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Original Article

Analysis of inpatient data on dengue fever, malaria and leishmaniasis in Ecuador: A cross-sectional national study, 2015–2022

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ABSTRACT

Background: Despite concerted efforts in South America, these diseases continue to pose a significant burden of morbidity and mortality in endemic regions. This study aimed to analyse hospital data and investigate the hospitalisation rates of dengue fever, leishmaniasis, and malaria in Ecuador between 2015 and 2022.
Methods: Open-access databases from the National Institute of Statistics and Censuses of Ecuador between 2015 and 2022 were analysed. Data were filtered using specific terms for each disease (ICD-10), and descriptive statistics of geographical distributions were calculated using Microsoft Excel, Stata 14.2, and Rstudio.
Results: Dengue had the highest burden, with 31,616 reported cases, followed by malaria (1,316) and leishmaniasis (283). From 2015 to 2022, the highest hospitalisation rate per 10^5 inhabitants for dengue was observed in Sucumbios province (697.2), for malaria in Pastaza province (108.4), and for leishmaniasis in Morona Santiago province (18.8). The data's trend analysis revealed a slight increase in dengue and mild downward trends in hospitalisation for malaria and leishmaniasis.
Conclusions: The results suggest that vector-borne disease control has failed in Ecuador. Unfortunately, there was no significant trend towards a decrease in dengue, malaria, and leishmaniasis in Ecuador during the years studied. This study highlights the need to optimise sustainable vector control programs and emphasises continuous monitoring of disease incidence and control measures.

1. Background

Vector-borne diseases (VBDs) are a major global health problem, with a high burden of disease and mortality. These include malaria, dengue fever, and leishmaniasis. According to the World Health Organization (WHO), dengue fever causes between 100 and 400 million infections yearly, malaria 247 million cases yearly, and leishmaniasis between 700,000 and 1 million new cases yearly.

Etiologically, in humans, dengue fever is caused by the dengue virus (DENV) and its genotypes DENV1, DENV2, DENV3, and DENV4 [1]. Malaria is caused by the genus *Plasmodium* and its species *falciparum, vivax*, *malariae, ovale*, and *knowlesi* [2]. However, infection by additional species has been reported in humans, including *P. cynomolgi* [3] and *P. simium* [4]. Leishmaniasis is caused by the genus *Leishmania,* and more than 20 species differ according to clinical phenotype and geographical region [5].

Despite etiological differences, they are all transmitted by the bites of different female vectors that produce VBDs in endemic areas. Dengue

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fever is mainly transmitted by *Aedes aegypti* and *Aedes albopictus* [1]. There is a concern in the Americas due to the presence of *Aedes vitattus* in some Caribbean islands [6]. Multiple *Anopheles* species transmit malaria. Leishmaniasis is transmitted through the bite of insects of the *Psychodidae* family [5,7].

Malaria, dengue fever, and leishmaniasis are among South America's most prevalent VBDs. Consequently, these diseases substantially impact the health and well-being of individuals, families, and communities, particularly those living in impoverished areas with limited access to healthcare [8].

Situated in northwestern South America, Ecuador is an endemic area for malaria, dengue, and leishmaniasis. The country has a diverse geography, ranging from the Pacific coast to the Andean highlands, the Amazon rainforest, and the Galápagos Islands. The presence of a wide range of vectors and their distribution in different regions of Ecuador create a perfect environment for transmitting VBDs [9].

The distribution of vectors in Ecuador is influenced by different factors such as temperature, humidity, and altitude [10]. The highlands of the Andes have a temperate climate and are less favourable for vector reproduction than the hot and humid regions of the Amazon rainforest and the Pacific coast. The distribution of vectors and their incidence in Ecuador is not well known, and few studies have provided an approximate estimate of the burden of VBDs in the country [10–13].

Apart from the cumulative data reported to international organisations, no studies have described the geographic distribution of leishmaniasis, dengue fever, and malaria in Ecuador.

