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FLOWS AND DISPERSION OF COVID-19 IN THE IMMEDIATE GEOGRAPHIC REGION OF TIMON, MARANHÃO, BRAZIL

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ABSTRACT

This work aims to discuss the dynamics of the spread of covid-19 from the flows of people in search of medical and hospital care in the urban network of the Immediate Geographic Region of Timon. The time frame corresponds to the period of one year, from the first case of covid-19 registered in Maranhão. The analysis considers that the selectivity of health services in the municipalities of Maranhão contributes to the creation of an intense network of connections and contagion driven by the circulation of people directed to medical care in the urban network. This is a quantitative research, followed by a qualitative examination of the data, extracted mainly from the databases of the Department of Informatics of the Unified Health System, the Health Department of the State of Maranhão and the Brazilian Institute of Geography and Statistics. The data refer to medical and hospital equipment, medical units and human resources, considered as drivers of the movement of people during the covid-19 pandemic. The results suggest that the density of health services within the region drives flows of passersby in search of care, reproducing the hierarchy patterns of the urban-regional network and promoting inaccuracies regarding the origin of contagion and the concentration of deaths in the main regional center.

Keywords: Density. Health Services. SARS-CoV-2.

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INTRODUCTION

Globalization has a symbiotic relationship with the technical-scientific-informational environment. While technological development drives it, it, in turn, also drives technological innovations and stimulates the mechanization of the environment, but at a pace that is not homogeneous and combined. That is, technical means have been incorporated into the geographical environment in a selective way, with some areas accumulating technical and informational densities more than others. This movement raised the standard of consumption, created a diversified commercial sector and fostered the diffusion of means of transport and communication (Almeida, 2005).

The road system implemented in 1950 was efficient for the integration of the territory and facilitated the circulation of people who were often vectors of some type of communicable disease. Andre Siegfried (1960) points out that the initial paths of epidemiological diseases coincide with major routes.

This dynamic returned to the spotlight in 2020, with the beginning of the covid-19 pandemic, a disease characterized by severe respiratory infections, high lethality, and easy transmission. The first pandemic of the twenty-first century had as its epicenter the city of Wuhan, China, a country with the second largest economy in the world, known as the "factory of the world", due to mass production and export. The occurrence of an atypical pneumonia was recorded in China at the end of December 2019, and soon the virus spread around the world.

According to official data from the Ministry of Health, the virus arrived in Brazil at the end of February 2020, detected in São Paulo, the most populous city and largest urban center in Brazil, the main financial, commercial and industrial center of the country. After that, the spatial diffusion of the virus continued throughout the national territory, reaching all states.

The first case of covid-19 identified in Brazil was a man from a trip to Italy. Likewise, the first case registered in Maranhão, on March 20, 2020, also referred to someone returning from a trip: the man had returned from São Paulo to the capital of Maranhão, São Luís.

Studies indicate an acceleration of globalization in the spatial diffusion of the virus from airport platforms, whose logistical efficiency allowed the shortening of space-time in the spread of the virus to anywhere in the globe in less than 32 hours, multiplying the epicenter of contagion (Monié, 2020).

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In the Immediate Geographic Region of Timon (RGIT), the first case was detected on April 5, 2020, in the municipality of Timon, the largest and most important urban center in the region. From then on, the virus followed a hierarchy pattern of cities, that is, more relevant urban centers concentrated more cases because they had a greater supply of health services, which generated more population flows, therefore, greater dispersion of the disease (Maranhão, 2020).

In this sense, diffusion is characterized as a process of expansion, which occurs both hierarchically and by contagion. In the first case, diffusion follows patterns of urban hierarchy and in a decreasing direction; in the second, contagion occurs through the central of the urban network – as a promoter of flows – in the propagation of phenomena (Catão, 2016).

In view of this, it is understood that the spread of the disease throughout the country followed spatial patterns, representing one of the greatest challenges of recent decades in terms of public health, considering the limitations of the health system in small centers and its saturation in large urban centers (Fundação Oswaldo Cruz, 2020).

In this context, this article aims to analyze the dynamics of the diffusion of covid-19 in the urban network of the Immediate Geographic Region of Timon, based on the flows of people seeking health care. And it considers the spatial segregation in the supply of medical-hospital services in the municipalities of Maranhão of the RGIT as an element that strongly conditioned the circulation of the virus in the pandemic.

In addition to this introduction, the methodology and the final considerations, this article is divided into three other sections. The first section, called *The Immediate Geographic Region of Timon*, points out historical and socioeconomic aspects of the region; the second, *Densities and rarefactions of the supply of health services in the urban network of Timon*, discusses the urban hierarchy and centrality based on a descriptive analysis of the variables of distribution of medical-hospital equipment and their correlation with the circulation of the virus. Finally, the section *Flows and dispersion of covid-19 in the Immediate Geographic Region of Timon* exposes the diffusion of covid-19 cases, based on the analysis of confirmed cases and deaths from the disease, as well as the geographical origin of the population served in the region in this context.

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METHODOLOGY

The study refers to an empirical research, supported by the systematization of public secondary data, followed by qualitative analysis. This research delimits the Immediate Geographic Region of Timon as a spatial cut, and the relationship of its urban network with the spatialization of SARS-CoV-2 constitutes the object of study, whose time frame corresponds to one year of pandemic in the state of Maranhão, followed from the first recorded case (March 20, 2020 to March 20, 2021). In this time frame, a broad dynamic of viral spread is considered, since it is the period before the start of vaccines.

It analyzes both the evolution of the pandemic in the RGIT and the reproduction of its urban hierarchy in the distribution of medical-hospital services, as well as the consequent mobility of people with covid-19 in search of care and, as a consequence, the dispersion of contagion in the region (Oliveira; Gates; Paz, 2021; Olive tree; Wood; Paz, 2021).

The identification of the supply of medical-hospital services was systematized based on two main data collection centers, directly linked to the demands triggered by the covid-19 pandemic: medical-hospital equipment, such as intensive care units (ICUs), ventilators/mechanical respirators, and public and private hospital beds; and human resources. In this last nucleus, the following medical specialties were considered: immunologist, cytopathologist, infectious disease specialist, intensive care physician, pulmonologist, and nephrologist. In addition, a survey was carried out on the distribution of medical establishments: general hospitals; specialized hospitals and pre-hospital level mobile units urgency and emergency.

