

## Analysis of potential accessibility to the primary care network in a municipality in the interior of the state Minas Gerais, Brazil

## Análise da acessibilidade potencial à rede de atenção primária em um município do interior mineiro

## Análisis de la accesibilidad potencial a la red de atención primaria en un municipio del interior del estado de Minas Gerais, Brasil

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**Objective:** to evaluate the distribution of Basic Health Units and the potential accessibility to Primary Health Care for the population in the urban area of a municipality in the state of Minas Gerais, Brazil. **Methods:** quantitative study carried out in the first trimester of 2024 in the city of Uberaba, Minas Gerais, using preliminary data from the 2022 Census, from the Brazilian Institute of Geography and Statistics, and location data of Basic Health Units obtained from the Municipal Health Department. It was based on the two-step Floating Catchment Area method to calculate the population's potential accessibility to the Primary Care network. The information generated was analyzed with the aid of thematic maps and descriptive statistics. **Results:** the city of Uberaba has a population of 337,836 inhabitants, of which 310,271 are concentrated in high-density urban areas, and it has 27 Basic Health Units in the urban area. Population distribution: 732 census sectors characterized by high density of buildings, with 48% concentrated between 372 and 721 inhabitants, 31% between 214 and 372, and 7% between 721 and 1265. When considering the radius of influence of 1,000 m from each Basic Health Unit, it is observed that approximately 15 (56%) cover a potential resident population of 6,400 and 12,500 people, while only two (7%) reach between 3,300 and 6,400. In turn, 10 units (38%) cover a potential resident population of 12,500 to 18,700. **Conclusion:** the distribution of Basic Health Units in terms of potential accessibility is adequate and follows the population distribution.

**Descriptors:** Spatial Analysis; Geographic Mapping; Access to Primary Care; Health Planning Support.

**Objetivo:** avaliar a distribuição das Unidades Básicas de Saúde e a acessibilidade potencial à Atenção Primária à Saúde das populações na área urbana de um município mineiro. **Método:** Estudo quantitativo realizado no primeiro trimestre de 2024 na cidade de Uberaba, Minas Gerais, utilizando dados preliminares do Censo de 2022, do Instituto Brasileiro de Geografia e Estatística, e dados de localização das Unidades Básicas de Saúde obtidos junto à Secretaria Municipal de Saúde. Baseou-se no método *two-step Floating Catchment Area method* para calcular a acessibilidade potencial da população à rede de Atenção Primária. As informações geradas foram analisadas por meio de mapas temáticos e estatísticas descritivas. **Resultados:** a cidade de Uberaba possui uma população de 337.836 habitantes, das quais 310.271 concentram-se em áreas urbanas com alta densidade, e dispõe de 27 Unidades Básicas de Saúde na área urbana. A distribuição populacional: 732 setores censitários caracterizados por alta densidade de edificações, sendo que 48% concentra-se entre 372 a 721 habitantes, 31% entre 214 a 372, e 7% de 721 a 1265. Ao considerar o raio de influência de 1.000m a partir de cada UBS, observa-se que, aproximadamente, 15 (56%) cobrem uma população residente potencial de 6.400 e 12.500 pessoas, enquanto apenas duas (7%) alcançam entre 3.300 e 6.400. Por sua vez, 10 unidades (38%) cobrem uma população residente potencial de 12.500 a 18.700. **Conclusão:** a distribuição das Unidades Básicas de Saúde na acessibilidade potencial é adequada e acompanham a distribuição populacional. **Descritores:** Análise espacial; Mapeamento geográfico; Acesso à Atenção Primária; Apoio ao planejamento em saúde.

**Objetivo:** Evaluar la distribución de las Unidades Básicas de Salud y la accesibilidad potencial de la Atención Primaria de Salud a la población en el área urbana de un municipio de Minas Gerais, Brazil. **Método:** Estudio cuantitativo realizado en el primer trimestre de 2024 en la ciudad de Uberaba, Minas Gerais, utilizando datos preliminares del Censo de 2022 del Instituto Brasileño de Geografía y Estadística, y datos sobre la localización de las Unidades Básicas de Salud obtenidos del Departamento Municipal de Salud. Se basó en el método *two-step Floating Catchment Area method* para calcular la accesibilidad potencial de la población a la red de Atención Primaria. La información generada se analizó mediante mapas temáticos y estadísticas descriptivas. **Resultados:** La ciudad de Uberaba tiene una población de 337.836 habitantes, de los cuales 310.271 se concentran en zonas urbanas de alta densidad, y cuenta con 27 Unidades Básicas de Salud en el área urbana. Distribución de la población: 732 secciones censales caracterizadas por una alta densidad de construcción, con un 48% concentrado entre 372 y 721 habitantes, un 31% entre 214 y 372, y un 7% entre 721 y 1265. Al considerar el radio de influencia de 1.000 m de cada UBS, se observa que aproximadamente 15 (56%) abarcan una población residente potencial de entre 6.400 y 12.500 personas, mientras que sólo dos (7%) alcanzan entre 3.300 y 6.400. A su vez, 10 unidades (38%) cubren una población residente potencial de entre 12.500 y 18.700 personas. **Conclusión:** la distribución de las Unidades Básicas de Salud en términos de accesibilidad potencial es adecuada y acorde con la distribución de la población.