In Ecuador, dengue fever is spread mainly by DENV-1 and DENV-2 viruses [14]. Malaria is predominantly caused by *P. vivax*, with a smaller proportion of cases due to *P. falciparum*, which has a higher mortality rate despite its lower prevalence [15]. According to a study by Kato et al. on the geographical distribution of *Leishmania* species, most cases in Ecuador are attributed to *L.* (V.) *guyanensis*, which accounts for 74.4 % of cases, followed by *L.* (V.) *braziliensis* with 20.0 % [16].

This study analysed inpatient hospital data to understand the incidence of malaria, dengue fever, and leishmaniasis in Ecuador between 2015 and 2022. For this purpose, we used an open-access database from the National Institute of Statistics and Census 2022.

2. Methods

2.1. Study design

This cross-sectional ecological study used anonymised databases from the National Institute of Statistics and Censuses (INEC) between 2015 and 2022 to characterise the hospitalisation rate with confirmed reports of dengue fever, leishmaniasis, and malaria in Ecuador. The 2015-2022 cumulative incidence data were obtained from an open-access and anonymised hospital discharge database. In Ecuador, dengue fever, malaria, and leishmaniasis are notifiable and recorded in national software distributed in public and private health facilities.

2.2. Sample and setting

We collected data on the confirmed cases from the INEC of Ecuador. Databases for 2015–2022 were extracted in comma-separated values (CSV) format. The documents were downloaded from the "*Ecuador en Cifras*" web portal (https://www.ecuadorencifras.gob.ec/camas-y-egresos-hospitalarios/). The study population included individuals of all ages living in Ecuador during the study period. The denominator of population numbers in Ecuador and its provinces for the calculus of annual incidence was obtained from the INEC population projections.

2.3. Data source and description

We filtered the data of all hospitalisation cases by specific terms for each disease based on the International Classification of Diseases, 10th Revision (ICD-10). Statistically, we analysed them using Stata (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC). Filter codes and their variants were considered for all diseases, including dengue fever A90, A91, and A97. Malaria B50, B51, B52, B53, and B54. Leishmaniasis B55. We included data on confirmed disease cases and geographic location in our analysis. The geographic area was divided into four regions: the Pacific coast, the Andean highlands, the Amazon rainforest, and the Galápagos islands.

Our study gathered continuous and categorical data at the national level and information on the above-diagnosed cases over eight years from 24 provinces within the country. In addition, we collected data from public healthcare providers with universal coverage and social security pension plans, as well as private healthcare providers, including for-profit and non-profit entities.

2.4. Data analysis

Hospitalisation rates for dengue, malaria, and leishmaniasis from 2015 to 2022 were calculated using hospitalisation data and population information by province provided by the INEC's open sources. For years 2015–2020, official population figures were used as the denominator, while for 2021 and 2022, in the absence of official projections, population estimates were derived using linear regression based on INEC data. This approach, employing a linear model to predict population changes over time, facilitated the projection of future population sizes and underscored the utility of linear regression in evidence-based planning and decision-making. For the hospitalisation incidence rate between 2015 and 2022, the total number of hospitalisation cases extracted from the INEC database was employed as the numerator. The denominator was the average population, calculated from 2015 (INEC) and 2022 (projected) information. The statistical package Stata 14.2 (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.) was employed for the linear regression and heat tables.

The percentage of cases per province relative to the cumulative gross number of cases each year was determined to identify patterns in the distribution of vector-borne diseases. Heat maps were used to graphically represent the hospitalisation rate of cases and show the distribution of diseases and regions over time. In addition, we performed a time series analysis based on population-adjusted annual hospitalisation rate to identify trends in disease incidence over the study period. These annual hospitalisation rates were calculated using INEC population data annually in Ecuador and adjusted to a population (pop.) of 100,000 (10^5).

