OPEN ACCESS Freely available online

ISSN: 2576-389X
Journal of Infectious Diseases and Diagnosis

Research Article

Aspects of SARS-CoV-2 Infection in an Indigenous Pataxo Community of Southernmost Bahia, Northeast Brazil

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ABSTRACT

Background and objectives: Severe acute respiratory syndrome-coronavirus 2 caused the coronavirus disease (COVID-19) pandemic. In Brazil, data remain limited in vulnerable populations, including indigenous people. We investigated epidemiological, demographic, and clinical aspects of COVID-19 in the Pataxó lands of the municipalities of Porto Seguro (PS) and Santa Cruz Cabrália (SCC), southernmost Bahia, Brazil, during the first 499 days of transmission.

Materials and methods: This was a cross-sectional observational epidemiological study on the clinical, demographic and epidemiological aspects of COVID-19 in the indigenous population of Pataxó ethnicity, resident in the municipalities of Porto Seguro (PS) and Santa Cruz Cabrália (SCC), southernmost Bahia, Brazil, conducted between May 22, 2020, and October 2, 2021.

Results: There were 655 COVID-19 cases, most in 2020 (67.79%, n=444), with an overall incidence rate of 6,575.6/100,000 inhabitants. Female sex (>58.4%) was a risk factor for COVID-19 (χ^2=24.682; df=1; P<0.001). The acceleration of new cases revealed a bimodal variation with a second peak on day 491 (epidemiological week 39/2021), greater than the first wave (0.131168 and 0.106299 new cases/day). The two municipalities showed no significant difference in severe outcomes (P=0.444); however, threefold higher mortality occurred in SCC (SCC 134.9/100,000 inhabitants and PS 36.3/100,000 inhabitants). Pataxó children (≤ 9 years) had a lower prevalence of acute symptoms (P<0.001), essentially low-grade fever (67.3%). Comorbidities were significantly associated with older age (48%).

Conclusion: These findings expose the gravity of COVID-19 in the Pataxó communities and may help better address the healthcare needs of this neglected population.

Keywords: COVID-19; Epidemiology; Health indigenous; Indigenous people; Pandemic; Pataxo ethnicity; SARS-CoV-2

INTRODUCTION

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infections were first reported in Wuhan, China, spreading rapidly worldwide, and was recognized by the World Health Organization (WHO) as coronavirus disease (COVID-19). It disproportionately affects vulnerable populations, such as indigenous people [1-4].The effect of the pandemic on these population has highlighted vulnerabilities marked by violence and discrimination, such as precarious conditions of sanitation and housing, confrontation with invaders in their territories, food insecurity and lack of regular access to potable water, high infant mortality, invisible presence in the urban context, and childhood marked by chronic malnutrition, potentiating epidemiological scenarios determined by infectious and parasitic diseases as the main causes of sickness and death [5-8].

Brazil's indigenous population is estimated at 817,963 and is heterogeneously distributed, with the Northeast region having the second largest indigenous contingent with 208,691 individuals (26%), after the North region (37%) [9]. Brazil has so far recorded approximately 31.8 million confirmed cases of COVID-19, with

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Received: 16-Feb-2023, Manuscript No. JIDD-23-19950; **Editor assigned:** 20-Feb-2023, PreQC No. JIDD-23-19950 (PQ); **Reviewed:** 07-Mar-2023, QC No. JIDD-23-19950; **Revised:** 14-Mar-2023, Manuscript No. JIDD-23-19950 (R); **Published:** 21-Mar-2023. DOI: 10.35248/2576-389X.23.8.214

Citation: Reis RL, Saad MHF (2023) Aspects of SARS-CoV-2 Infection in an Indigenous Pataxó Community of Southernmost Bahia, Northeast Brazil. J Infect Dis Diagn. 8:214.

6.3 million in the Northeast region. Among the northeastern states with the highest number of cases, a quarter of cases are concentrated in Bahia (1.5 million) representing 4.5% (30,000) of the overall national deaths (669.390) from the disease (BRASIL, PAINEL COROVAVÍRUS [10].

The state of Bahia houses the third largest indigenous population in the country and is organized in 138 villages spread across 33 municipalities and approximately 8,769 families, predominantly of Pataxó ethnicity (3,277 families), located in the southern end of Bahia [9]. In recent decades, these peoples have been the target public actions, mainly related to land demarcation and other socioeconomic and sanitary issues [11-12].

COVID-19 does not equally affect individuals in a population [13-16]. It is postulated that minority ethnic groups that are vulnerable because of precarious socioeconomic and health conditions may be increasingly affected by COVID-19. However, data remain limited in indigenous populations, although some studies show an increase in morbidity compared to non-indigenous populations [1, 17-18]. Most of these studies have been conducted in indigenous populations in general, but different ethnicities in Brazil may have peculiar characteristics affecting the epidemiology of COVID-19. Therefore, in this study, we aimed to characterize aspects of SARS-CoV-2 infection in the Pataxó indigenous of the extreme south of Bahia, during the first 499 days of the pandemic.

MATERIALS AND METHODS

This was a cross-sectional observational epidemiological study on the clinical, demographic and epidemiological aspects of COVID-19 in the indigenous population of Pataxó ethnicity, resident in the municipalities of Porto Seguro (PS) and Santa Cruz Cabrália (SCC), southernmost Bahia, Brazil. The study was conducted between May 22, 2020, and October 2, 2021, and approved by the National Council of Ethics in Research (details blinded for peer review).

