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Socioeconomic determinants for malaria transmission risk in Colombia: An ecological study

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Abstract

Introduction. The risk of becoming ill and dying from malaria is associated with social inequalities that are expressed through differential access to opportunities for protection and health care in different socioeconomic settings. Thus, it is important to study the role of socioeconomic determinants in the persistence of malaria transmission in Colombia. This study aimed to assess the effect of various socioeconomic factors on the cumulative incidence of malaria in areas of Colombia with active foci. **Methods**: This is an ecological study of municipalities with active malaria transmission between 2010 and 2019. Socioeconomic variables documented in the last National Population Census carried out in 2018 were used. Simple analyses of the variables of interest were performed, and a multivariate linear regression model was adjusted to assess the impact of independent socioeconomic factors with raw malaria incidence rate. **Results**: In the period studied, of the 1,122 municipalities in the country, 583 (51.9%) reported a total of 607,042 malaria cases. Of these municipalities, 107 presented active foci, and 96.7% (586,756 cases) of the total cases were registered in the country. The potential risk factors that are negatively associated with the average municipal raw malaria rate were the fiscal performance index (-0.034) and the absence of walls made from adequate material in houses (-0.042). In addition, illiteracy (0.065) and the absence of formal employment for the head of the household (0.065) had a direct positive relationship with the raw rate of malaria. **Discussion**: The present study has identified potential socioeconomic and housing factors associated with malaria in Colombia, many of which are closely related to poverty. Improving literacy, housing and employment conditions may help Colombia's malaria elimination effort.

Key word: malaria, socioeconomic determinants, transmission, Colombia.

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Introduction

Malaria is a complex, dynamic, and multidimensional problem that is expressed in its persistent, epidemic, and endemic transmission (1). The endemic/epidemic transmission of malaria is currently a field of intense investigation since the determinants that lead to the epidemiological behavior of this disease and hinder elimination goals are still unknown. Despite being a preventable and curable disease, it presents high rates of morbidity and mortality with a significant economic burden (2). According to the latest World Malaria Report, in 2020, there were 241 million cases of malaria worldwide, and the estimated death toll was 627,000 (3). The incidence of malaria decreased from 81 in 2000 to 59 per 1,000 population at risk in 2019, before increasing again to 59 per 1,000 in 2020. This increase in 2020 was associated with the disruption of one or more malaria-related services during the COVID-19 pandemic (4).

Heterogeneity and targeted malaria transmission are common epidemiological characteristics in endemic countries of the Americas, with moderate and low intensity (1). Variability in malaria transmission between regions, even within the same country, suggests that socioeconomic determinants such as poverty, access to effective health care, and prevention services, in association with various cultural, demographic, ecological, and climatic factors, as well as biological and human behavior could play an important role in the spread and persistence of malaria (5). Various studies have suggested that malaria is more common in socioeconomically deprived populations (6–10).

In the epidemiological public health scenario in Colombia, malaria is a serious problem due to its endemic and epidemic behavior with variability among different regions (1). Approximately 70,000 cases are registered annually, with Plasmodium vivax infection predominating. It is focused mostly on the Pacific coast and the region that includes Uraba, Sinu and Bajo Cauca (1). The country registered a reduction in the reported number of malaria cases (approximately 40%), decreasing from 117,650 cases in 2010 to 40,768 cases in 2014; however, from 2017 to 2018, an increase in the number of cases recorded was recorded, from 54,102 to 63,143 cases, respectively (11,12).

Reducing the incidence and mortality rate of malaria are goals established in the framework of the "Global Technical Strategy against Malaria 2016-2030" to accelerate progress toward the elimination of this disease (13). Colombia, committed to this purpose, has been promoting policies and implementing strategies to reduce the incidence and mortality of the disease, strengthening services aimed at primary care, and improving the social and economic conditions in which people develop (14). The National Strategic Plan for Malaria 2019–2022 includes strategies for malaria prevention, diagnosis, and treatment and improved surveillance and control. The goals included in the National Strategic Plan for Malaria are to reduce malaria mortality by 80% by 2021 and morbidity by 40% by 2022 compared to 2017 (14). In this context, the country has shown a significant reduction in mortality in recent years; however, the transmission scenario is currently characterized by a higher frequency of epidemic outbreaks caused by intense migration, illegal mining, illicit crop cultivation, and armed social conflict (2).

