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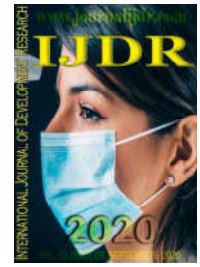
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## SPATIAL DISTRIBUTION AND INCIDENCE OF COVID-19 CASES IN INDIGENOUS POPULATIONS IN THE XINGU RIVER REGION, PARÁ, BRAZIL

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### ABSTRACT

COVID-19 is a disease caused by the new coronavirus (SARS-COV-2), which first appeared in December 2019 in Wuhan, China. The disease has spread from large urban centers to the most remote regions of the planet, affecting traditional populations such as the indigenous peoples of the Brazilian Amazon. Indigenous populations are more susceptible to infectious diseases and live in poor health and sanitation conditions. We carried out a descriptive cross-sectional study, with quantitative and secondary data, in addition to preparation of a geographical distribution map of Covid-9 cases in Indigenous Territory (IT) under the influence of the DSEI of Altamira-PA. During the investigated period, 417 cases were reported, 49% of which were women. One hundred and twenty cases (29%) were in children aged nine years and under and 23 cases (5%) in people over 60 years. The Trincheira Bakajá TI had the highest incidence per 10,000 inhabitants (342.88 cases per 10,000 inhab.), followed by Cachoeira Seca (180.46), Volta Grande do Xingu area (128.58) and Paquçamba (121.81). The mechanisms of dissemination of the new coronavirus in the villages are multifaceted, going through biological, cultural factors, agrarian conflicts, environmental devastation, migratory flows of Indians and non-Indians, requiring further investigations about these aspects.

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### INTRODUCTION

The new coronavirus (SARS-COV-2) causal agent of The Disease-2019 (COVID-19), appeared in Wuhan, China, and soon spread among countries around the world, becoming the most serious pandemic of the 21st century (Menezes-Navarro et al, 2020). The pandemic rapidly spread, infecting thousands of people and causing panic to populations. Residents of communities far from large centers were also affected, traditional peoples, mostly composed of indigenous people, started to run the risk of being affected by the pandemic (Marson, Ortega, 2020 and Zavaleta, 2020).

According to Pan et al, (2020), cultural, behavioral and socioeconomic differences between ethnic groups can influence viral spread and, consequently, the basic reproduction number in the specific place. For the authors, health behaviors and conditions are different in groups of black, Asian and minority ethnic groups, such as indigenous people compared to white people, and may be related to a higher number of cases of certain infectious respiratory diseases. Different culture types can also influence society responses to the government measures, there can be seen in the different blockade actions between countries in Asia, Europe and North America (Pan et al, 2020). Menezes-Navarro et al (2020) report that the indigenous people in Latin America is

42 million inhabitants and that countries like Bolivia, Guatemala, Mexico and Peru concentrate the majority of these individuals, with 80% living in marginalized regions, with poor public health, in addition be targets of discrimination because of ethnic origin, customs and the barrier of the native language. In Brazil, the indigenous people that, at the beginning of the 16th century, was comparable to that of Europe, with five million individuals, today has 817,963 people (Brasil, 2020a). Over five centuries, Brazilian indigenous, of about 300 ethnic groups, have faced the advance of white men civilization, the invasion of their lands and the consequent mortality caused not only by the physical strength of the invaders, but also by infectious diseases, such as tuberculosis, which, in 1998, was responsible for 22.7% of deaths among indigenous people in the Amazon region (Brasil, 2020a) and the H1N1 outbreak in 2007, which reinforced the fragility in this population part to diseases of the respiratory tract (Cupertino *et al*, 2020).

