for equitable and sustainable elimination.

Keywords: Malaria, Access to Healthcare, Public Policy, Malaria Elimination, Colombia, Health Inequities, Rapid Diagnostic Tests

Conflicts of Interest: None declared
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Introduction

Malaria remains one of the most pressing global health and socioeconomic challenges, disproportionately affecting regions with underdeveloped healthcare systems (1).

In 2023, an estimated 263 million malaria cases and 597,000 deaths were reported globally, with 94% concentrated in 29 sub-Saharan African countries (2). In the Americas, the burden is highly focalized, with Brazil, Venezuela, and Colombia accounting for 76.8% of regional cases (2).

In Colombia, malaria is a significant public health con-

↑What is "already known" in this topic:
Geographic and socioeconomic inequities are significant barriers to malaria elimination. In Colombia, most studies have analyzed epidemiological or climatic trends separately, without jointly assessing how unequal healthcare access and environmental factors shape malaria burden and persistence.

→What this article adds:
This study integrates indicators of healthcare access with climatic variables, such as rainfall and temperature, to explain malaria outcomes across Colombian municipalities. After accounting for environmental variability, inequities in access to timely diagnosis and treatment remained significant, confirming the independent effect of health system gaps on malaria control and elimination.

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cern, especially in rural, remote areas <1600 meters above sea level, where nearly 10 million people are at risk of infection (3). These regions experience low-intensity, unstable transmission and face systemic limitations in infrastructure, human resources, and supply chains (4). *Plasmodium vivax* is the predominant species, followed by *P. falciparum,* which causes most severe cases (5). On average, 70,000 malaria cases are reported annually, with 2% classified as severe and 10 to 18 deaths recorded each year (6).

Ensuring equitable access to healthcare is essential to reducing the malaria burden, as outlined in the Global Technical Strategy for Malaria 2016–2030 (7). This strategy calls for universal access to timely diagnosis, treatment, and prevention measures. However, rural populations in Colombia continue to face substantial barriers, including insufficient health infrastructure, shortages of trained personnel, and unreliable supply chains. These challenges are exacerbated by economic constraints and structural inequalities that disproportionately affect indigenous and Afro-Colombian communities (8, 9). Overcoming these disparities requires sustainable, equity-oriented strategies—including strengthening rural health systems, expanding community-based interventions, and increasing investment in infrastructure and human resources (10).

This study aimed to examine how inequalities in access to healthcare services influence malaria morbidity and mortality in Colombia, focusing on diagnostic timeliness, geographic accessibility, and structural determinants that shape health outcomes.

Methods

Study Site

This study was conducted in Colombia, a geographically and epidemiologically diverse country in northwestern South America, with nearly 50 million inhabitants. For malaria surveillance, the country is divided into 6 eco-epidemiological regions: Amazon, Andean, Caribbean, Orinoquia, Pacific, and Uraba–Bajo Cauca–Sinu–San Jorge. The highest transmission occurs in the Pacific and in the Urabá–Bajo Cauca–Sinú–San Jorge regions. Administratively, Colombia comprises 32 departments and 1122 municipalities, which served as the unit of analysis (11). The national health system, based on mixed public-private financing, achieves 99.1% formal coverage and maintains one of the lowest out-of-pocket health expenditures in Latin America (12%) (12, 13).

Study Design and Data Sources

This study employed a longitudinal ecological design at the municipal level in Colombia, covering the period from 2012 to 2023. The design was chosen to assess the temporal and spatial dynamics of healthcare access and its impact on malaria outcomes. Municipalities were used as the unit of analysis because they are key political-administrative units that enable effective data aggregation and policy interpretation.

