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Mortality due to schistosomiasis in an endemic area of Brazil: a population-based ecological study

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Abstract

Background Schistosomiasis is a communicable disease of neglected populations. The aim of this study was to analyze the temporal trend and spatial distribution of schistosomiasis mortality in an endemic area of Brazil.

Methods This is a study involving all deaths from schistosomiasis in residents of the state of Pernambuco, Brazil, from 2008 to 2021. The data were extracted from the Mortality Information System. The study was done in three steps: description of the sociodemographic profile before (2008–2019) and during the Covid-19 pandemic (2020–2021); time series analysis, using joinpoint regression; and spatial dynamics of schistosomiasis before (2015–2019) and during the Covid-19 pandemic (2020 and 2021), using Moran statistics.

Results The majority of deaths occurred in females (53.4%; $n=1222$), aged 60 years or older (74.5%; $n=1704$), and of brown race (61.18%; $n=1398$). Time series analysis showed linear declining trends in the state rate (APC -1.96%; 95% CI -3.65 to -0.25; $p=0.028$) and in the regions of Palmares (APC -4.73%; 95% CI -7.45 to -1.93; $p=0.003$) and Caruaru (APC -4.05%; 95% CI -7.95 to -0.54; $p=0.025$). In the other regions, the time trend was stationary. Moran's spatial statistics showed a heterogeneous spatial distribution in all study years. The number of municipalities in quadrant 1 (high-high) of the Moran diagram varied between 31 in 2016 and 10 in 2020.

Conclusions The study showed a decreasing mortality trend, heterogeneous spatial distribution, and no apparent impact of the Covid-19 pandemic on schistosomiasis mortality in Pernambuco, Brazil.

Keywords Schistosomiasis, Mortality, Spatial distribution, Neglected tropical diseases, Brazil

Impacts:

- In 2019, Approximately 19,900 people tested positive for schistosomiasis in Brazil, and 462 deaths were recorded.
- This study aimed to analyze the temporal trend and spatial distribution of schistosomiasis mortality in a vulnerable area of northeastern Brazil.
- The results showed a discrete decreasing trend in schistosomiasis cases between 2008 and 2021, With a heterogeneous spatial distribution.

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Introduction

Schistosomiasis is a transmissible disease caused by parasites of the genus *Schistosoma*, a helminth of the class Trematoda. In Brazil, *Schistosoma mansoni* has freshwater snails of the genus *Biomphalaria* as secondary hosts. Schistosomiasis can progress from subclinical forms to severe conditions that can lead to death [1]. The disease is prevalent in tropical and subtropical regions, mainly in rural areas. However, with urbanization, it has started to be seen in urban areas, since the migratory flow between these two environments has intensified in recent decades [2].

In 2019, around 235.1 million people needed preventive treatment for schistosomiasis worldwide [3]. In the same year, the disease caused 11,700 deaths, of which 80% (9,400) were in Africa. In the Americas, the disease caused 620 deaths in the same year [4].

In 2019, approximately 19,900 people tested positive for schistosomiasis in Brazil, and 462 deaths were recorded. Schistosomiasis is present in most states of the country, especially in the Northeast and Southeast regions. In the Northeast, seven of the nine states are endemic areas, i.e. where transmission is established, especially Bahia, Alagoas, Sergipe and Pernambuco [1]. In Pernambuco, in the same year, 3,900 people tested positive (19.8% of cases) and 164 deaths were recorded (35.5% of deaths) [5].

In 2020, the Covid-19 pandemic began [6] and the Ministry of Health structured a surveillance model for cases and deaths from the disease [7]. Although the Covid-19 pandemic has affected health systems around the world, the least developed countries have been most penalized, hampering the fight against other endemic diseases such as visceral leishmaniasis, leptospirosis, malaria and dengue [8]. In Brazil, in 2020, there was an increase of 32.64% in the mortality rate of visceral leishmaniasis, 38.98% in the mortality rate of leptospirosis, 82.55% in the mortality rate of malaria and 14.26% in the mortality rate of dengue compared to the averages from 2017 to 2019 [8].

Considering the importance of health surveillance of endemic diseases both during a pandemic, to prevent additional deaths and after, to promote the control of the disease, this study aimed to analyze the temporal trend and spatial distribution of schistosomiasis mortality in an endemic area of Brazil.

Methods

Study design, population and period

This is an ecological study involving all deaths due to schistosomiasis in residents of the state of Pernambuco from 2008 to 2021.

Study area

Pernambuco is a northeastern state in Brazil, with a territorial area of about 98,000 square kilometers, and its capital is the city of Recife [9]. According to the Brazilian Census of 2021, it has a population of about 9.674 million. The state has the 23rd highest per capita income (5th lowest) and the 19th highest Human Development Index (HDI) [9]. As reported by the Social Vulnerability Index (SVI), which uses 16 vulnerability indicators (i.e., poverty, illiteracy, lack of access to transportation, unplanned parenthood, child labor and mortality), Pernambuco had a score of 0.351 in 2021, which represents medium social vulnerability, ranking 25th among the 27 Brazilian states [10].

Pernambuco has 184 municipalities and the island of Fernando de Noronha, which are divided into 12 Regional Health Management Areas (GERES, in Portuguese) for administrative and management purposes, acting in a more localized manner in primary health care (PHC) and in actions to combat endemic and neglected diseases [11] (Fig. 1A). Of the 12 GERES, six are considered endemic regions for SM (I- Recife, II-Limoeiro, III-Palmares, IV-Caruaru, V-Garanhuns e XII-Goiana) [11] (Fig. 1B).

Data source

All schistosomiasis-related deaths diagnosed in the study area were included. Sociodemographic variables (sex, age group and race) were analyzed, as well as the absolute number of deaths. Data were extracted from the Mortality Information System (SIM, acronym in Portuguese). SIM is a health information system that aims to standardize the collection and processing of data on deaths in Brazil [12]. It was developed in the 90's and its information contributes to the analysis of the mortality profile and can be used to define priority actions to be taken at the municipal, state and federal levels [13].

