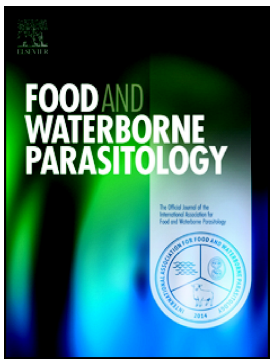

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An 11-Year Epidemiological Analysis of Schistosomiasis in Ecuador: Investigating a Non-Endemic, Neglected, and Challenging-to-Identify Parasitic Disease

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Abstract

Schistosomiasis is a neglected disease caused by parasites of the genus *Schistosoma* and transmitted by snails of the genus *Biomphalaria*. At least five species have the potential to infect humans living in or visiting tropical areas worldwide. In Latin America, *Schistosoma mansoni* is particularly common; however, it has not been reported in Ecuador. In this study, we assess the available official data on schistosomiasis in Ecuador to describe the prevalence of this neglected disease. We conducted a nationwide study to determine the demographic and spatial distribution patterns of schistosomiasis infection in Ecuador, using hospital discharge official data as a proxy for infection incidence from 2011 to 2021. We calculated crude and age-sex-adjusted morbidity and hospital admission rates by region, province, canton, and elevation. In the last decade of available data, schistosomiasis accounted for at

least 551 hospital admissions in Ecuador. Women represented 53.7% (n = 296) of cases, equivalent to 3.2 cases per 1,000,000 inhabits. The highest number of cases (61.2%, n = 337) was found in the Coastal region. However, the highest incidence rates were observed in the Amazon region's provinces of Pastaza (173.44 cases/1,000,000).

Keyword: Schistosomiasis; Zoonosis; Epidemiology; Neglected Disease; Ecuador

1. Introduction

Schistosomiasis, also known as bilharzia, is a neglected tropical disease caused by blood flukes of the genus Schistosoma. Five species of this genus are known to infect humans (McManus et al., 2018; Nelwan, 2019). The World Health Organization (WHO) estimated in 2019 that at least 236.6 million people across 78 countries required preventive treatment for schistosomiasis. In the Americas, nearly 1.6 million school-age children are estimated to need preventive medication against the disease (Mitchell, 2014; WHO, 2022). Schistosomiasis causes approximately 280,000 deaths annually and carries a global burden of 3.3 million disability-adjusted life years (DALYs). DALYs represent a measure of global disease burden, expressed as the number of years lost due to illness, disability, or premature death (Braun et al., 2018; Sundaraneedi et al., 2017).

In Latin America, *Schistosomiasis Mansoni* is endemic in Brazil, Suriname, Venezuela, the Dominican Republic, Guadeloupe, and Saint Lucia. Approximately 1.8 million people in the region (mainly in Brazil) are believed to be infected, and 25 million are at risk of contracting the disease (Noya et al., 2015). Zoni et al. in 2016 noted that Brazil, Venezuela, Suriname, and Saint Lucia needed to update their epidemiological status of schistosomiasis (Zoni et al., 2016). In these countries, the disease is primarily transmitted by freshwater snails of the *Biomphalaria* genus, specifically species such as *B. glabrata, B. tenagophila, and B. straminea* (Rumi et al., 2017).

At present, there are no reports or scientific studies available on the geographical distribution of schistosomiasis or its vector in Ecuador. It is important to note that Ecuador is currently not considered

an endemic country for this disease. However, contributing to our understanding of schistosomiasis infections is essential. Therefore, our objective was to describe the epidemiological status of schistosomiasis in Ecuador based on official data from between 2011 and 2021, serving as a foundation for future research on both the parasite and the vector of this disease. This information can also help inform potential preventive actions to mitigate future risks associated with schistosomiasis in Ecuador.

2. Materials and Methods

2.1 Study Design

We conducted a nationwide study to assess the demographic and spatial distribution patterns of officially reported schistosomiasis hospital admissions in Ecuador. We used hospital discharge and in-hospital mortality data from 2011 to 2021 as proxies for incidence and morbidity.

