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Inland expansion of COVID-19 in Western Bahia: epidemiological profile and spatial analysis of deaths and confirmed cases

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Abstract *This article aims to describe the epidemiological profile and the spatial distribution of deaths and confirmed cases of COVID-19 in the health macroregion of Western Bahia. An ecological study on the inland expansion of SARS-CoV-2 was performed from March 21, 2020 to March 31, 2021 considering incidence and mortality rate, case fatality rate, case density and moving average of cases and deaths. 37,036 cases and 536 confirmed deaths were registered. Of all cases, 94.5% recovered and 4.0% remained active. The incidence rate was 3884.1/100,000 inhabitants, the mortality rate 56.2/100,000 inhabitants and the fatality rate was 1.4% A predominance of very high and high intensity of the occurrence of COVID-19 in the macroregion was identified and moving average revealed an increasing trend. Findings show a high risk of infection and death in the macroregion, in addition to a growing trend in accumulated cases, confirming the inland expansion of the disease.*

Key words *Coronavirus, Spatial Analysis, Epidemiology, Brazil*

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Introduction

The new coronavirus, named SARS-CoV-2, was first identified in China in Wuhan (Hubei province) in December 2019[1]. It is considered the causative agent of COVID-19 and has spread rapidly across all continents. Given that situation, the World Health Organization (WHO) declared that the disease represents an international public health emergency[2] and characterized it as a pandemic in March 2020[3,4]. As the disease develops, a variety of possibilities come up in the clinical, radiological and laboratory relationship that may lead to a dilemma in conducting discordant manifestations[5]. On the other hand, it shows predominant respiratory features that may develop from respiratory discomfort to the need for intensive care[6].

In this sense, COVID-19 can spread fast and cause a large number of deaths, which makes it difficult to develop accurate strategies to tackle the pandemic in different parts of the world[7]. In Brazil, challenges are rather latent given great social inequality. A large part of the population suffers from precarious housing and sanitation conditions, lacks access to drinking water and is subject to crowding. Those people are extremely vulnerable, as they suffer from high unemployment rates and cuts in social policies[8].

A range of studies have been conducted in Brazil to estimate the spread of the disease[9-11]. However, despite relevant findings, one needs to consider the heterogeneity of indicators of the different health regions in which the disease has been transmitted, since they vary according to actions, routines, availability of supplies, structure of health services and surveillance, as well as cultural and political issues[12]. COVID-19 cases and deaths occur not only in large urban centres but also in the inland. For instance, the states of Amazonas and Amapá, defined as rural and remote, have presented high incidence and mortality rates, leading to a collapse of their health system. The belief that COVID-19 is "big city disease" hampers changes in behaviour and prevention which would be required to tackle the urgency caused by the pandemic in different regions[13].

Brazil registered 12,748,747 confirmed cases of COVID-19 and 321,515 deaths by March 31, 2021 (2.5% case fatality rate)[14]. In the state of Bahia, 803,664 cases and 15,330 deaths were recorded in the same period (1.9% case fatality rate)[15]. In addition, COVID-19 has spread heterogeneously in other health regions. The first cases were identified in Brazilian capitals but later, new cases were detected in more remote regions, to the detriment of community transmission[16].

Thus, the virus tends to spread to the inland, which challenges control of the pandemic in Brazil's most remote regions due to accelerated dissemination of COVID-19 in small municipalities[17]. To understand how the disease is spreading in different health regions helps figure out its dissemination pattern. In this sense, to be able to predict regional outbreaks is essential to develop strategies to tackle the COVID-19 emergency in the municipalities of Brazil's north-eastern region. Therefore, the present study aims to describe the epidemiological profile and spatial distribution of deaths and confirmed cases of COVID-19 in the health macroregion of Western Bahia.

Methods

The present ecological study on the inland expansion of SARS-CoV-2 in the health macroregion of Western Bahia was conducted from March 21, 2020, date of the confirmation of the first COVID-19 case in the region, to March 31, 2021. We used public data made available daily by epidemiological bulletins issued by Municipal Health Departments of the Western region and by the Integrated Health Command and Control Centre of the state of Bahia (https://bi.saude.ba.gov.br/transparencia/).

The health macroregion of Western Bahia counts 36 municipalities (Figure 1A), a population of 953,520 inhabitants and it is divided into three health regions: Barreiras, 15 municipalities (Angical, Baianópolis, Barreiras, Brejolândia, Catolândia, Cotegipe, Cristópolis, Formosa do Rio Preto, Luís Eduardo Magalhães, Mansidão, Riachão das Neves, Santa Rita de Cássia, São Desidério, Tabocas do Brejo Velho, Wanderley), Salvador, 9 municipalities (Barra, Brotas de Macaúbas, Buritirama, Ibotirama, Ipupiara, Morpará, Muquém do São Francisco, Oliveira dos Brejões, Paratinga) and Santa Maria da Vitória, 12 municipalities (Bom Jesus da Lapa, Canápolis, Cocos, Coribe, Correntina, Jaborandi, Santa Maria da Vitória, Santana, São Félix do Coribe, Serra do Ramalho, Serra Dourada, Sítio do Mato)[18].

This study analysed the following variables: number of confirmed cases, number of daily new cases, number of confirmed deaths, number of daily new deaths, active cases, recovered cases, demographic features (age group, sex, race/co-

lour, occupation) as well as pre-existing health conditions. Data of resident population were standardized with those used by the Health Department of the state of Bahia (SESAB) in the epidemiological bulletins of the state to compare them with each other.

Absolute and relative frequencies of confirmed cases were calculated, which were described according to demographic features and pre-existing health conditions. Based on the total number of confirmed COVID-19 cases and deaths, the incidence rate (number of confirmed cases divided by resident population, multiplied by 100,000 inhabitants) was calculated, as well as the mortality rate (number of COVID-19 deaths divided by resident population, multiplied by 100,000 inhabitants) and the case fatality rate (number of COVID-19 deaths divided by the total number of confirmed cases, multiplied by 100). The weekly moving average was calculated based on the sum of new cases and deaths of the last seven days, divided by seven (total days of the period counted). A stable epidemiological scenario is defined by a percentage change of up to 15%, an increasing scenario by a positive percentage change greater than 15% and a decreasing scenario by a negative percentage change greater than 15%.

A spatial analysis was performed by processing and storing data in the Geographic Information System (GIS) by means of the QGIS 2.18.28 software program. The vector files were obtained from IBGE[19] and the Superintendence of Economic and Social Studies of Bahia (SEI)[20]. Maps of confirmed cases, active cases, recovered cases, number of deaths, incidence rate, mortality rate, case fatality rate and case density were generated based on the creation of a Geographic Database (BDG) using SIG and on analyses made with QGIS. To draw up a case density map[21], the heat map technique was applied using a radius of 30,000 meters, which allowed us to identify the highest-density spots of confirmed COVID-19 cases per municipality of the macroregion studied. This technique allows to distinguish municipalities by the intensity of occurrence of COVID-19 cases, which are ranked either as very high/high (most critical municipalities), moderate (municipalities in a moderate situation) or low/very low (municipalities with less cases).