From the absolute number of deaths, the mortality rate was calculated using the following equation:

$$Schistosomiasis\ Mortality\ Rate\ (SMR) = \frac{Number\ of\ deaths\ from\ SM\ in\ place\ and\ year}{Population\ living\ in\ the\ place\ and\ year} \times 100{,}000$$

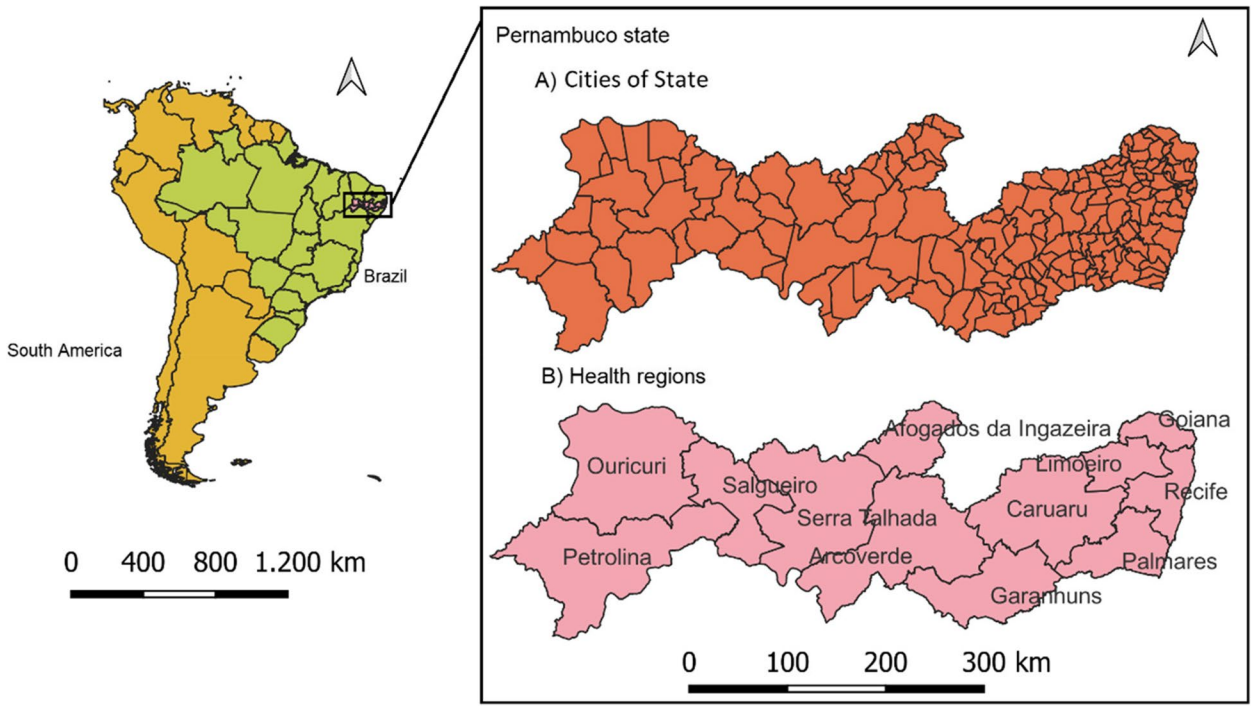

Fig. 1 Study area

Additionally, the population data needed to calculate the mortality rate was obtained from the Brazilian Statistics and Geography Institute (IBGE, acronym in Portuguese).

Study steps

As it is a study with a triple approach (temporal, spatial and impact of the Covid-19 pandemic), the study was divided into three phases:

Phase 1- Description of the sociodemographic profile before (2008–2019) and during the Covid-19 pandemic (2020–2021).
Phase 2- Time series analysis

For the temporal trend, a time series of 14 years (2008 to 2021) was adopted because of the need to understand this temporal behavior in the period before and during the Covid-19 pandemic. The variation in the number of deaths between the years of the time series was calculated. The trend was analyzed on two scales: state and endemic health regions.

To perform the temporal analysis, we used the joinpoint regression model of the four rates at different spatial levels: state and health regions. This model tests whether a line with multiple segments is statistically better at describing the temporal evolution of the data than a straight line or one with fewer segments. Thus, the model allows us to identify the temporal behavior of the indicator (whether stationary, increasing or decreasing, and its statistical significance) through the slope of the regression line, the points where there is change in this trend (joints), the annual percent change (APC, Annual Percent Change) and the average change for each period (AAPC, Average Annual Percent Change) [14].

The joinpoint regression model for the observations: $(\times 1, y1)$,, (xn, yn), where $\times 1 \leq \ldots \leq xn$ represents the time variable, and yi, $i=1, 2,\ldots, n$ is the response variable, being given by:

$$\sum y_i|x_i] = \beta_0 + \beta_1 x_1 + \gamma_1(x_i - \tau_1) + \cdots + \gamma_n(x_i - \tau_n)$$

where $\beta 0$, β_1, $\gamma_1,\ldots$, γ_n are regression coefficients and γ_k, $K=1, 2,\ldots, n$, $n<N$, is the k-th unknown jointpoints where

$$(x_i - \tau_k) = (x_i - \tau_k) if (x_i - \tau_k) > 0$$

$=0$, otherwise.

Parameters used in the joinpoint analysis: minimum: 0; maximum: 4; model selection: test with 4,499 permutations, 5% significance, 95% confidence interval, and date-based autocorrelation of errors. These analyses were performed in the Joinpoint Regression software, version 4.5.0.1 (*National Cancer Institute* – USA).

Phase 3- Spatial dynamics of schistosomiasis before (2015–2019) and during the Covid-19 pandemic (2020 and 2021)

For the spatial approach, the period 2008–2021 was considered. In this step, the global and local Moran statistic and the spatial scan statistic were used. The Moran statistic allows the analysis of the spatial dependence of the data. The global Moran index is given from the product of the deviations from the global mean. Values can range from −1 to +1, where values close to −1 indicate negative spatial autocorrelation, values close to +1 indicate positive spatial autocorrelation, and values close to zero indicate the absence of autocorrelation. The model is validated by applying the pseudosignificance test [15].