**Descritores:** Análisis Espacial; Mapeo Geográfico; Acceso a Atención Primaria; Apoyo a la Planificación en Salud.

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## INTRODUCTION

**A**ccessibility to Primary Health Care (PHC) is an important factor in promoting the health and well-being of populations<sup>1</sup>, just as its Basic Health Units (*Unidades Básicas de Saúde* - UBS) act as the first line of defense in disease control and health care<sup>2</sup>. The COVID-19 health crisis in 2020 drew worldwide attention to the importance of the health care network, the availability of services and their spatial distribution<sup>3,4</sup>.

The spatial analysis of PHC in the urban context is an issue that still requires the expansion of studies, and it is important to focus on its relationship with the distribution of the population across neighborhoods or urban subunits that have different population densities, often in areas that penalize users due to distances, resulting in conditions of segregation from both a socioeconomic and spatial separation point of view<sup>5-7</sup>.

PHC is made up of multidisciplinary teams, with a view to offering integrated care practices to the entire population, and has the capacity to offer both care and treatments, as well as preventive actions, such as referral to specialized services and communication with them, being the gateway to the Health Care Network (HCN)<sup>8</sup>.

To perform this role, the distribution of PHC equipment across the territory needs to be equitable<sup>9</sup>. Access is the possibility of using health equipment that is determined by geographic location, period of operation and the need or not for scheduling<sup>10</sup>.

Accessibility can occur by adjusting the characteristics of the equipment to the needs of the population served in order to facilitate access, whether these characteristics are organizational, sociocultural, economic and/or geographic in nature<sup>10</sup>. The geographic order in accessibility to PHC is presented in the distance, time, cost of transportation and barriers, natural and man-made, between the health unit and the group of individuals who depend on it<sup>11</sup>.

Research that analyzes geographic accessibility is essential for planning actions in the reorganization of the territory and in decision making. Geographic Information Systems (GIS) and spatial analysis tools prove to be effective in planning and decision-making in public health, providing resources for analyzing distances, travel time and conditions of spatial segregation caused by geographic barriers, in addition to allow the correlation of such information with the demographic characteristics of the population, whether of potential or registered users<sup>11-13</sup>. Thus, this study aims to evaluate the distribution of Basic Health Units and the potential accessibility to Primary Health Care for populations in the urban area of a municipality in the state of Minas Gerais, Brazil.

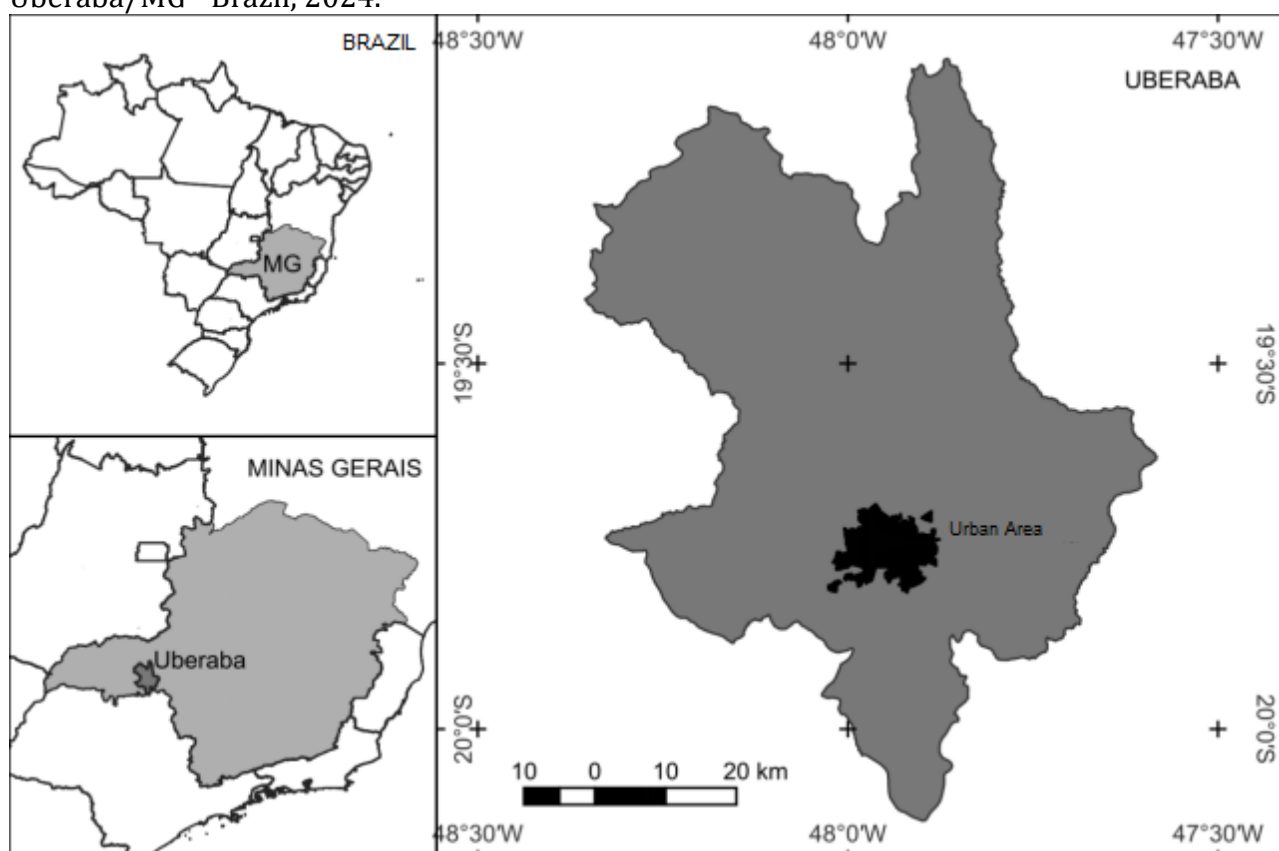
## METHODS

This is a quantitative and descriptive study, with preliminary data from the 2022 Census, made available by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE)<sup>14</sup> for the municipality of Uberaba, Minas Gerais, Brazil, as well as location data for the UBS, obtained from the Municipal Health Department (*Secretaria Municipal de Saúde* - SMS) of Uberaba/MG<sup>15</sup>, carried out in the first quarter of 2024.