We also sought to identify the geographical origin of patients with clinical problems in the respiratory system and/or covid-19, who, in the period analyzed, were treated in Timon, a municipality in the RGIT with the largest supply of health services. To this end, the International Classification of Diseases (ICD) was used as a reference, according to guidelines from the Ministry of Health for the management of patients with covid-19. The ministry specifies the ICD codes that should be used to classify covid-19 cases, and the specific codes for coronavirus infection are: B34.2 (coronavirus infection of unspecified location), U07.1 (covid-19, identified virus) and U07.2 (covid-19), the latter two being more recent than the first (Brasil, [2020]).

Data related to medical services and geographic origin of covid-19 cases were collected from the National Health Card (CNS) database and the report of hospitalization

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medical care, registered in the Department of Informatics of the Unified Health System (DATASUS), and data on the evolution of cases and deaths were collected from the databases of the Maranhão State Department of Health. From this, graphs and tables were elaborated. The maps built for this research were made based on geoprocessing strategies, using the ArcMap student version software.

THE IMMEDIATE GEOGRAPHIC REGION OF TIMON

The Immediate and Intermediate Geographic Regions were established by the IBGE in 2017 and, unlike the previous regionalizations – Physiographic Divisions (1940), Homogeneous Microregions (1970) and Micro and Mesoregions (1989) – have as their main elements of regional organization the urban network and the centrality exercised by a center. The assumption considered by this regionalization is that of the territory-network and the complex dynamics and functionalities of cities in the organization of space, based on daily human activities in an urban-regional context.

This model of regional division uses the urban network as the main reference for its spatial cut, composed of nearby urban centers, articulated in various ways by material and immaterial flows. The relationship between these centers is based on subordination and dependence. An example is the flows around a central city (hub city), where the main and most complex services are located, which must be guaranteed to all municipalities and towns in its region of influence. The centers are classified by hierarchy and urban centrality determined by the concentration of goods and services, such as: durable and non-durable consumer goods, provision of public services, education, work, health, employment, among others, intensifying connections through continuous flows (IBGE, 2017).

Specifically, the Timon Immediate Geographic Region (RGIT) is located in the east of the state of Maranhão and is part of the Caxias Intermediate Geographic Region. It is composed of four municipalities: Buriti Bravo (1,582.552 km²); Matões (2,108.671 km²); Parnarama (3,245,525 km²) and Timon (1,763.220 km²) (IBGE, 2010).

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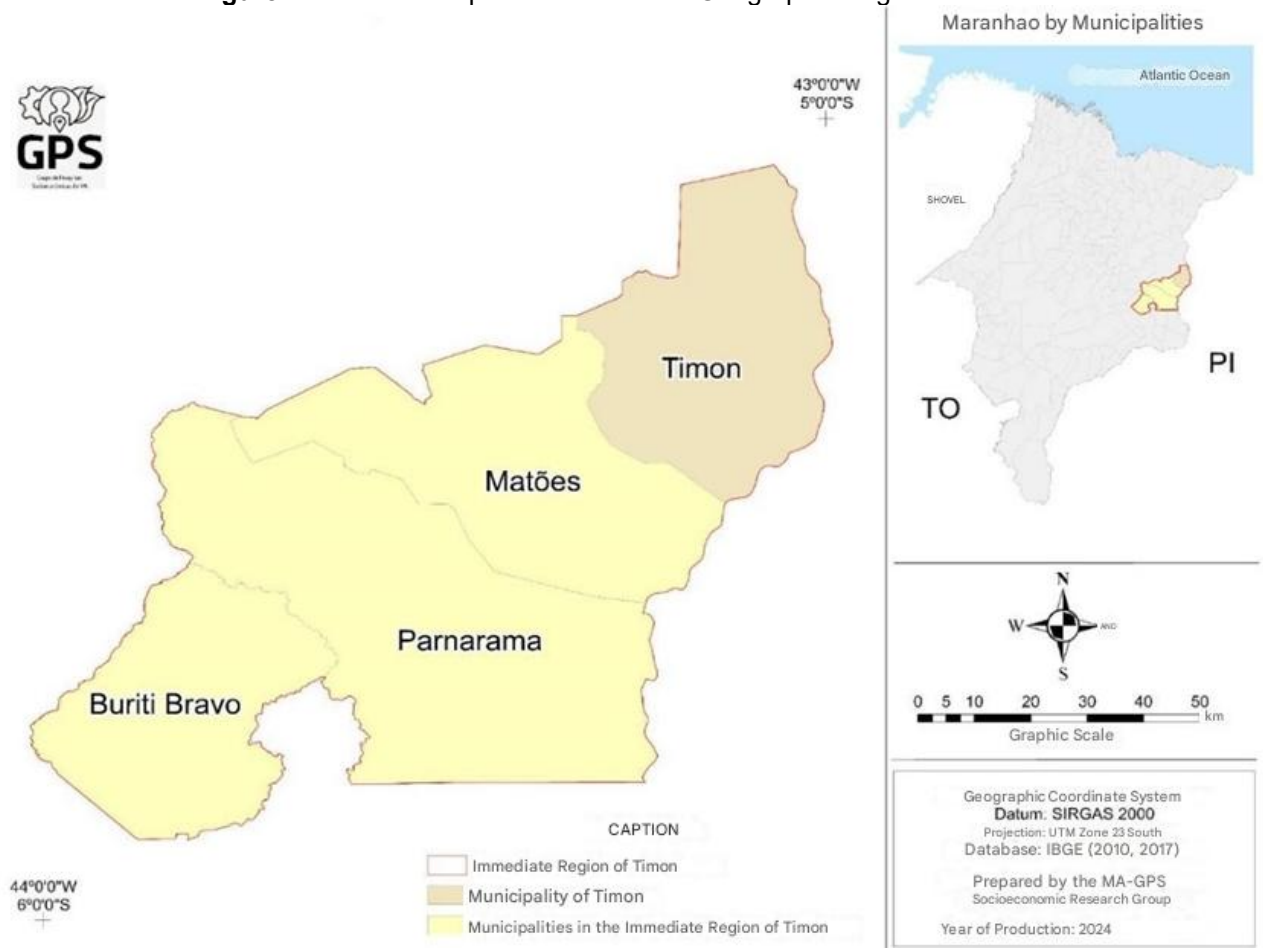
Figure 1. Location map of the Immediate Geographic Region of Timon.



Source: IBGE (2010, 2017). Org. by the authors (2024).

