


Identification of areas with geographic difficulties in accessing public health services in Costa Rica: a methodological proposal

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Abbreviations:

CCSS, Caja Costarricense de Seguridad Social; EBAIS, Equipos Básicos de Atención en Salud; INEC, Instituto Nacional de Estadísticas y Censos; UGM, Unidades Geoes-tadísticas Mínimas.

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Abstract

Aim: The purpose of this study is to present and apply a methodological tool to identify areas in which access to health services could be difficult for the population due to geographical barriers, both in terms of distance to the medical center and travel capacity, specifically in the cantons of Curridabat, Escazú, and Desamparados.

Methods: based on the geographic division of the country in minimum geostatistical units carried out by the National Institute of Statistics and Census, the distance in minutes was calculated for each unit that it would take to walk, by the fastest real route, from the minimum geostatistical unit to the headquarters of its assigned basic health care team.

Results: 3.4% of the population studied lived in a minimum geostatistical unit classified as *having significant difficulty in accessing health services*, as it had both the physical barrier of distance and low mobility by automobile and low socioeconomic status. Sixty-five minimum geostatistical units were identified (out of 2014 included in the study) that were more than a 20-minute walk from the headquarters of their basic health care team and whose population had low travel capacity and low socioeconomic status; most of them were in the Desamparados Health Area.

Conclusion: This study presents a methodological tool to be applied in the identification of areas whose population may find it difficult to access health services geographically, both because of their distance to a medical center and their ability to travel, specifically in the cantons of Curridabat, Escazú, and Desamparados.

Keywords: accessibility to health services, socioeconomic factors, medical geography, public health, mobility, primary care, cantons.

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Access to health care services is one of the fundamental determinants of the health of populations (World Health Organization. A conceptual framework for action on the social determinants of health. Geneva: WHO; 2010. [accessed 27-03-2022]. Available at: <https://apps.who.int/iris/handle/10665/44489>) and is considered part of the essential functions of public health (PAHO. Public health in the Americas. New concepts, performance analysis, and bases for action. Washington: PAHO; 2002. [accessed 21-04-2022]. Available at: https://iris.paho.org/bitstream/handle/10665.2/42858/9275315892_spa.pdf?sequence=1&isAllowed=y). In addition, it is essential to promote, protect and maintain health to prevent and treat morbidity

and mortality^{1,2} and to reduce social gaps or inequities in this area (Commission on Social Determinants of Health. Closing the gap in a generation: Health Equity Through Action on the Social Determinants of Health. Final Report. Geneva: WHO; 2008. [accessed 15-05-2022]. Available at: <https://www.who.int/publications/i/item/WHO-IER-CSDH-08.1>). Ideally, it should ensure entry into the public health care system with the broad coverage of universal, compulsory, equitable, accessible, quality, and timely social insurance. (Healthy People 2020. Access to health services. [accessed 01-12-2020] Available at: <https://www.healthypeople.gov/2020/topics-objectives/topic/Access-to-Health-Services#1>).

Access to health services has been defined and measured from various perspectives.³⁻⁶ One of these is the demand for services, which refers to the extent to which people obtain the care they require from health care services. Another perspective is that of supply, which considers the resources used in care to generate a result in the health status of individuals, measured in terms of variables such as the time to achieve the results, the effectiveness of actions, and the satisfaction of both users and providers; all these elements are integrated from a dimension of quality of health care services. Another perspective considers access from the point of view of universal and equitable health services and focuses on reducing social inequalities in health care by examining economic, geographic, ethnic, cultural, social, labor, policy, and regulatory aspects, among others.

Huot et al. in 2019 identified the main barriers to access to health services. In the case of the Nordic countries, these were (i) the influence of physical geography; (ii) the barriers related to health care providers; (iii) socioeconomic status, culture, and language; and (iv) the impact of systemic factors, related to the preparation and management of human resources in health, the existence of fragmented health care management, lack of communication between the managerial and operational levels, and financial difficulties of the health system. When studying the main barriers to accessing health services, the role of physical geography is evident, including the distance people must travel to health centers, seasonal weather conditions, and the state of public transportation.⁷ These barriers have short, medium, and long-term implications, such as an increase in unmet health needs, delays in receiving adequate care, difficulty in obtaining preventive services, increased financial burdens, and avoidable

hospitalizations, among others. Some authors have documented that people living closer to health centers and hospitals have higher rates of service use compared to those living farther away once the respective health needs are taken into account. For the most part, studies relating distance to health facilities to health impact have been consistent in showing that greater distance may be associated with poorer health.⁸