3. Results

3.1. Dengue fever

During the analysed period, there were 31,616 cases of dengue fever. The three central provinces affected were Sucumbios, Orellana, and Esmeraldas (Fig. 1A). Sucumbíos' hospitalisation rate per 10^5 pop was reported at 679,2, followed by Orellana (642,3) and Esmeraldas (472,4). The lowest hospitalisation rate was in 2018, with 4 cases per 10^5 pop. The highest rate was observed in 2015, with 41.2 cases per 10^5 pop (Fig. 1C). The yearly changes in the hospitalisation rate for dengue fever in Ecuador from 2015 to 2022, categorized by province, are illustrated in the e-component Heat Maps per year dengue, Ecuador.

3.2. Malaria

There were 1316 cases of malaria during the analysed period. The three central provinces affected were Pastaza, Esmeraldas, and Morona Santiago (Fig. 2A). Pastaza's hospitalisation rate per 10^5 pop was reported at 108,4, followed by Esmeraldas (96,2) and Morona Santiago (66,2). The lowest hospitalisation rate was in 2022, with 0,5 cases per

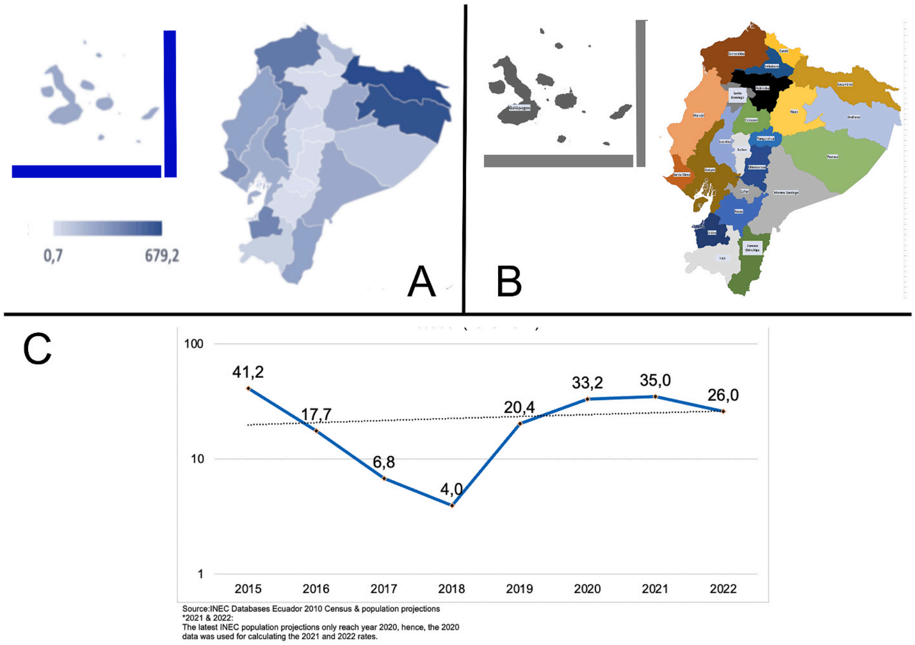

Fig. 1. Hospitalisation Rates by Province and Population-Adjusted Dengue Trends in Ecuador (2015–2022). 1A.- Population-Adjusted Dengue Heat Map by Province in Ecuador (2015–2022). 1B.- Reference map of the provinces of Ecuador. 1C.- Trend calculated from INEC population data from 2015 to 2020, while 2021 and 2022 populations adjusted from INEC projections for dengue hospitalisations in Ecuador.