The origin of these municipalities is linked to the broad process of occupation of the Brazilian "hinterlands" from the growth of the properties of squatters, with their subsistence crops. According to the census released by the IBGE in 2010, the region has a total population of 243,960 inhabitants, divided as follows: 64,648 inhabitants (26.5%) in the rural area and 179,312 inhabitants (73.5%) in the urban area, as shown in Graph 1. According to the last demographic census, in 2022, the region's population increased to 260,344 inhabitants (IBGE, 2010, 2023; Sousa, 2014).

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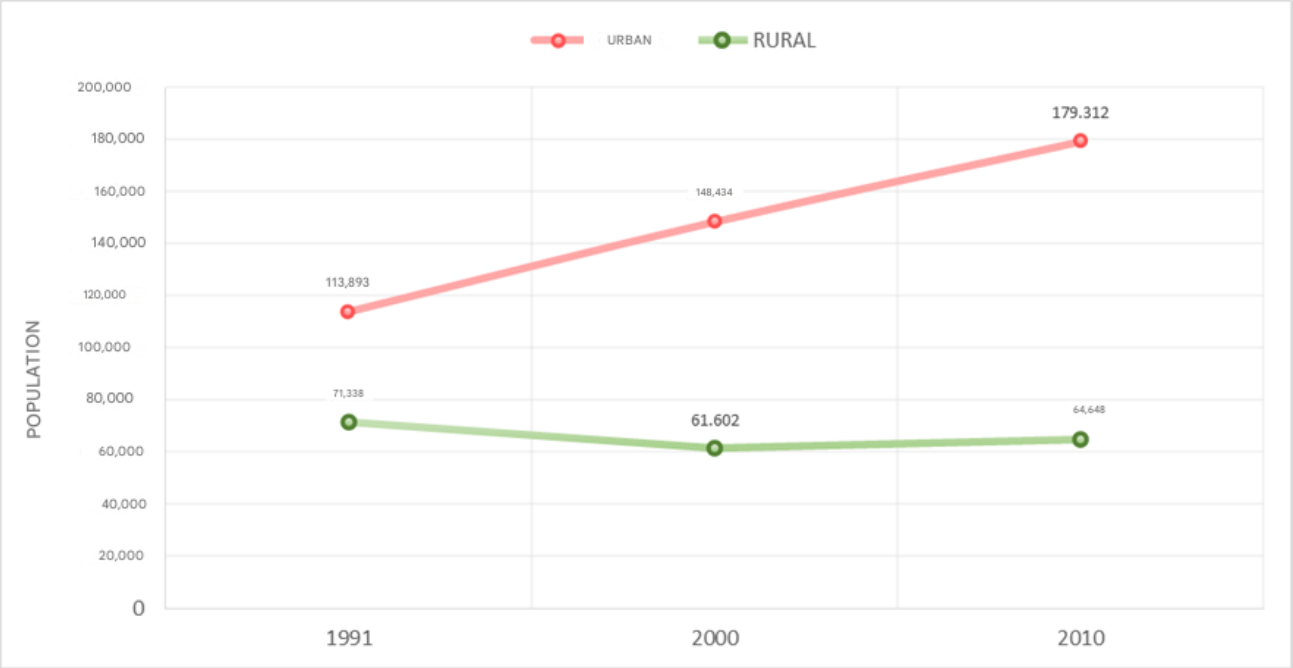
Graph 1. Population of the Immediate Geographic Region of Timon.



Source: IBGE (2010). Organized by the authors (2024).

It can be seen in the graph that all municipalities showed a gradual increase in their urban population, while the rural population of the municipalities of Buriti Bravo and Parnarama showed a gradual decrease. The municipality of Timon stood out among the others in the occupation of urban area, concentrating 74.36% of the urban population of the region. In the period from 1970 to 1980, urban occupation surpassed rural occupation in this municipality and continues to increase. This fact is associated with the locational advantage of the municipality's proximity to the capital of the state of Piauí, Teresina (Sousa, 2014).

In addition, as of the 2010 census, Timon became the fourth most populous municipality in Maranhão, with 155,460 inhabitants, behind only São Luís (1,080,999 inhabitants), Imperatriz (247,505 inhabitants) and São José de Ribamar (163,045 inhabitants) (IBGE, 2010).

In relation to the economy of the municipalities of the RGIT, the most important sector is services, especially public services. Timon is the most expressive municipality in the sectors of industry and especially in services, in which it registers the highest percentage of its Gross Domestic Product (GDP), similar to the state capital, which is also more economically expressed in these sectors. The capital São Luís, however, has an income 29.26 times higher in industry and 16.22 times more in the service sector,

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compared to Timon; in the agricultural sector, Parnarama leads as a prominent municipality, yielding twice as much as the capital itself (IBGE, 2020c).

As for socioeconomic indicators, as shown in Table 1 below, the average Municipal Human Development Index (MHDI) in the region is 0.58; Parnarama has the lowest index (0.54) and Timon the highest (0.64), which is still far below the MHDI of the capital São Luís (0.76) and even below the largest nearby center, Imperatriz (0.73). The average Gini index in the region is 0.55, with the most unfavorable index being that of the municipality of Matões (0.56) and the most favorable that of Timon (0.50); São Luís and Imperatriz have Gini coefficients of 0.62 and 0.56 respectively (IBGE, 2010).

Table 1. Socioeconomic indicators of the Immediate Geographic Region of Timon.

Municipalities	Urban hierarchy	Average monthly salary	Employed population (%)	Monthly income of up to half a minimum wage (%)	MHDI	Gini
Timon	Capital Regional A	1,7	10,52%	44,5%	0,64	0,50
Buriti Bravo	Local Center	1,9	3,51%	52,7%	0,59	0,55
Matões	Local Center	1,7	7,01%	54%	0,55	0,56
Parnarama	Local Center	1,6	6,12%	53,2%	0,54	0,55

Source: IBGE (2020c). Organized by the authors (2024).

Analyzing the employment and income indicators (IBGE, 2020c), a high level of poverty among the population can be perceived. In 2020, the average number of employed persons in all municipalities, in relation to the total population of the region, was 10%. In addition, more than half of the population lived on up to half a minimum wage (R$ 651.00).

The average salary in the region (Table 1) reached approximately 1.7 minimum wages, with the municipality of Buriti Bravo having the highest average salary and Parnarama the lowest: 1.9 and 1.6 minimum wages, respectively. It is worth noting that Buriti Bravo has the lowest percentage of employed population (people who perform formal or informal professional activity, paid or not), which – together with the highest average salary in the region – indicates a high rate of income concentration.