Software programs Microsoft Excel for Windows version 2016 and Statistical Package for the Social Sciences (SPSS) version 22.0 were used to process data, import them to BDG and analyse them, as well as to create the graphs. The present study was performed using secondary and aggregated data, following the recommendations of the research ethics guidelines.

Results

During the studied period, 37,036 confirmed COVID-19 cases were registered in the health macroregion of Western Bahia, 61.5% of which occurred in the Barreiras region, 24.8% in the Santa Maria da Vitória region and 13.7% in the Ibotirama region. The highest absolute numbers of cumulative confirmed cases were found in the municipalities of Barreiras (28.2%) and Luís Eduardo Magalhães (16.3%). Of the total confirmed cases in the macroregion, 94.5% recovered and 4.0% are active. Of the latter, 49.1% are located in the health region of Barreiras. Most registered active cases were found in the municipalities of Barreiras (n=304), Bom Jesus da Lapa (n=172) and Luís Eduardo Magalhães (n=162), which together make up 42.8% of all active cases in the macroregion (Table 1, Figure 1B, 1C, 1D).

Regarding age group, a higher prevalence of confirmed cases was found among individuals aged between 30 and 39 (25.72%). Regarding sex, 54.08% of the cases were women, 45.68% men and in 0.24% of the cases, no information was available. Regarding race/colour, there was a higher frequency of brown (59.85%), followed by white (14.36%) and yellow (11.76%). Regarding occupation, 4.40% were health professionals and concerning pre-existing health conditions, there were chronic heart diseases (3.99%), diabetes (2.00%), decompensated chronic respiratory diseases (1.16%), immunosuppression (0.30%), chronic kidney diseases at advanced stage (0.24%), chromosomal diseases or state of immune fragility (0.17%) and one case of high-risk pregnancy (0.00%) (Table 2). It should be noted that the number of cases in Table 2 is lower than the one in Table 1, since detailed and updated epidemiological data was not provided by all cases registered in the municipalities of the surveyed macroregion.

The COVID-19 incidence rate in the health macroregion was 3,884.1/100,000 inhabitants, the mortality rate was 56.2/100,000 inhabitants and the case fatality rate was 1.4% by March 31, 2021. The highest incidence rate was found in the health region of Barreiras (4,938.1/100,000 inhabitants) and in the municipalities of Luís Eduardo Magalhães (6,880.8/100,000 inhabitants) and Barreiras (6,726.1/100,000 inhabitants),