The Aday–Andersen framework was applied to conceptualize healthcare access (14). According to this model, potential access refers to the structural capacity of the health system—including availability, geographic proximity, and provider density—while realized access reflects the actual utilization of services by individuals once potential access exists. In this study, the Potential Access Index for Health Services (PAIHS) served as a proxy for potential access, while diagnostic timeliness (the proportion of cases diagnosed within 48 hours) served as a measure of realized access. This distinction was clarified to ensure consistency between the conceptual framework and variable definitions.

Secondary data for the analysis were obtained from 3 major national systems. Malaria incidence data, disaggregated by age and sex, were sourced from the National Public Health Surveillance System (SIVIGILA) for the 2010–2023 period. The SIVIGILA systematically collects mandatory reports on communicable diseases such as malaria, with geographic disaggregation down to the municipal level (https://www.ins.gov.co/Paginas/Inicio.aspx). Mortality data for the same period were retrieved from the National Administrative Department of Statistics (DANE) using the ICD-10 code B50 to identify deaths caused by malaria (http://www.dane.gov.co/). These data provided detailed mortality records, categorized by 5-year age groups and sex. Additionally, information on healthcare service availability was gathered from the Special Registry of Healthcare Providers, the official database of authorized healthcare providers in each territorial jurisdiction. This registry includes private clinics and institutional healthcare providers, such as hospitals and clinics, that offer a range of healthcare services.

Monthly climatic variables were incorporated to account for environmental variability. The mean monthly rainfall (millimeters) and the mean monthly temperature (°C) were obtained from national meteorological datasets and compiled at the municipality–month level. All records were linked to the analytical database using municipality codes and calendar month–year identifiers. Data underwent quality control procedures—including range validation, format harmonization, and temporal alignment—before analysis.

Data Analysis

The study variables were organized in a Microsoft Excel (Microsoft) database. Maps were generated in ArcGIS version 10.5 (ESRI), and all statistical analyses were performed in R (R Development Core Team).

Descriptive statistics were used to summarize the dataset—including absolute frequencies (e.g., the total number of malaria cases) and relative frequencies (e.g., the Annual Parasite Index [API] per 1,000 inhabitants). The API was calculated by dividing the number of malaria cases by the population at risk for each parasite species, adjusted for sex. The stratification of malaria transmission risk was conducted by adopting and adapting the criteria established by the Pan American Health Organization for area-based risk stratification (15).

Rainfall and temperature data were aggregated as municipality–month averages, centred at their overall means, and standardized (z-scores) to facilitate comparability across scales. For municipalities with <5% missing

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monthly values, single imputation by linear interpolation was applied within each time series; no municipality exceeded this threshold.

The Malaria Case Fatality Rate (mCFR) was defined as the proportion of malaria-related deaths among all severe cases. Diagnostic timeliness was assessed using 2 indicators: (1) the proportion of cases diagnosed within 48 hours of symptom onset, treated as a binary variable, and (2) the mean time to diagnosis, expressed in days.

The average distance from malaria cases to the nearest healthcare facility was calculated using the Euclidean distance approach. Straight-line distances between the geographic coordinates of municipalities with reported malaria cases and the nearest healthcare centers were computed using geospatial data. The average distance was expressed in kilometres, and the estimated travel time was calculated in hours, assuming an average walking speed of 2.5 km/h.

Spearman correlation coefficients were computed to evaluate relationships between healthcare access and malaria outcomes. Logistic regression models were applied to examine associations between severe malaria (dependent variable) and predictors, including PAIHS, distance to healthcare, diagnostic timeliness, age, and sex. The multivariate models included standardized climatic covariates (rainfall and temperature) as continuous predictors, together with structural and contextual controls such as rurality, poverty, and regional fixed effects. Nonlinearity in climatic effects was examined using restricted cubic splines with 3 knots, and multicollinearity was assessed using variance inflation factors (VIFs <5). Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were estimated for all covariates. Model diagnostics included tests for heteroscedasticity and overall goodness-of-fit, with robust standard errors to account for clustering and heterogeneity across municipalities.