Timon, in turn, has an average salary of 1.7 minimum wages and has the highest percentage of employed persons (10.52%), the best MHDI (0.64) and the best Gini index (0.50), which indicates the distribution of income. Compared to the state capital, São Luís has three times more employed persons (34.91%), an average monthly salary also higher (3.1) and a monthly income of up to half a minimum wage lower (37.7%) – lower than that of Timon (44.5%). The largest nearby center, the municipality of Imperatriz, classified as Regional Capital C, has a percentage of employed persons twice as high (25.73%),

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average monthly salary also higher (2.1) and average monthly income of up to half a minimum wage lower (37.4%) (IBGE, 2020a).

These data briefly express the socioeconomic characterization of the region, pointing to relevant elements when observing regions on the periphery of world capitalism with low development indicators. This characteristic ends up being reproduced in essential sectors of daily life.

DENSITIES AND RAREFACTIONS OF THE SUPPLY OF HEALTH SERVICES IN THE URBAN NETWORK OF TIMON

The urban network can be understood as a network of cities interconnected through the polarization of flows of people, goods and services and economic and social development. This type of connection between the centers is facilitated by the urbanization process, which provides more access to forms of mobility and technical advances in transport (Oliveira; Silva, 2023).

In abstract terms, it can be said that the network is a set of "nodes" that connect to each other through "arcs", which correspond to the flows that interconnect, "sew" the nodes. In this way, the flows of people, goods and information would be this seam, while the infrastructural elements – such as roads, streets or bridges – that enable the displacement of flows, would be the arches (Souza, 2002). The urban network can present itself as a mobile territory, as Oliveira and Silva (2023, p. 17) explain: "It alters regional contexts and boundaries that occur due to the concentrations and dispersions caused by the selective movements of people and the regional economy".

These selective movements are a reflection of the influence of one city on another, of the gravitational power of attraction that larger cities exert on smaller cities or those that have fewer service offerings. The degree of attraction will depend on the degree of supply of services, goods, infrastructure network, support and investment potential, which, through these exchange instruments, circulate among the agglomerations that define the urban network (Oliveira; Silva, 2022; Souza, 2002).

The cities that are part of this network articulation are classified according to a hierarchy. In the words of Corrêa (1997, p. 93), this is how an urban network is defined:

> A set of urban centers functionally articulated with each other. It is a particular type of network in which the vertices or nodes are the different nuclei of settlement endowed with urban functions, and the paths or connections of the various flows between these centers [...]. The urban network is a social product, historically

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> contextualized, whose role is [...] to articulate the whole of society in a given portion of space, ensuring its existence and reproduction.

The effectiveness of hierarchical urban networks is based on the social, technical and territorial division of labor, generating a relationship of interdependence. According to Corrêa (2006, p. 26), the urban network would be "[...] a reflection to the extent that, due to differentiated locational advantages, there is an urban hierarchy and functional specialization [...]".

The centers start to perform particular central functions, implying an asymmetrical spatial interaction between different localities on an interurban scale. As a result, urban centers capable of exercising centrality are called "central places" and function as distribution centers of goods and services in their area of influence, generating a hierarchical differentiation, determined by spatial reach. However, the centrality of a center is strongly linked to its degree of importance, defined from its central functions, that is, the greater the number of functions and the level of complexity, the greater its area of influence and the number of people served (Bessa, 2012).

Based on Christaller's concepts, Corrêa (1989) understands that there is a differentiation in the supply of goods and services based on the maximum and minimum spatial range. Those of frequent consumption require a reduced minimum spatial range, since few residents of the central location and nearby areas are already sufficient to justify their supply. The maximum spatial range of this type of product and service is also reduced. Corrêa (1989, p. 22) explains why:

> [...] From a relatively short distance from the central locality, transport costs become very high compared to the costs of goods and services, which are relatively low. There are several other centers that distribute these goods and services: their supply is widespread in numerous central locations that are close to each other.

Camagni (2006) classifies five basic principles of territorial organization that would explain the structures and laws of movement of cities: a) agglomeration, which implies demographic density and concentration of equipment in a given place; b) accessibility, which determines the lease of certain residential and productive activities; c) spatial interaction, which designates a complex set of displacements between fixed points of different locations; d) hierarchy, which is the articulation of groups of cities grouped from a scale of subordination; e) competitiveness, which refers to the dynamics between the

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centers, implying differentiated urban growth and the exercise of the capacity of attraction and functionality, as well as frequent flows in the search for services.

In this way, the polarization of the region is propagated based on the central functions performed by certain municipalities in its area of influence, based on their capacity to attract through the provision of services, such as education, health and commerce. This unequal socio-spatial production generates a pre-established dynamic due to its conditions and materializes differential access to services. In this sense, Corrêa (2006, p. 26) reiterates: "[...] It is through the urban network that the world can become, simultaneously, unequal and integrated". In other words, "health inequality manifests itself as deprivation related to access, control and power; it is the distribution of health and disease among social strata in a hierarchical manner [...]" (Siqueira, 2009, p. 14).

Considering territorial inequalities, according to Santos and Silveira (2001), the examination of the supply of services in the territory reveals the points of greatest notoriety of activity related to health services and, therefore, their zones of density and rarefaction. In other words, even though there is a place with an intense concentration of demographics, capital, goods, technology, services, infrastructure and jobs, some points have rarefaction, with low density and less advanced technological acquisition. These aspects are revealed, in the field of health, from the analysis of the distribution of components that foster health systems, such as medical demography and the distribution of inputs, health units and medical equipment.

In the Immediate Geographic Region of Timon, the municipality of Timon has most of the medical and hospital resources (Figure 2), generating supply and demands for health services specialized in consultations, exams, surgeries and treatments. As can be seen in the figure, Timon holds all the adult ICUs in the region, adding up to a total of 20 units. In addition, it also has all the CT scanners, with a total of 3 units, out of 4 of the 5 incubators in the region.

Timon also has the largest number of inpatient beds – 128 units – equivalent to 46.88% of the total number of beds in the region, almost the same value as the sum of the number of beds in the other three municipalities. It is necessary to consider, however, that there is also a demographic concentration in the territory, more than half of the RGIT population (63.72%).