In addition, it is well known that there are differences in access to health services according to the social, economic, and cultural characteristics of population subgroups.^{9,10} Thus, a gradient is observed that correlates groups with greater social vulnerability with reduced opportunities to access health services, compared to more advantaged social groups (OECD. Health for everyone? Social inequalities in health and health systems. Paris: OECD Health Policy Studies; 2019. [accessed 25-05-2022]. Available at: <https://bit.ly/3SLnibA>). This has been reported in both middle-income countries¹¹ and high-income countries with universal health systems (European Social Policy Network. Baeten R, Spasova S, Vanhercke B, Coster S. Inequalities in access to healthcare. A study of national policies 2018. Brussels: European Commission; 2018. [accessed 25-05-2022]. Available from: <https://www.ose.be/fr/publication/inequalities-access-healthcare-study-national-policies>).

In Costa Rica, the Caja Costarricense de Seguridad Social (CCSS) is a public institution that is part of the health sector and provides most healthcare services to the population. It is organized functionally into three levels of care and, territorially, into seven regions. The more than 1,000 Basic Health Care Teams (EBAIS), together with some peripheral clinics and deconcentrated outpatient clinics, represent the first level unit and are the gateway to the system (García González R. The national health system in Costa Rica: General Information. San José: CCSS; 2004. [accessed 17-01-2022]. Available at: <https://www.binasss.sa.cr/opac-ms/media/digitales/El%20Sistema%20Sistema%20nacional%20de%20salud%20en%20Costa%20Rica.%20Generalidades.pdf>). The EBAISs were developed following a model based on intra- and extramural care as a key tool for expanding the coverage of health services and ensuring care based on five preventive and timely care programs according to the life course.¹² They emerged within the framework of the health sector reform, which redefined the health care model and transcended medical actions to community-based ones,¹³ and are based on an effort

to deconcentrate care from the specialized services of public hospitals or clinics and serve on average population groups from 3,500 to 4,000 people.¹⁴ Each EBAIS is staffed by a medical professional, a nursing assistant, a primary care technical assistant, a medical records technician, and a support team that facilitates the management of the services provided in each CCSS health area. This support team may include a social worker, a nurse, a physician, a nutritionist, a pharmacist, a microbiologist, and a medical records technician.¹⁴ Individuals in the communities are assigned an EBAIS according to their residence; thus, individuals do not choose the EBAIS that corresponds to them (PAHO. Profile of Costa Rica's health system and services based on the monitoring framework of the regional universal health strategy. San José: PAHO; 2019. [accessed 27-03-2022]. Available at: <https://iris.paho.org/handle/10665.2/38590>).

In Costa Rica, a study on access to health services led by Rosero-Bixby was conducted in 2004 to assess the impact of the health sector reform on access to services.¹⁵ This study showed that nearly 50% of Costa Ricans live less than 1 km from an ambulatory health care center and less than 5 km from a hospital. It was observed that between 12% and 14% of the population encountered barriers to accessing health care services. The authors conclude that there was evidence of improvements in access to health care and that they were linked to the health sector reform implemented in 1995. This study had limitations inherent to the time at which it was developed. For example, distances were calculated by hand and in a straight line, which reduces the precision of the estimates and increases calculation times. In addition, it was not considered that the perception of physical distance may differ according to the socio-cultural and economic characteristics of the population¹⁶ and according to their access to motorized vehicles. An update of this methodology is necessary.