In the state of Bahia, the Pataxó ethnicity are organized in 36 villages, distributed in six Indigenous Lands (IL), located in the municipalities of Belmonte, Itapebí, Itamaraju, PS, Prado and SCC. An estimated 10 thousand indigenous people occupy an average area of 43,061,09 hectares. Currently, 54.6% of this population is located in urban areas mainly in the municipality of SCC (84.8%), while in rural areas most indigenous people are concentrated in the municipality of PS (67.0%) [9]. They live in diverse coastal ecosystems with basic economic activities including agriculture, plant extraction of piaçava and wood; craft production, trade activities and hunting [11,19-20]. Only Pataxó people living in the villages of the municipalities of PS and SCC were included in this study, representing 90% of the total Pataxó indigenous community shown in Figure 1.

Cases of COVID-19 were those notified from the official database of the Ministry of Health obtained in the Municipal Secretary of Health of PS and SCC, through the data platform of the e-SUS Notification, and deaths were obtained from the Mortality Information System. In the Indigenous Health Care Information System (SIASI) the demographic data refer only to those of the ethnic group residing in IL in 2020. The study population comprised cases with confirmed COVID-19 diagnosis and deaths, reported within the first 499 days of the epidemic (Epidemiological Week-EPI WEEK 21/2020 to EPI WEEK 39/2021). Duplicate notifications (n=76) in the two municipalities were excluded, in addition to 58 reported cases with addresses outside the indigenous village and 1,602 cases in which the diagnosis of COVID-19 was discarded in Figure 2.

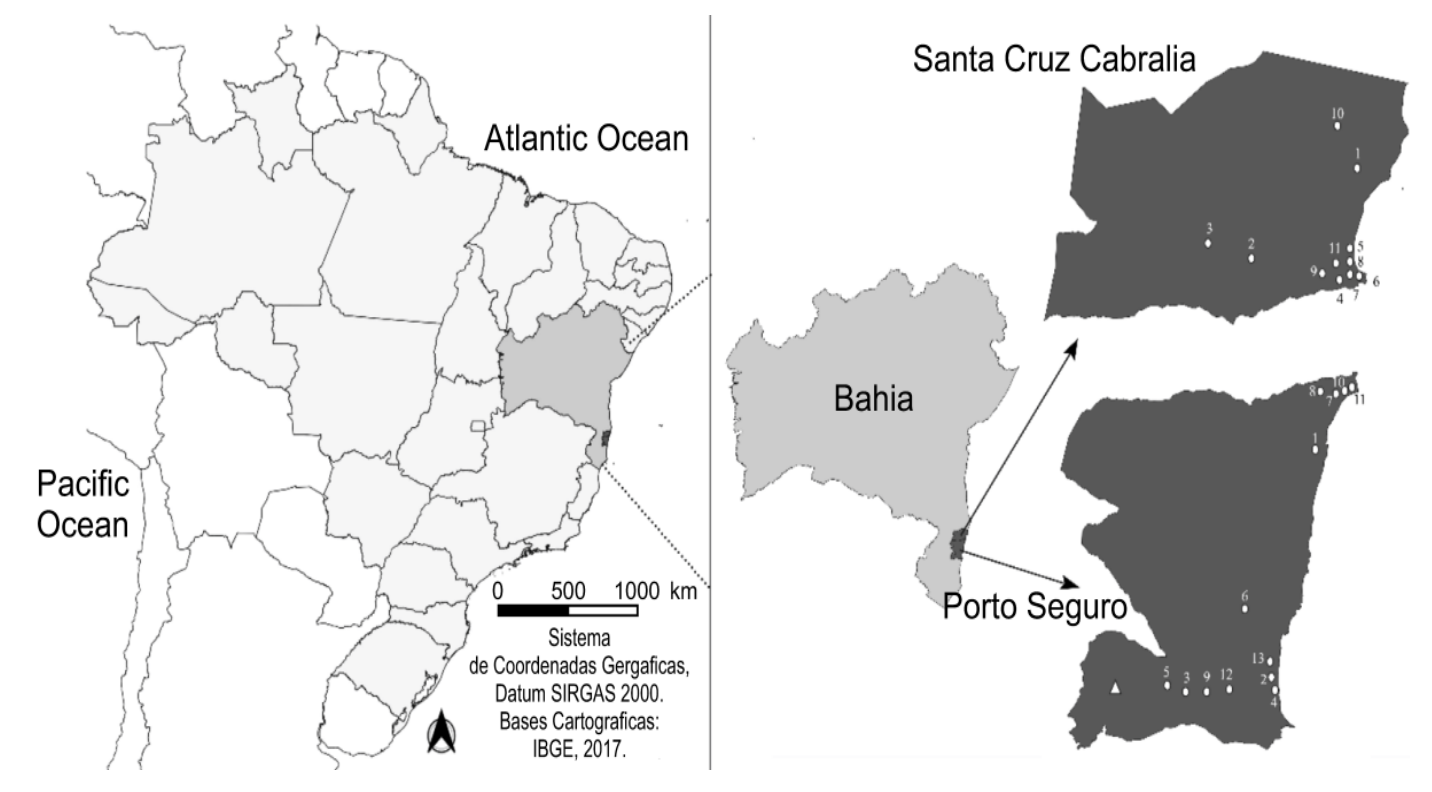

Figure 1: Map of Pataxó ethnic indigenous group in Santa Cruz de Cabralia (SCC) e Porto Seguro (PS), Southernmost of Bahia, Brazil. PS-1. Aldeia Velha, 2. Barra Velha, 3. Boca da Mata, 4. Bugigão, 5. Cassiana, 6. Imbiriba, 7. Jaqueira, 8. Juerana, 9. Meio da Mata, 10. Mirapé, 11. Ponta Grande, 12. Pará, 13. Xandó. SCC-1. Araticum, 2. Aroeira, 3. Agricultura, 4. Itapororoca, 5. Txihi Kamayurá, 6. Cruzeiro, 7. Coroa Vermelha Centro, 8. Carajá, 9. Campo, 10. Mata Medonha 11. Nova Coroa. ∆ Parque Nacional Monte Pascoal.