According to Ordinance No. 1.101/2002, of the Ministry of Health, the health care coverage parameters of the Unified Health System (SUS) determine the ideal number of

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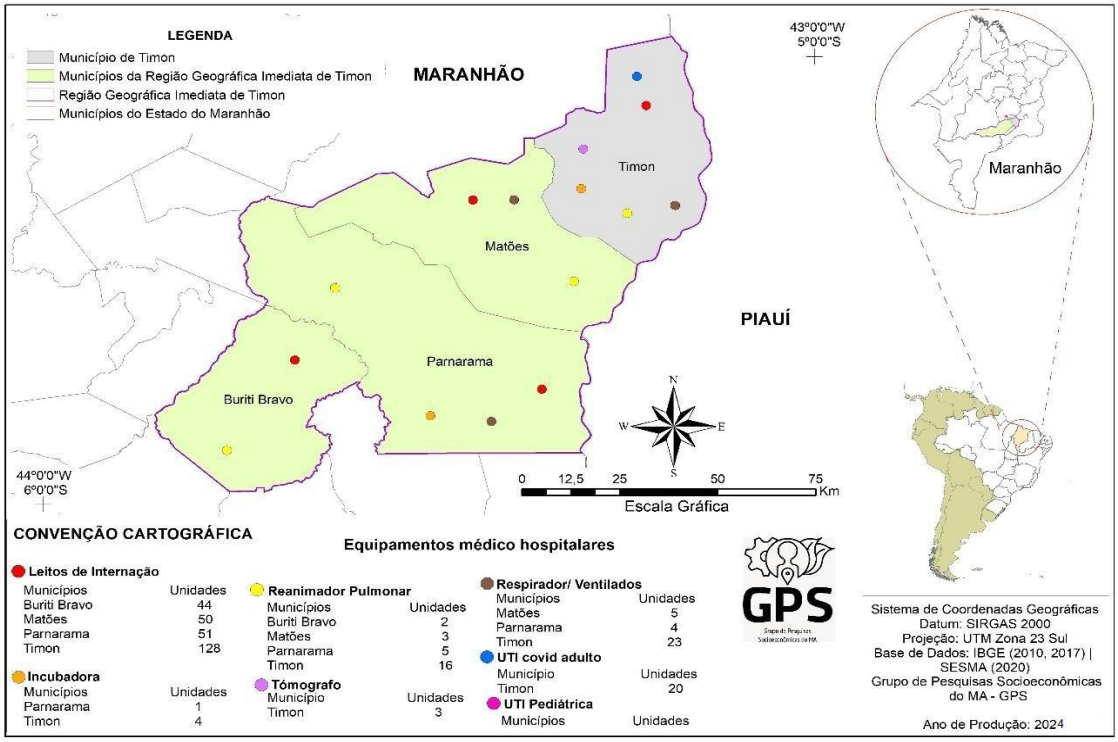
ICU beds: from 2.5 to 3 beds for every thousand inhabitants. This regulation was revoked in 2015, but is still used as a parameter by the Brazilian Association of Intensive Care Medicine. None of the municipalities in the RGIT reaches this standard; Buriti Bravo is the one that comes closest, with 1.92 beds per thousand inhabitants; Timon is the furthest away, with 0.82 beds per thousand inhabitants. On the other hand, the capital São Luís exceeds the recommended level and has 3.68 beds per thousand inhabitants (Brasil, 2002; CFM, 2016).

Figure 2. Distribution of medical and hospital equipment in the Immediate Geographic Region of Timon.



Source: Brazil (2021). Organized by the authors (2024).

Regarding the number of resuscitation bags used to provide rapid ventilation to patients with respiratory failure, RGIT has 23 units, and 69.5% of this equipment is in the municipality of Timon, equivalent to 16 units. Next come the municipalities of Parnarama, with 5 units; Matões and Buriti Bravo, with 3 and 2 resuscitators, respectively.

With regard to respirators, the scenario is no different. While Buriti Bravo does not have any units of this equipment, Timon has 23 units, followed by Matões (5) and Parnarama (4). Although some municipalities have a certain amount of equipment, there are gaps in some local centers, where the State has not been able to provide adequate provision, thus compromising the universality of health care.

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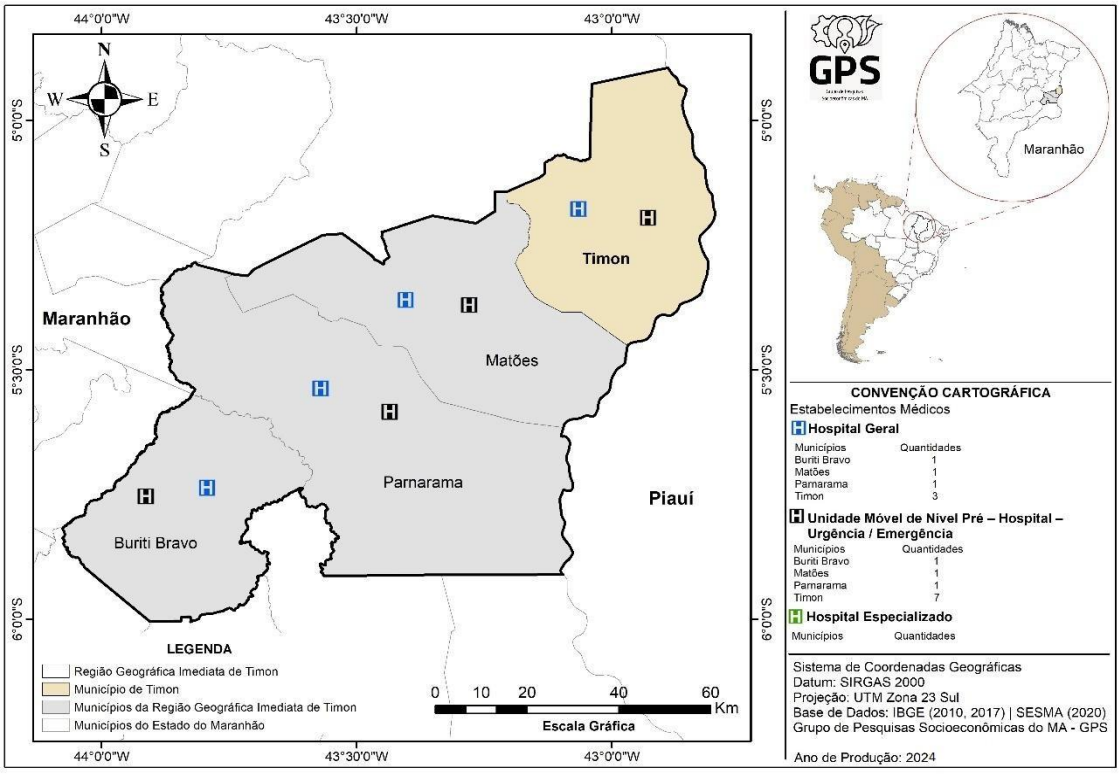
According to data from DATASUS (Brazil, 2021), the medical specialists demanded during the covid-19 pandemic, found in the RGIT, were the following: 4 geriatricians, 2 infectious disease specialists, 2 intensivists, 3 pulmonologists, 2 nephrologists, and 1 cytopathologist. All the doctors found concentrate care in the municipality of Timon. No record of any immunologist was found.