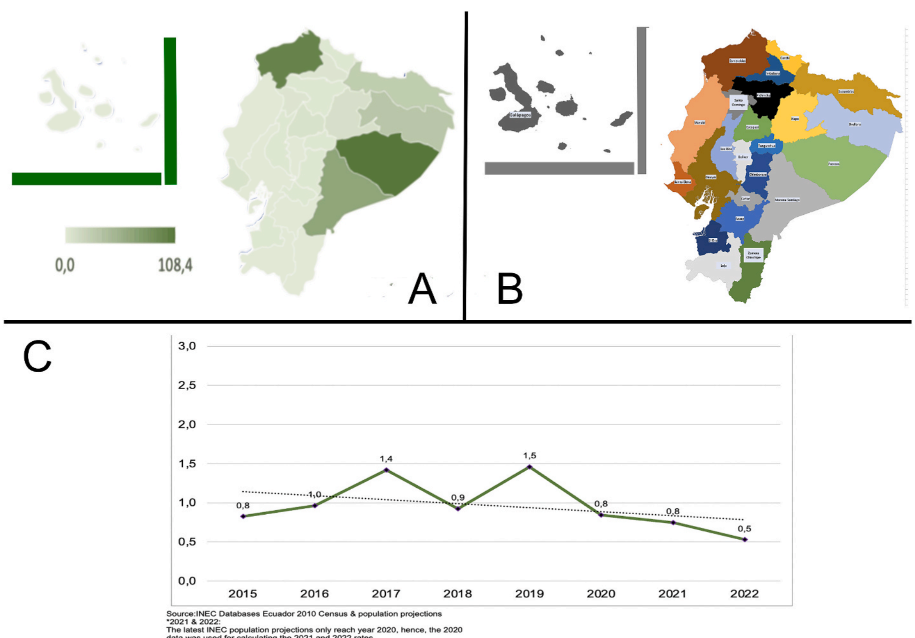

Fig. 2. Hospitalisation Rates by Province and Population-Adjusted Malaria Trends in Ecuador (2015–2022). 2A.- Population-Adjusted Malaria Heat Map by Province in Ecuador (2015–2022). 2B.- Reference map of the provinces of Ecuador. 2C.- Trend calculated from INEC population data from 2015 to 2020, while 2021 and 2022 populations adjusted from INEC projections for dengue hospitalisations in Ecuador.

10^5 pop. The highest rate was observed in 2019, with 1.5 cases per 10^5 pop (Fig. 2C). The yearly changes in the hospitalisation rate for malaria in Ecuador from 2015 to 2022, categorized by province, are illustrated in the e-component Heat Maps per year malaria, Ecuador.

4. Leishmaniasis

Leishmaniasis had 283 cases during the analysed period. The three central provinces affected were Morona Santiago, Zamora Chinchipe, and Pastaza (Fig. 3A). Morona Santiago's hospitalisation rate per 10^5 pop was reported at 18,8, followed by Zamora Chinchipe (10,5) and Pastaza (9,3). The lowest hospitalisation rate was in 2020 and 2021, with 0,1 cases per 10^5 pop. The highest rates were observed in 2018 and 2019, with 0.3 cases per 10^5 pop (Fig. 3C). The yearly changes in the hospitalisation rate for leishmaniasis in Ecuador from 2015 to 2022, categorized by province, are illustrated in the e-component Heat Maps per year leishmaniasis, Ecuador.