The reported COVID 19 cases in the indigenous communities of PS and SCC were confirmed by laboratory tests, such as molecular diagnosis by polymerase chain reaction (PCR)-real-time quantity and/or rapid serological and/or rapid antigen tests, and/or by clinical-epidemiological/imaging criteria, except when laboratory tests were inconclusive or unavailable, as recommended by the Brazilian Ministry of Health and the WHO [21, 22]. Initially an exploratory analysis was conducted (absolute number, frequency and rate of cases in each). The method of polynomial interpolation was then applied to calculate the acceleration of new cases. Polynomial interpolation is an accurate and derivable method of low complexity and simple for allowing adaptation to the variable of this curve [23].

The acceleration of new case curves was obtained from the historical series extracted from the official notification system of the Ministry of Health-e-SUS Notification, referring to the study period. The MATLAB, software version R2021, produced a polynomial, whose coefficients were adjusted for curves of daily cases, with a maximum degree of 8. The exact time of maximum acceleration in the ascending phase and maximum deceleration in the descending phase were determined using the roots of the second derivative of the polynomial. In the descending phase of the curve, the negative acceleration was analyzed from the absolute value, understood as deceleration [23].

Descriptive analysis of COVID-19 cases included the following variables: village of residence, sex, age, diagnostic criteria, and progression to hospitalization, and the incidence, weekly moving averages of new cases and related deaths were calculated. Descriptive statistics were used to present the results through absolute (n) and relative (%) frequencies, minimum and maximum values, arithmetic averages and respective standard deviations. The association analyses between the variables and differences between the mean scores were performed using the non-parametric Mann-Whitney test. Statistical procedures were performed using IBM SPSS (version 26.0), with a significance level of $P \leq 0.05$.

RESULTS

COVID-19 was confirmed in 655 cases, of which 67.8% (n=444) were in the last eight months of 2020 and 32.2% (n=211) in the first nine months of 2021. The highest number of infections occurred in the villages of PS with 333 cases observed in Figure 2 and Table 1. Notably, the number of indigenous people susceptible to SARS-CoV-2 varies, with higher rates of disease incidence observed in some villages despite these housing a similar number of people. Moreover, despite the fact that in both municipalities the incidence rate was lower than that estimated in the Northeast region of Brazil (8,367.7/100,000 inhabitants) or the national average (10,133.9/100,000), the general incidence of 6,576/100,000 confirms the fragility of the Pataxó population during the COVID-19 pandemic. SARS-CoV-2 in Pataxó communities was first recorded on May 22, 2020 (EPI WEEK 21/2020), in a 36-year-old woman without comorbidities, from the village of Coroa Vermelha (SCC). The disease spread over a few weeks to the nearest villages and, subsequently, to remote villages. The average weekly moving curve of new cases reached its peak in the EPI WEEK 39/2020, decreasing over the following weeks, achieving stability at EPI WEEK 47/2020, and remaining stable until WEEK 38/2021 with a further increase in the numbers of new cases in the EPI WEEK 39/2021 in Figure 5.

The weekly moving average of new cases, despite being widely used to monitor the behavior of the pandemic, does not allow calculation of acceleration and deceleration and therefore does not predict what is occurring. However, based on polynomial interpolation shown in Figure 4, unlike the first stage (P1), the acceleration peak of the second peak (P2), (day 491 and 0.131168 new cases/day 2) was higher than that of P1 (day 44, with 0.106299 new cases/day 2), interspersed with a negative phase (D1=-0.0575761). Of note, the introduction of the CoronaVac vaccine around the 248th day of the pandemic (January 20, 2021, ora round EPI WEEK 3/2021) did not prevent P2.

The majority of the diagnosed with COVID-19 were of the Pataxó ethnicity, and women (58%) of working age (>67.1%), with an average age of 33 years (SD ± 18.3) predominating shown in Table 2. Women had a significantly higher risk of infection than men (χ^2=24.682; gl=1; P<0.001).Rapid serological SARS-CoV-2 detection test diagnosed most cases of COVID-19 (56.2%, n=368), of which significantly high in PS (63.4%, n=211) *vs.* SCC (48.8%, n=157, P=0.0001), while in the last municipality the RT-PCR was the second most applied diagnostic (37.3%, n=120) compared to PS (11.7%, n=39, P=0.0002). As in other studies, most cases of COVID-19 were diagnosed by laboratory examination criteria (89.6%, n=567) observed in Table 3.

The Pataxó have a dynamic behavior, moving between villages where individuals have family or working relationships. Thus, analyzing the place of notification of COVID-19 related to the village of origin, 21% of PS residents were reported in SCC while the majority of SCC residents were diagnosed in SCC (89.8%). This, together with better laboratory diagnostic availability (89.4%), may explain why most Pataxó infected in SCC recovered (96.9%) along with timely closure of the case in e-SUS Notification, compared to those in PS (76.3%, 83.8%, and 66.1%, P<0.0001).

There was no significant difference between individuals with severe disease outcomes such as death and hospitalization (P=0.444) observed in Table 3. However, the mortality rate in SCC was three times higher (139.2/100,000) than that in PS (35.4/100,000). Notably, 75% (n=6) of cases of SARI (Symptoms of Acute Respiratory Infection) related to COVID-19 which evolved to death occurred in the elderly (≥ 60 years) and in individuals with a history of comorbidities.

The main symptoms reported by Pataxó with COVID-19 were cough (58.0%), fever (55.3%), headache (44.7%), runny nose (38.9%), and sore throat (35.7%) and were part of the symptomatology to define influenza in the general Brazilian population. However, approximately one third of the Pataxó presented olfactory (34.0%) and gustatory (29.6%) alterations, with low frequency of dyspnea (14.4%). None of the symptoms showed significant difference among residents of both municipalities; however, myalgia and diarrhea affected a greater proportion of individuals in the PS municipality (32.4% and 11.4%, $P \leq 0.05$), compared to SCC (23.3% and 7.8%, $P \leq 0.05$). The absence of symptoms was significantly higher among individuals from SCC (4% *vs.* 1.2%, P=0.026).