To estimate the potential health gains from improving healthcare access, stratified incidence rates by PAIHS quintile were compared to the national median. From this, the number of preventable cases was estimated annually under a counterfactual scenario where access levels in the lowest-performing quintile matched the national median.

Additionally, the population attributable fraction was estimated to quantify the proportion of malaria cases attributable to limited or delayed healthcare access. This was derived using standard epidemiological methods based on relative risks and exposure prevalence across access strata.

Finally, a generalized linear regression model was constructed to quantify the marginal impact of diagnostic timeliness on malaria incidence. The proportion of cases diagnosed within 48 hours was entered as a continuous independent variable. The model estimated the percent reduction in malaria incidence per 10-percentage-point increase in timely diagnosis, adjusting for regional API, rurality, poverty, and the standardized climatic covariates (rainfall and temperature). Sensitivity analyses were performed with a 1-month lag for climatic variables and month-fixed effects to account for seasonality.

Results

Malaria Burden in Colombia

During the study period, malaria in Colombia exhibited a variable endemic-epidemic pattern, with a total of 1,011,393 reported cases, corresponding to an annual average of 72,242 cases and an API of 10.1 (± 2.6). Of these, 55.9% (565,635) were attributed to P. vivax (Figure 1).

Malaria predominantly affected men, who represented 59.7% (603,854) of total cases. The most affected age group was 15-29 years, accounting for 35.4% (357,495), followed by the 5-14 year group with 23.1% (233,973) (Figure 1).

In terms of healthcare system affiliation, 89.2% (902,508) of cases occurred among individuals enrolled in the subsidized regime, indicating a substantial concentration of disease burden among economically disadvantaged populations.

From an ethnic standpoint, 38.7% (391,608) of cases were reported among Afro-Colombians, and 21.2% (214,557) among indigenous peoples, underscoring persistent ethnic and structural inequities in malaria risk and exposure.

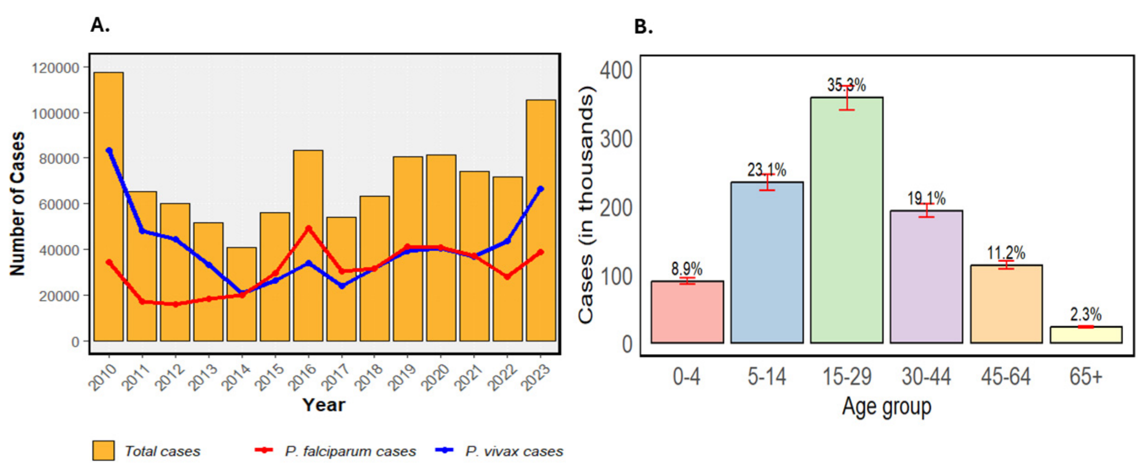

Figure 1. Distribution of malaria cases in Colombia (2010–2023): A) By parasite species, B) By age group

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Geographic and Eco-epidemiological Distribution

Geospatial analysis revealed that 51.6% (521,910) of malaria cases occurred in dispersed rural areas (Figure 2). When disaggregated by eco-epidemiological regions, the Pacific region contributed 42.7% (431,865) of cases, followed by Uraba–Bajo Cauca–Sinu–San Jorge (35.7%, 361,067) and the Amazon region (9.8%, 99,117). In 75% of the affected municipalities, *P. vivax* was the predominant species. In contrast, *P. falciparum* displayed a more focal distribution, mainly restricted to specific localities in the Pacific region. Areas with higher malaria incidence consistently overlapped with those with limited healthcare access, frequently exceeding an API of 10 per 1000 population.