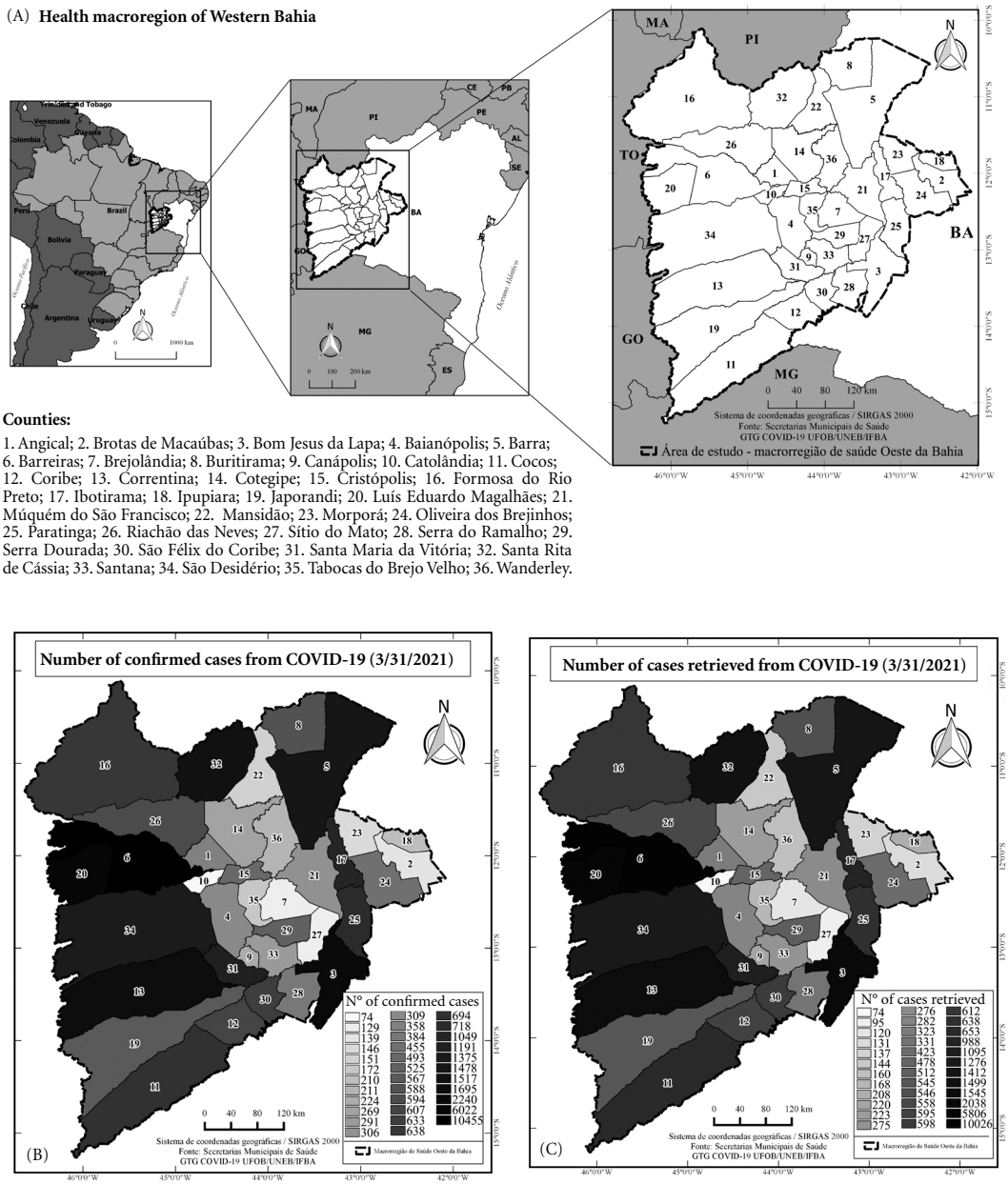

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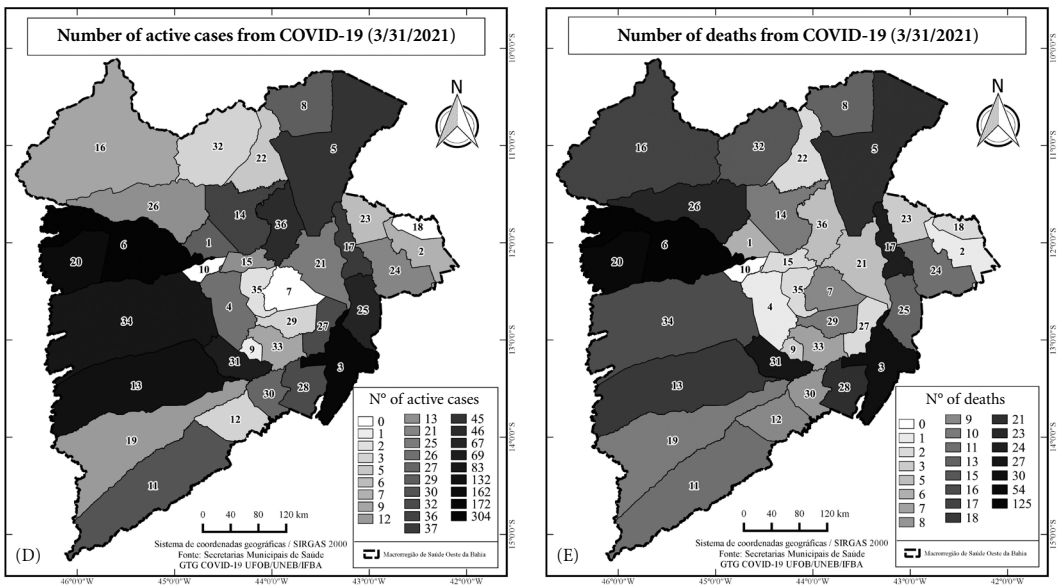
Figure 1. Spatial analysis of confirmed cases and deaths of COVID-19 in the health macroregion of Western Bahia by 31 March 2021. (A) Health macroregion of Western Bahia; (B) Confirmed cases; (C) Recovered cases; (D) Active cases; (E) Deaths.

both of which belong to the above-mentioned health region (Table 1, Figure 2A, 2B, 2C).

The highest mortality rate was found in the health region of Barreiras (62.2/100,000 inhabitants) and in the municipality of Jaborandi (119.3/100,000 inhabitants), followed by the municipalities of Riachão das Neves (103.0/100,000 inhabitants) Salvador (89.1/100,000 inhabitants), Brejolândia (85.3/100,000 inhabitants) and Barreiras (80,4/100,000 inhabitants). Of those five



Counties:

1. Angical; 2. Brotas de Macaúbas; 3. Bom Jesus da Lapa; 4. Baianópolis; 5. Barra; 6. Barreiras; 7. Brejolândia; 8. Buritirama; 9. Canápolis; 10. Catolândia; 11. Cocos; 12. Coribe; 13. Correntina; 14. Cotegipe; 15. Cristópolis; 16. Formosa do Rio Preto; 17. Ibotirama; 18. Ipupiara; 19. Japorandi; 20. Luís Eduardo Magalhães; 21. Múquém do São Francisco; 22. Mansidão; 23. Morporá; 24. Oliveira dos Brejinhos; 25. Paratinga; 26. Riachão das Neves; 27. Sítio do Mato; 28. Serra do Ramalho; 29. Serra Dourada; 30. São Félix do Coribe; 31. Santa Maria da Vitória; 32. Santa Rita de Cássia; 33. Santana; 34. São Desidério; 35. Tabocas do Brejo Velho; 36. Wanderley.

Figure 1. Spatial analysis of confirmed cases and deaths of COVID-19 in the health macroregion of Western Bahia by 31 March 2021. (A) Health macroregion of Western Bahia; (B) Confirmed cases; (C) Recovered cases; (D) Active cases; (E) Deaths.

Source: Municipal Health Departments, GTG-COVID-19 UFOB/UNEB/IFBA.

municipalities, three of them lie in the health region of Barreiras (Table 1, Figure 2C). Regarding case fatality rate, the highest numbers were found in the health region of Ibotirama (1.8%) and in the municipalities of Brejolândia (7.0%), Serra do Ramalho (5.5%) and Riachão das Neves (3.9%). The first and the last one of these municipalities belong to the health region of Barreiras and the second one to the health region of Santa Maria da Vitória (Table 1, Figure 2B).

The historical series of confirmed COVID-19 cases shows an increasing trend of cases, i.e., the highest absolute value was recorded in December (5,339 cases), followed by August (5,177 cases) and March 2021 (5,102 cases) (Figure 3A). Regarding the number of municipalities showing notification of confirmed cases, there was a significant increase from two in March 2020 (Barreiras and Barra) to thirty-six (100.0%) by March 31 (Figure 1B).

Regarding deaths caused by COVID-19, 536 deaths were confirmed in the health macroregion of Western Bahia, i.e., 287 deaths (53.5%) in the health region of Barreiras, 156 deaths (29.1%) in the health region of Santa Maria da Vitória and 93 (17.4%) in the health region of Ibotirama. The municipalities of Barreiras (n=125) and Luís Eduardo Magalhães (n=54) showed the highest absolute numbers of deaths and together, they accounted for 33.4% of all deaths (Table 1, Figure 1E).

The historical series of deaths shows that the first case in the macroregion was registered on May 10, 2020. The highest absolute values were reported in August (92 deaths), followed by March 2021 (83 deaths) and September (64 deaths). The number of municipalities with death notifications also increased considerably from one in May (Cristópolis) to thirty-five by March 31, 2021. (Figure 1E, 3B).

New cases and deaths increased more significantly from July. The highest monthly average of new cases occurred in December (172 new cases/day), followed by August (167 new cases/day) and March 2021 (165 new cases/day). The highest monthly average of deaths occurred in August (3

Table 1. Epidemiological profile of Covid-19 by municipality in the health macroregion of Western Bahia by 31 March 2021.

Health Microregion	Municipality	Population*	N° cases**	Incidence***	Active cases	%	Recovered cases	%	Deaths	Case fatality rate	Mortality***
Barreiras	Angical	13977	358	2561.4	29	8.10	323	90.22	6	1.7	42.9
	Baianópolis	13877	309	2226.7	26	8.41	282	91.26	1	0.3	7.2
	Barreiras	155439	10,455	6726.1	304	2.91	10,026	95.90	125	1.2	80.4
	Brejolândia	10557	129	1221.9	0	0.00	120	93.02	9	7.0	85.3
	Catolândia	3577	74	2068.8	0	0.00	74	100.00	0	0.0	0.0
	Cotegipe	13782	269	1951.8	36	13.38	223	82.90	10	3.7	72.6
	Cristópolis	13910	493	3544.2	13	2.64	478	96.96	2	0.4	14.4
	Formosa do Rio Preto	25591	638	2493.1	9	1.41	612	95.92	17	2.7	66.4
	Luís Eduardo Magalhães	87519	6,022	6880.8	162	2.69	5,806	96.41	54	0.9	61.7
	Mansidão	13643	151	1106.8	5	3.31	144	95.36	2	1.3	14.7
	Riachão das Neves	22339	594	2659.0	13	2.19	558	93.94	23	3.9	103.0
	Santa Rita de Cássia	28338	1,517	5353.2	3	0.20	1,499	98.81	15	1.0	52.9
	São Desidério	33742	1,375	4075.0	83	6.04	1,276	92.80	16	1.2	47.4
	Tabocas do Brejo Velho	12518	172	1374.0	2	1.16	168	97.67	2	1.2	16.0
	Wanderley	12238	211	1724.1	46	21.80	160	75.83	5	2.4	40.9
	Subtotal	461047	22,767	4938.1	731	3.21	21,749	95.53	287	1.3	62.2
Santa Maria da Vitória	Bom Jesus da Lapa	69148	2,240	3239.4	172	7.68	2,038	90.98	30	1.3	43.4
	Canápolis	9711	224	2306.7	1	0.45	220	98.21	3	1.3	30.9
	Cocos	18777	694	3696.0	30	4.32	653	94.09	11	1.6	58.6
	Coribe	14194	607	4276.5	3	0.49	595	98.02	9	1.5	63.4
	Correntina	32137	1,695	5274.3	132	7.79	1,545	91.15	18	1.1	56.0
	Jaborandi	8385	567	6762.1	12	2.12	545	96.12	10	1.8	119.3
	Santa Maria da Vitória	39845	1,191	2989.1	69	5.79	1,095	91.94	27	2.3	67.8
	Santana	26614	291	1093.4	9	3.09	275	94.50	7	2.4	26.3
	São Félix do Coribe	15391	633	4112.8	27	4.27	598	94.47	8	1.3	52.0
	Serra Dourada	18320	525	2865.7	3	0.57	512	97.52	10	1.9	54.6
	Serra do Ramalho	31472	384	1220.1	32	8.33	331	86.20	21	5.5	66.7
	Sítio do Mato	13012	129	991.4	32	24.81	95	73.64	2	1.6	15.4
	Subtotal	297,006	9,180	3090.8	522	5.69	8,502	92.61	156	1.7	52.5