Despite the efforts made to reverse this trend, the problem has been accentuated at the local level; thus, it is necessary to determine the socioeconomic risk factors that the population is exposed to, which will allow malaria control programs to develop and implement effective transmission interruption actions, in addition to applying methodological strategies to reduce or modify these factors and, therefore, the burden of the disease. In this context, this study aimed to assess the effect of various socioeconomic factors on the cumulative incidence of malaria in areas of Colombia with active foci.

Methods

Study design

An ecological study was carried out in 1,122 municipalities in Colombia using annual malaria cases from 2010–2019. To identify municipalities with high transmission, 1,600 m above sea level was used as a cutoff point. In addition, this study had indigenous cases from active foci (> 200 cases per year) for at least five years in the last decade. Non-receptive municipalities were those located above this altitude.

Data Collection

Information about malaria cases was obtained from the Departmental and District Malaria Prevention and Control Programs and the Integrated Information System of Social Protection (SISPRO is its Spanish acronym; https://www.sispro.gov.co/Pages/Home.aspx). In Colombia, it is mandatory that all malaria cases reported to surveillance systems be confirmed by identifying the type of *Plasmodium* species using microscopy diagnosis, rapid diagnostic tests and polymerase chain reaction. Microscopic examination of a blood smear is the gold standard in malaria diagnosis. The components of the multidimensional poverty index of the National Population Census were carried out in 2018 by the National Administrative Department of Statistics (DANE), and finally, the data was taken from the fiscal performance indicator generated by the National Planning Office.

Data analysis

All data were saved in Excel (Microsoft, Redmond, USA) and analyzed using Stata 15 (Stata Corporation, College Station, TX, USA). ArcGIS version 10.5 (ESRI, Redlands, CA, USA) was used to produce maps. Summary statistics were made for the whole dataset by making absolute and relative frequency measures. A multivariate log-linear regression model was adjusted to assess the association between the dependent variable and the independent variables. The dependent variable was the raw malaria incidence rate for each municipality. For the independent variables, the following components of the multidimensional poverty indicator were taken for each municipality in rural areas: illiteracy, inadequate wall materials, and informal employment of the head of the household. Additionally, the municipal fiscal performance index was included as an independent variable as it is a variable close to the institutional capacities that the municipality may have to face different problems that are subject to public policy, including public health.

This is the statistical model that was used:

$$Log(malaria\text{-}rate) = \beta 0 + \beta illiteracy + \beta inadequate\ wall\ material + \beta informal\ employment + \beta fiscal\ performance + error$$

Simple analyses of the variables of interest were performed, and a multivariate linear regression model was adjusted to assess the impact of independent socioeconomic factors with raw malaria incidence rate.

Ethical considerations

The present study met the ethical requirements established in Resolution 8430 of 1993 of the Ministry of Health of Colombia, Article 11, which establishes that studies such as the present one is risk-free and do not require approval by the Ethics Committee. The confidentiality and anonymity of the data were guaranteed.