The data correspond to the total population grouped by urban census sectors. The georeferenced territorial units (vector polygons) contain the preliminary count of this population. The data relating to the UBS were georeferenced as vector points from a list of addresses, using the Google Earth Pro software. These data were processed in Geographic Information Systems (GIS), using the QGIS software.

The municipality of Uberaba is located in the state of Minas Gerais (Figure 1), and has a total population of 337,836 inhabitants, of which 310,271 are concentrated in urban areas with a high density of buildings, representing 91.84% of the total population<sup>14</sup>. Urban areas with a high density of buildings were chosen as a way to exclude urban voids.

**Figure 1.** Location map of the city of Uberaba, based on the Brazilian map, of Minas Gerais. Uberaba/MG - Brazil, 2024.



Source: Brazilian Institute of Geography and Statistics, Territorial Organization, Territorial Meshes, Census Sectors/Municipal Mesh, 2022.

The PHC in the city of Uberaba is made up of 34 health units, 27 of which are located in the urban area and, therefore, will be the subject of this study<sup>15</sup>. The remaining units serve rural areas or function as support points. In addition to the Primary Care Units, SMS has two Regional Health Units (*Unidades Regionais de Saúde - URS*), which, in practice, are considered specialty outpatient clinics. SMS offers other services, such as psychosocial care, specialized outpatient clinics, the *Melhor em Casa* program, among others, which will not be part of this study.

To construct a measure of the potential accessibility of the urban population to UBS, the principles of accessibility were adopted, using the two-step Floating Catchment Area (FCA) method, which is carried out in two steps to capture floating areas<sup>16</sup>.

The first step consists of finding all people located within a coverage area for each UBS and calculating the UBS/population ratio,  $R_j$  within the coverage area (1). In this case, the distance criterion of 1,000 meters (circular buffer)<sup>16</sup> was applied.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} P_k} \quad (1)$$

In this case,  $j$  is the location of UBS,  $k$  is the population of all census sectors whose centroids are in the area of influence of UBS  $j$ ,  $d_0$  is the distance limit, that is, the area of influence of  $j$ ,  $R_j$  is the proportion of UBS per inhabitants,  $P_k$  is the population of census sector  $k$  whose centroid is in the area of influence ( $d_{kj} \leq d_0$ ) and  $d_{kj}$  is the distance between  $k$  and  $j$ <sup>16</sup>.

The second step consists of capturing the locations of UBS that are within the pre-defined distance limit and, based on the location of each census sector, represented by its centroid, adding the UBS/population ratios observed (2)<sup>16</sup>.

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j = \sum_{j \in \{d_{ij} \leq d_0\}} \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} P_k} \quad (2)$$

To this end,  $A_i^F$  is the accessibility of census sector  $i$  based on the Variable Influence Area (VIA) method in two steps;  $i$  is the population of the census sector;  $j$  location of UBS;  $d_0$  distance threshold from  $i$ ,  $R_j$  proportion between UBS and population for the location of UBS  $j$  whose centroid will be in the area of influence with center at  $i$  ( $d_{ij} \leq d_0$ ); and  $d_{ij}$  is the distance between  $i$  and  $j$ . The  $A_i^F$  value indicates both the existence or not, since the value 0 indicates the absence, of UBS close to that population, as well as the proportion between UBS supply and the population group that demands it, and is directly proportional to the potential accessibility to PHC<sup>16</sup>. The fictitious value 1 (one) would indicate a context in which there was a UBS for each inhabitant in that census sector.

In order to group the individual PA indices generated for each Census Sector, the  $A_i^F$  values obtained were classified according to the Natural Breaks (Jenks) method. This method considers that numerical data sequences have variable gaps or breaks. Thus, the classes would

be formed by individuals located between these breaks, ensuring that the individuals within each group are as similar as possible to each other, that is, they present a minimum variance, and that the groups are as different as possible from each other, presenting a maximum variance<sup>16-19</sup>.

6 (six) classes were established. The first, called PA Null and with a value of zero, indicating the absence of UBS within a radius of one kilometer from the centroid of the census sector. The remaining values were categorized using the Natural Breaks method, resulting in the following classes: Very Low, Low, Average, High and Very High.

After data processing, thematic maps were created representing the resident population by census sector, resident population within the area of influence of each UBS, number of UBS within the area of influence of each census sector and potential accessibility in relation to the PHC network of Uberaba for each census sector. Data analysis was carried out descriptively, using mean, median and standard deviation values, and spatially through the analysis of distribution patterns.

Because secondary data was used and without direct access to human beings, reassessment from the Research Ethics Committee was not requested for this work. However, this work is part of a larger study entitled: *“Referência e Contrarreferência na Prática de Enfermeiros e Médicos: da compreensão conceitual à implantação das ações entre a Atenção Primária à Saúde e Hospital Público de Ensino”* (“Reference and Counter-reference in the Practice of Nurses and Doctors: from conceptual understanding to the implementation of actions between Primary Health Care and Public Teaching Hospital”) and was submitted and approved under the opinion number 6,221,773 of the Ethics and Research Committee of the Universidade Federal do Triângulo Mineiro (UFTM) in compliance with the guidelines of resolutions 466/12.