Once the global autocorrelation is verified, a local spatial analysis (LISA—Local Indicator of Spatial Association) is performed to quantify the degree of spatial association to which each location of the sample set is subjected according to a neighborhood model, allowing to infer local patterns of spatial distribution of the variables analyzed. The Local Moran's I is a decomposition of the Global Moran's I, in which it is possible to develop an analysis of the local pattern of spatial data [16]. This model is able to indicate areas in which there is a tendency to find similar values. Each area receives a significance value and is allocated to a quadrant in the Moran's scatterplot: Q1 (positive values, positive means) and Q2 (negative values, negative means) indicate points of positive spatial association, in the sense that a location has neighbors with similar values; Q3 (positive values, negative means) and Q4 (negative values, positive means) indicate points of negative spatial association, in the sense that a location has neighbors with distinct values [15].

These analyses were performed with the help of the software GeoDa 1.10 (Center for Spatial Data Science, Computation Institute, The University of Chicago, Chicago, IL, USA) and Qgis QGis (version 2.14.11, Open Source Geospatial, Foundation (OSGeo), Beaverton, OR, USA).

Ethical aspects

The study used only secondary data from public domain information systems where individuals cannot be identified. Therefore, research ethics committee approval was not required.

Results

Between 2008 and 2021, 2,285 deaths with schistosomiasis as the underlying cause were recorded in the state of Pernambuco, of which 53.4% ($n=1222$) were female. This predominance remained unchanged in the pre-pandemic period (53.3%, $n=1063$) and in the pandemic period (54.4%, $n=159$). Regarding age group, the majority of deaths occurred in persons aged 60 years or older, 74.5% ($n=1704$) throughout the period, increasing from 73.5% ($n=1465$) in the pre-pandemic period to 81.8% ($n=239$) in the pandemic period. In terms of race, there was a predominance of brown individuals: 61.18% ($n=1398$) throughout the historical series. In the pre-pandemic period, 61% ($n=1216$) of individuals were brown, while in the pandemic period, 62.3% ($n=182$) were brown (Table 1).

Table 1 Sociodemographic profile of schistosomiasis deaths in Pernambuco, Brazil. 2008–2021

	Deaths due to Schistosomiasis N (%)		
	Total (2008–2021)	**Pre-pandemic (2008–2019)**	**Pandemic (2020–2021)**
Sex			
Male	1063 (46.52)	930 (46.66)	133 (45.55)
Female	1222 (53.48)	1063 (53.34)	159 (54.45)
Age range			
0 to 9	1 (0.04)	1 (0.05)	0 (0)
10 to 19	4 (0.18)	4 (0.2)	0 (0)
20 to 29	19 (0.83)	19 (0.95)	0 (0)
30 to 39	81 (3.54)	75 (3.76)	6 (2.05)
40 to 49	133 (5.82)	123 (6.17)	10 (3.42)
50 to 59	342 (14.97)	305 (15.30)	37 (12.67)
60 or more	1704 (74.57)	1465 (73.51)	239 (81.85)
No information	1 (0.04)	1 (0.05)	0 (0)
Race			
White	672 (29.41)	578 (29)	94 (32.19)
Black	144 (6.3)	133 (6.67)	11 (3.77)
Brown	1398 (61.18)	1216 (61.01)	182 (62.33)
Yellow	6 (0.26)	5 (0.25)	1 (0.34)
No information	61 (2.67)	57 (2.86)	4 (1.37)
Indigenous	4 (0.18)	4 (0.2)	0 (0)
Total	2285 (100)	1993 (100)	292 (100)

Of the total number of deaths, 89.9% ($n=2053$) were recorded in six health regions (Recife, Limoeiro, Palmares, Caruaru, Garanhuns and Goiana) where schistosomiasis infection is considered endemic. In absolute numbers, I GERES (Recife) concentrated the most deaths ($n=1180$), with an annual average of 85 deaths in the pre-pandemic period and 81 in the pandemic period. However, the highest mortality rate (deaths/100,000 inhabitants) was found in the XII GERES (Goiana), with 4.21 deaths/100,000 inhabitants, which decreased from 4.44 in the pre-pandemic period to 2.85 in the pandemic period. In GERES I and II (Recife and Limoeiro), the mortality rate decreased less between the periods (from 2/100,000 to 1.8/100,000 and from 3.3/100,000 to 3.2/100,000, respectively) (Table 2).

In the time series analysis of the state of Pernambuco and the six endemic regions, linear decreasing trends

Table 2 Schistosomiasis mortality in Pernambuco, Brazil, according to health regions. 2008–2021

Health region	Total period (2008–2021)			Pre-pandemic (2008–2019)		Pandemic (2020–2021)	
	No. deaths	Average deaths	Deaths/100,000	Average deaths	Deaths/100,000	Average deaths	Deaths/100,000
I- Recife[a]	1180	84	2.05	85	2.07	81	1.88
II- Limoeiro[a]	273	20	3.30	20	3.32	20	3.23
III- Palmares[a]	313	22	3.69	24	3.96	14	2.15
IV- Caruaru[a]	214	15	1.15	16	1.20	13	0.90
IX- Ouricuri	1	0	0.02	0	0.02	0	0.00
V- Garanhuns[a]	103	7	1.37	7	1.28	11	1.92
VI- Arcoverde	8	1	0.14	1	0.14	1	0.12
VII- Salgueiro	2	0	0.10	0	0.12	0	0.00
VIII- Petrolina	1	0	0.02	0	0.02	0	0.00
X- Afogados da Ingazeira	2	0	0.08	0	0.09	0	0.00
XI- Serra Talhada	2	0	0.06	0	0.07	0	0.00
XII- Goiana[a]	184	13	4.21	14	4.44	9	2.85
Pernambuco	***2283***	***163***	***1.76***	***166***	***1.80***	***146***	***1.51***

[a] Endemic regions

were observed in the state rate (APC −1.96%; 95% CI −3.65 to −0.25; $p=0.028$) and in the regions of Palmares (APC −4.73%; 95% CI −7.45 to −1.93; $p=0.003$) and Caruaru (APC −4.05%; 95% CI −7.95 to −0.54; $p=0.025$). In the other regions, the time trend was stationary. In none of the analyses was there an inflection point in 2020, suggesting that the pandemic did not affect the linear trend observed in the state and the six health regions since 2008 (Fig. 2 A to F).