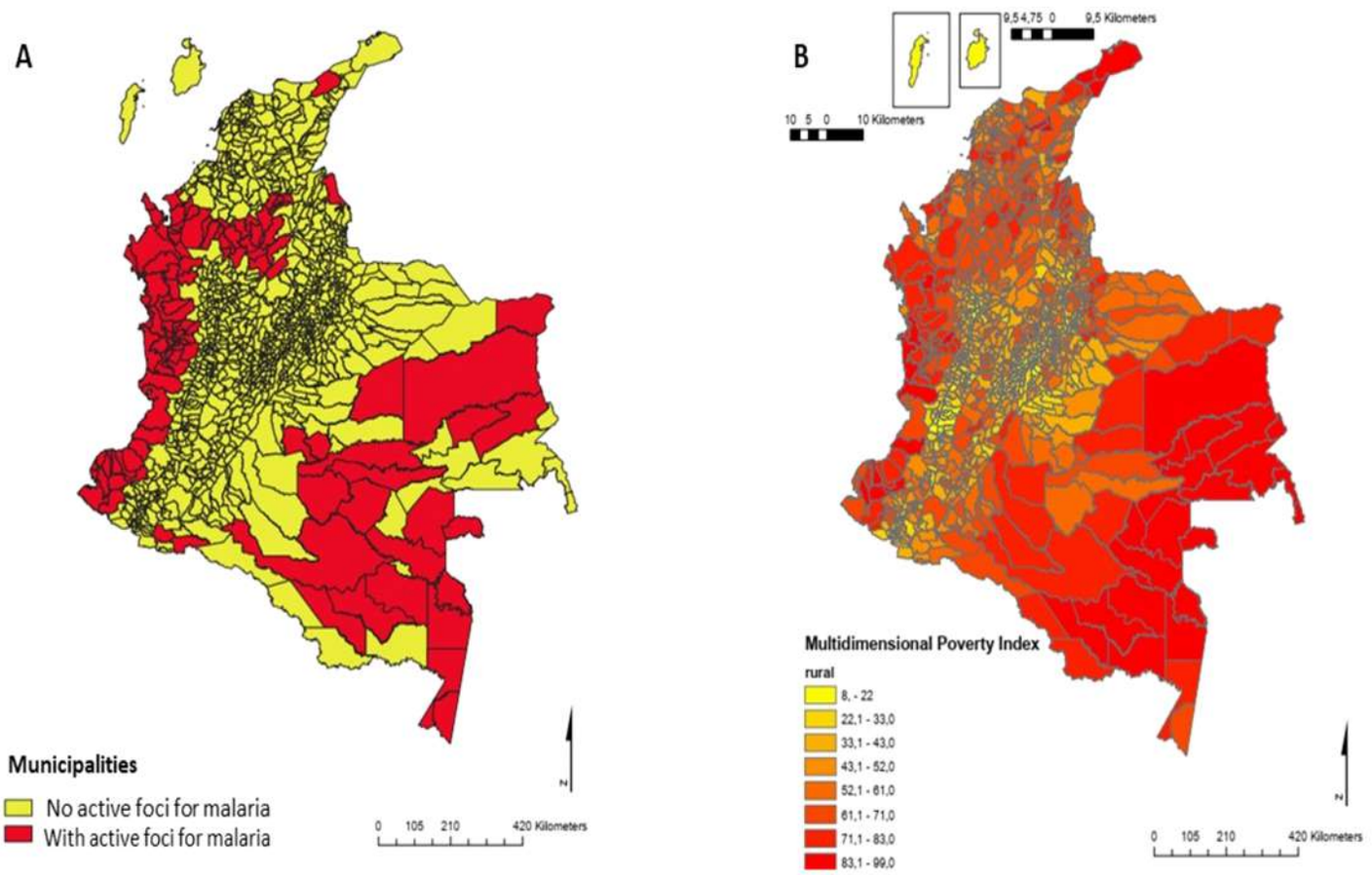
Results

The distribution of municipalities and population

Administratively, the country is divided into second-level territorial entities called departments (32) and districts (9) and third-level territorial entities called municipalities (1,122). Over the study period, 583 municipalities, which accounted for 51.9% of the municipalities in the country (583/1,122) reported a total of 666,901 malaria cases (1,144 cases per municipality). The area of high transmission included 107 municipalities (18.3% municipalities of the receptive area) that concentrated the cumulative burden of the disease between 2010 and 2019 of 644,893 cases, representing 96.7% of the cases registered in the country. The geographic distribution of municipalities is depicted in Figure 1.