The clear health inequality between indigenous and non-indigenous peoples is even more evident when assessing the mortality rate for the same type of disease, which is higher for indigenous than for non-indigenous (Brasil, 2016). This constant discrepancy between the values of various health indicators of indigenous peoples and the general Brazilian population corroborates the idea that the access of the indigenous to health services, remains affected even today (Mendes *et al*, 2018), which is due multiple barriers, be they organizational, linguistic, cultural, geographic and even the xenophobia of health professionals (Gomes and Esperidião, 2017). Roraima, Amazonas and Pará are states of that concentrate most of the country indigenous population. In Pará state, among the indigenous most vulnerable ethnic groups, are those located in the Xingu river region, a constant stage of conflicts over land irregular occupation and invasion of demarcated areas. In addition to the conflicts, the difficult access to many communities, the precarious assistance offered by the State and the fragile health, especially of children and the elderly, could result in a biological massacre of a considerable part of the Brazilian ethnic groups (ISA, 2011). The present study aims to present the spatial distribution and incidence of cases of COVID-19 in indigenous populations at Xingu river region, Pará, Brazil.

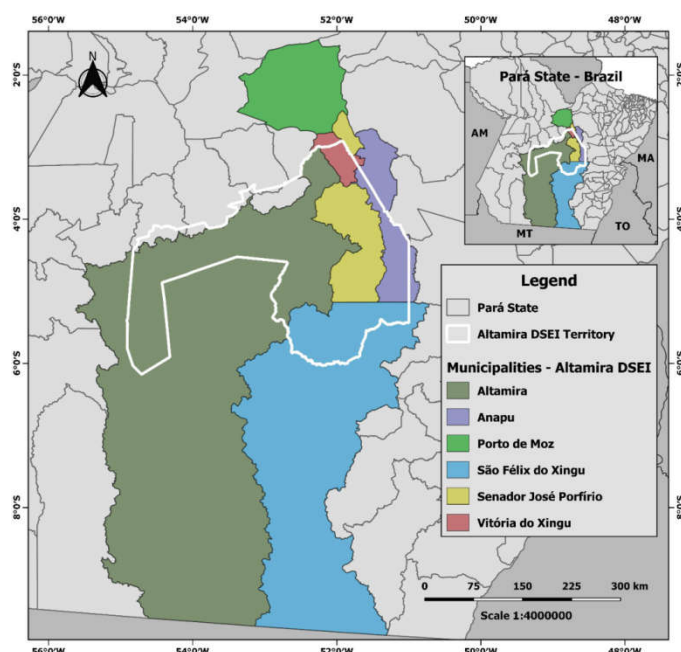
## METHODS

We performed a cross-sectional descriptive study with a quantitative approach, carried out by collecting secondary data referring to COVID-19 cases in the Xingu river region - PA. The description of the cases was carried out through the analysis of data on the notification, from April 24 to August 17, 2020, made available at the Special Indigenous Sanitary District (DSEI) of the Xingu river region and through the COVID-19 monitoring Pará state portal in the indigenous communities of the Special Secretariat for Indigenous Health (SESAI). Data collection took place from July 2 to August 17, 2020. The variables used in the study were: Indian territory, village, ethnicity, age, sex, municipality, and confirmed COVID-19 cases, discarded, hospitalized, cured and deaths. In the study, thematic maps were developed to represent the case incidence of COVID-19 in indigenous populations in the Xingu river region. For that, electronic spreadsheets were used to systematize the data. The maps elaboration it was used the Geographic Information System (SIG) from the database of the Brazilian Institute of Geography and Statistics (IBGE,

2019) and the National Indian Foundation (FUNAI) (Brasil, 2020a), that spatial reference it was used SIRGAS 2000 (EPSG: 4674) through the free software QGIS 3.10.1, which is the main work tool of the spatial study. The collected data were processed using Microsoft Office Excel 2010 software and analyzed using descriptive statistics.

## RESULTS

In Brazil, there are 34 DSEI areas, strategically divided by territorial criteria and, not necessarily, by states or cities, based on the geographical occupation of indigenous people. We investigated only the cases of COVID-19 in the area covered by the Altamira DSEI, which consists of 6 cities in the Xingu river region, including municipalities of Altamira, Anapu, São Félix do Xingu, Senador José Porfírio, Vitória do Xingu and Porto de Moz. The latter being outside the physical limits of the Altamira DSEI, being considered an attachment (Figure 1).