In all regions, the number of deaths varied over the years, reflecting the heterogeneity over time. In the state, there were 52 fewer deaths in 2009 than in the previous year (153 in 2009 and 205 in 2008). The following year (2010), there were 43 more deaths than in 2009 (196 deaths in 2010). In general, this heterogeneity was observed in all six endemic regions (Fig. 3).

In 2020, the first year of the Covid-19 pandemic, there were 8 fewer deaths from schistosomiasis compared to the previous year (2019). Reductions were also observed in Palmares (−13 deaths), and Goiana (−3 deaths). On the other hand, Recife (+5 deaths), Limoeiro (+4 deaths) and Garanhuns (+1 death) recorded more deaths in 2020 compared to the previous year. In Caruaru, there was no variation in the number of deaths recorded (12 deaths in each of the years). It should also be noted that since 2017, the number of deaths in the state has been decreasing, with no significant variation in 2020 and 2021 when compared to the previous years (2017, 2018 and 2019) (Fig. 3).

In the municipal analysis, the number of municipalities with no recorded deaths from schistosomiasis remained constant, varying between 117 and 138. The same pattern occurred in the group of municipalities with low rates (0.01 to 1.99/100,000). In the group of municipalities with high rates (≥10/100,00), the number of municipalities remained constant, varying between 3 and 8, with the exception of 2008. In addition, five municipalities had rates ≥10 deaths/100,000 in 2020 and three in 2021 (Figs. 4 and 5).

Moran's spatial statistics showed heterogeneous spatial distribution in all the years of the study. The number of municipalities in quadrant 1 (high-high) of the Moran diagram varied between 31 in 2016 and 10 in 2020 (Table 3 and Fig. 6.

Of the ten municipalities in the high-high quadrant of the Moran diagram in 2020, seven were located in the Limoeiro health region (Passira, Feira Nova, Paudalho, Nazaré da Mata, Vicencia, Carpina and Lagoa do Carro), two in Recife (Igarassu and Ipojuca) and one in the Garanhuns health region (Lagoa do Ouro). In 2021, the second year of the Covid-19 pandemic, the number of municipalities in the high-high quadrant was 17, reaching five of the six endemic regions—Garanhuns was the only one without municipalities in this quadrant (Fig. 6).

Discussion

This study aimed to analyze the temporal trend and spatial distribution of schistosomiasis mortality in a vulnerable area of northeastern Brazil. The results showed a discrete decreasing trend in schistosomiasis cases between 2008 and 2021, with a heterogeneous spatial distribution. The pandemic did not appear to have a uniform impact across endemic regions, suggesting that its impact on schistosomiasis mortality may not be significant.

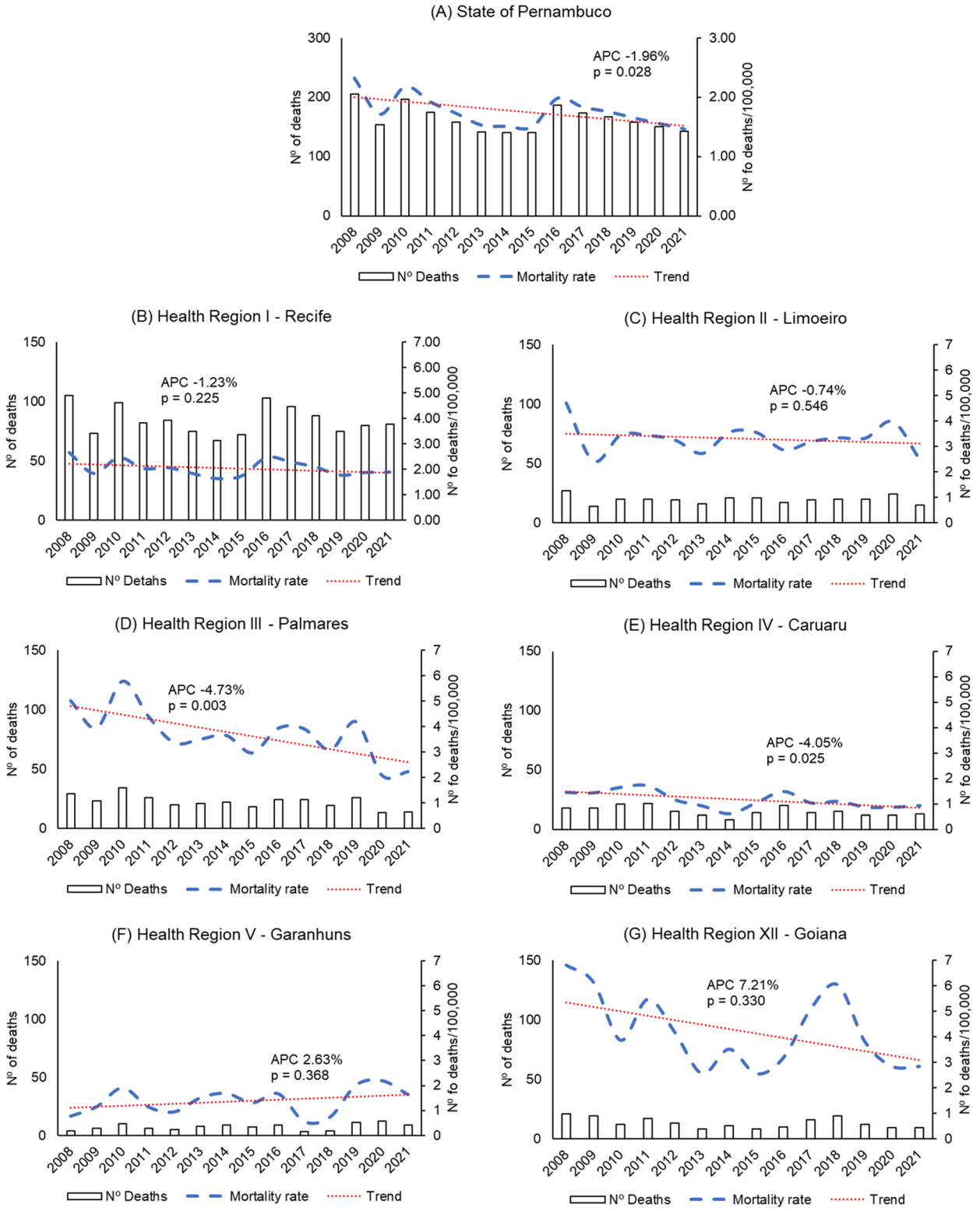

Fig. 2 Evolution of the number of deaths and mortality rate from schistosomiasis in Pernambuco, Brazil, according to endemic regions, 2008–2021