## RESULTS

The urban population of the municipality of Uberaba is distributed across 732 census tracts characterized by high density of buildings, 31% of which have a resident population between 214 and 372 inhabitants, and only 7% have a resident population between 721 and 1265 inhabitants. However, almost half of the population (48%) is concentrated in sectors with a resident population between 372 and 721 inhabitants. With regard to spatial distribution, it is observed that the census sectors located in central areas have a smaller resident population, a fact that is possibly explained by the urban center concentrating a greater number of services and commerce.

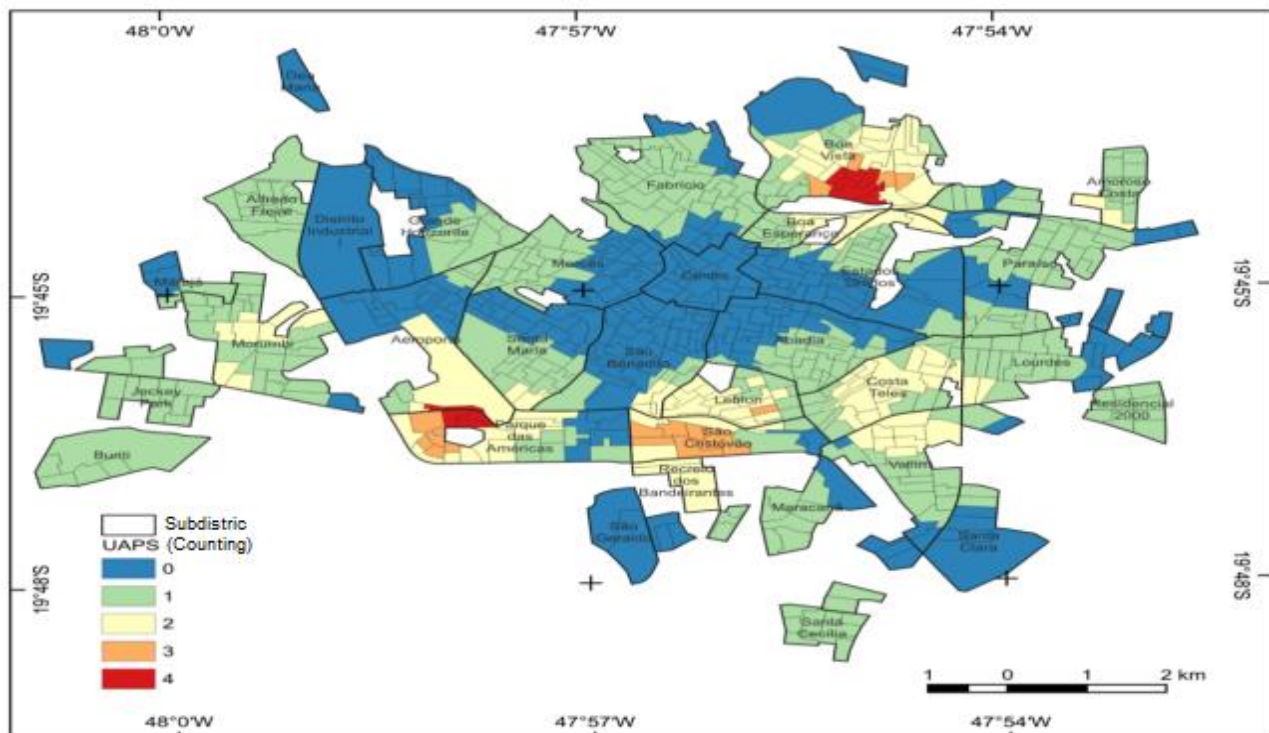
When considering the radius of influence of 1,000m from each UBS, it is possible to observe that approximately 15 (56%) cover a potential resident population of 6,400 and 12,500 inhabitants while only 2 (7%) reach between 3,300 and 6,400 inhabitants. In turn, 10 units (38%) cover a potential resident population of 12,500 to 18,700 inhabitants.

When looking at the data set of the population residing in census tracts whose centroids are included within the radius of influence of the UBS, there is an average of 11,087 inhabitants and a median of 10,869 inhabitants. The standard deviation is 3,929 inhabitants.

With regard to distribution, it is possible to verify that the largest concentration of UBS is located away from the central region, better served by hospital services and emergency care. In these areas, there is an emptying of UBS, however, this distribution is in accordance with the population distribution. Also, in the northeast and southeast portions there are the highest proportions of population per UBS (Figure 2).