**Figure 1.** The cases of COVID-19 in the area covered by the Altamira DSEI, which consists of 6 cities in the Xingu river region

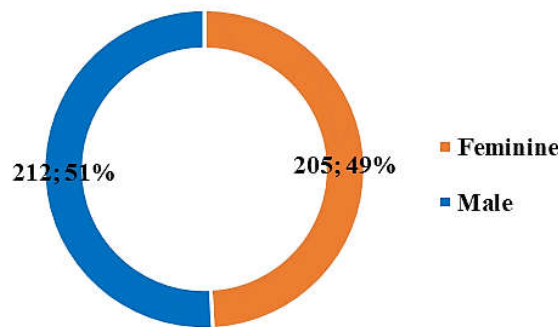
In this investigated area, it was find the Indigenous Territories (IT), under the tutelage of Altamira DSEI, composed by 13 IT (Apyterewa, Arara, Arara of Volta Grande do Xingu, Araweté, Cachoeria Seca, Ituma / Itatá, Kararaó, Kuruaya, Kwatinemu, Trincheira Bakajá, Xipaya, Paquiçamba and km17 Indian area) and 10 different ethnicities, with a population of 4,433 indigenous people (sense of January 2020), distributed in 60 different villages, within the territory of the municipalities that make up the Altamira DSEI (Table 1). It was found a total of 417 confirmed cases of COVID-19 in the Altamira DSEI (9.4% of the indigenous people), in the period between April 24 and August 17, 2020, with no predominant incidence between the sexes (Figure 2) and affecting mainly the age group between 20 and 39 years (Table 2).

The total number of confirmed cases of COVID-19, presented variable spatial distribution in each IT, presenting the highest number in the Trincheira Bakajá (152 cases), followed by Cachoeira Seca (80 cases) and Arara of Volta Grande do Xingu (57 cases) as we can see in Figure 3.

**Table 1. Distribution of villages by IT and municipality, belonging to the DSEI Altamira**

Municipality	Indigenous Territory (IT)	Village
Altamira	Kwatinemu	Kwatinemu
	Arara	Arara, Tagagemy, Aradó
	Cachoeira Seca	Iriri, Awy, Cujubim, Cupi
	Xipaya	Tukaman, Tukaya, Kamaratayã
Senador José Porfírio	Kuruaya	Anapiwi, Curuá, Irinapãin, Kuruatxe
	Trincheira	Pykajaká, Pykatum, Kamóktikô
Anapu	Bakajá	Mrôtidjãm, Moinoro, Kenkro, Pryndjan, Pytotko, Bakajá, Rápko
São Felix do Xingu	Apyterewa	Paranopiona, Xahytata, Kato, Xingu
Senador José Porfírio	Arara Volta Grande do Xingu	Itkom, Guary-duan, Terrã wangã
Vitória do Xingu	Área Indígena km 17	Boa vista
	Paquiçamba	Furo Seco, Jericoá/Kaniamã, Pupekari, Lakariká, Mayaka, Muratu, Paquiçamba
Porto de Moz	Área Indígena km 17	Anexo Boa Vista