Figure 1

Malaria by municipalities in Colombia, 2010 to 2019. A. Municipalities with active malaria foci. B. Multidimensional Poverty Index at the rural level



Most individuals who had malaria were male (60.4%), and the highest proportion of cases (80.1%) occurred after 19 years of age, particularly among those aged 27-44 years (29.7%), followed by those aged 19-26 years (14.5%) (Figure 2). Most of the cases occurred among people affiliated with the subsidized regime (64.6%), i.e., people with incomes below the current legal monthly minimum wage. In terms of ethnicity, 38.9% of the cases occurred in the Afromestizo population. Most of the cases occurred in individuals who worked as farmers (11.5%) and miners (11.5%) (Table 1).

Association of socioeconomic factors with crude malaria incidence in areas with active foci

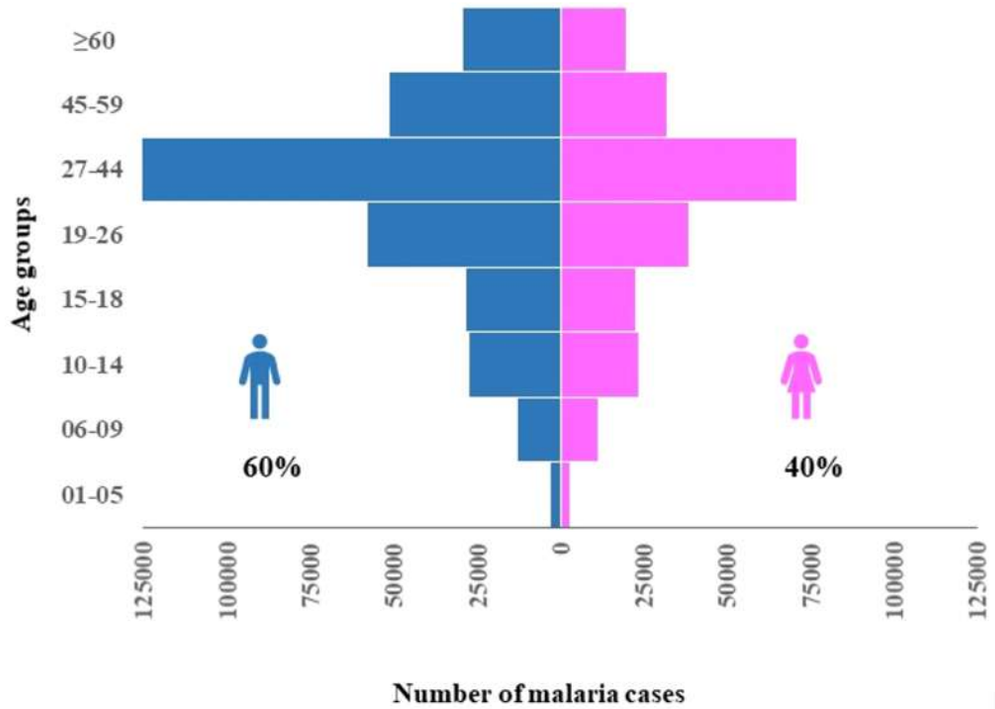
The results of the model suggest that there is a statistically significant negative association between the fiscal performance index (-3.4%), the lack of adequate material walls in a home (-4.2), and the municipal average raw rate of malaria. On the other hand, illiteracy (6.5%) and the absence of formal employment for the head of the household (6.5%) have a direct relationship with the municipal average raw rate of malaria (Table 2).

Discussion

Overall, our findings suggest a spatial focus and significant heterogeneity in malaria transmission for both P. falciparum and P. vivax infections in Colombia, reflecting the need for location-specific interventions that address as many social determinants of health as possible. The present study identified potential socioeconomic risk factors that contribute to the persistence of transmission in the country, many of which are closely related to poverty.

Figure 2

Age-sex pyramid of the total population with malaria, Colombia 2010 to 2019



Of the risk factors identified, only rural illiteracy is considered potentially modifiable. According to data from the DANE, from the "Large Integrated Household Survey" in 2017, the illiteracy rate in the country was 5.24%, equivalent to 1.8 million Colombians (15). Although the illiteracy rate has decreased at the country level, in rural areas the problem persists. The 2014 National Agricultural Census indicated that in the rural sector, the illiteracy rate was 12.6%; that is, this sector concentrated 50% of the illiterate population, demonstrating the gap between the urban and rural sectors (16).