Spatial patterns of malaria transmission showed partial correspondence with environmental gradients, with municipalities with higher mean rainfall and temperature also exhibiting elevated incidence. However, these geographic patterns remained consistent after considering the spatial distribution of healthcare access, indicating that structural access barriers coincided with ecologically favorable transmission areas.

Healthcare Access and Malaria Burden

A significant negative correlation was identified between the PAIHS and malaria incidence ($\rho = -0.65$; $P < 0.01$), indicating that as healthcare access decreases, malaria incidence increases. Moreover, case fatality rates were higher in municipalities with poor healthcare access. The API ratio between municipalities in the "very low" PAIHS quintile and those in the "very high" PAIHS quintile was significantly higher among men than among women. However, in cases of complicated malaria, the difference in API ratios between these quintiles was less pronounced, making the ratios more comparable. Specifically, for *P. vivax*, the API ratio between the "very low" and "very high" PAIHS quintiles was 12.1 in men and 6.0 in women. For *P. falciparum*, the API ratio was 26.5 in men and 22.6 in women. In cases of complicated malaria, the API ratio was 0.67 in men and 0.56 in women (Figure 3). These findings highlight that municipalities with the highest API were predominantly located in the lowest PAIHS quintiles, especially for *P. vivax* and *P. falciparum*. In contrast, municipalities with elevated API due to complicated malaria were concentrated in the "very high" PAIHS quintile.

After adjusting for climatic covariates, including mean monthly rainfall and temperature, the magnitude and direction of the associations between healthcare access and malaria indicators remained consistent. The negative correlation between the PAIHS and malaria incidence persisted after adjustment for climatic factors.

Malaria Case Fatality and Sex Disparities

Analysis of mCFR indicated that women consistently exhibited higher mCFRs across all PAIHS quintiles. Both men and women showed differences in average mCFRs between municipalities in the "very low" and "very high" PAIHS quintiles. However, the mCFR across these quintiles was higher in men, suggesting that healthcare access disparities may have a greater impact on male survival outcomes (Figure 4). These findings highlight the compounding effects of sex and geographic barriers on malaria-related mortality.

Adjusted models that included climatic covariates yielded similar mCFR patterns across sex and access catego-