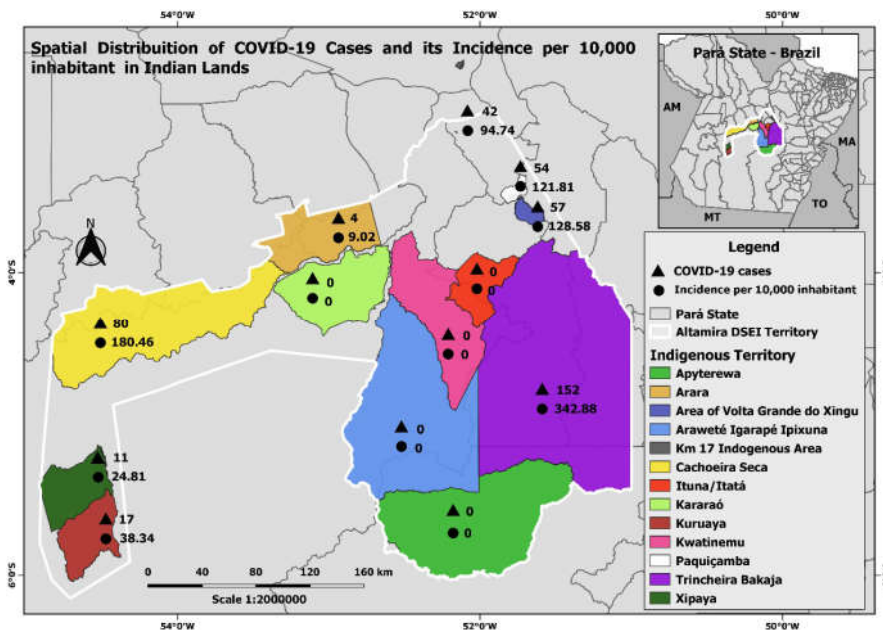
**Nº Confirmed cases / sex; %**



**Figure 2. Distribution of confirmed cases of Covid-19, according to incidence by sex. Data off the period April 24 and August 17, 2020**

**Table 2. Distribution of confirmed cases of Covid-19, according to incidence by age group. Data referring to the period between April 24 and August 17, 2020. \* Age group most affected**

Age range	Nº Confirmed cases
< 1 year	13
1 to 4 years	40
5 to 9 years	67
10 to 14 years	64
15 to 19 years	25
20 to 39 years*	137
40 to 59 years	48
60 to 79 years	19
80 years or more	4
Total	417



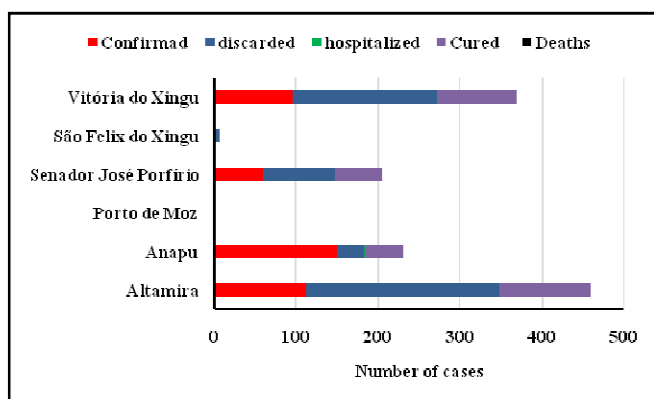
**Figure 3. Spatial Distribution of Covid-19 cases and its incidence per 10 mil in habitant in Indigenous Territory (IT), Xingu, PA, Brasil.**

Figure 4 also shows the incidence rate of cases, considering the total indigenous people (4,433) and the number of confirmed cases for every 10,000 individuals, as listed in Table 3. The highest incidence was recorded at Trincheira Bakajá IT (342.88), followed by Cachoeira Seca (180.46) and Arara of Volta Grande do Xingu (128.58). The average incidence related to the scope of the Altamira DSEI IT was 94.77 (data not shown in the table).