2.2 Population and setting

Ecuador has an area of more than 283,000 km^2, making it the smallest country in the Andean region in South America. According to the 2010 National Institute of Census and Statistics (INEC) data projections, Ecuador has a population of 17,082,730, women represent a slight majority with 51%, with men at 49%. Albeit geographically small, Ecuador has highly divergent climactic diversity, where the continental Western Pacific Coast features tropical and subtropical lowlands with average temperatures of 25°C and high annual rainfall (refers to the total amount of precipitation, usually measured in millimeters or inches, that falls in a specific location over the course of a year). Central Andean region where climates can range from temperate to subtropical with temperature ranging from 8 to 22°C, and the Eastern Amazon with humid tropical forests with temperature of 28°C and annual rainfall of 3,300 mm (Calvopina et al., 2020; Calvopiña et al., 2022).

2.3 Data Source and Description

We retrieved data using the following ICD-10 codes which represent cases officially reported as schistosomiasis in Ecuador: B659, B652, B651, B653, B650, B658, B65, K770, J998 and J173 (Table 1). Data included information reported from all 24 provinces, and the 221 cantons reported by both, the public and the private health care sub-systems.

2.4 Data Analysis

The hospital discharge information and the population at risk (obtained from 2010 Population Census data) were used to compute incidence rates by an amplification factor of one million. Sex and age were standardized using the INEC population projections from 2011 to 2021 with a canton-level resolution.

3. Results

During the last 11 years of available data, a total of 551 hospitalizations were recorded, but no deaths from schistosomiasis. Men accounted for 46.3% (n = 255), with an overall adjusted incidence rate of 5.66 per 1,000,000 population, whereas women accounted for 53.7% (n = 296), which is 5.27 per million (Table 2).

The mean age of patients hospitalized with schistosomiasis was 44 (SD ± 18) years for men and 40 (SD ± 17) years for women. On the other hand, among women the highest incidence rate was observed in the group older than 80 years (12.11/1,000,000), while among men the highest rate was in the group between 75 and 79 years (21.12/1,000,000) (Table 2).

Schistosomiasis is more common within the Coastal region (El Oro, Santa Elena, Santo Domingo, Esmeraldas, Los Rios, Manabí, and Guayas) with 337 cases (61.2%) recorded. However, the highest incidence rates were found in provinces of the Amazon region, such as Pastaza with an incidence rate of 173.44 cases per 1 million inhabitants, followed by Morona Santiago and Zamora Chinchipe, with 155.84 and 115.02 cases per 1 million inhabitants, respectively.

The geographical distribution by canton shows that the coastal cantons are the ones that report the highest incidence of schistosomiasis. In the first place we have Nobol with 472.76 cases per 1 million inhabitants, followed by Isidro Ayora, and Pucara with 287.93, and 230.71, respectively (Figure 1).

4. Discussion

Schistosomiasis is an under-reported health issue that could potentially be present in Ecuador, as indicated by the official reports from the Ministry of Health analyzed in this study. This possibility exists despite the apparent absence of its natural vector in the country. The vector of this disease comprises freshwater snails belonging to the genus *Biomphalaria*. Species within the *Biomphalaria* genus, such as *Biomphalaria glabrata, Biomphalaria tenagophila,* and *Biomphalaria straminea,* are the primary vectors of schistosomiasis in Latin America and the Caribbean (Rumi et al., 2017). Although we emphasize the need for further research on host abundance in Ecuador, the presence of *Biomphalaria peregrina* has been reported in swamps near Chillogallo in Quito, Ecuador (Paraense, 2004; Paraense and Corrêa, 1973). This species has also been experimentally demonstrated as a reservoir for *S. mansoni* suggesting it could potentially serve as a vector.

According to the Pan American Health Organization, schistosomiasis is endemic in only four countries in the Americas: Brazil, Venezuela, Suriname, and Saint Lucia. Consequently, Ecuador is not considered a country where this disease is endemic, nor is it currently monitored within the epidemiological surveillance system of Ecuador. However, schistosomiasis was identified in 551 cases throughout the country, as reported in the INEC hospital discharge database from 2011 to 2021. This situation presents two possible scenarios for these infections. On one hand, the infections could represent imported cases where individuals acquired the disease abroad and were diagnosed within Ecuador. There is currently a void in studies on the presence of potential vector species in Ecuador, yet we emphasize this does not indicate it is unlikely vector species are present.

