Severe Acute Respiratory Syndrome in Pernambuco: comparison of patterns before and during the COVID-19 pandemic

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Abstract *The aim of this study was to analyze the Severe Acute Respiratory Syndrome (SARS) pattern in Pernambuco before and during a COVID-19 pandemic. Ecological study conducted from January to June, 2015 to 2019 and from January 1 to June 15, 2020. The detection rates by municipality and by Regional Health of residence were calculated. The spatial area of SARS was estimated through the risk ratio. Before the pandemic, there were 5,617 cases of SARS, 187 cases/month and 23.8 cases/100 thousand inhabitants, while during the pandemic there were 15,100 cases, 2,516 cases/month and 320.3 cases/100 thousand inhabitants, which represents a 13-fold increase in detection. The following expanded (p < 0,001): the occurrence in elderly people, the collection of samples and the identification of SARS etiological agent with predominance of SARS by COVID-19. Most municipalities experienced a 20-fold higher detection than expected, suggesting a process of virus spread to the hinterlands. The excess risk associate with lower IDHM, the condition of the municipality being the headquarters of the Regional Health and the presence of a highway in the municipality. The change in the pattern of occurrence of SRAG, combined with Spatial analysis may contribute to action planning at different levels of management.*
Key words *COVID-19, Pandemics, Epidemiological monitoring, Spatial analysis*

Introduction

Surveillance for Severe Acute Respiratory Syndrome (SARS) was established in 2009 due to the influenza pandemic caused by the H1N1 virus. The system was initially limited to notifying those affected by influenza viruses in the country but has improved and incorporated the monitoring of other respiratory viruses, increasing the scope of surveillance[1].

In September 2012, the case of SARS compulsorily notified to the National System of Notifiable Diseases (SINAN) is defined as the individual of any age, hospitalized with a flu-like syndrome (fever and cough or sore throat) and with dyspnea or O_2 saturation below 95%, or respiratory distress. SARS-related deaths should also be recorded regardless of hospitalization[1,2].

In Brazil, 40,294 cases of SARS were reported until epidemiological week 52 of 2019, 14.2% of which were classified as SARS due to influenza, 19.3% were caused by other respiratory viruses, 0.4% by other etiological agents, 59.7 % were unspecified, and 6.4% were still under investigation. The Northeast accounted for 16.2% of national SARS cases (n = 6,612), and Pernambuco was the largest notifier in the region, with approximately 40% of cases (n = 2,486). In the state, 5.2% of notifications were confirmed for influenza. Other etiological agents and respiratory viruses accounted for 0.1% of the total cases; 76.8% were unspecified, and 17.9% are under investigation[3].

This surveillance's syndromic nature allows monitoring the behavior of seasonal respiratory viruses and the introduction of new etiological agents. In December 2019, an outbreak of a new coronavirus disease (COVID-19, caused by Severe Acute Respiratory Syndrome Coronavirus 2 - SARS-CoV-2) was reported in Wuhan, China, and emerged as one of the biggest global health challenges of this century[4]. By mid-April, just a few months after the epidemic began, more than 2 million cases and 120,000 deaths worldwide by COVID-19[4] had already been reported. In the same period, Brazil recorded about 28,000 confirmed cases and 1,745 deaths from the disease[5].

The clinical presentation resembles mild symptoms of viral pneumonia, and the severity of the disease ranges from mild to severe. Approximately 80% of patients have a mild illness, 15% have a severe illness, and 5% have a critical illness[6]. Initial reports suggest that the severity of the disease is associated with advanced age and comorbidities[6,7]. Besides requiring radical changes in behavior at the individual and community levels, COVID-19 demanded rapid responses concerning preventive actions, expansion, and acquisition of hospital supplies and beds, reorganizing human resources in health, among other control strategies[8,9].