**Table 3. The incidence rate of Covid-19 cases in the DSEI Altamira IT, period between April 24 and August 17, 2020.**  
Calculation formula: The incidence = number of confirmed cases / indigenous population of 4,433 X 10,000

Indigenous Territory (IT)	Incidence / 10 thousand in habitants
Kwatinemu	0
Arara	9,02
Cachoeira Seca	180,46
Xipayá	24,81
Kuruaya	38,34
Trincheira Bakajá	342,88
Apyterewa	0
Área da Volta Grande do Xingu	128,58
Área indígena Km 17	94,74
Paquiçamba	121,81

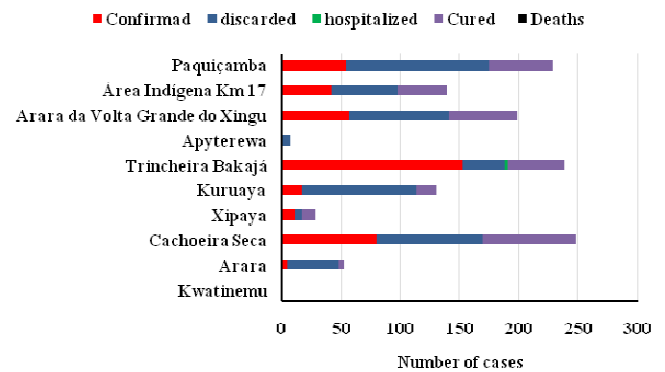
As for the monitoring of COVID-19 cases by cities covered by IT, it was found that the municipality that reported the largest number of confirmed cases was Anapu (150 cases), followed by Altamira and Vitória do Xingu, with 112 and 96 cases, respectively. The number of cases cured is 100% for almost all municipalities, with the exception of Anapu, Senador José Porfírio and Altamiracity, with the number of cases cured was 47 (31.33%), 58 (98.31%) and 111 (99.11%), respectively (percent not shown in Figure 4). São Félix of Xingu and Porto de Mozcities did not record any confirmed cases. Only 2 cases of hospitalization were reported, belonging to the Anapucity. There was no notification of death (Figure 4). The discarded cases were those in which the individual was subjected to the test and the result was negative, whereas the suspected cases were those in which the individual presented only flu-like symptoms.



**Figure 4. Monitoring of Covid-19 cases in the municipalities covered by the DSEI's Indigenous Territory, Altamira, PA, between April 24 and August 17, 2020.**

The distribution of the number of cases within the IT showed variations, we can view that Trincheira Bakajá, in addition to presenting the largest number of confirmed cases for Covid-19 (152 cases), also had the lowest number of cured cases (48 cases - 31.58%), different from the other IT, where the number of cured patients was around 100%, except Cachoeira Seca,

with 79 out of 80 cases, representing 98.75% (percent not shown in Figure 5). Only 2 cases of hospitalization were reported, belonging to Trincheira Bakajá. There were no notifications at the Apyterewa and Kwatinemu IT (Figure 5).



**Figure 5. Monitoring of Covid-19 Cases, by Indigenous Territory (IT) at DSEI Altamira, period between April 24 and August 17, 2020**

The villages also had a varied incidence for the cases of COVID-19, where the Irii village, belonging to Cachoeira Seca IT, was the most affected, with 75 confirmed cases, followed by Mrôtidjãm and Boa Vista, with 65 and 42 cases, respectively. All villages that reported cases were 100% cured, except Mrôtidjãm village, with only 44 cured, of the 65 confirmed cases. The villages Kwatinemu (\*) and Xingu (\*\*) did not present confirmed cases, only discarded cases (Table 4).

**Table 4. Villages with the highest incidence of Covid-19 by IT, from the DSEI Altamira, in the period between April 24 and August 17, 2020**

Village	Confirmed	Cured	Indigenous Territory (IT)
Kwatinemu*	0	0	Kwatinemu
Arara	2	2	Arara
Irii	75	75	Cachoeira Seca
Karmaratayã	9	9	Xipayá
Curuá	8	8	Kuruaya
Mrôtidjãm	65	44	Trincheira Bakajá
Xingu**	0	0	Apyterewa
Terrã Wangã	40	40	Área da Volta Grande do Xingu
Boa Vista	42	42	Área Indígena Km 17
Paquiçamba	25	25	Paquiçamba