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Table 1. Epidemiological profile of Covid-19 by municipality in the health macroregion of Western Bahia by 31 March 2021.

Health Microregion	Municipality	Population*	N° cases**	Incidence***	Active cases	%	Recovered cases	%	Deaths	Case fatality rate	Mortality***
Ibotirama	Barra	53,578	1,478	2758.6	45	3.04	1,412	95.53	21	1.4	39.2
	Brotas de Macaúbas	10231	139	1358.6	7	5.04	131	94.24	1	0.7	9.8
	Buritirama	21174	588	2777.0	29	4.93	546	92.86	13	2.2	61.4
	Ibotirama	26,927	1,049	3895.7	37	3.53	988	94.18	24	2.3	89.1
	Ipupiara	9865	210	2128.7	0	0.00	208	99.05	2	1.0	20.3
	Morpará	8,519	146	1713.8	6	4.11	137	93.84	3	2.1	35.2
	Muquem do São Francisco	11348	306	2696.5	25	8.17	276	90.20	5	1.6	44.1
	Oliveira dos Brejinhos	21,825	455	2084.8	21	4.62	423	92.97	11	2.4	50.4
	Paratinga	32000	718	2243.8	67	9.33	638	88.86	13	1.8	40.6
	Subtotal	195,467	5,089	2603.5	237	4.66	4,759	93.52	93	1.8	47.6
Grand Total Macroregion		953,520	37,036	3884.1	1490	4.02	35,010	94.53	536	1.4	56.2

*SESAB Information Bulletin; **Municipal Health Department Information Bulletins; ***Per 100,000 inhabitants.

Source: Elaborated by the authors.

deaths/day) and March 2021 (3 deaths/day) (Figure 3A, 3B). Moving average of new cases varied greatly throughout the entire period and peaked in August (202 new cases on 07 and 08/08/20), in December (250 new cases on 19/12/20), which showed the highest moving average value of the analysed period, and in March 2021 (190 new cases on 31/03/21). Moving average of deaths caused by COVID-19 varied less but behaved similarly to moving average of new cases and also peaked in August (4 new cases on 04, 08, 09 and 23/08/20), in December (4 new cases on 15 and 16/12/20) and in March 2021 (4 new cases on 31/03/21). In the last 14 days of the analysed period (18 and 31/03/2021), moving average of new cases increased from 165 to 190 (15.1%) and moving average of new deaths increased from 2 to 4 (50.0%), which shows a growing trend in the number of both new cases and new deaths caused by COVID-19 in the region (Figure 3C, 3D).

Regarding the spatial analysis of confirmed cases, density mapping of cases was performed to understand the spatial distribution pattern of COVID-19 in the health macroregion of Western Bahia. We noticed both a very high and a high intensity of COVID-19 occurrence in that macroregion. Municipalities that showed a critical intensity of occurrence are represented by a hue close to black (very high) and dark grey (high). Those in a moderate (medium) situation are represented by a hue close to medium grey and those with a lower intensity of occurrences by light grey (low) and white (very low) hues (Figure 2D).

Discussion

This study analysed the epidemiological profile and spatial analysis of COVID-19 in the health macroregion of Western Bahia. Regarding incidence, the value of the macroregion (3.884,1/100,000 inhabitants) was lower than the one of Bahia (5,403.5/100,000 inhabitants)[15] and of most of its other health macroregions, except the Northern region (3,721.2/100,000 inhabitants)[15]. In contrast, the incidence of COVID-19 in Western Bahia was higher than in the states of Sergipe (2,049.0/100,000 inhabitants), Paraíba (1,713.0/100,000 inhabitants) and Ceará (1,713.0/100,000 inhabitants)[22], but lower than in the North-eastern region (4,994.4/100,000 inhabitants)[23] and in Brazil (5.898,5/100,000 inhabitants)[23]. However, the municipalities of Barreiras and Luís Eduardo Magalhães showed higher incidence rates than those registered at state

Table 2. Proportional distribution of confirmed Covid-19 cases by demographic features and pre-existing health conditions in the health macro-region of Western Bahia by 31 March 2021.

Variables	Confirmed cases*	
	n	%
Age group (n=35,553)		
<1	290	0.82
1-4	498	1.40
5-9	673	1.89
10-19	2,722	7.66
20-29	7,247	20.38
30-39	9,144	25.72
40-49	6,560	18.45
50-59	4,138	11.64
60-69	2,308	6.49
70-79	1,268	3.57
80+	701	1.97
Not informed	4	0.01
Sex (n=35,553)		
Female	19,227	54.08
Male	16,240	45.68
Not informed	86	0.24
Race/colour (n=35,553)		
Yellow	4,180	11.76
White	5,107	14.36
Indigenous	116	0.33
Brown	21,277	59.85
Black	1,432	4.03
Not informed	3,441	9.68
Health professional (n=35,553)		
Yes	1,564	4.40
No	32,781	92.20
Not informed	1,208	3.40
Decompensated chronic respiratory diseases (n=35,553)		
Yes	413	1.16
No	33,920	95.41
Not informed	1,220	3.43
Chronic heart diseases (n=35,553)		
Yes	1,417	3.99
No	32,939	92.65
Not informed	1,197	3.37
Diabetes (n=35,553)		
Yes	711	2.00
No	33,636	94.61
Not informed	1,206	3.39
Chronic kidney diseases at an advanced stage - degree 3, 4 or 5 (n=35,553)		
Yes	86	0.24
No	34,247	96.33
Not informed	1,220	3.43
Immunosuppression (n=35,553)		
Yes	105	0.30
No	34,225	96.26
Not informed	1,223	3.44

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Table 2. Proportional distribution of confirmed Covid-19 cases by demographic features and pre-existing health conditions in the health macro-region of Western Bahia by 31 March 2021.

Variables	Confirmed cases*	
	n	%
Carriers of chromosomal diseases or state of immunological frailty (n=35,553)		
Yes	60	0.17
No	34,324	96.54
Not informed	1,169	3.29
High-risk pregnancy (n=35,553)		
Yes	1	0.00
No	34,383	96.71
Not informed	1,169	3.29

*Data obtained by the Integrated Health Command and Control Centre of the state of Bahia.