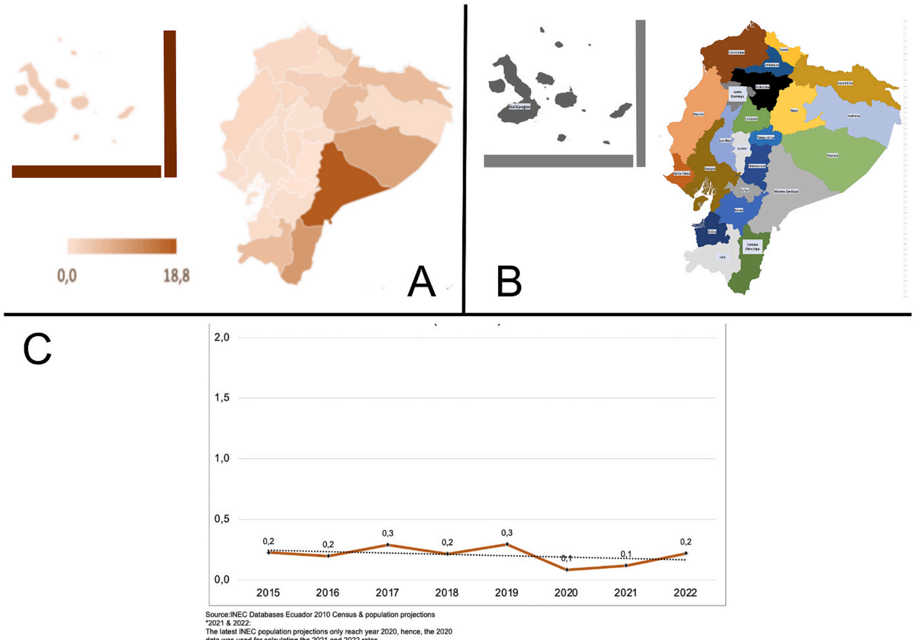

Fig. 3. Hospitalisation Rates by Province and Population-Adjusted Leishmaniasis Trends in Ecuador (2015–2022). 3A.- Population-Adjusted Leishmaniasis Heat Map by Province in Ecuador (2015–2022). 3B.- Reference map of the provinces of Ecuador. 3C.- Trend calculated from INEC population data from 2015 to 2020, while 2021 and 2022 populations adjusted from INEC projections for dengue hospitalisations in Ecuador.

4.1. Analysis of the population-adjusted hospitalisation rates by region in Ecuador

Regarding regions related to Dengue Fever, the Galápagos Islands exhibited the highest hospitalisation rate in 2015, with 122.2 per 10^5 population. Nevertheless, Dengue predominates notably in the Amazon rainforest, followed by the Pacific Coast (Table 1A).

Leishmaniasis in the Galápagos Islands exhibited the highest hospitalisation rate in 2018, with 3.2 per 105 population (Table 1C). This occurrence was unusual and occurred solely in 2018. Conversely, the predominance of Malaria in the Amazon rainforest remained consistent across all years studied, followed by the Andean highlands (Table 1B).

Table 1
Hospitalisation rates by region and population-adjusted for dengue fever, malaria, and leishmaniasis (2015–2022).

1A.- Hospitalization Rate Dengue								
Region/Year	2015	2016	2017	2018	2019	2020	2021	2022
Pacific Coast	67,9	24,7	10,6	5,3	30,9	54,5	58,6	42,0
Andean highlands	5,2	4,2	1,0	0,7	2,0	2,2	2,9	2,2
Amazon rainforest	61,0	57,1	15,9	16,6	63,4	70,3	56,8	58,7
Galápagos Islands	122,2	3,3	6,5	3,2	0,0	57,5	53,3	14,5

1B.- Hospitalization Rate Malaria								
Region/Year	2015	2016	2017	2018	2019	2020	2021	2022
Pacific Coast	1,0	1,2	1,9	0,9	1,8	0,9	0,6	0,3
Andean highlands	0,4	0,3	0,4	0,4	0,5	0,3	0,1	0,3
Amazon rainforest	2,9	4,0	5,2	4,8	5,0	4,2	6,8	5,8
Galápagos Islands	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

1C.- Hospitalization Rate Leishmaniasis								
Region/Year	2015	2016	2017	2018	2019	2020	2021	2022
Pacific Coast	0,1	0,2	0,2	0,1	0,1	0,0	0,1	0,0
Andean highlands	0,3	0,2	0,3	0,3	0,4	0,1	0,1	0,3
Amazon rainforest	1,2	0,8	1,0	1,1	1,5	0,9	0,7	1,2
Galápagos Islands	0,0	0,0	0,0	3,2	0,0	0,0	0,0	0,0

The hospitalisation rate was adjusted to each region's population for each disease. It is depicted as a heat map, with darker shades of green representing higher rates.

See more details in the supplementary figures (GIF archives).