## DISCUSSION

According to the Brazilian institute of geography census (2010), more than 890,000 self-declared indigenous people were registered, being present in the five regions of Brazil, distributed in all Brazilian states (505 indigenous lands, occupying 12.5% of the national territory), corresponding to 0.4% of the Brazilian population. The North region has 342.8 thousand individuals and it is the highest population in Brazil (Mendes et al 2018; IBGE, 2010; ISA, 2011), maintaining its position, together with the Amazonian environment, throughout the censuses, which can be justified by the offer of

better environmental conditions, enabling the physical and cultural survival of the diverse ethnic groups and indigenous groups that live there (IBGE, 2010). In Pará state, the same census indicated that there would be about 39,081 self-declared indigenous people in the state, with an average geometric annual growth rate of 3.9 (IBGE, 2010). Indigenous peoples, due to their wide geographical distribution, difficult access to some communities and ethno-cultural diversity, are included in an old problem, related to indigenous health in Brazil, which already begins with their basic concepts, often neglected, how to trace the epidemiological profile of each group. In fact, there is still poor information on health and illness of indigenous people in Brazil, which hinders the planning of specific actions in this area, in the various indigenous groups (Brasil, 2016). The impact of pandemic crises (H1N1, for example), relating viral infections and indigenous peoples, are reported in many studies, and point out the consequences, often disastrous, of these infections in indigenous populations, with high rates of infection and mortality (Zavaleta, 2020). The predictions followed the same line of concern with new coronavirus disease.

There was no predominant distribution of COVID-19 infection between sex, although some data in other studies show that male sex as the most infected (Chen et al, 2020), perhaps due to the important role that the X chromosomes of women and sexual hormones play in the immune system response (Jaillon et al, 2019; Lima et al, 2020). Regarding the age group most affected by the infection, some surveys carried out with non-indigenous populations, point out that the age groups above 40 years are the most affected, however they point out that other factors influence this age group classification, such as comorbidities and the own age (Lima et al, 2020; Chen et al, 2020). In contrast to these findings, the results reported indicate the range between 20 and 39 years old, as the one with the highest incidence among indigenous people. Despite the number of confirmed cases reported in this study (417) and the average incidence in each of the IT (94.06), the number of deaths remained null, but this fact does not constitute greater resistance in this population, as an important point permeates the relationship of the new coronavirus and indigenous communities: the lack of knowledge about the immune response of these populations, since they have important genotypic differences (Marson and Ortega, 2020; Gomes and Esperidião, 2017; Novo, 2011). Thus, the immuneresponse of indigenous peoples to Covid-19 is still unknown and may be different from populations located in the same region, allowing deadly outcomes for these minorities (Lane, 2020).

In a serological survey carried out by the Pará State of University in association with the Pará State Health Department, whose data were released by the media of the State Government on 31/07/2020 (Abreu, 2020), it was found that the population tested in the Xingu river region has the second lowest serological response rate, only 9.9%, which is worrying, because with such a low rate there is still no immunity that could be a protective factor for risk groups, like the indigenous people. In this same perspective, when assessing the historical context of the impacts of other pandemics on indigenous societies groups, it is supposed that the effects of Covid-19 may be different for this risk group (Zavaleta, 2020), since during the H1N1 pandemic there were 11 years old ago, the incidence of acute respiratory failure for this group was 4.5 times higher than the general Brazilian population (LaRuche et al, 2020). Among the municipalities

that are part of the assessed DSEI, the Anapu was the one that presented the highest number of confirmed cases, with 150 cases, 38 more than Altamira city, which comes next in the placement ranking. Anapu has a territorial extension of 11,895,270 km<sup>2</sup> and an estimated population of 28,607 inhabitants, while Altamira has a territorial area of 159,533,328 km<sup>2</sup> and an estimated population of 144,594 inhabitants (IBGE, 2019). Anapu, despite having a small number of inhabitants, comprises 1 IT and 7 villages, this in an area approximately 15 times smaller than Altamira, which has a vast territory occupied by 5 IT and 15 villages, showing a greater proximity between urban areas and the indigenous villages in Anapu, which may explain the municipality with the most significant numbers in this study.