Regarding the distribution of medical-hospital establishments (Figure 3), in general the region has few units, concentrated in the municipality of Timon. The city has 3 general hospitals, while the other municipalities in the region have only 1 hospital each. In the distribution of pre-hospital mobile urgent and emergency units, 7 units are concentrated in Timon and 1 unit in each of the other municipalities. There are no specialized hospitals in RGIT.

Figure 3. Distribution of medical and hospital establishments in the Immediate Geographic Region of Timon.



Source: Brazil (2021). Organized by the authors (2024).

Although Timon presents itself to the region as a reference in medical care, it shows precariousness in terms of health facilities. In the municipality there are only 3 general hospitals, which provide basic specialty care, which is little considering the total population of 155,460 inhabitants, that is, a rate of 0.019 hospital for every thousand inhabitants. The

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concentration around Timon, the main center in the region, represents a challenge for health care, which has worsened in the covid-19 pandemic.

COVID-19 FLOWS AND DISPERSION IN THE TIMON GEOGRAPHIC REGION

Global connections have boosted the advance of covid-19, qualifying it as a transsecular disease, by overcoming territorial barriers. This advance in diffusion was driven by transport networks, which establish interconnections with a high social load, articulated from flows. In other words, the spread of the disease was intrinsically related to the mobility of people via modes of transport. In the case of Brazil, SARS-CoV-2 landed in the country by air transport and followed its continuous flow through the highways, which functioned as the main propagator of the disease, as highlighted by Rodrigues (2022).

The author considers that access and the degree of exposure do not occur in the same way everywhere, they depend on the position of the place at a hierarchical level. This is an important factor in generating flows, and flows are directly linked to access capacity; Some places will have immediate access to innovations and pathogens, while others will have late access or never at all. Therefore, in order to make it feasible to map the expansion of the disease, the established flows and fixed flows and their preferred routes must be taken into account.

In his study on the diffusion of dengue in the state of São Paulo, Catão (2016) based himself on two theories of diffusion, in order to understand the point of origin of the disease and its dispersion. He was based on analogies in the aspect of diffusion by extension, from the spatio-temporal propagation. In this case, the widespread phenomenon does not leave the place of origin, but rather intensifies its action in that place and then propagates over a greater extent.

Diffusion by extension can be of two types: by contagion and by hierarchy. Diffusion by contagion occurs through interpersonal contact, as in cases of contagious diseases, in which the distance of travel interferes with the affected portion. In Harvey's (1980) terms – in analogy with absolute space – the greater the friction of space, the lower the probability of contact. On the other hand, diffusion by hierarchy follows a logic of order, obeys a decreasing movement, such as, for example, the urban network, where the phenomena begin in the metropolises and leave towards the local centers, which are at the end of the nature of the processes (Catão, 2016).

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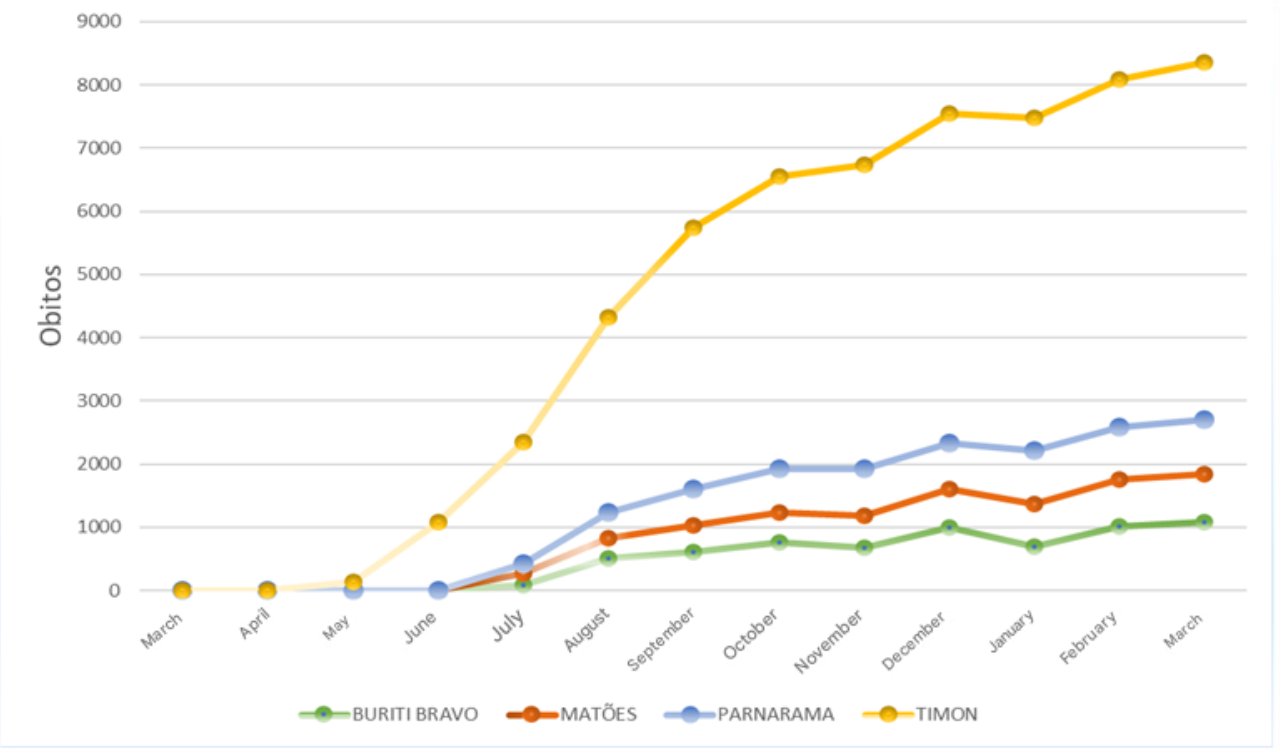
The first case of covid-19 in Brazil was confirmed on February 20, 2020, registered in the country's main metropolis, São Paulo. In Maranhão, the first record of a confirmed case happened a month later, on March 20, 2020, in the capital São Luís. In both cases, the first contaminated were men who had recently arrived from a trip: one from an international trip to Italy, the other from a national trip to São Paulo. Many studies point to airports as the main diffusers of the SARS-CoV-2 virus, particularly international and large metropolises, responsible for the phenomenon of the virus moving inland from intermediate cities to small cities (Oliveira; Soares; Oliveira, 2021).