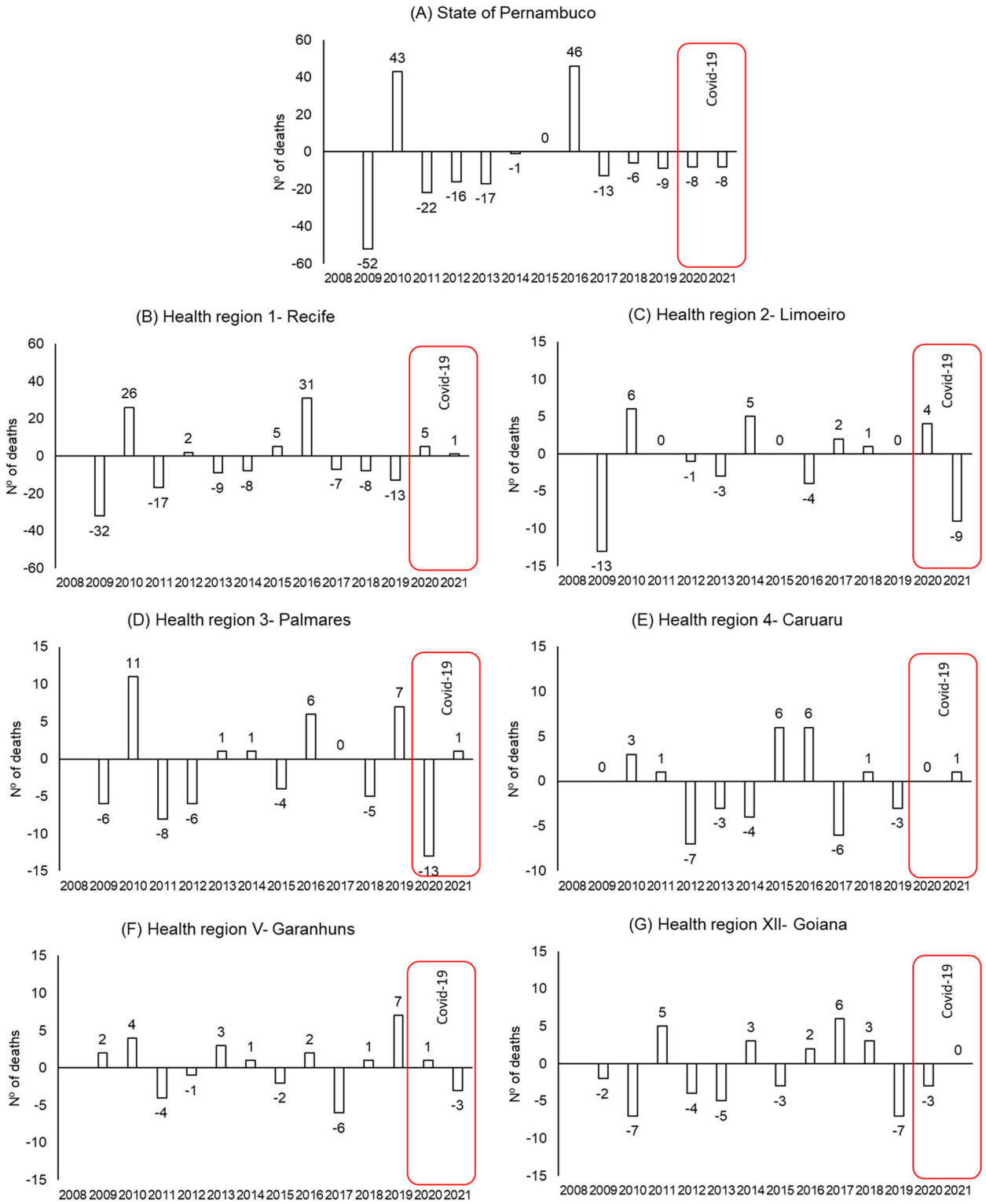

Fig. 3 Variation in the number of deaths from schistosomiasis in Pernambuco, Brazil, 2008–2021