Most indigenous persons reported three to four symptoms and only 15.3% (100/655) reported 5 or more symptoms. In the inferential statistical analysis, symptoms were associated with age. Cough was reported in 66.4% of individuals aged 30-39 (P=0.005) with a lower prevalence among adolescents (<20 years, 41.4%), with all other SARI, except fever which was prevalent in small children (≤ 9 years, 67.3%, P=0.036). Interestingly, sore throat (15.6%, P=0.005) and myalgia (35.9%, P=0.001) were the most common symptoms in the elderly. Children and adolescents had a lower prevalence of symptoms (P<0.001), a milder, non-classical clinical picture observed in Figure 3. Interestingly, more symptoms were observed in adult indigenous (30-49 years) and over a third of adult young indigenous (>20 years) presented with myalgia.

Analysis of the main pre-existing risk factors for the Pataxó, 21.2% (139/655) of individuals had some history of increased risk of complications, such as chronic cardiopathies (59.7%, 83/139), diabetes mellitus (24.4%, 34/139), and being pregnant (9.3%, 13/139). The percentage of pregnant women with COVID-19 was significant in SCC (7.2%, n=10/139) compared to PS (2.1%, n=3/139, P<0.05), and as expected, in younger women (5.1%, 8/156, 20 to 29 years *vs.* 2.5%, 4/156, 30 to 39 years and 0.6%, 1/156 ≥ 40 years, P<0.01). Among comorbidities, a greater association of chronic heart disease was observed in the elderly ≥ 60 years, compared to the other age groups (43.8%, P<0.001), as well as that of diabetes (21.9% in ≥ 60 years, P<0.001). Among younger children (≤ 9 years) and adolescents (≥ 12 to ≤ 18 years), 18.4% (8/52) and 4.5% (3/66), respectively, showed some comorbidity. Chronic respiratory disease was two to four times more common in small children (2.9%, 4/139) than in adults (1.4%, 2/139) and the elderly (0.7%, 1/139), suggesting a risk factor for this group.

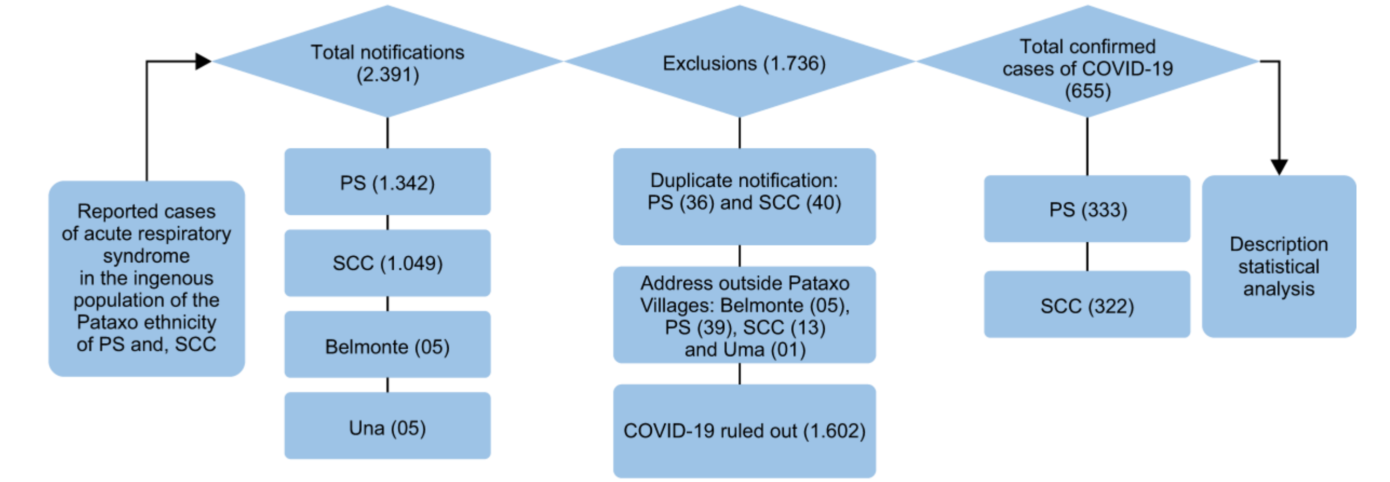

Figure 2: Flowchart of reported cases of COVID-19 in indigenous Pataxó of the Southernmost of Bahia, Brazil, included in the study, between May 22, 2020 and October 2, 2021, as reported in e-SUS Notifica.

Table 1: Number and incidence rate of COVID-19 in indigenous people of the ethnic Pataxó (n=655) of the Southernmost of Bahia, second village and municipality of origin, May 2020 to October 2021.

Municipality							
Porto Seguro				Santa Cruz Cabrália			
Village	Population	No. of cases	Incidence*	Village	Population	No. of cases	Incidence*
Aldeia Velha	1249	17	1361.1	Araticum	26	1	3846.2
Barra Velha	1202	183	15224.6	Agricultura	185	8	4324.3
Boca da Mata	717	12	1673.6	Aroeira	182	16	8791.2
Bugigão	178	12	6741.6	Coroa Vermelha	2809	206	7333.6
Cassiana	135	8	5925.9	Itapororoca	135	15	11111.1
Imbiriba	449	7	1559	Mata Medonha	298	9	3020.1
Jaqueira	76	4	5263.2	Nova Coroa	558	49	8781.4
Juerana	241	13	5394.2	Txihi Kamayurá	253	18	7114.6
Meio da Mata	254	3	1181.1	-	-	-	-
Mirapé	172	16	9302.3	-	-	-	-
Novos Guerreiros	238	16	6722.7	-	-	-	-
Pará	266	11	4135.3	-	-	-	-
Xandó	338	31	9171.6	-	-	-	-
Total	5515	333	6038.1	**Total**	4446	322	7242.5
Overall incidence rate				6575.6			

Source: e-SUS Notifies, 2021. *100,000 inhabitants.