In the future, SARS-CoV-2 is expected to be among the seasonal respiratory viruses in the country, remaining in the routine monitoring of universal SARS surveillance. However, possible differences in the occurrence of SARS in a pre-pandemic scenario and during the COVID-19 pandemic may influence the routine of this surveillance in the post-pandemic period. An investigation to contribute to planning actions that promote health equity care and epidemiological surveillance becomes relevant, emphasizing municipal and regional levels.

Thus, this study aimed to analyze Pernambuco's SARS pattern before and during the COVID-19 pandemic.

Methods

This is an ecological study conducted in the state of Pernambuco, Northeast Brazil. Administratively, it is divided into 185 municipalities distributed in 12 Regional Health Offices (RHO), grouped into 4 Macro Regional Health Offices[10] (MRHO), which are: Metropolitana (4 RHOs and 72 municipalities); Agreste (2 RHOs and 53 municipalities); Sertão (3 RHOs and 35 municipalities); and Vale do São Francisco and Araripe (3 RHOs and 25 municipalities) (Figure 1). The estimated population for 2019 was 9,557,071 inhabitants[11].

Considering the seasonality of the main SARS etiological agents, Pernambuco residents were considered cases of the disease, detected in the pre-pandemic period (January 1 to June 30 for all years, from 2015 to 2019) and in the period that includes the onset of the pandemic (January 1 to June 15, 2020). From 2015 to 2018, the notifications were made in the database of the National System of Notifiable Diseases – Sinan Influenza Web, and, in 2019, SARS records were from the Sivep-Gripe platform.

In the analysis plan, absolute and relative frequencies and mean detection rates (per 100 thousand inhabitants) of SARS cases were calculated per study periods (pre-pandemic and pandemic) for the state of Pernambuco. The distribution of cases was compared according to the variables age group (< 10, 10-39, 40-59, 60 years and over), gender (male and female), sample collection (yes,
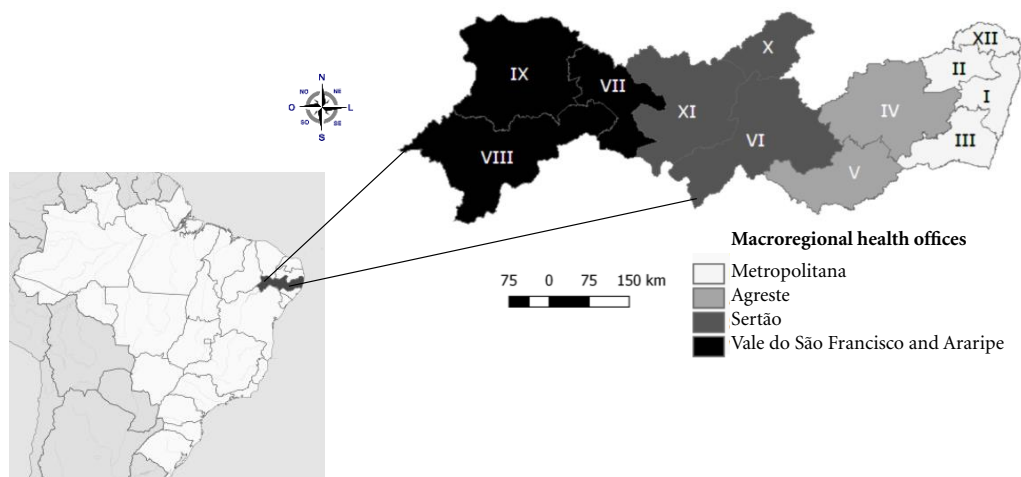
Figure 1. Macroregional and Regional Health Offices. Pernambuco, Brazil. 2020.

Source: Prepared by the authors based on the Pernambuco Regionalization Master Plan (2011).

no) and final classification (SARS due to influenza and other respiratory viruses, SARS due to another etiological agent, SARS due to COVID-19, and unspecified SARS). Pearson's chi-square test was adopted to identify the existence of a statistically significant difference.