Graph 2 shows the evolution of confirmed cases of covid-19 in the RGTI in the period analyzed. It can be seen that in the first months, from May to June 2020, the cases were restricted only to the Regional Capital of Timon; From July onwards, the proliferation of the virus to other local centers was verified, no longer limited to private areas. From then on, all municipalities registered at least one case.

Graph 2. Confirmed cases of covid-19 in the Immediate Geographic Region of Timon.



Source: Maranhão (2020, 2021). Organized by the authors (2025).

The first confirmed case of covid-19 in the region was recorded on April 5, 2020, in the municipality of Timon; At the time, two cases were registered. Considering a year of analysis of the virus in the region, Timon had the highest number of cases, followed by the

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municipalities of Buriti Bravo, Parnarama and Matões. RGIT registered a total of 8,358 cases, 67.63% of which were registered in Timon. In the same period, Brazil had 11,958,814 confirmed cases.

The municipality of Timon registered 5,653 cases, the highest number in the period analyzed, followed by the municipalities of Buriti Bravo (1,080 cases), Parnarama (866 cases) and Matões (759 cases), equivalent to 12.92%, 10.36% and 9.08% of the confirmed cases in the region, respectively. The month of August stands out, which had the fastest increase in the number of cases, with a surplus of 1,972 cases.

It is important to consider that Brazil, as well as other countries, had a small percentage of testing, especially at the beginning of the pandemic, and the limited testing capacity meant that medical care centers only carried out mandatory tests on patients with symptoms suggestive of severe acute respiratory syndrome. Despite investments by the Brazilian government to expand tests and reference centers, there was initially no availability of free tests, and the values of testing in the private sector were considerably high. Thus, the lack of tests made it difficult to diagnose the disease, increasing underreporting (Almeida *et al.*, 2020).

The first death recorded in the region dates back to May 20, 2020. From then on, there was a gradual increase in the number of deaths, with about 23.5 more occurrences per month, especially in August, when there were 50 more deaths than the average. The municipality of Timon registered 88.55% of all RGIT deaths, totaling 209 registered deaths. The other municipalities recorded fewer deaths, 11 in Matões, 10 in Buriti Bravo and 6 in Parnarama.

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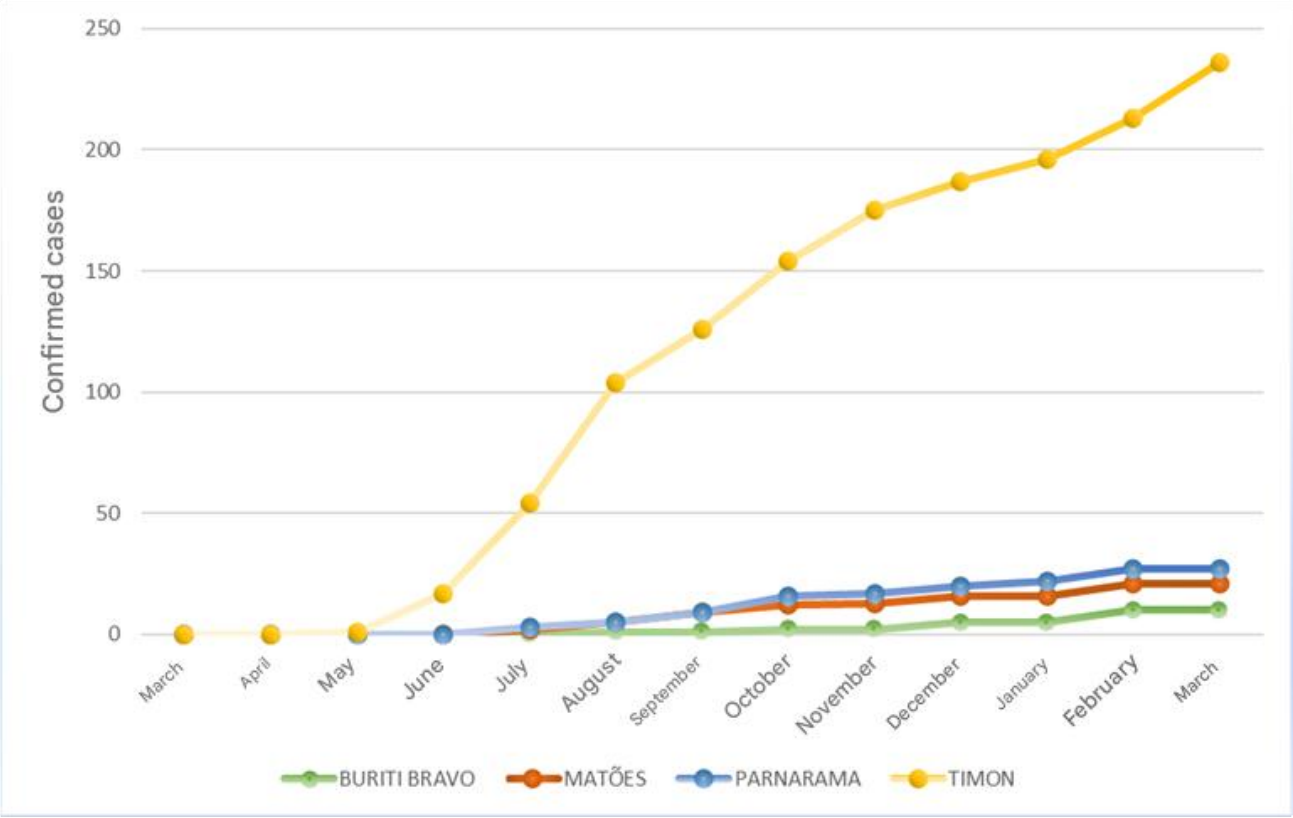
Graph 3. Deaths from covid-19 in the Immediate Geographic Region of Timon.



Source: Maranhão (2020, 2021). Organized by the authors (2025).

The analysis of the variable of deaths is important for understanding the geography of covid-19, since the place of death of the patient, therefore, of death registration, does not necessarily coincide with his city of origin, reiterating the role of flows and circulation of people. Another determining factor is that death records originate from fixed health institutions, which would explain the fact that Timon, the municipality that centralizes medical care in the region, does not concentrate the highest detection rate of the virus, but has the highest mortality coefficient.