These findings suggest that illiteracy represents a major challenge to achieve malaria elimination and, in turn, is an obstacle to poverty reduction in malaria endemic regions. Previous studies have found that people who live in high-transmission areas with higher levels of literacy and higher socioeconomic status practiced more modern preventive measures than those who live in low-transmission areas with low levels of literacy and were economically poor (17). On the other hand, countries that have managed to eliminate malaria in their territories experienced the greatest advances in education, measured by the number of years of complete schooling or literacy (18–21).

Informal work in rural areas is a difficult factor to address. In Colombia, it is estimated that only 18% of workers are classified as formal; that is, more than 80% are classified as having informal work (22). This high percentage is due in part to poor academic training and low levels of productivity in rural areas, causing the inhabitants of these areas to be forced to use any activity to survive(22–24). On the other hand, the age analysis revealed a greater number of informally employed men, especially between the ages of 20 and 59, where 50% of the total rural informal population is found (22). This age group coincides with the group that most frequently becomes infected with malaria (11,12). Most likely, this is related to the tasks that lead people to come into greater contact with the vector, such as mining, farming and employment as a merchant (25–27). These results agree with those reported in Iquitos, in which they identified that trips to rural areas were a risk factor associated with the presentation of malaria (28). To reduce informal employment, policies aimed at payroll tax reduction and investment in education must be implemented.

Another factor that must be taken into account in explaining malaria targeting is housing. The poverty conditions of a population are also reflected in houses with incomplete construction (10). However, in the present study, it was observed that houses with incomplete constructions had a lower incidence of malaria, which is contrary to expectations. We believe that it is likely that houses with incomplete infrastructure use insecticide-impregnated mosquito nets or long-lasting insecticidal nets more frequently as a protection mechanism, avoiding man-mosquito contact given the infrastructure conditions. Mass distribution campaigns for mosquito nets have been successful in increasing access to mosquito nets, and the percentage of use has also increased due to educational campaigns (29). The use of mosquito nets combined with other control measures, such as residual insecticide spraying, reduction of vector breeding sites, and timely treatment, is known to reduce the burden of malaria (30,31). However, these results contrast with other investigations that have described a higher risk of contracting malaria in houses with incomplete construction compared to in houses with complete construction (8,32,33).

Table 1
Characteristics of the population with malaria in Colombia, 2010 to 2019

Characteristics	Numbers	Percent (%)
All malaria cases	666,901	100
Age group (years)		
01-05	5,807	0.90%
06-09	24,239	3.60%
10-14	51,401	7.70%
15-18	50,945	7.60%
19-26	96,598	14.50%
27-44	198,285	29.70%
45-59	83,403	12.50%
≥60	49,562	7.40%
No data	106,661	16.00%
Sex		
Male	402,817	60.40%
Female	264,084	39.60%
Affiliation		
Subsidized	430,588	64.60%
Contributory	62,117	9.30%
No data	174,196	26.10%
Residence		
Urban	146,262	21.90%
Populated center	165,434	24.80%
Scattered rural	355,205	53.30%
Occupation		
Farmers	76,957	11.50%
Operators/mining	76,745	11.50%
Salespeople/unskilled jobs	22,296	3.30%
Public force	7,482	1.10%
Technicians/Professionals	5,985	0.90%
No data	477,436	71.60%
Social groups		
Afromestizo	259,487	38.90%
Indigenous	121,056	18.20%
Others	286,358	42.90%

Table 2
Association between crude malaria incidence rate and socioeconomic variables

Variable	Coefficient	IC 95%	
Fiscal performance index	-0,034**	-0,064	-0,004
Illiteracy	0,065***	0,038	0,092
Inadequate wall material	-0,042***	-0,064	-0,021
Informal employment	0,065**	0,008	0,121
C	-10.109**	-13,785	-1,436

Note: R^2 = 0.4311 *** p< 0.01 ** p< 0.05

In the endemic areas, the World Health Organization recommends universal coverage with insecticide-treated nets in populations at risk of contracting malaria (34,35). Mosquito nets treated with insecticide not only act as a physical barrier, but the presence of the insecticide is a protective factor since the insecticide produces two effects. First, it results in the mass mortality of mosquitoes, and second, it has repellency effect on mosquitoes (36).