Although the data source provides other variables, those with a field completion higher than 80% were considered. The analysis consisted only of valid data. The exception was for the variable's final classification, which brings relevant information about SARS etiological agents' profile in the studied period, although it showed a field completion below the level stipulated.

Concerning spatial analysis, the SARS detection coefficient ([number of resident cases/resident population] × 100,000 inhabitants) was calculated for each RHO, for both periods.

Regarding the analysis by municipality, considering that small populations or underreporting can cause variability of the gross rates, the local empirical Bayesian smoothing was used, which allowed smoothing the estimates of the coefficients calculated for small (or underreported) geographical areas, eliminating random fluctuations not associated with risk[12].

The spatial dynamics of the SARS detection in the territory of Pernambuco during the pandemic was shown by calculating the risk ratio (RR) between the pre-pandemic and pandemic detection rates, from the crude rates for the RHOs and smoothed rates for municipalities.

Finally, the association between the occurrence of the highest risk factors (the so-called excess risk) between municipal detection rates with socioeconomic indicators was investigated, which were the Municipal Human Development Index (MHDI) (Geometric mean of the indices of dimensions income, education, and longevity, with equal weights); Proportion of vulnerable to poverty (Proportion of individuals with per capita household income ≤ 1/2 of the minimum wage in August 2010); Proportion of extremely poor (Proportion of individuals with per capita household income ≤ 1/4 of the minimum wage in August 2010); Presence of a federal highway in the municipal territory; Municipality being the RHO's headquarters (coinciding with the headquarters of the state's economic development hubs).

The municipal risk ratio (dependent variable) was classified as 0 (when less than the median) and 1 (when equal to or higher than the median) to identify the associated factors, allowing the calculation of the Wald's backward-type binary logistic regression, adopting a p-value

higher than 0.10 as a criterion for excluding model variables.

The software packages used were electronic spreadsheets, SPSS V.22, TerraView V.4.2.2, and QGis 2.18.9. The results were represented in the digital cartographic base of the state of Pernambuco provided by the Brazilian Institute of Geography and Statistics (IBGE)[13].

The data analyzed in this study are freely accessible, and SARS cases are available on the Integrated Health Surveillance Platform on the Ministry of Health's website[5]. Population estimates were extracted from IBGE[11], and socioeconomic data were obtained from the Atlas of Human Development in Brazil[14]. The study used a publicly available secondary database, with no possibility of identifying individuals, waiving the mandatory submission to, and approval of an ethics committee. The authors guarantee the confidentiality and anonymity of all data.

Results

In the pre-pandemic period, 5,617 SARS Pernambuco resident cases were reported between January 1 and June 30 of the years 2015 to 2019, a mean of 187 cases per month and a half-yearly mean detection rate of 23.8 cases/100 thousand inhabitants. From January 1 to June 15, 2020, a period that includes the beginning of the pandemic, 15,100 SARS cases were reported, with detection of 320.3 cases/100 thousand inhabitants and a mean of 2,517 SARS cases/month, which is around a thirteen-fold increase of notifications in the recent period. Some differences between the pattern of SARS occurrence in the analyzed periods were observed (Table 1), except for gender, with males predominating in both contexts. In the pre-pandemic period, children under 10 years of age accounted for 78.6% of cases, while in the pandemic phase, 76.8% were concentrated among those over 40 years of age, with 48.3% of cases aged 60 years or over ($X^2=10670$; $p < 0.001$).

The collection of clinical samples was carried out in 60.9% of the pre-pandemic cases, then expanded to 96.5% of the cases during the epidemic ($X^2=70.6$; $p < 0.001$). In the previous period, 88.2% of cases were classified as unspecified SARS, followed by 11.5% of cases with SARS due to Influenza and other respiratory viruses. During the pandemic, 66.0% of the cases of SARS were due to COVID-19, followed by 2.5% of cases with SARS due to Influenza and other respiratory viruses, and SARS was unspecified in 31.2% (Table 1).