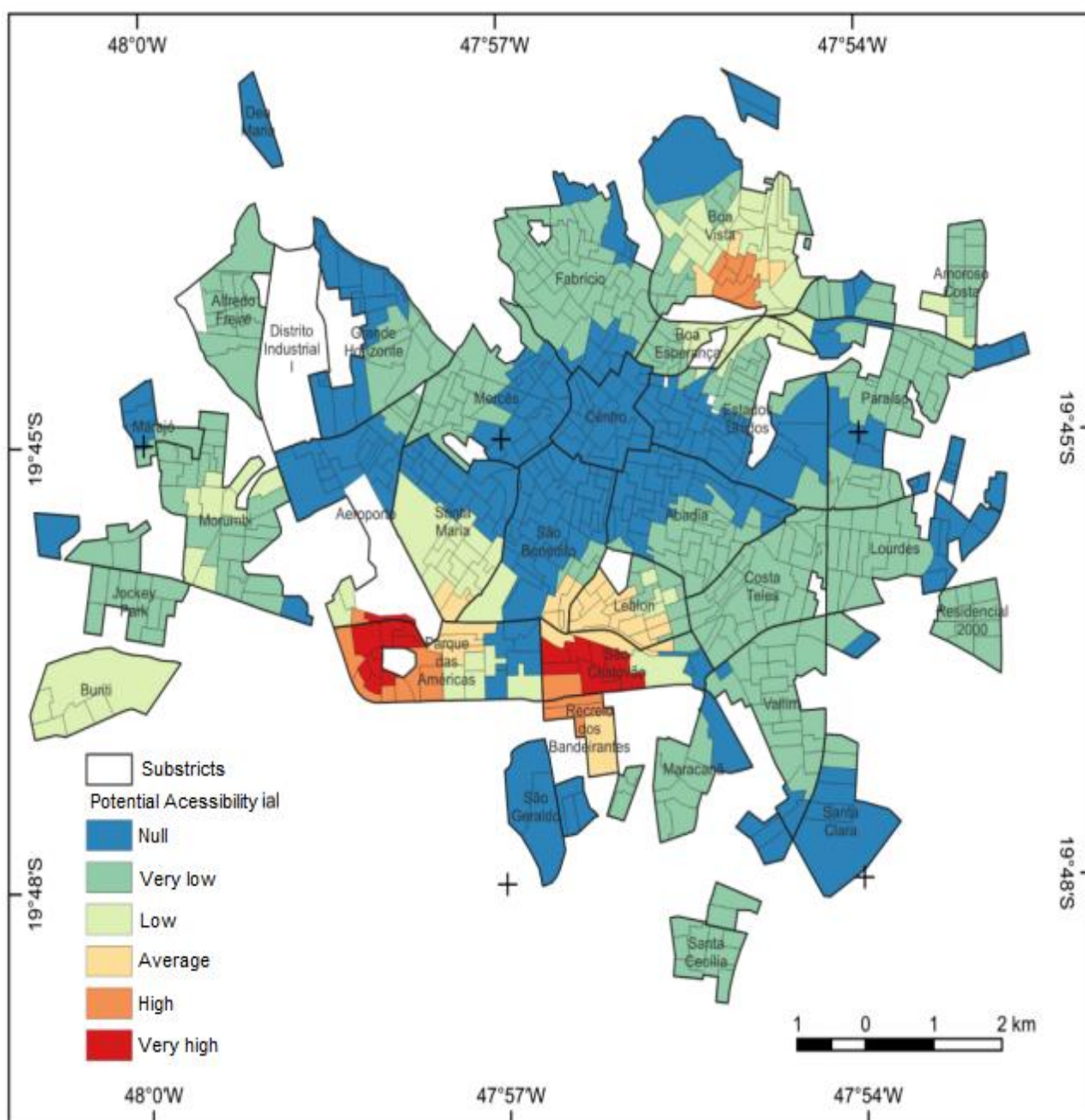
The analysis of the number of UBS per census sector, which is the first step of the two-step FCA method<sup>16</sup>. From this analysis it is observed that approximately 70% of the urban population (214,449 inhabitants) is close to a UBS (Figure 2). In other words, of the 732 census sectors, 459 (approximately 63%) have at least one UBS nearby. However, approximately 30%, or 95,772 inhabitants, residing in 273 census sectors (approximately 37%) do not have UBS nearby. These sectors are predominantly located in the central region, in accordance with what was observed both in the population distribution and in the distribution of UBS.

**Figure 2.** Number of UBS in the area of influence of the census sector. Uberaba/MG - Brazil, 2024.



The second step of the two-step FCA method was carried out by calculating the  $A_i^F$  values, which represent Potential Accessibility (PA). These values ranged from zero, which represent census sectors that do not have UBS within a radius of one kilometer from the radius of their centroids, to 0.0012, which are the sectors with the highest proportion between UBS supply and population living in a census sector whose centroid is in the area of influence of this UBS (Figure 3). In this context, it appears that 36.84% of census sectors have zero accessibility to PHC, 44.74% have very low accessibility, and 8.73% of sectors have PHC with high, high or very high average accessibility. The areas with zero PA are concentrated in the central regions, which have a lower population concentration and lower provision of UBS.

**Figure 3.** Potential accessibility to the PHC network. Uberaba/MG - Brazil, 2024.



From Table 1, it can be seen that there is a relatively equitable PA for health services, with a greater concentration of Basic Health Units (UBS) in the outskirts, with PA of around 67%, and a scarcity of these services in central areas, where there is a lower population density. This pattern is in line with the idea that central areas are better served by hospital and emergency services. However, this indicates that around 12.5% of the population residing in the main urban area of the municipal territory has a critical PA to the UBS, considering the threshold of 1 (one) kilometer away.

**Table 1.** Average potential accessibility, average UBS and resident population per subdistrict, Uberaba/MG - Brazil, 2022.