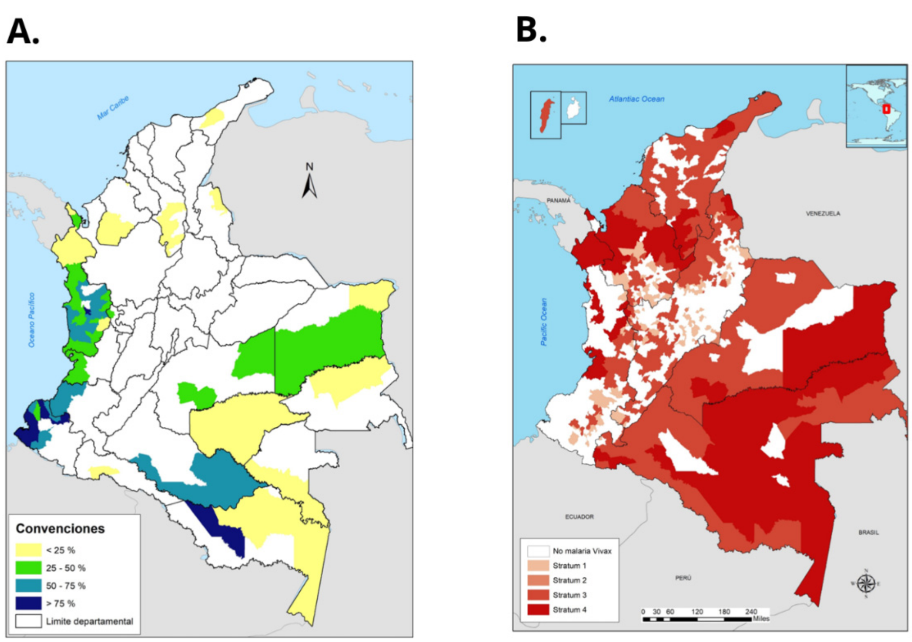

Figure 2. Geographic distribution of P. falciparum (A) and P. vivax (B) malaria in Colombia, 2010–2023. High-incidence areas overlap with low healthcare access zones and humid tropical regions

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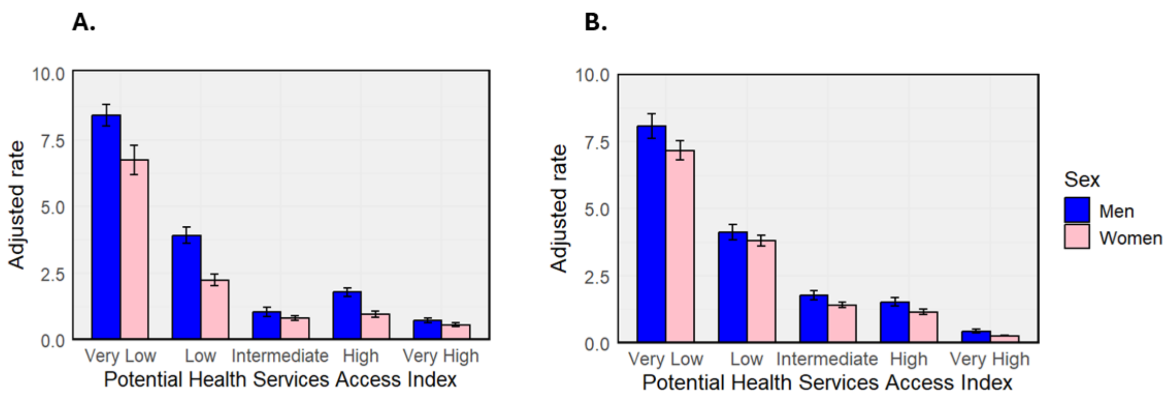

Figure 3. Adjusted annual parasitic index of malaria by quintile of potential access to health services and sex, Colombia 2013-2017: A. P. vivax. B. P. falciparum

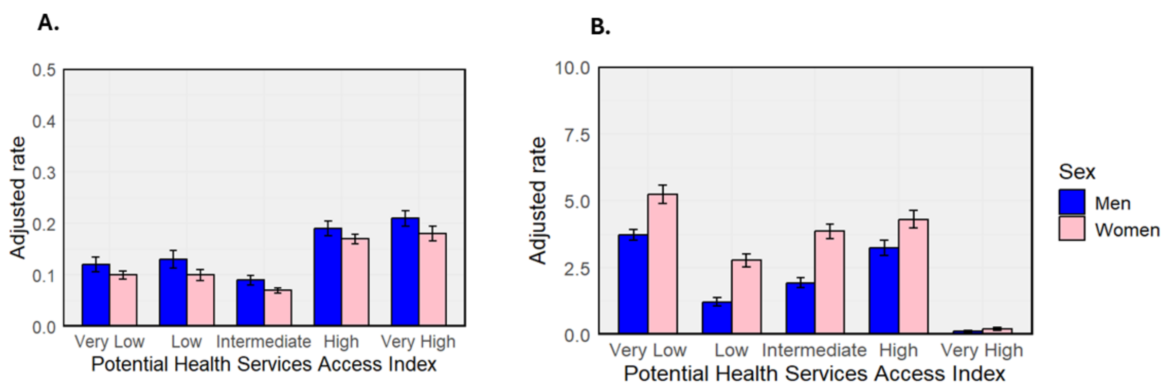

Figure 4. Adjusted annual parasitic index of malaria by quintile of potential access to health services and sex, Colombia 2013-2017: A. Severe malaria. B. Case fatality rate