Source: Elaborated by the authors.

level[15], in the states of the Southeast and Northeast[23] and at national level[23].

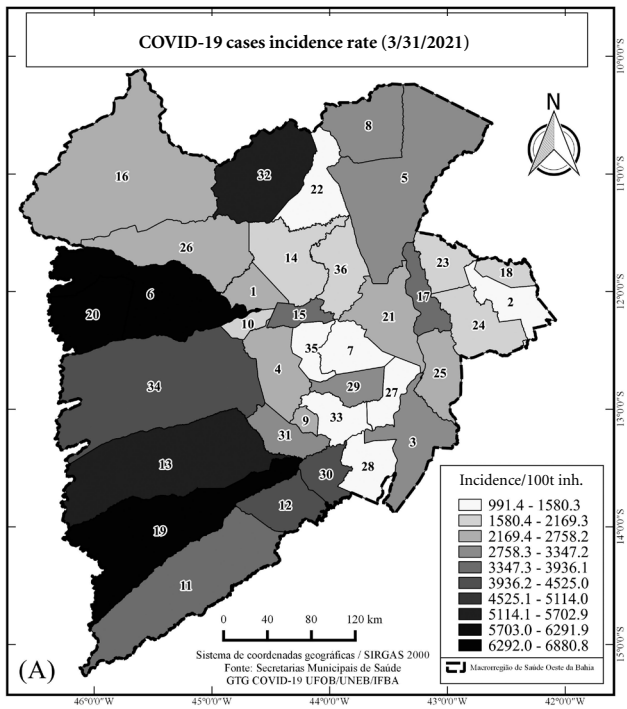
Cumulative mortality in the health macroregion was lower than in the state of Bahia (103.0/100,000 inhabitants)[15], in the Northeast (116,8/100,000 inhabitants)[23] and in Brazil (146,7/100,000 inhabitants)[23]. However, the municipality of Jaborandi showed a higher mortality rate than the one registered in the state[15]. This pattern did not apply to the macroregional case fatality rate, which showed a lower value than Bahia (1,9%)[15], the North-eastern region (2.3%)[23] and Brazil (2.4%)[23]. However, in the municipalities of Brejolândia, Cotegipe, Formosa do Rio Preto, Riachão das Neves and Serra do Ramalho, case fatality rate was higher than at state level[15], regional level[23] and national level[23]. Regional mortality was also higher than in the states of Alagoas (43.3/100,000 inhabitants), Paraíba (38.8/100,000 inhabitants) and Piauí (35.4/100,000 inhabitants)[22].

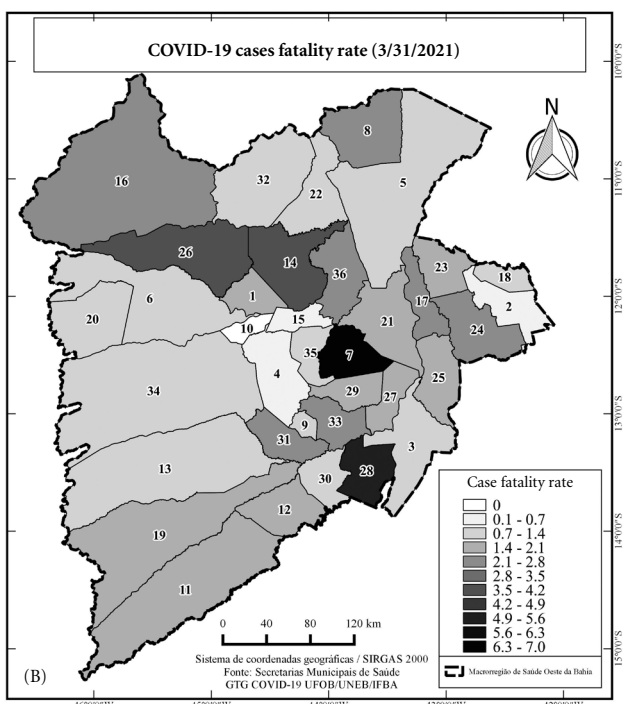
Of all registered cases, the female sex prevailed, following the profile of Bahia (54.9%)[15] and of the city of Rio de Janeiro (51.4%)[9], but deviating from national average (45.1%)[23]. Young adults were the most affected age group, in line with both state level[15] and national level[23]. Similar findings were found at international level[24], which shows that COVID-19 mainly affects the economically active population. However, it mainly causes the death of the elderly and of patients with pre-existing health conditions, such as chronic diseases and immunosuppression[25], which makes monitoring and notification of that data essential. The present study found a low prevalence of pre-existing health conditions, but around 3.4% of the cases did not provide that type of information, revealing a failure in the notification of one of the COVID-19 vulnerability factors.

In terms of race/colour, brown patients made up almost 60.0% of all cases, a higher value than in Bahia (49.9%)[15]. Despite showing the highest number of cases, Brazil has a lower percentage of brown patients (31.7%)[23], since white patients prevail (47.1%), which also differs from the pattern of the health macroregion of Western Bahia. It is common knowledge that health differences between racial and ethnic groups are usually due to economic and social conditions[26]. In addition, racism also prevents adopting preventive measures against COVID-19, considering that social distancing, the main measure proposed by WHO[27], cannot be practiced by everyone, since the black population represents most informal workers, as well as domestic service, commercial, food, transport, warehouse, and postal service workers who remained active during the pandemic[28]. This fact explains the high increase of infected black people[26].

Percentage of COVID-19 infection of health professionals was lower than in Bahia (5.85%)[15]. According to the SESAB bulletin on health workers, the most affected ones are outsourced workers. The most affected higher-level professionals are nurses (17.2%), auditors (16.7%) and health clinic managers, coordinators, and supervisors (15.5%). At technical level, laboratory and pathology technicians and aides (20.6%) stood out, followed by nurses and auxiliary nurses (19.0%) and dental technicians and aides (14.7%)[29].

COVID-19 developed differently among the municipalities. Initially, only two of them showed