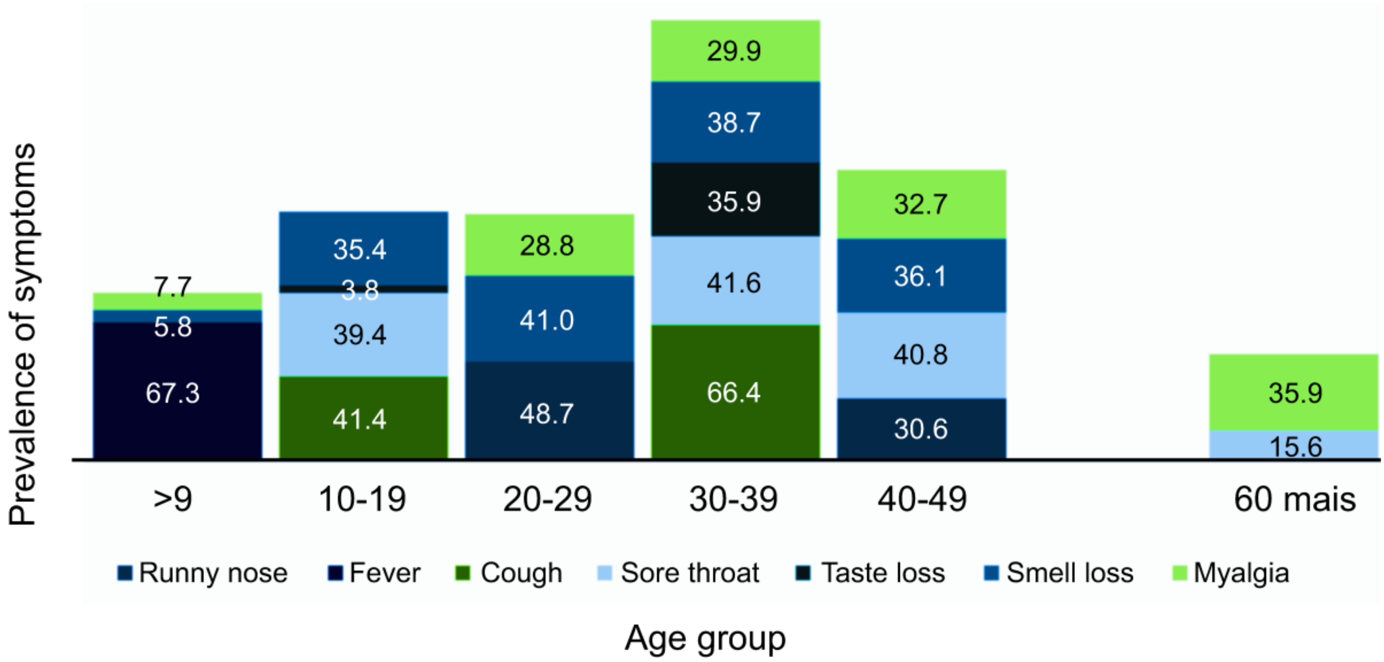

Figure 3: New cases of COVID-19 per epidemiological week in indigenous Pataxó of the municipalities of Porto Seguro and Santa Cruz Cabralia, Southernmost of Bahia, Brazil, May 2020 to October 2021. Source: e-SUS Notifica, 2021. **Note:** (■) Runny nose; (■) Fever; (■) Cough; (■) Sore throat; (■) Taste loss; (■) Smell loss; (■) Myalgia.