ries. Including rainfall and temperature did not alter the associations between healthcare access and mortality outcomes.

Risk Factors for Severe Malaria

Timely diagnosis was achieved in 39.7% (401,427) of reported cases, with an average delay of 5.9 days (±8.9 days) between symptom onset and consultation. Severe malaria was more frequent among children under 5 years of age and in municipalities with limited healthcare access.

In bivariate analysis, diagnostic delays greater than 48 hours, very low healthcare access, and travel times exceeding two hours to the nearest facility were significantly associated with a higher OR of severe malaria ($P < 0.001$ for all comparisons).

In multivariate analysis, diagnostic delay remained a strong predictor of severe malaria (aOR 4.1, 95% CI, 2.24–7.11). Very low healthcare access (aOR, 3.5; 95% CI, 1.94–6.37) and travel distances greater than 2 hours (aOR, 2.8; 95% CI, 1.62–5.15) were also independently associated with greater odds of severe disease. Children under 5 years had a higher probability of severe malaria (aOR, 1.9; 95% CI, 1.28–3.32; $P < 0.01$). Sex was not significantly associated with severity.

Rainfall and temperature, standardized as continuous covariates, showed modest but significant associations with severe malaria (rainfall aOR 1.3; 95% CI, 1.05–1.46; $P = 0.008$; temperature aOR 1.2; 95% CI, 1.01–1.35; $P = 0.036$). Their inclusion did not change the direction or magnitude of associations observed for access-related variables. The full bivariate and multivariate model results are presented in Table 1.

Implications for Value-Based Health Policy and Disease Reduction

Regions with the lowest PAIHS consistently exhibited the highest malaria incidence, even after adjusting for rurality and poverty. These associations remained significant after adjustment for climatic variability. Using stratified models, it is estimated that 6,000–9,000 malaria cases could be prevented annually if access levels in the lowest quintile were raised to match the national median, equivalent to an 8.3%–12.5% reduction in national incidence.

Additionally, population attributable fraction estimates suggest that up to 27% of malaria cases may be attributable to delayed or inadequate access to healthcare.

A regression model revealed that for every 10% increase in timely diagnosis (within 48 hours), there was an associated 8.5% decrease in malaria incidence ($P < 0.01$),

Table 1. Bivariate and multivariate analysis of severe malaria in Colombia

Covariate	Bivariate analysis			Multivariate analysis		
	OR	95% CI	P-value	aOR	95% CI	*P*-value
Time from symptom onset to diagnosis						
≤48 hours	Ref					
>48 hours	3.3	1.87–4.36	<0.001	4.1	2.24–7.11	<0.001
Access to health services (PAIHS)						
Very high	Ref					
Very low	2.1	1.52–2.95	<0.001	3.5	1.94–6.37	<0.001
Distance to health center						
≤2 hours	Ref					
>2 hours	1.9	1.44–2.63	<0.001	2.8	1.62–5.15	<0.001
Age						
≥5 years	Ref					
<5 years	1.5	1.10–2.05	0.012	1.9	1.28–3.32	<0.001
Sex						
Women	Ref					
Men	1.2	0.95–1.54	0.125	1.1	0.62–2.34	0.852
Climatic covariates (standardized)						
Rainfall (per 1 SD)	1.2	1.08–1.37	0.001	1.3	1.05–1.46	0.008
Temperature (per 1 SD)	1.1	1.01–1.28	0.028	1.2	1.01–1.35	0.036

Ref: Reference; OR: Odds Ratio; aOR: Adjusted Odds Ratio; 95% CI: Confidence Interval 95%; SD: Standard Deviation; PAIHS: Potential Access Index for Health Services. Rainfall and temperature were standardized (OR per 1 SD monthly increase).

reinforcing the substantial return on investment in access-enhancing interventions, especially in high-burden, under-served municipalities.