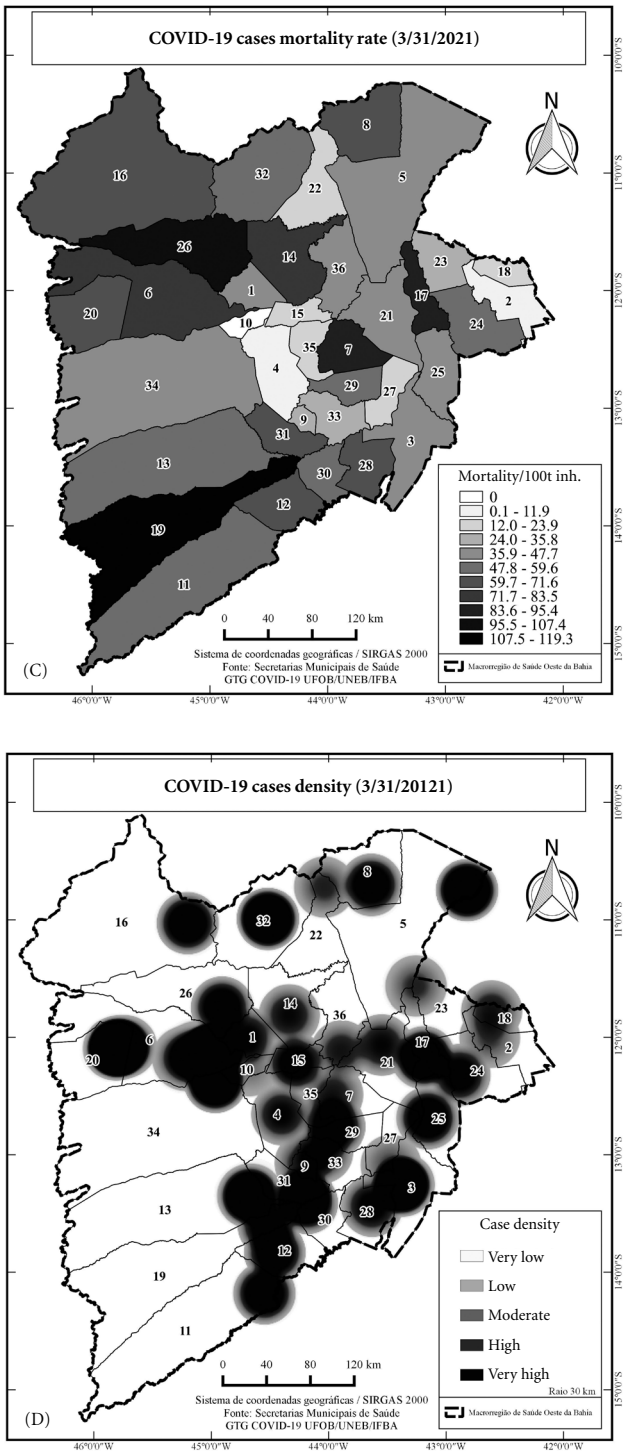


Counties:

1. Angical
2. Brotas de Macaúbas
3. Bom Jesus da Lapa
4. Baianópolis
5. Barra
6. Barreiras
7. Brejolândia
8. Buritirama
9. Canápolis
10. Catolândia
11. Cocos
12. Coribe
13. Correntina
14. Cotegipe
15. Cristópolis
16. Formosa do Rio Preto
17. Ibotirama
18. Ipupiara
19. Japorandi
20. Luís Eduardo Magalhães
21. Múquém do São Francisco
22. Mansidão
23. Morporá
24. Oliveira dos Brejinhos
25. Paratinga
26. Riachão das Neves
27. Sítio do Mato
28. Serra do Ramalho
29. Serra Dourada
30. São Félix do Coribe
31. Santa Maria da Vitória
32. Santa Rita de Cássia
33. Santana
34. São Desidério
35. Tabocas do Brejo Velho
36. Wanderley

it continues

Figure 2. Spatial analysis of COVID-19 in the health macro-region of Western Bahia by 31 March 2021. (A) Incidence rate; (B) Case fatality rate of confirmed cases; (C) Mortality rate; (D) Density of confirmed cases.



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Source: Municipal Health Departments, GTG-COVID-19 UFOB/UNEB/IFBA