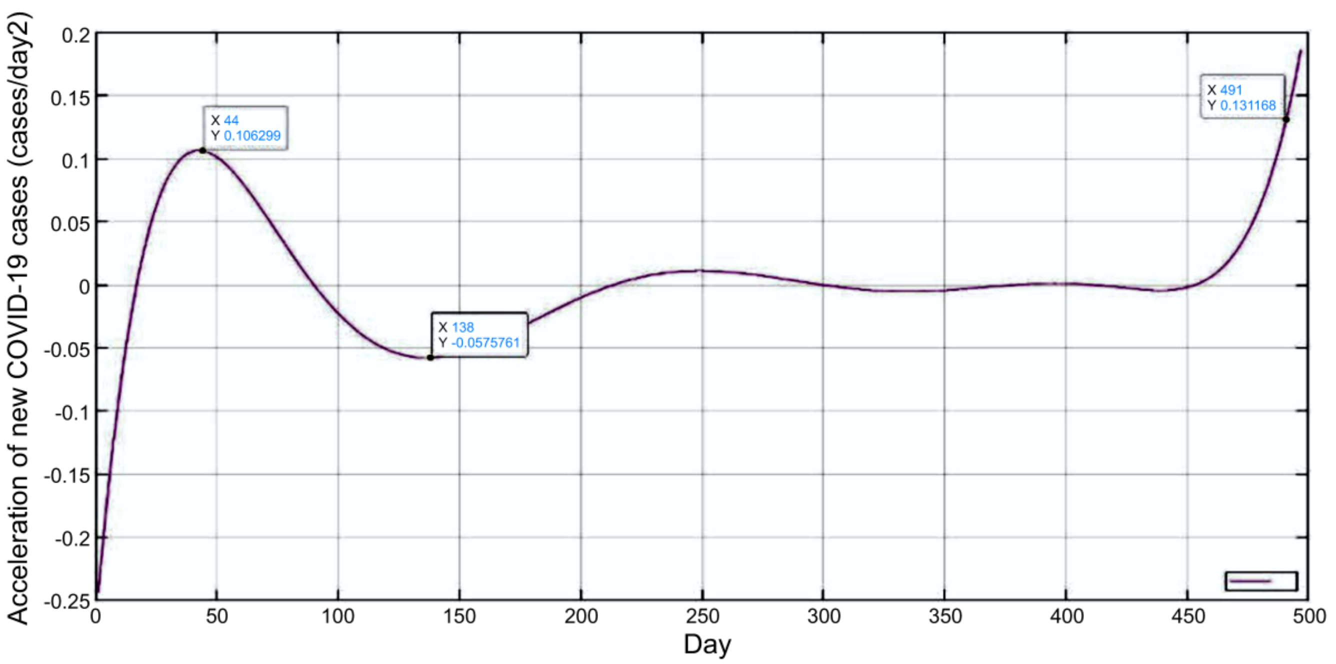

Figure 4: Acceleration curve of new cases of COVID-19 by the method of polynomial interpolation, in indigenous of the Pataxó ethnicity of the municipalities of PS and SCC, of the Southernmost of Bahia, Brazil, along of the 499 days of the pandemic. Source: e-Sus Notifica, 2021: introduction CoronaVac vaccination. **Note:** (▬) Acceleration curve indicates new cases of COVID-19.

Table 2: Socio-demographic characteristics of indigenous people reported by COVID-19 (n=655), in the municipalities of Porto Seguro and Santa Cruz Cabralia, Southernmost of Bahia, Brazil, May 2020 to October 2021.

Variables	Parameters	Porto Seguro		Santa Cruz Cabrália		Total	
		n	%	n	%	n	%
Sex	Female	195	58.6	188	58.4	383	58.5
	Male	138	41.4	134	41.6	272	41.5

Age group (years)	≤ 9	27	8.1	25	7.8	52	7.9
	10-19	50	15	49	15.2	99	15.1
	20-29	85	25.5	71	22	156	23.8
	30-39	68	20.4	69	21.4	137	20.9
	40-59	72	21.6	75	23.3	147	22.4
	≥ 60	31	9.3	33	10.2	64	9.8
Health worker	No	325	97.6	318	98.8	643	98.2
	Yes	8	2.4	4	1.2	12	1.8
Ethnicity	Pataxó	331	99.4	314	97.5	645	98.5
	Pataxó Há-Há-Há	2	0.5	4	1.4	6	0.9
	Pitaguari	0	0	3	0.9	3	0.5
	Aimoré	1	0.3	0	0	1	0.2
	Kariri	0	0	1	0.3	1	0.2

Source: e-SUS Notifies, 2021.

Table 3: Number and frequency of COVID-19 notification, diagnostic examinations and outcome, in indigenous of Pataxó ethnicity, of the municipalities of Porto Seguro and Santa Cruz Cabralia, Southernmost of Bahia, Brazil, May 2020 to October 2021.

Variables		Municipality of origin					
		Porto Seguro		Santa Cruz Cabrália		Total	
		N	%	N	%	N	%
Municipality of notification	Santa Cruz Cabrália	77	23.1	289	89.8	366	55.9
	Porto Seguro	254	76.3	21	6.5	275	42
	Eunápolis	1	0.3	7	2.2	8	1.2
	Bonfim	0	0	3	0.9	3	0.5
	Ilhéus	0	0	1	0.3	1	0.2
	Itamaraju	0	0	1	0.3	1	0.2
	Salvador	1	0.3	0	0	1	0.2
Diagnostic toll*	TR-Antibody	211	63.4	157	48.8	368	56.2
	RT-PCR	39	11.7	120	37.3	159	24.3
	Clinic-Epidemiological	54	16.2	34	10.6	88	13.4
	RT-Antigen	28	8.4	11	3.4	39	6
	ELISA IgM	1	0.3	0	0	1	0.2
Outcome	Cure	220	66.1	310	96.9	530	80.9
	Home treatment	109	32.7	6	1.9	115	17.6
	Death	2	0.6	6	1.8	8	1.2
	Hospitalization	2	0.6	0	0	2	0.3

Confirmed cases	Laboratory toll	279	83.8	288	89.4	567	89.6
	Clinical-Epidemiological	54	16,2	34	10.6	88	13.4

Source: e-SUS, Notifies, 2021.