In this study, the fiscal performance index of the municipalities was found to be inversely related to the incidence of malaria, showing that municipalities with good fiscal performance showed a lower incidence of malaria in their territories. This can be explained by the fact that a good fiscal performance is associated with having the administrative and financial capacity to carry out local policy programs in the areas of education, health, drinking water and basic sanitation, as well as actions to promote health and disease prevention (37). The fiscal performance index is an analytical tool established by Law 617 in 2000, which seeks to measure the degree of management that municipalities and departments give to their public finances (37). This indicator has a scale from 0 to 100, where values close to 0 reflect low fiscal performance. In contrast, values close to 100 mean that the territorial entity achieved a good balance in its fiscal performance, has sufficient resources to sustain its operation, high levels of investment, and has generated current savings necessary to guarantee its financial solvency in order to generate socioeconomic development and satisfy the needs of the population and its own interests (37).

The main limitation of this study is related to possible information and selection bias due to the use of secondary data. In the surveillance system, only cases that came to official health services for a malaria diagnosis were reported, and there is little information on the entities that carry out diagnoses outside the system, which could lead to under-reporting. In the national surveys used, the mode of selection of the surveyed subjects could be related to a lower or greater exposure compared to the base population. To control for potential biases, the information contained in the public health surveillance system's database, which are refined and analyzed by the departmental referent of the event, was taken into account, and the national census database was chosen. Despite these limitations, we think the results are very accurate and representative of the country.

Conclusion

This study demonstrates that malaria transmission persistence in Colombia municipalities with high and low endemicity is strongly related to socioeconomic determinants that cannot be addressed solely by the Colombian health system. Malaria transmission is determined by known environmental factors, whereas successful disease control requires an in-depth understanding of the economic and social factors that influence the disease's transmission. Interventions must include strategies to increase access to education and housing, as well as vector control and interventions that ensure timely diagnosis and treatment.

Conflict of interest

The authors had full freedom of manuscript preparation and there are no potential conflicts of interest to disclaim.

Author's Contributions

All authors made substantial contributions in following aspects: (1) conception and design of the study, acquisition of data, and analysis and interpretation of the data; (2) draft of the article and critical review of the intellectual content; and (3) final approval of the version presented.

Ethical Statement

In writing the manuscript, the authors followed the policy of the Committee on Publication Ethics.