Recent studies have used Geographical Information System (GIS) mapping technologies to determine levels of health accessibility by mapping users' places of residence and calculating travel times to their corresponding health facilities. The National Institute of Statistics and Census (INEC) has divided the country geographically and created a more precise unit, called the minimum *geostatistical unit* (MGU). This is defined by INEC as "the geographic space of polygonal shape (block or square) and variable surface. It is made up of a group of dwellings, buildings, properties, lots, or land for

housing, commercial, industrial, and service, among others. [...] it is delimited by streets, sidewalks, fences, ravines, crop areas, and other elements". In Costa Rica, there is more than 38,000 MGUs, according to the 2011 census, with an average population of 111 people each. With this information, it is then possible to calculate the distance between each MGU and its respective EBAIS in each health area. (INEC. Geographical classification manual for statistical purposes of Costa Rica. San José: INEC; 2016. [accessed 12-12-2021]. Available at: <https://www.inec.cr/sites/default/files/documentos-biblioteca-virtual/meinstitucionalmcgfeocr.pdf>).

The CCSS has certainly promoted equitable access to health services for all the country's inhabitants,¹⁴ however, this study aims to generate evidence on whether at the local level the primary healthcare centers where EBAISs are located, have a geographic location that favors equitable access to user populations.

The objective of this study is to present and apply a methodological tool to identify the areas in which the inhabitants may have difficulties in geographic access to health services, both because of their distance to the health center and their ability to travel, specifically in the cantons of Curridabat, Escazú, and Desamparados.

Methods

Description of the health areas and cantons studied

The study included the health areas of Escazú, Desamparados 1, 2, and 3, and Curridabat. The MGUs of these health areas that did not belong to the cantons of Escazú, Desamparados, or Curridabat were excluded (n=25), except for the MGUs of La Unión (Desamparados Health Area 3), which were included in the canton of Desamparados. The characteristics of the three cantons (Escazú, Desamparados, and Curridabat) are presented in Table 2.

In total, 2014 MGUs were included. According to the 2011 Census, 291,000 people lived in the area studied, representing 7% of Costa Rica's population. The average population of a MGU in the studied area is 145 people. Half of the MGUs have 96 people or less, 75% have 174 people or less, and only 1% have more than 705 people.

Centroids of the MGUs

In the 2011 Census, the CRTM05 projection was used as the reference system to georeference the centroid (or barycenter) of each MGU. The QGIS geographic information system program was used to transform the projections of the geographic coordinates to the WGS84 system. Both systems (CRTM05 and WGS84) allow referencing

longitude and latitude coordinates to identify a particular point on a map. However, the system used by the INEC is the CRTM05, so a mathematical transformation of the coordinates had to be performed to transfer the INEC data to the corresponding version in the WGS84 system. This transformation was done using the QGIS program. In the maps presented in this article, each point represents the centroid of a MGU.

	Escazu	Desamparados	Curridabat	Total
<i>Number of MGUs</i>	471	477	1066	2014
Displacement capacity N (%)				
<i>High</i>	351 (74,4%)	384 (36,6%)	331 (67,1%)	1066 (52,9%)
<i>Medium</i>	78 (16,5%)	334 (31,8%)	65 (13,2%)	477 (23,7%)
<i>Low</i>	43 (9,1%)	331 (31,6%)	97 (19,7%)	471 (23,4%)
Distance to EBAIS				
<i>Less than 10 minutes</i>	124 (26,3%)	384 (36,6%)	204 (41,4%)	712 (35,4%)
<i>10 to 20 minutes</i>	197 (41,7%)	456 (43,5%)	185 (37,5%)	838 (41,6%)
<i>20 minutes or more</i>	151 (32,0%)	209 (19,9%)	104 (21,1%)	464 (23,0%)
The difficulty of access to EBAIS				
<i>Without difficulty</i>	429 (90,9%)	790 (75,3%)	459 (93,1%)	1678 (83,3%)
<i>With moderate difficulty</i>	30 (6,4%)	210 (20,0%)	31 (6,3%)	271 (13,5%)
<i>With significant difficulty</i>	13 (2,8%)	49 (4,7%)	3 (0,6%)	65 (3,2%)
Population distribution by travel capacity				
<i>High</i>	63,2%	31,4%	52,3%	42,1%
<i>Medium</i>	27,6%	39,8%	18,8%	32,9%
<i>Low</i>	9,2%	28,7%	28,9%	25,0%
Distance to EBAIS				
<i>Less than 10 minutes</i>	27,5%	34,7%	41,8%	34,9%
<i>10 to 20 minutes</i>	41,5%	46,6%	39,6%	44,1%
<i>20 minutes or more</i>	31,0%	18,7%	18,5%	21,0%
The difficulty of access to EBAIS				
<i>Without difficulty</i>	89,6%	74,2%	87,2%	80,0%
<i>With moderate difficulty</i>	7,7%	21,4%	11,4%	16,5%
<i>With significant difficulty</i>	2,7%	4,4%	1,4%	3,4%