Another reason why these cases appear in the database may be due to errors by health professionals when identifying the disease or reporting it. A major limitation of our study is that the analysis of hospitalized cases overlooks asymptomatic infections or cases with mild symptoms, instead focusing only on severe cases. This means that the true prevalence of schistosomiasis in Ecuador may be underestimated in our analysis. We currently don't know the distribution of hosts in Ecuador, but our data suggest that they may be present and potentially expanding. It is crucial to monitor both snail populations and infections to better understand and manage the potential risk of schistosomiasis in the country.

Despite the absence of previously published studies on the prevalence of *Biomphalaria* snails in Ecuador, some researchers have reported a moderate to high habitat suitability for the proliferation of this genus of snails (Rumi et al., 2017). This finding suggests a potential expansion of *Biomphalaria* snails, which could lead to an increased prevalence of schistosomiasis in Ecuador. Current evidence points to a spread originating from northeastern Brazil, and it is expected that the distribution of schistosomiasis will expand as the geographic presence of snails acting as intermediate hosts increases ahead of the pathogen (Ault et al., 2011). Therefore, it is crucial to monitor the distribution and expansion of *Biomphalaria* snails in Ecuador to better understand and manage the potential risk of schistosomiasis in the country.

It is prudent to assume that a disease could be present in a location where it has never been identified before rather than to confirm its absence when there might be actual cases. From a public health perspective, we believe it is essential to explore the context surrounding the possible existence of a vector-borne disease in Ecuador, as it is a plausible possibility due to the climate and similarities with other regions where the disease is prevalent. We believe it is crucial to conduct more in-depth studies, particularly entomological research aiming to determine the presence of snails carrying this disease.

Moreover, it is important to empower health authorities to conduct controls and monitor people entering and leaving the country. This is especially relevant in a time when migration and territoriality have significant impacts on public health, particularly in Latin America.

Limitation

The primary limitation of this study is that, to date, Ecuador has not been identified as an endemic country for schistosomiasis, despite numerous reported cases. Consequently, the disease may be underdiagnosed or treated as an atypical parasitosis. As prevalence has never been reported previously, we can only track the infection frequency in the last decade using data obtained from the hospital admissions and discharges system. Most cases of schistosomiasis do not require hospitalization, which means a considerable number of cases may be excluded from this investigation. Another limitation of this study is the lack of follow-up studies and entomological analysis of the snails currently found in Ecuador. The absence of such investigations makes it difficult to establish a comprehensive understanding of the disease's transmission dynamics and potential vector species within the country. Further research, including entomological surveys and long-term monitoring of snail populations, would provide valuable insights into the presence of potential vector species and their role in the transmission of schistosomiasis in Ecuador.

Conclusion

This study represents the first investigation of schistosomiasis in Ecuador. Our findings reveal that schistosomiasis has caused a significant number of hospital admissions, even though it is not considered endemic in Ecuador. The presence of snails with the potential for transmission increases the chances that some of the reported cases are not only imported or misdiagnosed, but real cases. We identified the highest incidence of infections in regions with temperatures ranging between 8-22ºC, such as the Andean region and parts of the Amazon region within Ecuadorian territory. Although

detailed information on this pathology at the local level is currently lacking, our study serves as a foundation for future research in this field. With the insights provided by this study, we hope that medical professionals and the governmental health system will not only expand the evaluation of infections but also implement strategies and public policies to reduce the risk of the population contracting schistosomiasis in Ecuador.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found at: www.ecuadorencifras.gob.ec/camas-y-egresos-hospitalarios.

Research Ethics Approval

In this study, we analyzed publicly available, secondary-source, and fully anonymized data; therefore, ethics approval is not applicable. In accordance with local and international regulations, all data from secondary and publicly available sources that do not compromise or violate the rights of any patient are exempt from full review by local bioethics committees. Additionally, this project adheres to the international recommendations of the Declaration of Helsinki and follows international guidelines for good clinical practice in biomedical research.