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References

1. Padilla-Rodríguez JC, Olivera MJ, Ahumada-Franco ML, Paredes-Medina AE. Malaria risk stratification in Colombia 2010 to 2019. PLoS One. 2021;16(3):e0247811.
2. Rodríguez SNI, Rodríguez JAI, Rodríguez JCP, Olivera MJ. Malaria mortality in Colombia from 2009 to 2018: a descriptive study. Rev Soc Bras Med Trop. 2021; 54: e04412020.
3. World Health Organization. World malaria report 2021 [Internet]. Geneva, Switzerland; 2021. Available from: https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021
4. World Health Organization. World malaria report 2019 [Internet]. Geneva, Switzerland; 2019. Available from: https://www.who.int/publications/i/item/world-malaria-report-2019
5. Cardona-Arias JA, Salas-Zapata WA, Carmona-Fonseca J. [Social determination and determinants of malaria: a systematic review, 1980-2018Determinação social e determinantes sociais da malária: revisão sistemática, 1980-2018]. Rev Panam Salud Publica. 2019;43:e39.
6. Banguero H. Socioeconomic factors associated with malaria in Colombia. Soc Sci Med. 1984;19(10):1099–104.
7. Shayo EH, Rumisha SF, Mlozi MRS, Bwana VM, Mayala BK, Malima RC, et al. Social determinants of malaria and health care seeking patterns among rice farming and pastoral communities in Kilosa District in central Tanzania. Acta Trop. 2015 Apr;144:41–9.
8. Sharma RK, Rajvanshi H, Bharti PK, Nisar S, Jayswar H, Mishra AK, et al. Socio-economic determinants of malaria in tribal dominated Mandla district enrolled in Malaria Elimination Demonstration Project in Madhya Pradesh. Malar J. 2021 Jan;20(1):7.
9. Lowassa A, Mazigo HD, Mahande AM, Mwang'onde BJ, Msangi S, Mahande MJ, et al. Social economic factors and malaria transmission in Lower Moshi, northern Tanzania. Parasit Vectors. 2012 Jun;5:129.
10. Sojo-Milano M, Cáceres J, Pizzo N. Prevalencia y factores asociados a infección por Malaria Parroquia Yaguaraparo, Estado Sucre, Venezuela, año 2004. Comunidad y Salud. 2009;7(1):38–45.
11. Instituto Nacional de Salud. Informe de evento malaria, 2017. [Internet]. Bogotá; 2017. Available from: https://www.ins.gov.co/buscador-eventos/SitePages/Evento.aspx?Event=13
12. Instituto Nacional de Salud. Informe de evento malaria, 2018. [Internet]. Bogotá; 2018. Available from: https://www.ins.gov.co/buscador-eventos/Informesdeevento/MALARIA_2018.pdf
13. World Health Organization. Global Technical Strategy for Malaria 2016–2030 [Internet]. Geneva, Switzerland; 2015. Available from: https://www.who.int/malaria/publications/atoz/9789241564991/en/
14. Ministerio de Salud y Protección Social. Plan estrategico nacional de malaria en Colombia, 2019–2022. [Internet]. Bogotá, Colombia.; 2020. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/PP/PAI/plan-estrategico-malaria.pdf
15. Departamento Administrativo Nacional de Estadística. Great Integrated Household Survey [Internet]. 2017. Available from: https://www.dane.gov.co/index.php/eng/pib-cuentas-nacionales/investigaciones-especiales/178-economicas/agropecuario/2920-noviembre
16. Departamento Administrativo Nacional de Estadística. Censo Nacional Agropecuario [Internet]. 2014. Available from: https://www.datos.gov.co/widgets/6pmq-2i7c
17. Singh MP, Saha KB, Chand SK, Savargaonkar D. Socioeconomic determinants of community knowledge and practice in relation to malaria in high- and low-transmission areas of central India. J Biosoc Sci. 2020 May;52(3):317–29.
18. Cirera L, Castelló JV, Brew J, Saúte F, Sicuri E. The impact of a malaria elimination initiative on school outcomes: Evidence from Southern Mozambique. Econ Hum Biol [Internet]. 2022;44:101100. Available from: https://www.sciencedirect.com/science/article/pii/S1570677X21001258
19. Fernando D, de Silva D, Wickremasinghe R. Short-term impact of an acute attack of malaria on the cognitive performance of schoolchildren living in a malaria-endemic area of Sri Lanka. Trans R Soc Trop Med Hyg. 2003; 97(6): 633–9.
20. Lucas AM. Malaria Eradication and Educational Attainment: Evidence from Paraguay and Sri Lanka. Am Econ J Appl Econ. 2010 Apr;2(2):46–71.
21. Feng J, Tu H, Zhang L, Zhang S, Jiang S, Xia Z, et al. Mapping transmission foci to eliminate malaria in the People's Republic of China, 2010-2015: a retrospective analysis. BMC Infect Dis. 2018 Mar;18(1):115.
22. Fedesarrollo, ACRIP. Informe Mensual del Mercado Laboral. [Internet]. Bogotá, Colombia.; 2017. Available from:

https://www.repository.fedesarrollo.org.co/bitstream/handle/11445/3418/IML_Mayo_2017.pdf?sequence=1&isAllowed=y
23. Leibovoch J, Nigrinis-Ospina M, Ramos-Veloza M. Caracterización del mercado laboral rural en Colombia. Borradores Econ [Internet]. 2006;408. Available from: https://www.banrep.gov.co/es/caracterizacion-del-mercado-laboral-rural-colombia
24. Otero-Cortés A. El mercado laboral rural en Colombia, 2010-2019. Doc Trab sobre Econ Reg y Urbana [Internet]. 2019;281. Available from: https://repositorio.banrep.gov.co/handle/20.500.12134/9762
25. da Silva NS, da Silva-Nunes M, Malafronte RS, Menezes MJ, D'Arcadia RR, Komatsu NT, et al. Epidemiology and control of frontier malaria in Brazil: lessons from community-based studies in rural Amazonia. Trans R Soc Trop Med Hyg. 2010 May;104(5):343–50.
26. Souza PF, Xavier DR, Suarez Mutis MC, da Mota JC, Peiter PC, de Matos VP, et al. Spatial spread of malaria and economic frontier expansion in the Brazilian Amazon. PLoS One. 2019;14(6):e0217615.
27. Ferreira IM, Yokoo EM, Souza-Santos R, Galvão ND, Atanaka-Santos M. Factors associated with the incidence of malaria in settlement areas in the district of Juruena, Mato Grosso state, Brazil. Cien Saude Colet. 2012 Sep;17(9):2415–24.
28. Vargas J, Elgegren J, San Miguel A, Cardozo R. Malaria en una Población Urbano Marginal de Iquitos. Revista Peruana de Epidemiología. Rev Peru Epidemiol. 2003;11(1):1–8.
29. Ministerio de Salud y Protección Social. Lineamiento TILD para la prevención de malaria. Planeación, ejecución, monitoreo y evaluación de la estrategia de toldillos insecticidas de larga duración [Internet]. Bogotá, Colombia.; 2016. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/PP/ET/lineamiento-tild-prevencion-malaria.pdf
30. Choi L, Pryce J, Garner P. Indoor residual spraying for preventing malaria in communities using insecticide-treated nets. Cochrane database Syst Rev. 2019 May; 5(5): CD012688.
31. Pryce J, Richardson M, Lengeler C. Insecticide-treated nets for preventing malaria. Cochrane database Syst Rev. 2018 Nov;11(11):CD000363.
32. Sharma RK, Singh MP, Saha KB, Bharti PK, Jain V, Singh PP, et al. Socio-economic & household risk factors of malaria in tribal areas of Madhya Pradesh, central India. Indian J Med Res. 2015 May;141(5):567–75.
33. Mohan I, Kodali NK, Chellappan S, Karuppusamy B, Behera SK, Natarajan G, et al. Socio-economic and household determinants of malaria in adults aged 45 and above: analysis of longitudinal ageing survey in India, 2017-2018. Malar J. 2021 Jul;20(1):306.
34. World Health Organization. Scaling-up insecticide-treated netting programs in Africa: A Strategic Framework for Coordinated National Action. (WHO/CDS/RBM/2002.43) [Internet]. Geneva, Switzerland; 2002. Available from: https://www.who.int/malaria/publications/atoz/winitn_strategicframework.pdf?ua=1
35. World Health Organization, Malaria Control Unit & United Nations Children's Fund (UNICEF). The Africa Malaria Report, 2003. (WHO/CDS/MAL/2003.1093) [Internet]. 2003. Available from: https://apps.who.int/iris/handle/10665/67869
36. Lindblade KA, Dotson E, Hawley WA, Bayoh N, Williamson J, Mount D, et al. Evaluation of long-lasting insecticidal nets after 2 years of household use. Trop Med Int Health. 2005 Nov;10(11):1141–50.
37. Departamento Nacional de Planeación. Desempeño Fiscal [Internet]. 2018. Available from: https://www.dnp.gov.co/programas/desarrollo-territorial/Estudios-Territoriales/Indicadores-y-Mediciones/Paginas/desempeno-fiscal.aspx