Table 2. Confirmed cases and deaths in the Immediate Geographic Region of Timon.

Municipalities	Hierarchy	Confirmed	Rate detection	Deaths	Coefficient mortality
Timon	Capital Regional A	5.653	36,36	209	1,34
Buriti Bravo	Local Center	1.080	47,16	10	0,43
Matões	Local Center	759	24,47	11	0,35
Parnarama	Local Center	866	25,03	6	0,17

Source: Maranhão (2020, 2021); IBGE (2020b). Organized by the authors (2025).

The data suggest that, to a certain extent, this coefficient follows a hierarchical order on a scale of subordination, according to the classification of urban centers, established by the IBGE's Regions of Influence of Cities (REGIC) study. According to this hierarchy, the

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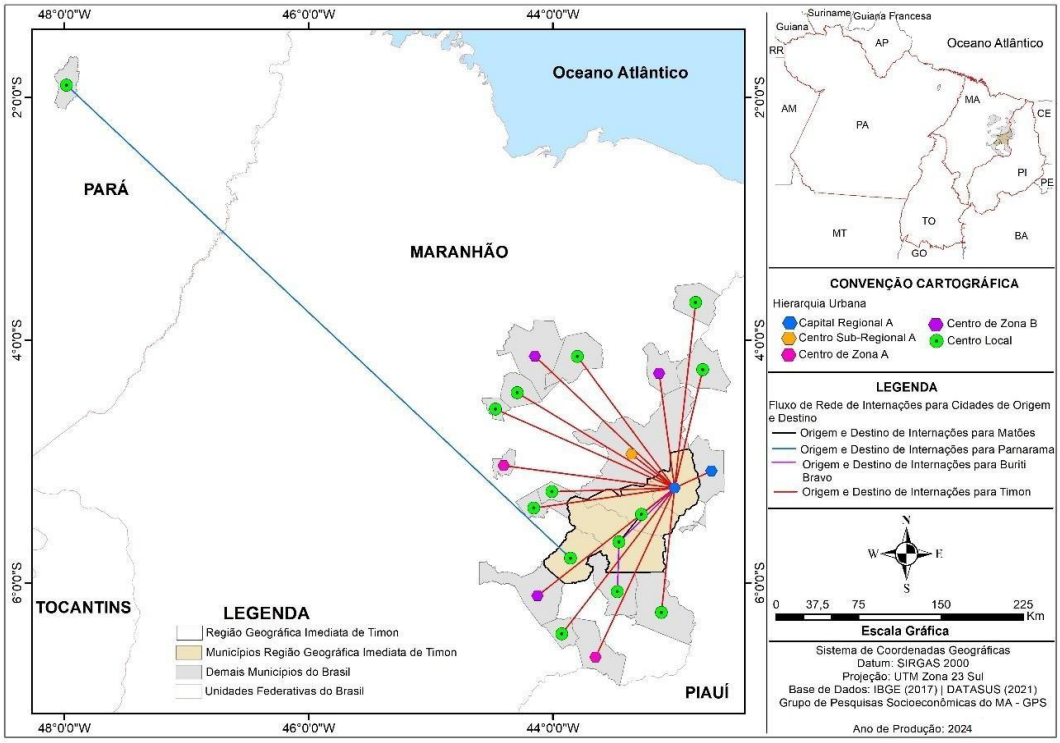
highest percentages are concentrated in the main center, following in a decreasing manner to local centers, showing that the socioeconomic organization of a region can not only point the direction, but can also dictate the intensity and temporality of the cases. In this way, the path taken by covid-19 corresponds to the same as that of mobility networks (Rodrigues, 2022).

Figure 4. Geographical origin of patients treated with covid-19 in the Immediate Geographic Region of Timon.



Source: Brazil (2021). Organized by the authors (2024).

The data on the geographic origin of patients treated with covid-19 in the Immediate Geographic Region of Timon, as shown in figure 4, highlight the polarization of the municipality of Timon and the flows of patients from nearby municipalities who, during the pandemic, sought health services in this polarizing center.

In total, 1,525 patients with covid-19 received some type of medical care in Timon, 94.95% of whom are patients who are part of the Immediate Geographic Region; of these, 88.91% are local residents of Timon. People from 15 other municipalities in Maranhão other than those that make up the RGIT were also assisted in Timon, corresponding to

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4.39% of the attendances. In addition to these, in the period under review, 10 patients[8] from the state of Piauí were treated.

Considering the hierarchical system and the concentration of public health services, the center with the greatest offer of services should accommodate patients from smaller centers, over which it exerts some degree of influence, thus enhancing its role as regional capital. It is up to the urban center classified as regional capital to be responsible for meeting the demands of smaller cities, where the supply of services is limited, and this implies the displacement of people from these cities to those with greater structure. This pendulation also creates a wide area of viral diffusion in the region of influence, where there is a population contingent of 243,960 inhabitants, possible vectors transiting in the flows.

CONCLUSION

The rarefied and concentrated supply of health services reflects the vulnerabilities of the system and the unequal pattern of reproduction of access to essential services in the municipalities that make up the RGIT. In this context, Timon presents itself as the epicenter of density in the supply of health services in the region, concentrating fixed health facilities (general hospitals and mobile urgent and emergency outpatient clinics) and medical-hospital objects (incubators, inpatient beds, ICUs, pulmonary resuscitators, respirators, and CT scanners) – essential elements for the treatment of patients with covid-19.

This concentration stimulates the gravitational attraction towards the municipality of Timon, attracting people from smaller centers, where the supply of health services is limited, especially those required in the treatment of covid-19. The consequent increase in medical care in the main municipality makes data on the origin of contagion inaccurate, in addition to contributing to the concentration of deaths in the main regional center, generating disparities between the coefficients of infected and deaths.

Such movements not only make it difficult to register the disease, but are also extremely harmful to the control of contagion, since SARS-CoV-2 is a highly transmissible virus, and the movement of people weakens the maintenance and effectiveness of social isolation measures. In addition, the centrality of health services in the context of the pandemic also hinders and delays treatment, due to the patient having to travel to be seen.

[8] Given the region's capacity for polarization, it is believed that the interaction with the municipality of Timon through patient care was occasional, not the result of the city's gravitational role in relation to medical services.

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Finally, it is worth highlighting the relevance and contribution of studying phenomena of this nature through the logic of the urban network, which reinforces the theoretical-methodological rigor of the establishment of Brazilian urban hierarchies, but which highlights the disparities with which the territory is used by health services, historically, especially in poorer regions such as the one in question.

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