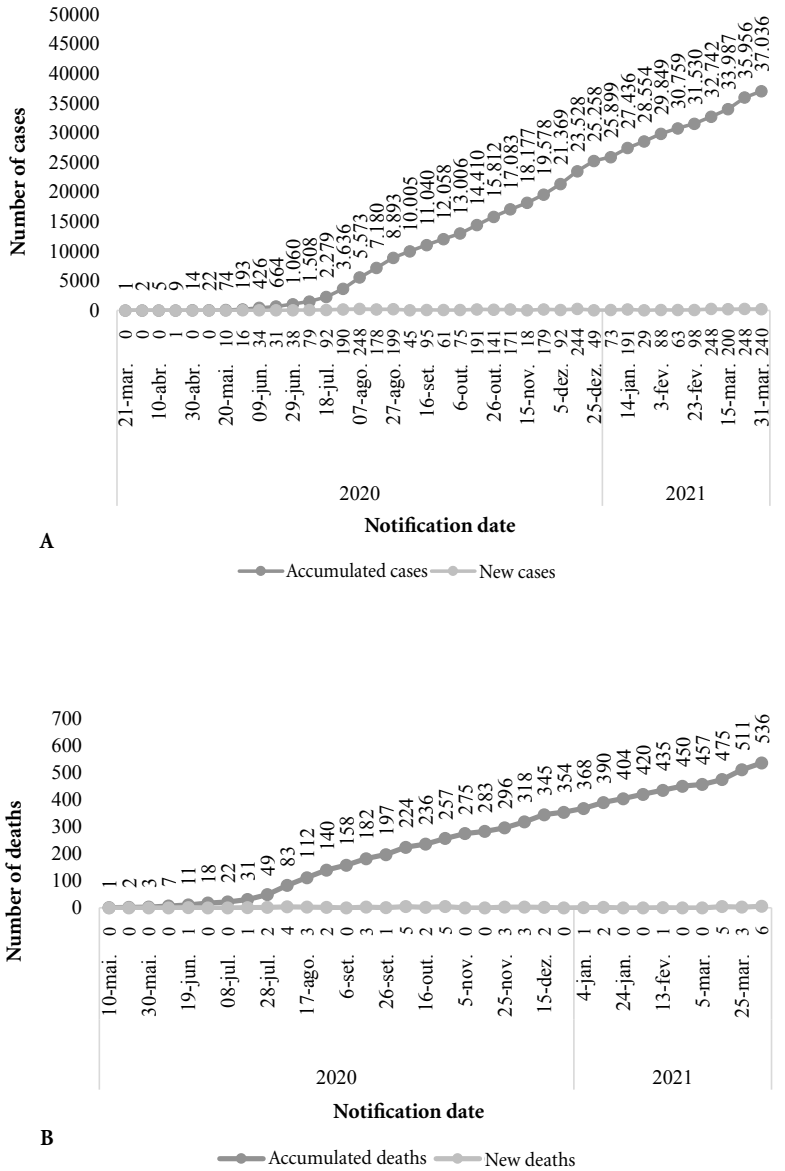

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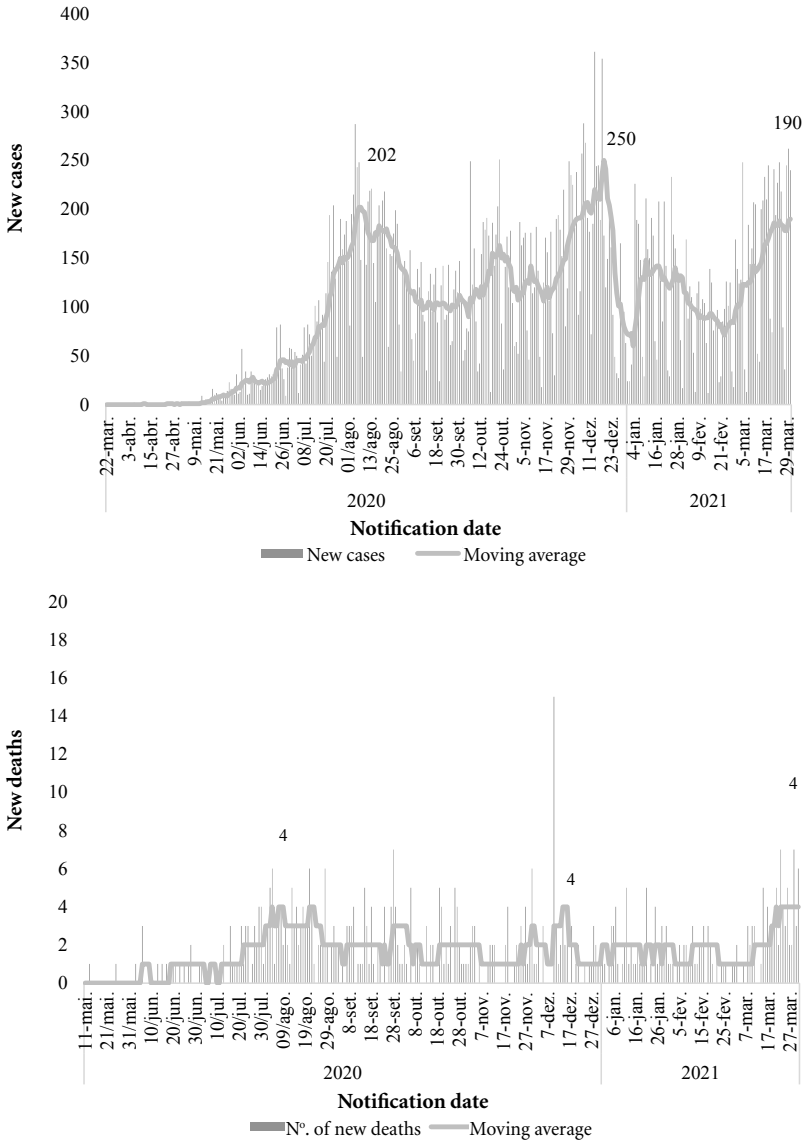
Figure 3. Historical series of confirmed cases and deaths and moving average of Covid-19 in municipalities of the health macroregion of Western Bahia by 31 March 2021. (A) Historical series of accumulated and new confirmed cases; (B) Historical series of accumulated and new confirmed deaths; (C) New confirmed cases and moving average; (D) New confirmed deaths and moving average.

confirmed cases in March 2020. One year later, all the 36 municipalities of the health macroregion of Western Bahia showed confirmed cases. Regarding recovered cases, the macroregion presented a lower percentage than Bahia (96.2%)[15] and a higher percentage than Brazil (87.1%)[23]. To evaluate data on the ratio of recovered cases versus active cases, one needs to consider that the collection of tests for diagnostic confirmation of infection by the new coronavirus is restricted to the audience defined by the protocols of the Ministry of Health and by municipal protocols, which has resulted in underreporting of cases.

The first confirmed COVID-19 case in the macroregion occurred in the municipality of Barreiras, which shows the highest number of ac-



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Source: Elaborated by the authors.

cumulated cases. It is one of the largest farming hubs in Bahia and in the Northeast of Brazil and drives and influences the economy of the health regions. In 2017, it ranked among the municipalities with the highest GDP per capita in Bahia, BRL 24,676.48[30]. Barreiras is the only municipality with an airport and its flights serve various Brazilian cities. In addition, the main highway junction lies in the region, all of which results in intense road and air traffic, offering mobility to nearby regions and to other Brazilian states, which may be related to the transmissibility of the disease. The flow of tourists to the region in the high seasons, such as Christmas, New Year, Carnival, and St. John's Day, may also have contributed to the arrival and spread of the virus in

the region. Although the first cases of COVID-19 were recorded in March, contamination probably occurred long before, due to periods of large flows of tourists at the airport, on the roads and crowding of people in other spaces[31].

Moving average of cases and deaths of the last day of the study (March 31, 2021) showed a growing trend of both new cases and new deaths. However, considering that the epidemiological scenario is directly influenced by the control measures adopted and that it may undergo changes over time, increase condition may be related to the relaxation of COVID-19 prevention measures in municipal territories.

Density of confirmed cases allowed us to understand the spatial COVID-19 distribution pattern in the health macroregion of Western Bahia. That kind of mapping allowed us to pinpoint spots of higher density of occurred cases, which shows the need to intensify measures to fight the disease, such as social distancing and epidemiological and sanitary surveillance measures to prevent the spread of new cases in these municipalities. In addition, COVID-19 needs to be addressed in a coordinated way in the intra and intermunicipal context, considering the proximity and flow of people among the cities in the region.

Some restrictions need to be considered to interpret the findings of the present study. Confirmed cases are predominantly related to laboratory criteria. Thus, potential underreporting has been noticed in the studied territory, mainly due to the existence of only one regional Public Health Laboratory. The incidence and mortality ratios may not accurately reflect information on municipalities with small populations, such as Catolândia and Cotegipe, which show high rates. Likewise, some municipalities show a small number of cases and deaths, such as Brejolândia (7.0% case fatality rate).

Findings indicate a high risk of COVID-19 infection and death in the municipalities of the health macroregion of Western Bahia. In addition, they show an increasing trend of new cases, confirming the national inland expansion profile of COVID-19 in smaller cities. It is acknowledged that the distribution may change rapidly due to transmission and features of municipal interventions, health services structure, as well as socioeconomic, cultural, and political aspects.

However, it should be noted that the gradual inland expansion of the disease may further affect the health system of the macroregion, since many municipalities lack hospitals, so that patients need to travel to a reference municipality of the health region. Thus, prevention measures issued by health authorities need to be intensified, especially in the municipalities with the highest incidence rates, to avoid overload and collapse of the Regional Health System of Western Bahia. A coordinated regional action by municipalities is also required to increase the efficacy of decisions and strategies to fight COVID-19.

Collaborations

The authors contributed to all the stages of the study: a) concept and design or analysis and interpretation of data, b) writing or critical review of the article, and c) approval of the version to be published.