By 2019, the RHOs most affected by SARS, with detection above 20 cases/100 thousand inhabitants, were concentrated in the Metropolitana and Sertão MRHOs (Figure 2A). During the period studied that considers the pandemic, all RHOs had a detection of more than 60 cases/100 thousand inhabitants; three of the four RHOs located in the Metropolitana MRHO had a detection of more than 200 cases/100 thousand inhabitants, reaching a level of 575 cases/100 thousand inhabitants in the 1st RHO (Figure 2 B).

An excess risk of SARS was noted throughout the state. A risk ten times greater than the expected mean was detected in all MRHOs, with MRHOs Sertão and Vale do São Francisco and Araripe achieving an excess risk 20 times higher than the expected mean (Figure 2C).

In the pre-pandemic period, 83.2% of the municipalities (n = 154) had a rate lower than the mean annual detection (20 cases per 100 thousand inhabitants) (Figure 3A). Only two municipalities had more than 60 cases/100 thousand inhabitants: Goiana (67.0 cases/100 thousand inhabitants) and Afogados da Ingazeira (66.1 cases/100 thousand inhabitants) (Figure 3A).

A change in the pattern was observed during the pandemic, when 98.4% of the municipalities (n = 182) had a detection rate higher than 20 cases/100 thousand inhabitants (Figure 3B). More than 60 cases/100 thousand inhabitants were recorded in 80% of the municipalities (n = 148) (Figure 3B). Excess risk reveals that all municipalities experienced increased detection of SARS during the pandemic. However, regions further away from the Metropolitan Region had a more significant impact on this increase, such as Vale do São Francisco and Araripe. Of the 25 municipalities that make up the Macroregion, 17 had detection higher than 10 times the expected, and in 12 of these, the detection was 20 times greater than estimated (Figure 3C).

The multivariate analysis identified three factors associated with SARS detection's excess risk through binary logistic regression, namely, the MHDI, the municipality being the headquarters of the RHO, and having a federal highway in its territory. The initial and final regression models are shown in Table 2.

Table 1. Comparison of the Severe Acute Respiratory Syndrome profile according to the pre-pandemic period and during the Covid-19 pandemic. Pernambuco, Brazil, 2015 to 2020.

Analyzed variables	Pre-pandemic*		Pandemic**		X²; P-value
	n	%	n	%	
Age group					
< 10	4,417	78.6	1,146	7.6	10,670; p<0.001
10_39	489	8.7	2,357	15.6	
40_59	277	4.9	4,297	28.5	
≥ 60	434	7.7	7,300	48.3	
Gender					
Male	2,989	53.2	8,011	53.1	0.014; p=0.906
Female	2,627	46.8	7,067	46.9	
Sample collected					
Yes	3,364	60.9	11,649	96.5	70.6; p<0.001
No	2,160	39.1	417	3.5	
Final classification					
SARS due to Influenza and other respiratory viruses	628	11.5	196	2.5	5,960; p<0.001
SARS due to another etiological agent	18	0.3	28	0.4	
SARS due to COVID	0	0.0	5,235	66.0	
SARS unspecified	4,807	88.2	2,470	31.2	

*January 1 to June 30 of 2015 to 2019, **January 1 to June 15, 2020.
Source: Own elaboration based on SINAN Web Influenza and Sivep Gripe.

Discussion and conclusions

This study compared the occurrence of SARS in Pernambuco before and during the rise of the COVID-19 pandemic. Identifying a thirteen-fold higher volume of notifications during the pandemic, compared to the previous period suggests that, even subject to underreporting, the SARS surveillance system in Pernambuco is sensitive to changes in the occurrence of the disease, with the potential to capture epidemics and changes in the profile of cases[15].

As for the age group, the highest concentration of cases shifted from children under 10 years old to those aged 60 or over, compatible with the situation found in Brazil and the world[2,16-18]. The protection of older adults is a priority strategy, given that they are the group with the highest risk of complications and death by COVID-19[7,18].