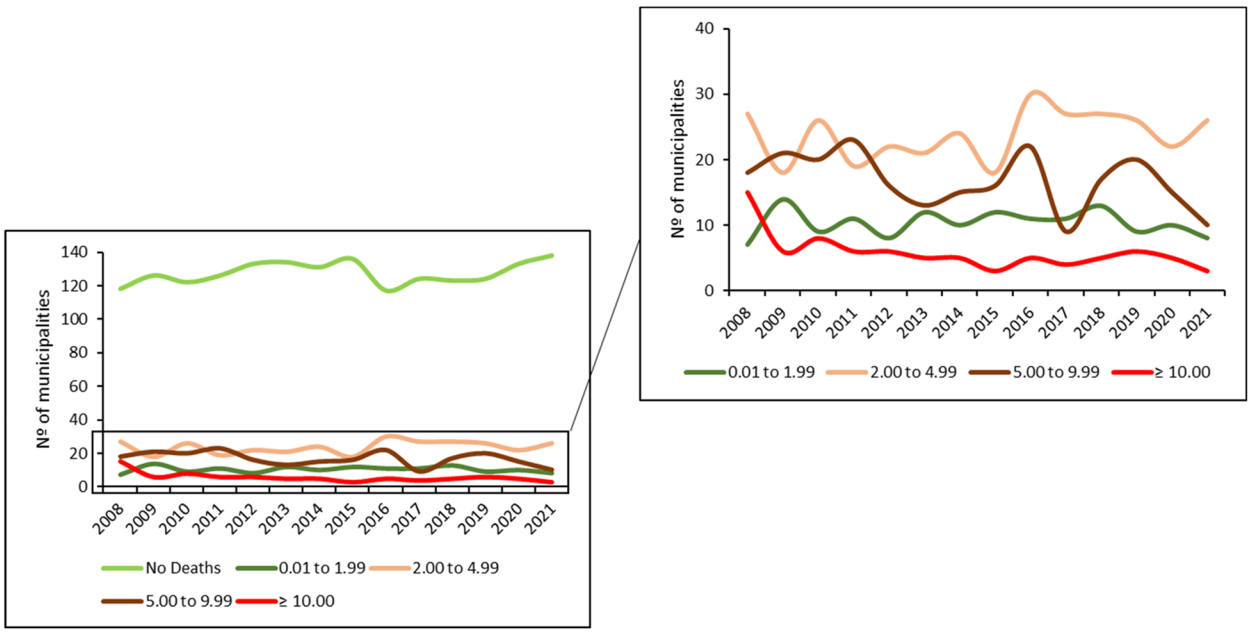

Fig. 4 Stratification of the number of municipalities by Schistosomiasis mortality rate. Pernambuco, Brazil, 2008–2021

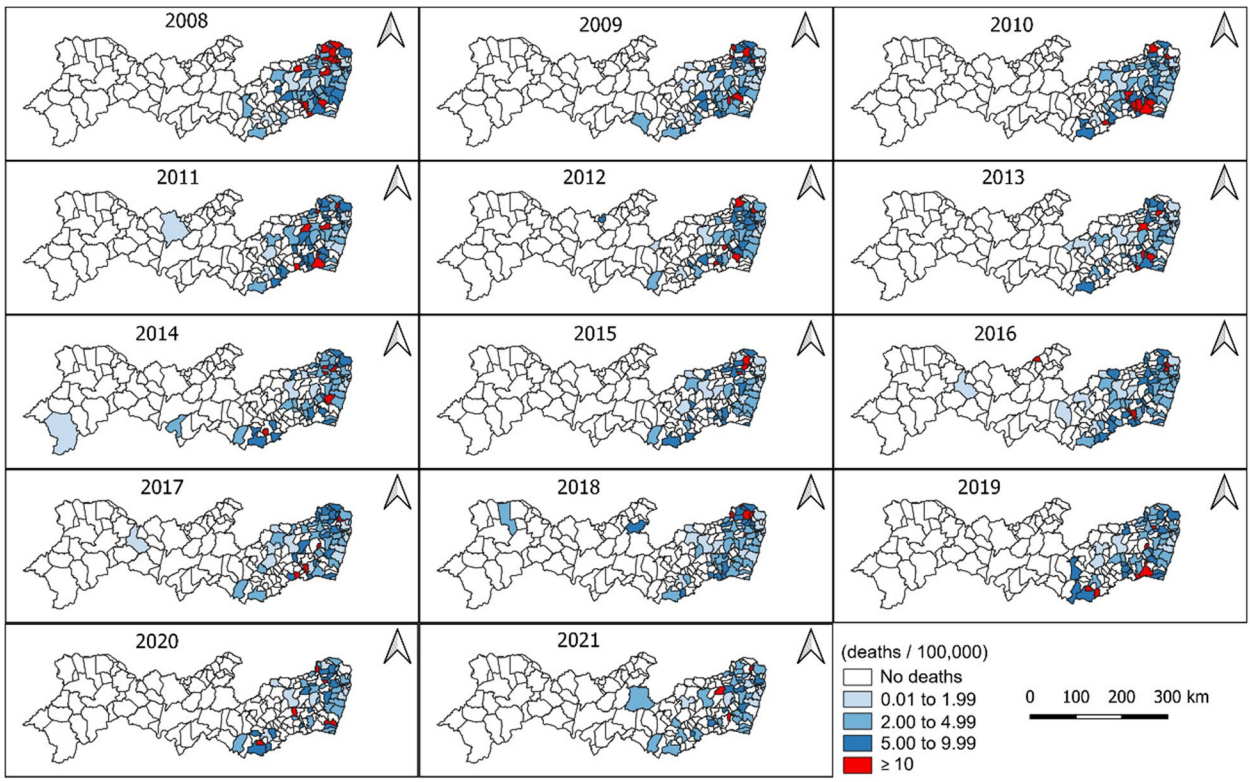

Fig. 5 Spatial distribution of the Schistosomiasis mortality rate. Pernambuco, Brazil, 2008–2021

Table 3 Global and local Moran statistics of Schistosomiasis mortality in Pernambuco, Brazil. 2008–2021

Year	Global Moran's I	*P*-value	Local Moran No of municipalities High-High Quadrant
2008	0.285	0.001	28
2009	0.283	0.001	19
2010	0.260	0.001	28
2011	0.167	0.002	16
2012	0.196	0.008	28
2013	0.205	0.001	20
2014	0.233	0.004	22
2015	0.134	0.001	11
2016	0.213	0.001	31
2017	0.258	0.001	23
2018	0.272	0.003	24
2019	0.187	0.001	13
2020	0.144	0.001	10
2021	0.128	0.001	17

It is important to note that both the Federal Government of Brazil and the State Government of Pernambuco have implemented programs to control schistosomiasis in endemic regions, which may be partially responsible for the decrease in the absolute number of deaths over the entire period; however, these efforts may not be sufficient [17].

In order to detect and prevent cases of schistosomiasis, the Brazilian Schistosomiasis Control Program (PCE, acronym in Portuguese), initially called the Special Schistosomiasis Control Program (Pece, acronym in Portuguese), was created in 1975 [18]. In 1976, it began to operate on a regular basis, carrying out coprological surveys and other activities. This program has since reduced mortality and the development of severe forms of schistosomiasis, but has not managed to eradicate the disease, which is still endemic in several regions of the country [18].