Trincheira Bakajá IT, which covers two municipalities (Senador José Porfírio and Anapu) and 10 villages, had a higher incidence of cases per 10,000 inhabitants (342.88), which can be directly influenced by the average growth of the national indigenous population, which decreases in the urban area (17.77% reduction) and increases in the rural area (43.31% increase), and also the indigenous population growth in the state of Pará, which went from 25,962 to 29,386, in a survey carried out over a decade (2000 to 2010), according to the IBGE (2010, 2011a, 2011b). Several factors may explain the arrival of the new coronavirus in the IT evaluated in this study, from the flow of displacement of indigenous people to nearby cities, to find better living and economic conditions (Arnault, 2016; IBGE, 2005), such as the historic advance of indigenous border lands on various fronts of internal and external territorial expansion, such as agriculture, land grabbing and large project facilities, configured by conflicts involving the most varied actors, among them the indigenous people (Becker, 2005; IBGE, 2005). The large bands of deforestation that form the “Arco do Desmatamento”, as a consequence and proof of these territorial advances in indigenous areas, there are, where the indigenous areas evaluated in this study are also reported (Silva et al, 2019 and Becker, 2005 and IBGE, 2005).

Regarding this theme, it is known that according to data from the National Institute for Space Research (INPE), in 2020 there was a record increase in the rate of deforestation in the Amazon (g1.globo.com), including IT in this study. Associated with this, there are still (often illegal) hunting activities, the wood itself and the minerals, (Cupertino et al, 2020), which demonstrate the increasing proximity of the non-indigenous people to the restricted Indian people areas, bring the Covid-19, in addition to the devastation already known. The Belo Monte Hydroelectric Plant was built within the area called “Volta Grande of Xingu river”, which is also a factor to be considered as relevant for the arrival of Covid-19 to the indigenous villages of the region, since the context of its construction there have been significant changes in the way of life of the indigenous people and their relationship with non-indigenous (Oliveira, 2016). Such changes both promoted a greater displacement of indigenous people into and out of the urban areas, as well as brought the urban people closer to the indigenous villages, including criminal relationships (Oliveira and Pinho, 2014 and Oliveira, 2016). Many of these relationships already existed before the Belo Monte hydroelectric plant was inserted, however, they have been expanded since its implementation (Oliveira and Pinho, 2014). Oliveira (2016) describes the way in which the relations between the towns and indigenous peoples of the various IT in

the region and their villages have been configured within the scope of the hydroelectric plant installation from a critical perspective on sexual and child violence. When evaluating how these flows and relationships occur, we can find evidence of justifications for the Covid-19 numbers found in this study.

Oliveira (2016) also comments on the Cachoeira Seca IT (which presented 80 confirmed cases in this study), affirming its direct impact by the Belo Monte Hydroelectric Plant, with cases of sexual abuse and major problems with alcohol in Paquiçamba. In this context, it is evident that in the aforementioned IT there are large flows of Indians and non-Indians, tending to remain and reproduce over time, which could allow the spread of SARS-COV-2 in these communities. Several non-indigenous people groups enter the IT and villages for various reasons, such as evangelical missionaries and several professional types (Cupertino et al, 2020; Oliveira, 2016). Among them, the ones related to indigenous health: as doctors, nurses, nursing technicians and assistants, indigenous health agents (AIS) and NGO agents (Novo, 2011), who generally do not stay in this service for a long time (except AIS), which characterizes their high turnover (Mendes et al, 2018) and greater chance of transmitting Covid-19 to indigenous communities, since these professionals can work in other locations on the front lines against the virus.