Subdistrict	PA Mean	UBS Mean	Population
Abadia	0.000026	0.4	15,621
Aeroporto	0.000114	0.6	9,971
Alfredo Freire	0.000147	1.0	6,797
Amoroso Costa	0.000129	1.0	10,895
Boa Esperança	0.000187	1.4	3,385
Boa Vista	0.000256	1.9	22,464
Buriti	0.000304	1.0	3,288
Centro	0.000000	0.0	5,313
Costa Teles	0.000090	1.6	14,019
Dea Maria	0.000000	0.0	24
Distrito Industrial I	0.000000	0.0	-
Estados Unidos	0.000063	0.4	16,938
Fabício	0.000073	0.7	17,730
Grande Horizonte	0.000030	0.3	11,781
Jockey Park	0.000093	1.0	7,539
Leblon	0.000272	1.7	8,149
Lourdes	0.000048	0.8	10,469
Maracanã	0.000096	0.7	7,852
Marajó	0.000053	0.6	6,766
Mercês	0.000041	0.4	11,756
Morumbi	0.000109	1.2	17,326
Paraíso	0.000046	0.6	25,495
Parque das Américas	0.000557	1.8	14,568
Recreio dos Bandeirantes	0.000229	1.0	5,986
Residencial 2000	0.000157	1.0	6,351
Santa Cecília	0.000116	1.0	6,575
Santa Clara	0.000024	0.3	4,742
Santa Maria	0.000124	0.5	13,206
São Benedito	0.000047	0.3	11,934
São Cristóvão	0.000412	1.9	6,566
São Geraldo	0.000000	0.0	1,600
Vallim	0.000087	1.2	13,028

## DISCUSSION

In this study, although the focus is on evaluating the potential accessibility of the urban population to primary health care services, a distinction must be made between urban and rural landscapes. In rural areas, health services are limited in both quantity and density, which leads residents of these regions to tolerate longer trips to access health services in urban centers<sup>20</sup>. In this sense, when establishing the operational criteria for the analysis presented here, this



issue must be viewed with care, as the centroids used in the model analysis vary significantly depending on the location of the population in the polygon.

In urban population polygons (census sectors; neighborhoods; communities, and others), the measure of accessibility generally varies by a few hundred meters, whereas, in rural areas, this measure can reach tens of kilometers, due to the greater dimensions of counting polygons<sup>20</sup>. Therefore, adopting the 1,000 meter threshold as a reference for urban analysis does not correspond to a standard that can be replicated in any geographic situation, which needs to be considered according to each reality.

The 2SFCA model is especially relevant in research to evaluate the provision of health services for the urban population of a medium-sized Brazilian city (100 thousand to 500 thousand inhabitants). Due to the various modifications and propositions that the original 2SFCA model underwent, it is essential to highlight the most recent evidence on its applicability. The applicability and limitations of the different 2SFCA<sup>20</sup> models are widely discussed. Based on service location and population data, an international study analyzed 24 variations of the model and compared the results using statistical methods. From this, recommendations are proposed on how to choose the most appropriate parameters for the model, aiming to analyze equity in spatial access to health services in planning contexts<sup>20</sup>.

Therefore, regardless of which variation of the 2SFCA model is being used, the size of the capture area plays a fundamental role in assessing accessibility. On a smaller spatial scale (such as: neighborhood level or urban area), the threshold distance must be carefully examined due to the high variability of the accessibility index according to the size of the buffer, requiring a thorough assessment of the size of the capture area in 2SFCA applications. In practice, when defining the size of the capture area, it is important to consider a distance that people are willing to travel<sup>16</sup>.

The acceptability of this travel distance varies not only between different modes of transport, but also between individuals. Therefore, when analyzing accessibility for a specific population, such as people with disabilities or specific limitations (not having a car, being a group of mobility impaired people, pregnant women, children), it is necessary to reconsider this standard parameter.

In urban-scale approaches, the size of the capture area (buffer) is the most important criterion in the model, which can result in a high degree of uncertainty in measurements, when not considered appropriately. In some research that addresses the decline over distance in the use of services, not necessarily health services, it is suggested to use a buffer of 0.5 miles, approximately 800 meters<sup>21,22</sup>.

Studies related to walkability in urban built environments have empirically demonstrated that self-reported travel behaviors indicate that the majority of walking trips occur within a 1,000 meter range, suggesting that this may be a meaningful measure for evaluating Primary Healthcare (PHC)<sup>23,24</sup>.

The research results represent significant exploratory measures for the initiation of planning projects that consider the Geographic Accessibility component. In the case of Uberaba, the PA indicates a general overview of the population's accessibility to UBS in the territory, suggesting an exploratory assessment of the distribution of health services.

However, a detailed analysis of the areas where AP was in the “null”, “very low”, “low” and “average” classes within the 1,000m threshold is recommended, as they represent around 1/3 of the urban population. Furthermore, it is imperative to think about instruments that can empirically measure coverage in these regions, thus advancing more accurate information on the level of real accessibility in these areas, with a view to improving planning for the provision of health services in the territory.

Refining the accessibility model, based on empirical data on the use of and demand for basic health services, can consider specific contextual factors, such as population mobility and the availability of public transport. This would improve the accuracy of analyzes and help guide more effective policies. The integration of participatory approaches, which involve the community in identifying needs and prioritizing actions, can also contribute to greater equity in access to health services.

The relevance of monitoring and evaluating accessibility to health services is added using approaches such as that provided by the 2SFCA model, adapting it to local specificities. It is important to add other demographic variables and empirical data, allowing more precise analyzes of the spatialization of services in the territory and providing pertinent information for the management of health services.

## CONCLUSION

This research analyzed the AP of the urban population of the city of Uberaba to the primary care network, verifying that there is an equitable distribution of UBS in relation to the population in the urban area. There is a greater number of UBS located in areas with the highest population concentration, which are mainly in peripheral regions. However, approximately one third of the resident population is located in areas with access to PHC classified as average to zero. Therefore, a more detailed investigation is recommended, including instruments that can empirically measure the real accessibility of these areas.