5. Discussion

We found that Dengue fever was the most common VBD in Ecuador between 2015 and 2022, followed by malaria and leishmaniasis, with Sucumbios, Orellana, and Esmeraldas the provinces most affected by these diseases. This study provides valuable information regarding VBDs in Ecuador, focusing on the most frequent VBDs and allows an understanding of the disease's evolution in the country to improve surveillance of VBDs. It is noteworthy that it is precisely in these three provinces where the main sites of mining and oil pollution in Ecuador are concentrated; moreover, they bear significant burdens of poverty and extreme poverty, highlighting the economic and social inequality therein [17].

As in other studies, these diseases have worldwide importance. According to the World Health Organization, there are over 100 endemic countries. Malaria has caused a disproportionate burden in Africa. However, it remains a problem in the Americas, notably Venezuela and Brazil [18]. Leishmaniasis primarily affects the eastern Mediterranean region, accounting for 80 % of cutaneous leishmaniasis cases reported worldwide [19]. Moreover, leishmaniasis remains a problem in the Americas, with the disease being reported in 19 countries [18].

The cumulative dengue rate in the Andean region decreased from 138.49 cases per 10^5 in 2015 to 96 cases per 10^5 in 2019 [13]. The hospitalisation rate of dengue fever in Ecuador is low, reaching 45 cases per 10^5 pop. Still, evidence shows that endemic-epidemic transmission in the country has been especially accentuated after the COVID-19 pandemic [20]. The highest rate of dengue fever was reported in 2015, which declined in subsequent years. Unfortunately, the rate has increased again in 2020 and 2022. By comparison, Brazil's cumulative incidence ranged from 121 (2018) to 735 (2019) cases per 10^5 pop [20]. Colombia, a neighboring country, reported 475.4 cases per 10^5 pop. in 2019 [21]. The three most affected provinces in Ecuador are Guayas, Manabí, and Los Rios, in the Pacific coastal areas, with environmental conditions such as temperate climate, humidity, and altitude favour easy vector reproduction [22]. Regarding cumulative mortality, 0.24 cases per 10^5 pop. were reported, which is low compared to other countries in the region [23]. Nevertheless, dengue remains the most prevalent mosquito-borne disease, principally in the coastal province of Guayas, where the disease seems hyper-endemic.

Malaria, based on World Bank data from Brazil, shows a rate of 4 (2015) to 3.7 (2022) cases per 10^3 pop [24]. In Colombia, the rate is 8.1 (2015) to 9 (2022) cases per 10^3 pop [25]. Patients hospitalised for malaria showed a low hospitalisation rate in Ecuador. In this study, a pop ratio of 10^5 was used. To allow comparison, the hospitalisation rate was adapted; the highest incidence was reported in 2017, with 0,014 cases per 10^3 population. That is low compared with that in other countries in this region. The highest burden is in the provinces of Morona Santiago in second place and Pastaza in third place. These provinces are part of the Amazon Rainforest. That is comparable to the distribution in countries such as Brazil, where many cases are associated with the Amazon rainforest [26].

However, the main province with malaria cases was Esmeraldas, with a disproportionate burden of 45 %. A significant difference in the number of malaria cases between two provinces in Ecuador, Esmeraldas and Guayas, warrants reflection on the underlying factors, including social, economic, and environmental differences. While less populated than Guayas, Esmeraldas has a very high malaria burden. This difference can be attributed to more significant socioeconomic inequalities such as poverty, poorer access to health care, and a higher proportion of inadequate infrastructure, contributing to increased malaria vulnerability in Esmeraldas [27]. In addition, environmental conditions such as proximity to stagnant water and deforestation create favourable breeding grounds for disease vectors [28].

The interplay of these factors influences transmission dynamics and increases the disease burden in Esmeraldas. These emerging inequalities require specific interventions to address socioeconomic inequalities, strengthen health infrastructure, and implement sustainable environmental management practices [29]. Mortality was relatively lower than in Colombia, where the average annual mortality rate between 2009 and 2018 was 0.032 deaths/10^5 [30].