Although indigenous populations, in general, are more sensitive to respiratory infectious agents of high infectivity and / or virulence (Brasil, 2016), both in national and international studies, there is a death rate generally below 10% (Heymann and Shindo, 2020 and Cavalcante and Abreu, 2020 and Cupertino et al, 2020 and Marson and Ortega, 2020), and despite the Pará state being among the 10 states with the highest Covid-19 Mortality Coefficient (70.9) (<https://covid.saude.gov.br/>), there was no case of death in this study. In contrast, four of the 13 IT did not present a record of relevant variables for this study, they were: Apyterewa, Araweté Igarapé Ipixuna, Kararaó and Ituna. An explanation for this would be the fact that certain villages are still with a certain degree of isolation, requiring many hours of boat trip to reach them (Teixeira, 2007), so they present relative protection in the advance of COVID-19. High percentage of recovery (cured cases - 74.82%) was found in indigenous peoples belonging to the Altamira DSEI, a rate very close to that of the Pará state, which was 90.6% on August 6, 2020 (Secretaria de Saúde Pública - Pará, 2020), in addition to the very low rate of hospitalizations (0.95%). Many villages presented a number of cases that approached the number of cases of the Indigenous land itself, as is the case of Iriri indigenous village (75 cases) belonging to the Cachoeira Seca IT (80 cases). In this context, the cultural factor can be a favorable element for the spread of the virus, since the typical community behaviors of these ethnic groups, such as community housing and sharing of utensils can favor the mass contamination of these populations (Cupertino et al., 2020), a since indigenous people houses tend to have many residents and have a poorly ventilated structure, characteristics that facilitate the spread of respiratory infectious diseases such as tuberculosis (Rios et al, 2013) and COVID-19.

A delicate point to be analyzed refers to the clarification, disclosure and adoption of protective measures against the infection by the new coronavirus, such as the elaboration of materials in the mother language, which contemplate the correct washing of the hands, the use of alcohol gel and masks

for part of the indigenous peoples (Martins et al, 2020), as they are not common practices of the culture of these peoples, causing strangeness, and may constitute a barrier to the implementation of health education practices, with the preventive intention. However, it is still necessary to evaluate the infection behavior in this at-risk population, as it is already known that other indigenous peoples in Brazil are suffering greater complications and a higher mortality rate when compared to the general population of their region ([www.value.globo.com](http://www.value.globo.com)). Only 9.41% of the indigenous population of the Altamira DSEI has provenly contracted, COVID-19 (Brasil, 2020b), thus it can be further corroborated the idea that there is still some isolation between the city man and the indigenous people, however, suspected cases can be positive, as well as asymptomatic indigenous people who spread the virus. Although there is a government effort to provide access and quality in indigenous health care, mainly in the implementation of the National Policy for the Attention to Health of Indigenous Peoples (PNASPI) in 2002, with positive, but partial results, there are still many difficulties and precariousness in the attention to the health of these peoples, as inadequate structures for the reception of the sick Indian and the lack of basic supplies (Gomes and Esperidião, 2017; Mendes et al, 2018), which may have had a direct influence on the results of this work.

## Conclusion

Given the context of the present study, it can be supposed that the most isolated indigenous communities are still the most protected, obtaining low rates of infection by COVID-19, although there is concern with these communities, due to the risk of them going through a process of decimation of its members, due to a series of obstacles related to health services and the precariousness of inputs in the health institutions that provide care to these peoples, we recorded very few hospitalizations and no deaths attributed to COVID-19 in the Altamira DSEI indigenous people. This fact can demonstrate that the populations studied so far apparently have an adequate immune response to this condition, reinforcing the idea that the mechanisms of dissemination of the new coronavirus in the indigenous villages of the Altamira DSEI are multifaceted, crossing cultural, biological and conflict factors agrarian, installation of major development projects, environmental devastation, migratory flows of Indians and non-Indians. However, further studies are needed to find the real genetic and / or environmental reasons that explain the differences in patterns of severity of infection in different populations. However, the characterization of local epidemiological patterns are important planning tools for coping with the HIV pandemic. COVID-19.

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