Discussion

Malaria remains one of the most persistent public health challenges in Colombia, with an uneven impact across regions and population groups. This study analyzed inequalities in access to healthcare services and their potential influence on the malaria burden, emphasizing how structural barriers in healthcare infrastructure may shape disease outcomes. The findings suggest a strong association between limited healthcare access and higher malaria morbidity and mortality. Municipalities with poor access to healthcare services had the highest rates of uncomplicated and severe malaria, reflecting persistent inequities in the spatial distribution of the disease. After accounting for climatic variability, including rainfall and temperature, these associations remained consistent, indicating that access inequities likely exert an independent influence on malaria outcomes.

These results are consistent with previous evidence showing that disparities in healthcare access exacerbate the burden of tropical diseases such as malaria. A multi-country analysis in 40 endemic nations reported that higher malaria expenditures were inversely correlated with inequality in incidence and mortality, and that a 10% increase in health spending per capita among at-risk populations was associated with an 11.5% reduction in mortality inequality (16). Similar trends have been described in studies showing that malaria incidence doubled when travel time to healthcare increased from 10 minutes to two hours, while strengthening local diagnostic capacity was linked to a substantial reduction in disease burden (17). The consistency of these findings across diverse settings supports the interpretation that structural barriers to healthcare remain essential drivers of malaria persistence.

Delays in diagnosis remain one of the most critical challenges in malaria control. In this study, diagnosis after 48 hours of symptom onset was associated with a higher probability of severe malaria. Beyond quantitative findings, several contextual factors may help explain these delays, including interruptions in diagnostic supply chains, shortages of trained personnel, limited availability of rapid diagnostic tests (RDTs), and sociocultural barriers to care-seeking. Addressing these determinants requires both health system strengthening and community-based strategies that encourage timely symptom recognition and healthcare utilization. Enhancing the diagnostic capacity in peripheral facilities and integrating community participation have proven effective in similar endemic contexts (18, 19).

Sex-related differences were also observed, with men experiencing a higher incidence and women showing higher case fatality rates. Occupational exposure likely explains the greater incidence among men. At the same time, biological and social determinants such as pregnancy, caregiving responsibilities, and potential underdiagnosis or delayed treatment among women could contribute to the observed differences in outcomes (20). These patterns highlight the need for gender-sensitive approaches that ensure equitable diagnostic and treatment access for women, particularly in rural and peri-urban areas.

Expanding the use of RDTs remains a key strategy to reduce diagnostic delays and mortality. Currently, RDTs account for only 8% of malaria diagnoses in Colombia (21). Increasing their availability could shorten diagnostic time in remote areas and improve treatment outcomes. However, scaling up requires reliable supply chains, ongoing training of community health workers, and mechanisms for quality assurance and supervision. While this study did not include a formal cost-effectiveness assessment, evidence from similar settings suggests that RDT expansion is an efficient strategy when integrated with community participation and strengthened surveillance systems (22, 23).

Community-based interventions have been shown to improve early diagnosis, treatment adherence, and overall disease outcomes in endemic regions (24, 25). The involvement of local leaders and community volunteers builds trust, raises awareness, and enables rapid case detection, particularly in hard-to-reach areas. Expanding such participatory approaches could strengthen Colombia's malaria control programs and ensure long-term sustainability (26).