On June 15, 2020, Pernambuco had 46,427 confirmed cases of COVID-19, including mild and severe cases, with 4,994 hospitalized cases and 3,959 deaths[19]. In the same period, the collection of samples for laboratory investigation of the 15,100 SARS cases in the state was over 95%, with the identification of 5,235 cases of SARS due to COVID-19.

Faced with the pandemic, the State Health Secretariat of Pernambuco prioritized the laboratory testing of severe cases, followed by other population groups, such as health and public safety professionals, and the suspected deaths due to COVID-19[20]. Although the strategy influences the improved qualification of the SARS diagnosis, one of the main discussions during the pandemic is the importance of extensive laboratory testing in the population. Children and those developing asymptomatic infections can contribute to the spread of the disease and infection in groups more prone to complications. However, it is a fact that the country has a limited production capacity and diagnostic tests[7].

Brazil is among the countries with the lowest number of tests per inhabitant. By the end of May 2020, the country recorded 2.28 tests per 1,000 inhabitants, the lowest rate among South American countries, such as Chile (28.59), Paraguay (3.97), Argentina (3.33), and Uruguay (11.94)[21]. In the same period, Pernambuco's testing rate was 5.54 per 1,000 inhabitants, more than double that observed in Brazil[22].

As for the final laboratory classification, the unspecified SARS stands out throughout the analyzed period, a finding similar to that found in
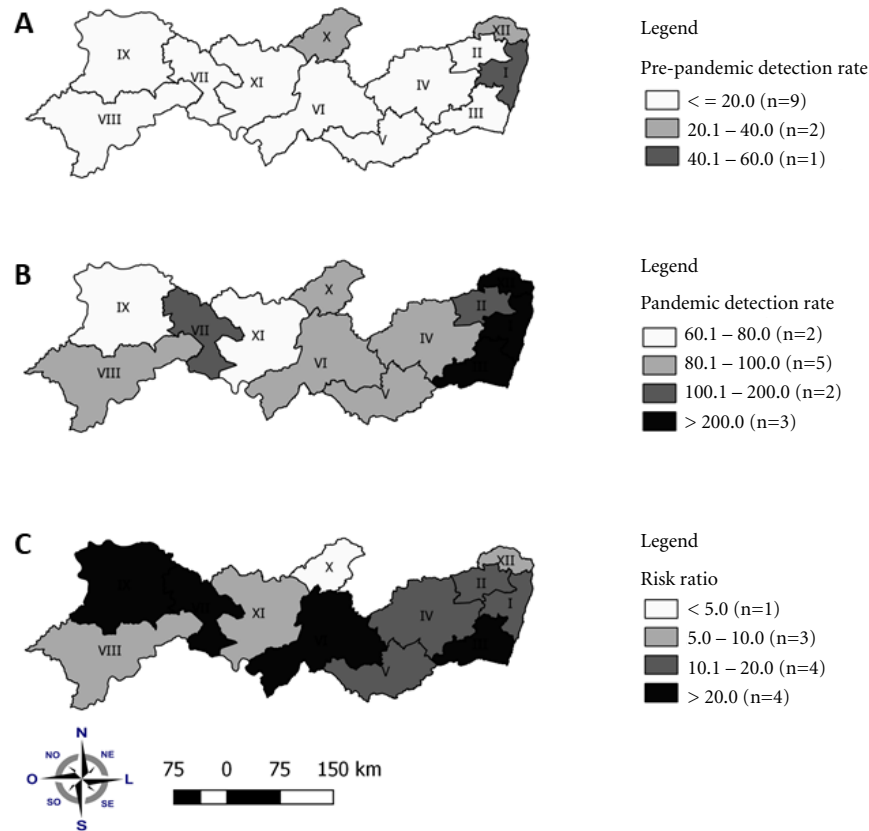
Figure 2. Detection rate of Severe Acute Respiratory Syndrome (cases/100 thousand inhabitants), according to the Regional Health Office of residence. Pernambuco, Brazil. (A) Pre-pandemic (B) Pandemic (C) Risk ratio.