In addition to the PCE, the state government of Pernambuco created the SANAR program in 2011 to combat schistosomiasis and seven other communicable diseases

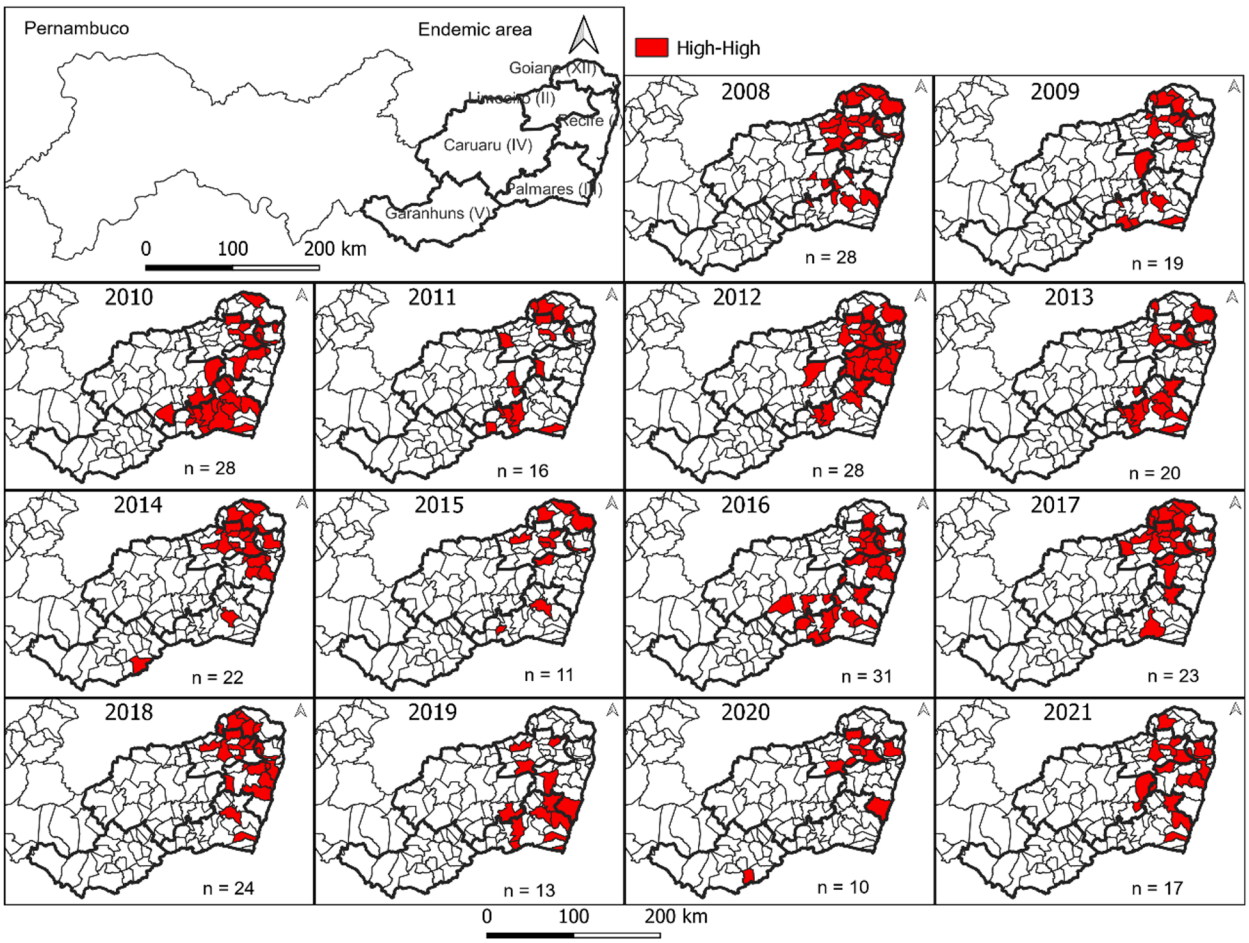

Fig. 6 Moran's map of the schistosomiasis mortality rate in the six endemic regions of Pernambuco, Brazil, 2008–2021

(tuberculosis, leprosy, schistosomiasis, geohelminthiasis, Chagas disease, filariasis, and leishmaniasis) that are on the international agenda [19]. The SANAR program was able to reduce the percentage of schistosomiasis positives by 68.4% from 2008 to 2017, and the mortality rate from schistosomiasis by 21.7% in the same period [19].

Both programs have limitations, among which we highlight the lack of professional training and epidemiological surveillance studies [11], the lack of integration of PCE with primary health care, and local pragmatic social vulnerability [20]. A study conducted in Pernambuco indicates a negative correlation between water supply, garbage collection and the level of urbanization with the cumulative mortality rate of schistosomiasis in Pernambuco, supporting the thesis that improving the living conditions of the population is a way to control the disease [20]. This relationship has also been observed in other regions of the country. In Minas Gerais, for example, a study found a positive correlation between vulnerability to poverty and the incidence of schistosomiasis [21].

Another issue affecting programs such as the PCE and SANAR is underfunding [18]. A study that analyzed the degree of implementation of the PCE in three municipalities in the Zona da Mata region of Pernambuco found that the lack of sufficient human and material resources for schistosomiasis control activities contributed to the poor results, which contributed to the low degrees of implementation (GI) of 26.31%, 36.3%, and 24.77% found [22]. In this scenario, there was an initial degree of implementation of the PCE in Pernambuco of 33.24% (to be considered implemented, this index would have to be above 75%) [23].

In our study, the downward trend in schistosomiasis mortality continued between the pre-pandemic and pandemic periods, from 1.8/100,000 to 1.51/100,000 population. In 2020, there were 8 fewer deaths in the state (compared to 2019). The impact on the endemic municipalities, in turn, proved to be heterogeneous: in Palmares (III GERES), Caruaru (IV GERES) and Goiana (XII GERES), 13, 3 and 3 fewer deaths, respectively, were recorded in the interval; in Recife (I GERES) and Limoeiro (II GERES), 5 and 4 more deaths, respectively. In this context, it can be concluded that the Covid-19 pandemic had no impact on schistosomiasis mortality.