This study's limitation is that it is an analysis of potential geographic accessibility, which does not allow comparisons with real accessibility, since there are no studies that allow such comparisons on real access to PHC in the municipality studied. However, this issue opens up an opportunity for future work that can expand the topic and its importance in understanding accessibility in PHC, in addition to supporting municipal health planning.

## REFERENCES

1. Kim K, Kwon K. Time-varying spatial accessibility of primary healthcare services based on spatiotemporal variations in demand, supply, and traffic conditions: A case study of Seoul, South Korea. *J Transp & Heal* [Internet]. 2022 [cited in 20 May 2024]; 27:101531. Available from: <https://www.sciencedirect.com/science/article/pii/S2214140522002031>
2. Xu H, Zhao J, Yu X. A Community-Oriented Accessibility Index of Public Health Service Facilities: A Case Study of Wuchang District, Wuhan, China. *Sustainability* [Internet]. 2023[cited in 20 May 2024];15(14):10870. Available from: <https://www.mdpi.com/2071-1050/15/14/10870>
3. Pereira RHM, Braga CKV, Servo LM, Serra B, Amaral P, Gouveia N, et al. Geographic access to COVID-19 healthcare in Brazil using a balanced float catchment area approach. *Soc Sci & Med* [Internet]. 2021[cited in 20 May 2024]; 273:113773. Available from: <https://www.sciencedirect.com/science/article/pii/S0277953621001052>
4. Silva LL, Carvalho Dutra A, Andrade L, Iora PH, Rodrigues Ramajo GL, Peres Gualda IA, et al. Emergency care gap in Brazil: geographical accessibility as a proxy of response capacity to tackle COVID-19. *Front Public Heal* [Internet]. 2021[cited in 20 May 2024]; 9:740284. Available from: <https://www.frontiersin.org/articles/10.3389/fpubh.2021.740284/full>
5. Menezes TA, Sousa MAC, Gomes LB, Barbosa DS, Sampaio J. Distribuição espacial dos serviços de saúde especializados para pessoas com deficiência em João Pessoa/PB: uma análise sobre o acesso em saúde. *Rev Bras Estud urbanos e Reg* [Internet]. 2022[cited in 20 May 2024];24:e202241. Available from: <https://www.scielo.br/j/rbeur/a/K4YGk3cw4tH6dCTy6vP8hzM/?lang=pt>
6. Goudard B, Oliveira FH, Gerente J. Avaliação de modelos de localização para análise da distribuição espacial de unidades básicas de saúde. *Rev Bras Cartogr* [Internet]. 2015[cited in 20 May 2024];67(1):15-34. Available from: <https://seer.ufu.br/index.php/revistabrasileiracartografia/article/download/44723/23737/185155>
7. Shah TI, Bell S, Wilson K. Spatial accessibility to health care services: Identifying under-serviced neighbourhoods in Canadian urban areas. *PLoS One* [Internet]. 2016[cited in 20 May 2024];11(12):e0168208. Available from: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0168208>
8. Ministério da Saúde (Br). Gabinete do Ministro. Portaria nº 2,436, de 21 de setembro de 2017. Aprova a Política Nacional de Atenção Básica, estabelecendo a revisão de diretrizes para a organização da Atenção Básica, no âmbito do Sistema Único de Saúde (SUS)[Internet]. Brasília, DF: Ministério da Saúde; 2017 [cited in 20 May 2024]. Available from: [https://bvsms.saude.gov.br/bvs/saudelegis/gm/2017/prt2436\\_22\\_09\\_2017.html](https://bvsms.saude.gov.br/bvs/saudelegis/gm/2017/prt2436_22_09_2017.html).
9. Mendes EV. As redes de atenção à saúde. *Cien Saude Colet* [Internet]. 2010[cited in 22 May 2024]; 15:2297–305. Available from: <https://www.scielosp.org/pdf/csc/2010.v15n5/2297-2305/pt>
10. Pinho ECC, Cunha TAN, Lemos M, Ferreira GRON, Lourenção LG, Pinheiro HHC, et al. Acceso y accesibilidad en la atención primaria de salud en Brasil. *Enferm Foco* [Internet]. 2020[cited