References

1. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T, Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang R, Gao Z, Jin Q, Wang J, Cao B. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; 395(10223):497-506.
2. World Health Organization (WHO). *Statement on the second meeting of the international health regulations (2005) emergency committee regarding the outbreak of novel coronavirus (2019-nCoV)*. Genebra: WHO; 2020.
3. Organização Pan-Americana da Saúde (OPAS). *Folha informativa – COVID-19 (doença causada pelo novo coronavírus)*. Brasília: OPAS; 2020.
4. World Health Organization (WHO). *WHO announces COVID-19 outbreak a pandemic*. Genebra: WHO; 2020.
5. Shi H, Han X, Jiang N, Jiang N, Cao Y, Alwalid O, Gu J, Fan Y, Zheng C. Radiological findings from 81 patients with COVID-19 pneumonia in Wuhan, China: a descriptive study. *Lancet Infect Dis* 2020; 20(4):425-434.
6. Frater JL, Zini G, d'Onofrio G, Rogers HJ. COVID-19 and the clinical hematology laboratory. *Int J Lab Hematol* 2020; 42(Supl. 1):11-18.
7. Hallal PC. Worldwide differences in COVID-19-related mortality. *Cien Saude Colet* 2020; 25(1):2403-2410.
8. Werneck GL, Carvalho MS. A pandemia de COVID-19 no Brasil: crônica de uma crise sanitária anunciada. *Cad Saude Publica* 2020; 36(5):e00068820.
9. Cavalcante JR, Abreu AJL. COVID-19 no município do Rio de Janeiro: análise espacial da ocorrência dos primeiros casos e óbitos confirmados. *Epidemiol Serv Saude* 2020; 29(3):e2020204.
10. Hallal PC, Horta BL, Barros AJD, Dellagostin OA, Hartwig FP, Pellanda LC, Struchiner CJ, Burattini MN, Silveira MF, Menezes AMB, Barros FC, Victora CG. Evolução da prevalência de infecção por COVID-19 no Rio Grande do Sul, Brasil: inquéritos sorológicos seriados. *Cien Saude Colet* 2020; 25(Supl. 1):2395-2401.
11. Silva JH, Oliveira EC, Hattori TY, Lemos ERS, Terças-Trettel ACP. Descrição de um cluster da COVID-19: o isolamento e a testagem em assintomáticos como estratégias de prevenção da disseminação local em Mato Grosso, 2020. *Epidemiol Serv Saude* 2020; 29(4):e2020264.
12. Freitas ARR, Napimoga M, Donalisio MR. Análise da gravidade da pandemia de Covid-19. *Epidemiol Serv Saude* 2020; 29(2):e2020119.
13. Floss M, Franco CM, Malvezzi C, Silva KV, Costa BR, Silva VXL, Werreria NS, Duarte DR. A pandemia de COVID-19 em territórios rurais e remotos: perspectiva de médicas e médicos de família e comunidade sobre a atenção primária à saúde. *Cad Saude Publica* 2020; 36(7):e00108920.
14. Brasil. Ministério da Saúde (MS). *Painel Coronavírus – Covid-19* [Internet]. [acessado 2021 maio 4]. Disponível em: https://covid.saude.gov.br/.

15. Secretaria do Estado da Bahia (SESAB). *Boletim Epidemiológico Covid-19 - Bahia, n. 372* [Internet]. 2021 [acessado 2021 maio 4]. Disponível em: http://www.saude.ba.gov.br/wp-content/uploads/2021/03/BOLETIM_ELETRONICO_BAHIAN_372___31032021.pdf.
16. Pedrosa NL, Albuquerque NLS. Análise espacial dos casos de COVID-19 e leitos de terapia intensiva no estado do Ceará, Brasil. *Cien Saude Colet* 2020; 25(1):2461-2468.
17. Monitora Covid-19. *Tendências atuais da pandemia de Covid-19: interiorização e aceleração da transmissão em alguns estados. Nota Técnica* [Internet]. 2020 [acessado 2020 ago 25]. Disponível em: https://www.agb.org.br/covid19/wp-content/uploads/2020/06/MonitoraCovid_NotaTecnica_Tend%C3%AAncias-atuais-da-pandemia-de-Covid-19-Interiorizacao-e-aceleracao-da-transmissao-em-alguns-estados.pdf.
18. Secretaria de Saúde do Estado da Bahia (SESAB). *Regiões de Saúde do estado da Bahia* [Internet]. [acessado 2020 ago 20]. Disponível em: http://www1.saude.ba.gov.br/mapa_bahia/result_macroch.asp?MACRO=OESTE&Button122=Ok.
19. Instituto Brasileiro de Geografia e Estatística (IBGE). *Geociências: Downloads* [Internet]. 2010 [acessado 2020 ago 22]. Disponível em: https://www.ibge.gov.br/geociencias/downloads-geociencias.html.
20. Superintendência de Estudos Econômicos e Sociais da Bahia (SEI). *Geoinformação: Limites Territoriais* [Internet]. 2019 [acessado 2020 ago 22]. Disponível em: https://www.sei.ba.gov.br/index.php?option=com_content&view=article&id=2617&Itemid=537.
21. Câmera G, Carvalho MS. Análise Espacial de Evento. In: Druck S, Carvalho MS, Câmera G, Monteiro AMV, editores. *Análise Espacial de Dados Geográficos*. Brasília: Emprapa; 2004. p. 21-52.
22. Kerr L, Kendall C, Silva AAM, Aquino EML, Pescarini JM, Almeida RLF, Ichihara MY, Oliveira JF, Araújo TVB, Santos CT, Jorge DCP, Miranda Filho DB, Santana G, Gabrielli L, Albuquerque MFPM, Almeida-Filho N, Silva NJ, Souza R, Ximenes RAA, Martelli CMT, Brandão Filho SP, Souza WV, Barreto ML. COVID-19 no Nordeste brasileiro: sucessos e limitações nas respostas dos governos dos estados. *Cien Saúde Colet* 2020; 25(Supl. 2):4099-4120.
23. Brasil. Ministério da Saúde (MS). *Boletim epidemiológico especial nº 56. Doença pelo Coronavírus COVID-19. Semana epidemiológica 12 (21 a 27/03/2021)* [Internet]. [acessado 2021 abr 1]. Disponível em: https://www.gov.br/saude/pt-br/media/pdf/2021/abril/01/boletim_epidemiologico_covid_56.pdf.
24. Heymann DL, Shindo N. COVID-19: what is next for public health? *Lancet* 2020; 395(10224):542-545.
25. Croda J, Oliveira WK, Frutuoso RL, Mandetta LH, Baia-da-Silva DC, Brito-Sousa JD, Monteiro WM, Lacerda MVG. COVID-19 in Brazil: advantages of a socialized unified health system and preparation to contain cases. *J Brazilian Soc Trop Med* 2020; 53:e20200167.
26. Santos MPA, Nery JS, Goes, EF, Silva A, Santos ABS, Batista LE, Araújo EM. População negra e Covid-19: reflexões sobre racismo e saúde. *Estud Av* 2020; 34(99):225-244.
27. World Health Organization (WHO). *Coronavirus disease (Covid-19) advice for the public* [Internet]. [acessado 2020 ago 29]. Disponível em: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.
28. Goes EF, Ramos DO, Ferreira AJF. Desigualdades raciais em saúde e a pandemia da Covid-19. *Trab Educ Saude* 2020; 18(3):e00278110.
29. Secretaria do Estado da Bahia (SESAB). *Boletim informativo COVID-19: Trabalhadores da saúde* [Internet]. [acessado 2020 ago 29]. Disponível em: http://www.saude.ba.gov.br/wp-content/uploads/2020/08/16%-C2%BA-Boletim-Informativo-COVID-19-TRABALHADORES-DA-SA%C3%9ADE.pdf.
30. Instituto Brasileiro de Geografia e Estatística (IBGE). *Cidades: Bahia* [Internet]. 2017 [acessado 2020 ago 29]. Disponível em: https://cidades.ibge.gov.br/brasil/ba/barreiras/pesquisa/38/0.
31. Marinelli NP, Albuquerque LPA, Sousa IDB, Batista FMA, Mascarenhas MDM, Rodrigues MTP. Evolução de indicadores e capacidade de atendimento no início da epidemia de COVID-19 no Nordeste do Brasil, 2020. *Epidemiol Serv Saude* 2020; 29(3):e2020226.

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