According to the Pan-American Health Organisation, there are many cases of leishmaniasis in North and South America, especially in Brazil, Peru, and Colombia [31]. Colombia reported an incidence of 33.6 per 10^5 pop. in 2015 [32]. The incidence of hospitalised persons in Ecuador showed an incidence of 0.2 (2015), 0.3 (2017), and 0.1 (2022) per 10^5 pop. There were no deaths in 2015, 2019, 2020, or 2022. A low cumulative incidence of mortality indications per year was noted in 2017 and 2018, which may be related to the fact that clinical presentations are usually cutaneous and mucocutaneous forms [31].

Visceral leishmaniasis is uncommon in Colombia, Ecuador, and Peru. Therefore, the province of Pichincha was most affected by cutaneous leishmaniasis. That is mainly associated with rural areas of cities such as Puerto Quito and San Miguel de los Bancos. Although the capital of Ecuador, Quito, is located in Pichincha at an altitude of 2850 metres above sea level, the presence of vectors is not possible. However, the cities at risk are located 90 km from the capital, such as San Miguel de los Bancos, 1110 m above sea level, with an altitude and humidity compatible with the presence of the vector and the parasite.

The results of this study are consistent with those of previous studies that reported a high burden of VBD in South America, especially in areas with limited access to healthcare and poor living conditions [33]. Moreover, as exposure to vectors is an essential factor in relative gendered risks for contracting infectious diseases, and as gender-differentiated activities and spaces determine this exposure and given that susceptibility to VBD has social relations, especially under extractive contexts such as Ecuadorian one, policies must consider the gender, race, and class determinants of health [34].

Effective vector-control programs are essential for the prevention and control of these diseases. However, implementing these programs in resource-limited areas remains challenging. For example, the National Arthropod Vector-Borne Disease Control Service (SNEM) has historically overseen vector management in Ecuador. Until 2015, SNEM was a budgeted and staffed institution. 2015, the SNEM was incorporated into the Ecuadorian Ministry of Health [35]. The impact of this incorporation on vector spread and disease control is yet to be assessed. Based on the data analysed, there was no significant reduction in the disease hospitalisation rate.

Another aspect that demands thoughtful consideration is the realm of social and economic inequalities and the disparity in access to health services experienced by the populations in the provinces where vector-borne diseases predominantly occur. Reports indicate that in territories where there is increased extractivism, deforestation, urbanisation, gender inequalities, and diminished support for rural communities in social and health terms, there is a heightened incidence of diseases—not only acute infectious diseases but also chronic non-communicable diseases, and notably cancer [36]. It is for this reason that combating these diseases should be a priority, supported by local development plans that incorporate the Sustainable Development Goals on a short, medium, and long-term basis, fostering the reduction of inequalities, especially those related to poverty and gender, respecting nature, and tailoring interventions to cultural contexts [37].

The Pan American Health Organization proposed changes to Ecuador's vector control program for 2019 to overcome the main problems of the previous strategy. This proposal emphasised the need for more trained personnel and resources for nationwide program coverage, previously based in specific cities. In addition to the usual measures such as reservoir control, use of repellents, mosquito nets with or without insecticide, and spraying with insecticides [38]. Other strategies should also be considered, such as genetic modification of vectors, the introduction of approved vaccines (DENGVAXIA), etc. A pilot project is underway in Ecuador to combat dengue fever, the Zika virus, and the chikungunya virus with genetically modified sterile vectors starting in 2023 [39]. These and other measures should be explored and adapted to the context of each population to increase impact and effectiveness in combating VBDs.

6. Conclusions

This manuscript comprehensively analyses vector-borne diseases (VBDs) in Ecuador, focusing on dengue fever, malaria, and leishmaniasis. The study shows that dengue fever is the most prevalent VBD in the country, followed by malaria and leishmaniasis. These diseases are prevalent in the provinces of Guayas, Esmeraldas, and Pichincha.