From a conceptual perspective, this study distinguished between "realized access," referring to the actual use of services, and "potential access," which captures the health system's structural capacity. The PAIHS reflects the latter and enables spatial assessment of equity in healthcare provision. The convergence of low realized and potential access in the same territories indicates that improving malaria outcomes will require not only the physical availability of services but also the reduction of sociocultural barriers that limit their utilization (18-22).

The empirical estimates from this analysis indicate the potential health gains from improving access. If municipalities in the lowest quintile of healthcare access reached the national median, between 6,000 and 9,000 malaria cases could be prevented annually, equivalent to an 8.3% to 12.5% reduction in national incidence (27). Furthermore, approximately 27% of malaria cases may be attributable to delayed or inadequate access, according to the population attributable fraction. These associations remained statistically significant after adjusting for rainfall and temperature, suggesting that social and infrastructural factors play a predominant role in sustaining malaria transmission.

Colombia has implemented several national initiatives to advance equitable malaria elimination (28). The Regional Initiative for Malaria Elimination (2019) in the Pacific region, where most national cases occur, prioritizes diagnosis within 48 hours and treatment within 24 hours through improved surveillance and intersectoral coordination (29). More recent programs, such as the Colombia Volunteer Collaborators strategy (2023) and the Decadal Public Health Plan (2022–2031), have expanded community participation and diagnostic coverage in remote areas (30). In 2024, the National Plan for the Elimination and Eradication of Transmissible Diseases reaffirmed malaria elimination by 2030 as a national goal for universal health coverage and equity (31). These initiatives align with the equity-based priorities identified in this study and illustrate a progressive shift toward more inclusive public health policies.

This study has several limitations that should be considered. The use of administrative data may have introduced misclassification errors. Mortality data may be incomplete or subject to reporting inconsistencies, potentially leading to underestimation of case fatality rates. Euclidean distances likely underestimate real travel times to health centers. Although climatic covariates were included, unmeasured ecological or behavioral factors may still contribute to residual confounding. In addition, the absence of qualitative data limited the ability to assess contextual determinants of diagnostic delay and healthcare-seeking behavior, which merit further investigation.

Despite these limitations, this study provides quantitative evidence supporting the importance of healthcare access as a determinant of malaria outcomes in Colombia. By integrating social, geographic, and environmental dimensions, it offers a comprehensive empirical foundation to guide equitable and sustainable malaria elimination strategies in endemic regions.

Conclusion

This study highlights the persistent challenge of malaria in Colombia and the substantial disparities in diagnosis, healthcare infrastructure, and access that drive higher morbidity and mortality. Despite national initiatives—such as the Regional Initiative for Malaria Elimination, the Colombia Volunteer Collaborators strategy, and the Decadal Public Health Plan—timely diagnosis and treatment remain limited in rural and hard-to-reach areas. While ecological and climatic factors affect transmission, social and structural inequities in access to care are the most consistent barriers to elimination. Addressing these gaps will require greater investment in diagnostic capacity (including expanded RDT use), strengthened local health systems, and community-based strategies for early detection and treatment. Sustainable malaria elimination will depend on equity-focused policies, stronger primary healthcare networks, and multisectoral commitment to ensuring timely, high-quality care for all Colombians.

Authors' Contributions

Mario Javier Olivera contributed to the conceptualization and design of the study, organized the information, conducted the statistical analyses, and drafted the manuscript. Haydi Magali Caro and Javier Ricardo Gómez participated in information organization, performed statistical analyses, and contributed to the drafting and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript.

Ethical Considerations

This study was conducted in accordance with the ethical guidelines established in Resolution 8430 of 1993, issued by the Ministry of Health of Colombia, which defines the scientific, technical, and administrative standards for health research and emphasizes the minimization of risks to participants. According to this resolution, the study qualifies as research without risk, as it relies exclusively on secondary data sources and involves no intervention or direct contact with human participants. No identifiable data were used, and all analyses were performed on fully anonymized datasets.

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Conflict of Interests

The authors declare that they have no competing interests.

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