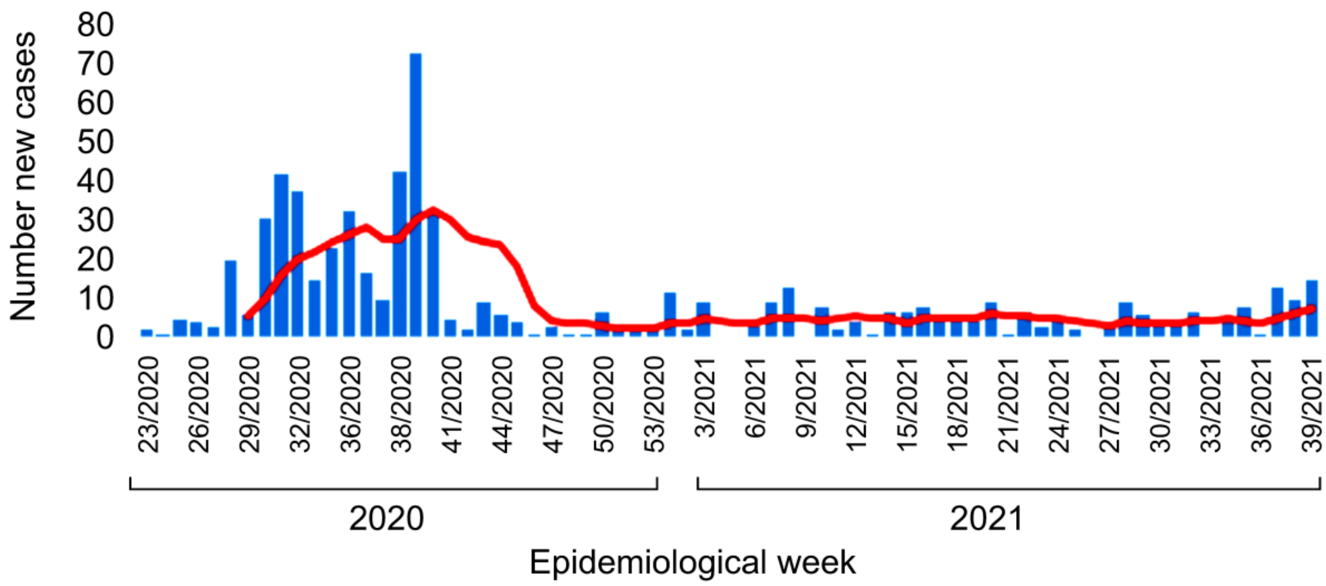

Figure 5: Prevalence of symptoms of COVID-19 in indigenous Pataxó, in the municipalities of PS and SCC, Southernmost of Bahia, Brazil, May 2020 to October 2021. Source: e-SUS Notifica, 2021. **Note:** (■) COVID-19 new cases per epidemiological week; (—) Moving average.

DISCUSSION

SARS-CoV-2 transmission occurred rapidly in the Pataxó community, and in less than a year and a half, 655 cases of COVID-19 and 8 deaths were recorded. This rapid transmission is multifactorial and may be associated with different epidemiological, socioeconomic and cultural scenarios of the Pataxó communities. Although the overall incidence of COVID-19 in the Pataxó communities was lower than that estimated in the Northeast region of Brazil (8,367.7/100,000 inhabitants) and the national average (10,133.9/100,000 inhabitants), some villages had higher incidence rates, such as Barra Velha/PS (15,141.4/100,000) and Itapororoca/SCC (11,111.1/100,000) [24]. These findings confirm the vulnerability of the Pataxó communities which deserve special attention from health surveillance.

Disease distribution was heterogeneous among villages with similar population numbers, revealing the need for healthcare strategies that reinforce individualized prevention actions, according to the epidemiological, demographic, cultural and socioeconomic characteristics of the villages, in order to minimize greater health, psychosocial, and economic impact. The young indigenous of working age (67.1%, n=440) were the most affected by COVID-19, as in the general population and communities of other ethnicities [4, 17, 24-26]. This had both health and socioeconomic effects affecting the main, and sometime only, source of income of these communities, notably handicrafts and tourism. Intersectoral public policies mitigating the economic impact are necessary to encourage the free market, diversified commercial activities, and better exploitation of territorial wealth, guaranteeing indigenous people's social, economic and cultural rights to maintain their lifestyle and promote full citizenship, equity, and economic sustainability [18, 27].

Cultural and sociodemographic issues also determine disease transmission in the Pataxó community, similar to other ethnicities in Brazil [2, 3, 8, 26, 28, 29]. The Pataxó have numerous family members living in different villages, determining a dynamic process of mobility and transmission. The main migration route, evidenced by duplicate notifications, occurred in Barra Velha (PS) and Coroa Vermelha (SCC). One explanation for this finding is that Barra Velha was the first village constituted by the settlement process and Coroa Vermelha is an urban village and an important center for the sale of handicrafts; thus, most of the indigenous Pataxó have links with those villages [30]. In addition, the average distance of 177 km between the two villages, where access is often made without complying with health standards, generated a greater risk of transmission of SARS-CoV-2 infection, creating challenges for the population and specifically, for the health subsystem and local managers in developing COVID-19 contingency strategies to overcome low-quality transport and social habits.

The bimodal acceleration curve of new cases may suggest a new phase of the pandemic. Considering that vaccination with CoronaVac of the Pataxó as a priority group was initiated on January 20, 2021 (EPI WEEK 3/2021), the emergence of new variants that may have escaped immunity, elicited by previous vaccination, may explain the second peak. The COVID-19 incidence in 2021 (2,108.2/100.000 inhabitants), although smaller than that in 2020 (4,447.3/100.000), may signal some deficiency in the efficiency of the vaccine to generate lasting immunity and break the chain of transmission. Each COVID-19 vaccine available on the market has different potency and duration of efficacy depending on the antigen design, adjuvant molecules, vaccine delivery platforms, and immunization method [31-35]. Although inactivated vaccines are safe and well tolerated and used globally [36-39], they show reduced efficacy in the neutralizing antibody over time, similar to other platforms for COVID-19 vaccines [40-44]. SARS-CoV-2-specific humoral and cellular immune responses induced by inactivated COVID-19 vaccines are known to decrease after a single vaccine dose but are boosted and become more sustained after a second dose [45], and after homologous or heterologous boosters, albeit with lower immunogenic expression when compared to other vaccine platforms [42,46-56]. Therefore, studies to monitor the levels of neutralizing antibodies produced by those who developed the natural disease and those vaccinated are necessary to better understand the bimodal COVID-19 curve in the Pataxó community.

Notably, in the surroundings Coroa Vermelha territory (SCC) there is an urban cluster of 7 villages, among which Itapororoca, with higher incidence rate in Table 1, that maintain an intense traffic with the Coroa Vermelha village, associated with tourism and craft commercialization. Considering only this cluster, the incidence of new COVID-19 cases occupies the seventh position in the ranking among the villages of the ethnic Pataxó (7.669.8/100.000), putting them in focus in the process of determining disease transmission. These factors may represent a greater risk of virus spread combining vulnerabilities with high density population and circulation, diversifying the transmission risks in these communities [8, 57]. Moreover, most residents outside the village have more than once entered the reference service in indigenous health, showing that despite living outside the village, strong bonds are maintained with the villages of their families, adding risk to virus transmission.