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Figure 1 *Schistosomiasis Incidence rate per 1'000,000 inhabitants, per canton in Ecuador 2011-2021.*

Figure created by the authors.

Declaration of interests

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.

Table 1. *ICD-10 Codes for schistosomiasis.*

ICD-10*	Diseases name
B650	Schistosomiasis due to *Schistosoma haematobium*
B651	Schistosomiasis due to *Schistosoma mansoni*
B652	Schistosomiasis due to *Schistosoma japonicum*
B653	Cutaneous schistosomiasis
B658	Schistosomiasis of specified type NEC*
B659	Another schistosomiasis
B65-J998	Schistosomiasis of the lung
B65-J173	Schistosomiasis of the lung with pneumonia
B65-K770	Hepatosplenic schistosomiasis

*ICD-10: acronyms used in the medical field that stand for International Classification of Diseases

*NEC: Not Classified Elsewhere

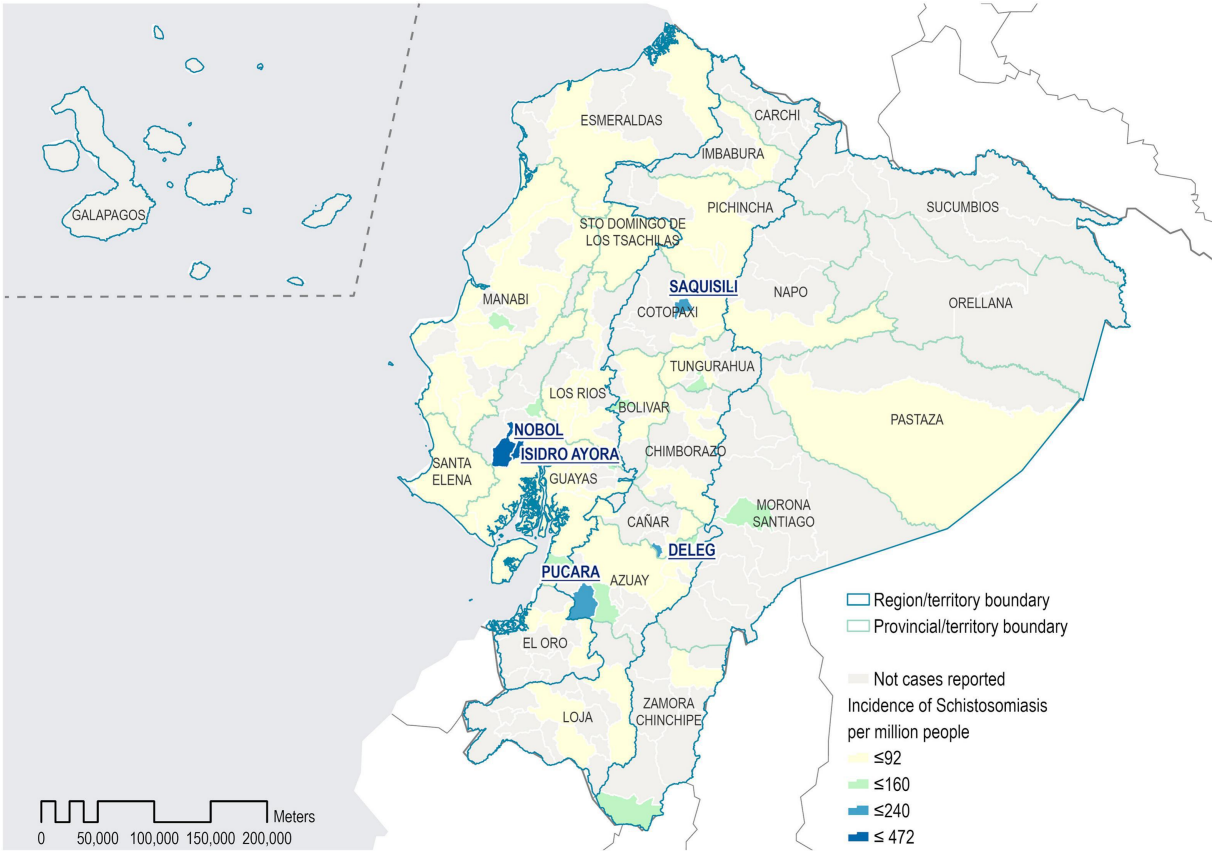
Table 2. *Total number of cases and incidence rates (per 1,000,000) by age group from 2011 to 2021, with confidence intervals presented in brackets.*