The results show the importance of improving surveillance and control measures for VBDs in Ecuador. The study results show that targeted interventions in specific provinces and age groups are needed to combat these diseases effectively. In addition, the disproportionately high malaria burden in Esmeraldas underscores the importance of addressing socioeconomic inequalities and implementing sustainable environmental management practices to reduce transmission.

Overall, this manuscript provides valuable insights into the burden of VBDs in Ecuador and lays the groundwork for further research and implementation of evidence-based interventions to mitigate the public health impact of these diseases. By addressing the unique challenges posed by each disease, Ecuador can make significant progress in reducing the burden of VBDs and improving the well-being of its population by reducing extractivism, addressing social and gender inequalities, and achieving social justice.

7. Limitations

When interpreting our results, it is crucial to consider the limitations of our study. First, our study was an observational ecological design, meaning causality could not be established for the entire population. Furthermore, since no attempt was made to establish associations between potentially determinant factors and VBDs, there is no possibility of committing an ecological fallacy. In addition, we could not obtain detailed information on patient complications and treatments, which limited our ability to draw specific conclusions about the burden of the disease from VBDs. In addition, our data analysis did not distinguish between repeat and single hospitalisations. In addition, our study examined only hospital discharge data, which excluded mild or moderate VBD cases that did not require hospitalisation. Therefore, our results may underestimate the disease's burden and limit our findings' generalisability to the entire population. In the case of asymptomatic or mildly symptomatic patients, they often do not have an objective laboratory-confirmed diagnosis. In this context, we cannot have data on this reality, and we cannot issue a commentary since it extrapolates the objectives of this study.

Despite these limitations, our study provides valuable insights into the burden of VBDs on Ecuador, as approached from the geographic distribution of the disease. We determined the incidence of hospitalisation rate among the different age and sex groups in other geographic regions. However, further research is needed to fully understand the burden of the disease and develop effective prevention and treatment strategies.

Ethical approval statement

This study has been developed by analysing the open-access database provided by the National Institute of Statistics and Census of Ecuador (INEC). According to the document from the Ministry of Public Health (2022), Agreement No. 00005–2022: Issuance of the Substitutive Regulation for the Approval and Monitoring of Research Ethics Committees on Human Beings (CEISH) and Health Care Ethics Committees (CEAS), Official Register, Year I - No 118, Quito, Tuesday, August 2, 2022 (https://www.registroficial.gob.ec/index.php/registro-oficial-web/publicaciones/suplementos/item/17082-quinto-suplemento-al-registro-oficial-no-118), approval by a research ethics committee on human beings is not required for studies utilising secondary sources. Consequently, the ethics committee's approval is optional. The data are publicly accessible via the portal "*Ecuador en cifras*" (https://www.ecuadorencifras.gob.ec/estadisticas/).

Consent for publication

Not applicable.

Availability of data and materials

The databases are publicly accessible through the "*Ecuador en Cifras*" web portal: https://www.ecuadorencifras.gob.ec/. Supplementary Document 1 contains data analysed for all diseases and by region.

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CRediT authorship contribution statement

Jaime David Acosta-España: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Ivan Dueñas-Espín:** Formal analysis, Methodology, Supervision, Validation, Visualization, Writing – review & editing. **David Francisco Grijalva Narvaez:** Data curation, Formal analysis, Software. **Jenny Belén Altamirano-Jara:** Conceptualization, Data curation, Writing – original draft. **Ana María Gómez-Jaramillo:** Formal analysis, Visualization, Writing – review & editing. **Alfonso J. Rodriguez-Morales:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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List of abbreviations

DENV	dengue virus
ICD-10	International Classification of Diseases, 10th Revision
INEC	National Institute of Statistics and Censuses
RStudio	Integrated Development for R. RStudio
VBD's	Vector-borne diseases
WHO	World Health Organisation

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.nmni.2024.101421.

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