Source: Own elaboration.

a study that analyzed this behavior nationwide[2]. Besides issues related to the quality of the sample collected, inappropriate handling or processing delay, other etiological agents' circulation different from those routinely tested should be considered[2,23,24].

Although the system has improved, with the viral panel modification in recent years, the influenza virus has knowingly always been the priority of this surveillance[1,2]. The Brazilian population dynamics and national and international movements, combined with the circulation of other respiratory viruses in other countries[25,26], must be considered in expanding the viral panel, which can influence the ability to identify new etiological agents and impact the volume of unspecified samples.

The First RHO, which encompasses the Metropolitan Region of Recife, showed the highest concentration of cases in both periods. While accounting for 44.3% of the state's population[11], this territory concentrated more than 75% of the total SARS cases. This geographical space has a high density of highly complex health establishments in Pernambuco, and the access of this population to this more sensitive network may justify such findings in the pre-epidemic period. During the epidemic, especially at the beginning, a higher volume of notifications in this region can also be related to international air and maritime traf-
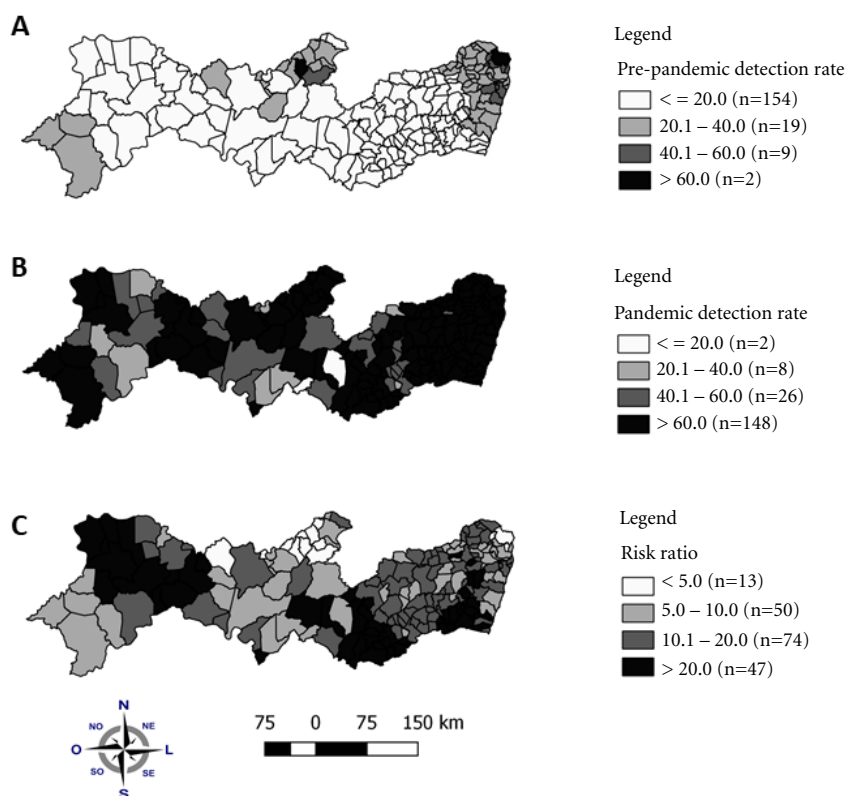
Figure 3. Detection rate of Severe Acute Respiratory Syndrome (cases/100 thousand inhabitants smoothed by the local Bayesian estimator) according to the municipality of residence. Pernambuco, Brazil. (A) Pre-pandemic (B) Pandemic (C) Risk ratio.

Source: Own elaboration.

fic, high population density, and urban mobility, factors that are known to facilitate the circulation of numerous etiological agents[1,27,28].