	Women			Men		
Age [years]	**Cases [n]**	**Frequency**	**Incidence Rate per 1,00,000 population**	**Cases [n]**	**Frequency**	**Incidence Rate per 1,00,000 population**
< 1	2	0.7	6.08 [6.08 to 6.08]	NA	0.0	NA
1 to 4	2	0.7	1.54 [1.54 to 1.54]	7	2.7	3.39 [2.93 to 3.85]
5 to 9	7	2.4	2.15 [1.39 to 2.9]	9	3.5	1.72 [1.34 to 2.11]
10 to 14	12	4.1	3.03 [2.17 to 3.89]	8	3.1	3.27 [1.33 to 5.21]
15 to 19	11	3.7	2.06 [1.82 to 2.3]	1	0.4	1.37 [NA to NA]

20 to 24	16	5.4	2.81 [2.4 to 3.22]	9	3.5	2.14 [1.81 to 2.47]
25 to 29	24	8.1	4.55 [3.73 to 5.37]	15	5.9	2.83 [2.41 to 3.26]
30 to 34	30	10.1	4.41 [4.06 to 4.75]	18	7.1	4.46 [3.62 to 5.3]
35 to 39	38	12.8	7.49 [6.57 to 8.42]	32	12.5	6.78 [5.78 to 7.79]
40 to 44	34	11.5	8.59 [7.32 to 9.86]	27	10.6	8.41 [7.55 to 9.27]
45 to 49	26	8.8	7.33 [6.15 to 8.51]	19	7.5	6.69 [5.6 to 7.79]
50 to 54	28	9.5	8.14 [7.11 to 9.17]	24	9.4	9.61 [8.25 to 10.98]
55 to 59	25	8.4	7.78 [6.27 to 9.3]	32	12.5	12.01 [10.43 to 13.59]
60 to 64	13	4.4	6.28 [5.69 to 6.88]	19	7.5	8.77 [7.73 to 9.8]
65 to 69	14	4.7	8.52 [7.63 to 9.41]	10	3.9	7.71 [7.03 to 8.38]
70 to 74	7	2.4	9.71 [7.67 to 11.75]	15	5.9	16.18 [13.2 to 19.15]
75 to 79	1	0.3	10.21 [NA to NA]	6	2.4	21.12 [11.09 to 31.14]
> 80	6	2.0	12.11 [10.2 to 14.03]	4	1.6	9.09 [9.09 to 9.09]
Total	**296**	**100**	**5.27 [4.92 to 5.61]**	**255**	**100**	**5.66 [5.31 to 6.01]**

Highlights

- First study on schistosomiasis from hospital admissions records in Ecuador.
- The potential burden of a previously unreported disease is described
- Highlighted the public health impact of schistosomiasis in Equador
- Need for further research on potential vector species
- Proactive public health strategies are suggested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CARCHI
IMBABURA
PICHINCHA
SUCUMBIOS
STO DOMINGO DE LOS TSACHILAS
SAQUISILI
MANABI
NAPO
ORELLANA
COTOPAXI
TUNGURAHUA
LOS RIOS
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PASTAZA
NOBOL
ISIDRO AYORA
CHIMBORAZO
SANTA ELENA
GUAYAS
MORONA SANTIAGO
CAÑAR
DELEG
PUCARA
AZUAY
EL ORO
ZAMORA CHINCHIPE
LOJA
Region/territory boundary
Provincial/territory boundary
Not cases reported
Incidence of Schistosomiasis per million people
≤92
≤160
≤240
≤ 472
Meters
0 50,000 100,000 150,000 200,000

Figure 1