At the national level, there was a slight increase in the schistosomiasis mortality rate from 2019 to 2020 (from 0.22/100,000 to 0.23/100,000), but the rates for 2021 and 2022 were lower, at 0.18/100,000 and 0.11/100,000 inhabitants, respectively [1]. For hospitalizations, there was a slight decrease in the hospitalization rate from 2019 to 2020, from 0.09/100,000 to 0.05/100,000 inhabitants [1]. These variations were not unique in the historical series from 2010 to 2022, since at other times there were more significant variations, such as from 0.23/100,000 to 0.25/100,000 inhabitants from 2015 to 2016 in the mortality rate [1], which could support the hypothesis that the variations observed during the pandemic were random and not determined by the presence of Covid-19.

This finding is counterintuitive, not only given the study linking the pandemic to an increase in mortality from visceral leishmaniasis, leptospirosis, malaria, and dengue [8], but also given that funding for research and resource acquisition for neglected tropical diseases was further reduced in 2020 and 2021 when SARS-CoV-2 was tackled [24]. This may have happened because the PCE was already established was able to register the deaths in spite of the pandemic or due to the fact that, overall, mortality information systems are the most reliable.

In low- and middle-income countries, it was estimated that the Covid-19 pandemic would cause deaths not only directly, but also through the disruption of already precarious health systems [25]. A study analyzing strategies for neglected tropical diseases suggests that the Covid-19 pandemic disrupted drug distribution and vector control programs for several parasitic diseases, including schistosomiasis [26], which could contribute to an increase in both mortality and the proportion of severe forms.

An analysis of the impact of the pandemic on PCE interventions in Alagoas showed that in 2020 and 2021, the percentage of people testing positive for schistosomiasis who received treatment fell to less than 80% (77.44% and 77.38%), respectively [27]. This study concluded that the pandemic negatively affected schistosomiasis control and detection activities in the state of Alagoas in 2020 and 2021 [27]. This study differs from ours in that it analyzed the impact on surveillance activities and not on mortality itself. Until this research was conducted, there were no other publications addressing the impact of the pandemic on schistosomiasis mortality, and for this reason, it is not possible to know whether the context observed in Pernambuco differs from what happened in other endemic areas.

In addition to the impact of the Covid-19 pandemic, it was possible to describe the spatial distribution of schistosomiasis deaths in Pernambuco, which are concentrated in GERES I to V and XII, which can be explained by the fact that *Biomphalaria glabrata* and *B. straminea*, vectors of *Schistosoma mansoni*, are typically freshwater animals and rainy regions [28], but have been selected by the salinity of the coastal environment [29] and are also present on the coast.

This ability of the genus *Biomphalaria* to live and reproduce on the state's coast, combined with pollution, changes in the course of water bodies and dumping, as well as the rainy climate and favorable temperature [28] are very important in explaining, for example, the

schistosomiasis outbreak that occurred in 2000 in the municipality of Ipojuca (I GERES), in which 662 people tested positive and an average of 48% of the vector snails found were infected with Schistosoma mansoni [30]. In our study, in 2020, in I GERES, only the municipalities of Igarassu and Ipojuca were in the high-high quadrant of the Moran diagram for the spatial distribution of schistosomiasis deaths in Pernambuco, which may indicate an increase in schistosomiasis endemicity in the municipality of Ipojuca.

Another interesting finding was that most of deaths (89,6%) occurred in individuals older than 50 years. This aligns with other studies that point that chronic comorbidities, such as cardiovascular disease and cancers can increase the risk of mortality in this population [31]. Furthermore, considering the chronic and progressive nature of schistosomiasis, the disease tends to become more severe after the 4th decade of life [31]. This contrasts with the fact that there was no deaths in individuals younger than 30 years old in the pandemic period.

Even taking into account the methodological care taken, the present study has some limitations. The first is related to the use of secondary data, which is influenced by the quality of the health surveillance systems of the cities. It is well known that mortality surveillance in smaller municipalities faces even greater challenges, especially with regard to death investigation and monitoring the quality of records. On the other hand, mortality records are considered to be the most reliable of all information systems.

Further studies are needed to determine the impact of the pandemic on schistosomiasis mortality trends in Brazil or in other endemic countries, as well as the impact of the pandemic on schistosomiasis hospitalization rates.

Conclusion

The spatial distribution showed that the disease was concentrated in the Agreste and Zona da Mata regions of the state, confirming the results of previous studies and that there was a discrete decreasing trend in schistosomiasis cases between 2008 and 2021. The Covid-19 pandemic did not increase the number of schistosomiasis deaths in the State of Pernambuco, nor did it affect the trend observed in previous years. The results regarding the mortality rate were heterogeneous, which may indicate that they were most likely due to chance.

It is recommended that governments adopt public policies capable of controlling the incidence of the disease in endemic regions and detecting new cases as early as possible, thereby effectively reducing the number of deaths from schistosomiasis, which can only be achieved by improving the quality of life of vulnerable people.

Abbreviations

SVI	Social Vulnerability Index
HDI	Human Development Index
GERES	Regional Health Management Areas
PHC	Primary Healthcare
SM	*Schistosoma mansoni*
SIM	Mortality Information System
SMR	Schistosomiasis Mortality Rate
IBGE	Brazilian Statistics and Geography Institute
APC	Annual Percent Change
AAPC	Average Annual Percent Change
LISA	Local Indicator of Spatial Association
PCE	Schistosomiasis Control Program
Pece	Special Schistosomiasis Control Program
GI	Degree of implementation

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Data availability

A statement to confirm that all methods were carried out in accordance with relevant guidelines and regulations. The study used secondary data in the public domain, which meant that it did not need to be examined by the Research Ethics Committee. Link: http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinannet/cnv/ltape.def.

Declarations

Ethics approval and consent to participate

The study used only secondary data from public domain information systems where individuals cannot be identified. Therefore, research ethics committee approval was not required.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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