Spatial analysis reveals the spread of the disease throughout the state of Pernambuco by the smoothed detection rate. However, the growth dynamics were heterogeneous, considering the elevated risk ratios found in Agreste and the Vale do São Francisco e Araripe. Besides these findings is the association found between the excess risk of SARS detection and the municipality's condition in being the headquarters of the RHO, having a federal highway in its territory or a reduced MHDI.

The RHO headquarters is a proxy for economically developed areas in the state. The association found, along with a federal highway in the

municipal territory, suggests that the progress of the disease may be influenced by the social and economic relationships of inland municipalities of Pernambuco with Recife, which is a common characteristic among cities in the northeastern inland region and their respective capitals[27,29,30]. However, the association with low levels of MHDI is also of concern.

As mentioned by Maciel et al.[27], besides the population's vulnerability, low levels of MHDI point to difficulties in health services regarding the diagnosis and treatment of the disease. The spread of COVID-19 is expected to affect infrastructure in the inland region strongly. Moreover, unlike other diseases in a non-pandemic period, there may not be enough time to transfer to the capitals or the capacity to attend to all the de-

Table 2. Initial and final model of logistic regression for the excess risk of detection of Severe Acute Respiratory Syndrome during a pandemic period. Pernambuco, 2020*.

	Variables	β	Wald	Valor de p	OR	IC95%
Initial Model	Municipal Human Development Index	Wald	P-value	OR	95%CI	0,789 – 0,943
	Proportion of vulnerable to poverty	-0.148	10.604	0.001	0.863	0.789 – 0.943
	Proportion of extremely poor	0.019	0.048	0.692	1.019	0.927 – 1.120
	Presence of federal highway	-0.013	0.081	0.776	0.987	0.904 – 1.078
	No	**Benchmark category**			1.0	
	Yes	0.550	2.912	0.088	1.733	0.922 – 3.259
	Regional Health Office Headquarters					
	No	**Benchmark category**			1.0	
	Yes	1.780	5.658	0.017	5.929	1.368 – 25.700
	Final Model	**β**	**Wald**	**Valor de p**	**OR**	**IC95%**
Final Model	Municipal Human Development Index	-0.150	12.420	0.001	0.861	0.792 – 0.936
	Presence of federal highway					
	No	**Benchmark category**			1.0	
	Yes	0.547	2.908	0.088	1.728	0.922 – 3.240
	Regional Health Office Headquarters					
	No	**Benchmark category**			1.0	
	Yes	1.760	5.627	0.018	5.810	1.358 – 24.864

*Up to June 15, 2020.

mands of critically ill patients, which may reflect on different lethality coefficients associated with social inequalities[29,31].

Among the study's main limitations, the possible underreporting of SARS and the non-use of other variables, due to the low completeness, to characterize the profile of the disease in Pernambuco stand out. The elaborate health database management routine, such as removing duplicates and closing cases, difficulties that lead to delayed processing of clinical samples and release of laboratory results, besides work overload of the professionals involved in this surveillance[32], especially in a pandemic scenario, justify the gaps identified. The availability of the SARS database should be highlighted in due course, even sub-ject to changes, allowing researchers and health professionals to access data of interest to public health.

This study presented the progress of SARS in Pernambuco's territory in the period that comprises the beginning of the COVID-19 pandemic. It is an uneven spread, with greater force in distant regions in the Metropolitan Region. Knowing the SARS data retrospectively and prospectively, as well as the use of spatial analysis techniques are relevant strategies that help in understanding the scenario of COVID-19 in its severe form and contribute to planning actions to address the pandemic in the short, medium, and long term at different levels of management.

Collaborations

APSC Silva and WV Souza contributed substantially to the design of the manuscript, analysis and interpretation of data, critical review of the content. LTS Maia contributed significantly to the interpretation of data and critical review of the content; all authors approved the final version of the manuscript.

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