- in 22 May 2024];11(2):168–75. Available from: <https://enfermfoco.org/es/article/acceso-y-accesibilidad-en-la-atencion-primaria-de-salud-en-brasil/>
11. Silva Júnior ES, Medina MG, Aquino R, Fonseca ACF, Vilasbôas ALQ. Acessibilidade geográfica à atenção primária à saúde em distrito sanitário do município de Salvador, Bahia. *Rev Bras Saúde Matern Infant* [Internet]. 2010[cited in 22 May 2024];10:s49-s60. Available from: <https://www.scielo.br/j/rbsmi/a/KNnhNntdkYkkLtBG39Bw7rM/?format=html&lang=pt>
12. Ferreira RV, Graca Raffo JG. O tempo de viagem da população rural aos serviços de saúde mapeado em sistemas de Informação Geográfica (SIG). *GEOUSP Espaço e Tempo* [Internet]. 2014[cited in 22 May 2024];18(1):211–29. Available from: <https://www.revistas.usp.br/geousp/article/view/81101>
13. Calistro MO, Teixeira Y, Lacerda IRAS, Sousa SM, Neto JA, Duavy SMP, et al. Territorialization using georeferencing and stratification of the social vulnerability of families in primary care. *Cienc e Saude Coletiva*[Internet]. 2021[cited in 22 May 2024]; 26(6):2141-8. Available from: <https://www.scielo.br/j/csc/a/Z5cJ6HN8kzbYMstfHGd7PxD/abstract/?lang=pt>
14. Instituto Brasileiro de Geografia e Estatística. Censo Demográfico [Internet]. 2022 [cited in 22 May 2024]. Available from: <https://www.ibge.gov.br/estatisticas/sociais/trabalho/22827-censo-demografico-2022.html?=&t=downloads>
15. Prefeitura Municipal de Uberaba. Lista de gerentes atualizada 2024: Unidades da Atenção Básica [Internet]. 2024 [cited in 22 May 2024]. Available from: <http://www.uberaba.mg.gov.br/portal/acervo/saude/arquivos/unidades%20basicas.pdf>
16. Luo W, Wang F. Measures of spatial accessibility to health care in a GIS environment: Synthesis and a case study in the Chicago region. *Environ Plan B Plan Des* [Internet]. 2003[cited in 24 May 2024]; 30(6):865-84. Available from: [https://journals.sagepub.com/doi/abs/10.1068/b29120?casa\\_token=o0A5AyjeB0gAAAAA:AkPtGKvH1kaIF\\_QNfHw5M8J44ExVkPszFI3XkuziEQweYhT2XRGF0YVNo85Wkobi80YZI41WTIpo](https://journals.sagepub.com/doi/abs/10.1068/b29120?casa_token=o0A5AyjeB0gAAAAA:AkPtGKvH1kaIF_QNfHw5M8J44ExVkPszFI3XkuziEQweYhT2XRGF0YVNo85Wkobi80YZI41WTIpo)
17. Ward M, Poleacovschi C, Perez M. Using AHP and spatial analysis to determine water surface storage suitability in Cambodia. *Water*[Internet]. 2021[cited in 27 June 2024];13(3):367. Available from:<https://www.mdpi.com/2073-4441/13/3/367>
18. Menezes Ribeiro DD, Silva HS. Sistema de informações geográficas aplicado à análise espacial da covid-19 no estado de alagoas, nordeste do brasil. *Hygeia Rev Bras Geogr Médica e daSaúde* [Internet]. 2020[cited in 27 June 2024];16:397. Available from: <https://seer.ufu.br/index.php/hygeia/article/download/56929/30397>
19. Dent BD, Torguson JS, Hodler TW. *Cartography: Thematic map design*. 6th ed. WCB/McGraw-Hill; 2009.
20. Chen X, Jia P. A comparative analysis of accessibility measures by the two-step floating catchment area (2SFCA) method. *Int J Geogr Inf Sci* [Internet]. 2019[cited in 04 June 2024];33(9):1739-58. Available from: [https://www.tandfonline.com/doi/abs/10.1080/13658816.2019.1591415?casa\\_token=URBMxFAz1TsAAAAA:2egxxQyqtti8u1V0JALiwpbRjYbSr2WMcO6p7hwotMqJPd-wJrweDqrxAff19G53nAIHiM4GqGEIFw](https://www.tandfonline.com/doi/abs/10.1080/13658816.2019.1591415?casa_token=URBMxFAz1TsAAAAA:2egxxQyqtti8u1V0JALiwpbRjYbSr2WMcO6p7hwotMqJPd-wJrweDqrxAff19G53nAIHiM4GqGEIFw)
21. Li B, Huang Z, Xia J, Li W, Zhang Y. Coupling degree between the demand and supply of bus services at stops: a density-based approach. *ISPRS Int J Geo-Information* [Internet]. 2021 [cited in 08 June 2024]; 10(3):173. Available from: <https://www.mdpi.com/2220-9964/10/3/173>
22. Chen X. Take the edge off: A hybrid geographic food access measure. *Appl Geogr* [Internet]. 2017[cited in 08 June 2024]; 87:149–59. Available from: <https://www.sciencedirect.com/science/article/pii/S014362281730173X>

23. Houston D. Implications of the modifiable areal unit problem for assessing built environment correlates of moderate and vigorous physical activity. *Appl Geogr* [Internet]. 2014[cited in 23 June 2024];50:40-7. Available from: [https://www.sciencedirect.com/science/article/pii/S0143622814000307?casa\\_token=4wDRRCiOmrIAAAAA:AAbJu389UCeaazw\\_KgABj5DilgD0z05EhU4lYxEBxjOuAr6NMIKAZ8K4CijniW8XO\\_BfzGBELuc](https://www.sciencedirect.com/science/article/pii/S0143622814000307?casa_token=4wDRRCiOmrIAAAAA:AAbJu389UCeaazw_KgABj5DilgD0z05EhU4lYxEBxjOuAr6NMIKAZ8K4CijniW8XO_BfzGBELuc)
24. Leão ALF, Abonizio HQ, Reis RS, Kanashiro M. Walkability variables: an empirical study in Rolândia - PR, Brazil. *Ambient constr* [Internet]. 2020[cited in 23 June 2024]; 20(2):475-88. Available from: <https://doi.org/10.1590/s1678-86212020000200410>

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**Januário Chirieleison Fernandes** contributed to the design, data collection and analysis, writing and revision. **Ricardo Vicente Ferreira** contributed to the design, data analysis, writing and revision. **Manuela de Abreu, Daniel Edson Silva Caixeta** and **Célia Maria Oliveira Carvalho** contributed to writing and revision. **Álvaro da Silva Santos** contributed to the conception, writing and revision.

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