The distribution of COVID-19 cases among the Pataxó, as in the general population and some indigenous communities, tends to predominantly affect the female sex [1, 3, 17, 24-26], although male predominance is reported in some Mexican and Colombian ethnicities [58]. The effect of sex may present important evidence on biological and immunological mechanisms that determine disease in individuals [59], inclusive of COVID-19 [60-64], although studies are needed for better elucidation. Furthermore, social and structural factors influence risk and vulnerability to the disease [15, 65, 66]. Pataxó women conduct craft activities, besides tending to loved ones, making them an efficient vehicle of transmission. Interestingly, there was no significant difference in mortality between men and women, although some studies reported a higher risk of disease severity and mortality among men [4, 17, 26]. Although women were commonly infected with SARS-CoV-2, age was the significant risk factor for the prevalence of symptoms. Fever and a less syndromic clinical picture were significantly associated with children (67.3%, P=0.036), corroborating other studies [67, 68].

A positive point in the management of COVID-19 in the Pataxó community was the diagnostic confirmation by laboratory criteria (86.6%), following the national trend (76.6%) and that of Bahia (99%) [24, 25, 69]; however, there was a difference in the availability of examinations among the cities studied. The logistics of access between the villages of PS being more complex may have created barriers in the performance of the RT-PCR test, which could explain the higher frequency of healing and timely closure of the cases in the villages of SCC (96.9%). However, paradoxically, SCC showed higher COVID-19 mortality (139.2/100,000) compared to PS (35.4/100,000), and other indigenous communities in the country [2,3]. This may be explained by the fact that the SCC villages (84.8%) are located in an urban perimeter and host a craft marketing center with intense flow of tourists which may facilitate transmission. Conversely, the municipality of PS has a higher percentage of indigenous villages in rural areas (67.0%) and a more structured health service network with better access to therapies, which may have contributed with lower mortality.

In the indigenous Pataxó, the main presenting symptoms were the same as those associated with acute respiratory infection (or influenza) and, only 2.6% (n=17) of confirmed cases were asymptomatic. Of note, 79.5% of individuals with 3 or more symptoms sought the health service, corroborating with the study of Moreira [70], which highlights the need for early diagnosis to implement preventive contingency measures [17].

Overall, 23.8% of COVID-19 cases in the Pataxó had some comorbidity, which may increase disease severity risk [4, 17]. Children with COVID-19 have shown a higher prevalence of chronic respiratory disease, and although estimates of the prevalence of chronic respiratory diseases among indigenous children are similar to those in non-indigenous groups, morbidity is higher in indigenous children [71, 72]. Thus, comorbidities, associated with disparities in healthcare and poverty, can contribute to widening the burden of COVID-19 in more vulnerable and socioeconomically disadvantaged children [73]. Elderly deaths in the Pataxó communities, where related to comorbidities such as cardiovascular diseases including hypertension and diabetes, which combined constituted a risk factor for disease severity and mortality, as reported in other indigenous populations [4,17]. A meta-analysis identified that the prevalence of arterial hypertension in indigenous people in Brazil was 6.2% (95% CI: 3.1%-10.3%), with a 12% chance of an indigenous person presenting with hypertension each year [74]. Few studies among specific ethnicities have reported an increased prevalence of type 2 diabetes [75-78].

Therefore, the pandemic of COVID-19 in Pataxó communities highlights the need to consider mitigation policies which address the specific epidemiological, environmental, socioeconomic and demographic vulnerabilities of this population. Cultural, socioeconomic, and behavioral aspects determine SARS-CoV-2 transmission in these communities. There is concern that socioeconomic relations based on local tourism without appropriate prevention measures, combined with the location of Pataxó villages in urban clusters and the emergence of new variants, may establish new patterns of COVID-19 dissemination affecting health status in these populations.

This study has some limitations. First, although official data were used, these do not necessarily represent the full extent of the pandemic and its epidemiological impact in these communities, considering the limitations of obtaining reliable information on real COVID-19 cases and complications of the disease, deaths, and hospitalizations. Furthermore, underreporting of the disease attributable to insufficient availability of tests by ethnicity and geography could not be excluded. Nonetheless, the data described here represent the Pataxó residing in the villages studied.

CONCLUSION

The acceleration curve of new cases reveals a bimodal variation with a second acceleration peak greater than the first wave. In addition to maintaining a high incidence of the disease in 2021, even after vaccination was introduced in these communities, this may reveal a new pandemic phase with the occurrence of post-vaccine cases of COVID-19. Further studies to monitor the levels of neutralizing antibodies produced by those who have developed the natural disease or have been vaccinated, are required to better understand the behavior of this second rising wave.

The susceptibility to SARS-CoV-2 is heterogeneous among groups with similar population numbers, even belonging to the same ethnicity, while young age and female sex were risk factors for COVID 19, unlike in some South American indigenous communities in which the male sex was predominantly affected. However, there was no significant difference in disease mortality according to sex, unlike in the general population, in which male sex with comorbidities is associated with higher mortality compared to the female sex. Pregnant women, with higher prevalence in the villages in SCC, require monitoring and care, as more deaths associated with the elderly with heart and diabetic comorbidities occurred in these villages. Dyspnea, although at low frequency, was significant in children compared to adults.

These data reinforce the need for preventive actions for vulnerable groups, according to the evolution of the disease in these communities, to minimize its psychological, social, and economic impact.

ACKNOWLEDGEMENT

The authors thank Editage for English language editing. This work was carried out with the support of CAPES and FAPERJ.

FUNDING

This work was partially supported by the Cellular Microbiology Laboratory fund provided by the Oswaldo Cruz Foundation/ Oswaldo Cruz Institute/Health Ministry.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

UN-BLINDED ETHICS STATEMENT

The study was conducted between May 22, 2020 and October 2, 2021 and approved by the National Council of Ethics in Research (CAAE no. 34866720.1.0000.5248).

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