Allocation of EBAIS

In Costa Rica, individuals can access their respective assigned EBAIS, according to their area of residence. To link the EBAIS corresponding to each MGU and to geolocate the different EBAIS, the CCSS sector layers were used. In other words, the geolocation unit of the CCSS has all the maps of the health areas of Costa Rica, which contain, geographically, the areas covered by each EBAIS. Since some layers are outdated, communication was established with each of the health areas studied to obtain the physical maps and thus corroborate and update the information provided. These necessary adjustments were made using the QGIS program. Finally, the updated sector layers and the MGU centroid layers were merged using the *Attributes by location* option of the QGIS program.

Calculation of the distance between the MGU and the EBAIS

The distance was calculated according to the number of minutes it would take to walk it, to consider the topography of the itinerary based on the fastest actual route between the MGU and its assigned EBAIS.

An algorithm was programmed with the Excel program and the VBA programming language was used to calculate the distance according to the minutes it would take to walk from the MGU centroid to the EBAIS. The algorithm allowed systematizing the queries to the Google Maps System, Distance Matrix. These were done through the URL maps.googleapis.com/maps/api/distancematrix/xml?units=metric. The options *& origins* and *& destinations* were used with the geographic coordinates (latitude and longitude) of the centroids of each MGU and its assigned EBAIS. *Distance Matrix* uses WGS84 as a reference system. Using these tools and the algorithm, it was possible to systematize a database with the geographic location of each MGU, as well as that of all the EBAIS of the areas. Based on the map layers, the EBAIS corresponding to each MGU was identified. Subsequently, physical constraints were considered. For example, when people live in a neighborhood that has only one exit, only that exit was considered and not the nearest theoretical distance between the MGU and their respective EBAIS. Other physical barriers were also taken into account, such as areas without roads, or distances on flat or sloping terrain. The MGUs were divided into three groups according to the time it would take to travel the distance to the EBAIS:

less than 10 minutes, 10 to 20 minutes, 20 minutes, and more. According to the data from this analysis, in the area studied, 10 minutes on foot corresponds on average to 800 meters (4.8 km/h) and 20 minutes to 1550 meters (4.7 km/h).

The capacity of the population to travel by motor vehicle in each MGU

The MGUs were divided into three categories (low, intermediate, and high) depending on the travel capacity of the population living in them. We used the percentage of people per household that had a motor vehicle, whether it was a motorcycle (motorcycle) or a car (car) according to the 2011 Census; this indicator is also a tool for measuring the socioeconomic position of people in the district. Indeed, in Costa Rica, wealth indicators are established according to the devices used in the household, including car and motorcycle ownership.¹⁷ In addition, in the 2011 Census, the number of unsatisfied basic needs (UBN) was used to classify households from the most advantaged (no deprivations) to the most disadvantaged (4 deprivations). Within the households without deprivations, 49% had a car or a motorcycle. In households with 1, 2, or 3 deprivations, 28%, 14%, and 7% respectively had a car or a motorcycle. Finally, in households with 4 deprivations, only 5% had a car or a motorcycle.

Based on the 2011 Census data, the Costa Rican population was divided into three equal groups in terms of size. From these terciles, it was defined that one out of every three inhabitants of Costa Rica lived in a MGU in which less than 34.4% of the population owned a motorcycle or car in 2011; these MGUs were categorized as “low traveling capacity” MGUs. Similarly, one out of every three inhabitants of Costa Rica lived in a MGU in which more than 52.8% of the population had a motorbike or car in 2011; these MGUs were categorized as having “high traveling capacity”. Finally, one out of every three inhabitants of Costa Rica lived in a MGU in which between 34.4% and 52.8% of the population owned a motorcycle or a car in 2011 (“intermediate traveling capacity”).

The difficulty of access to the EBAIS

Three categories of MGUs were defined, according to the difficulty of access to the EBAIS: “with no difficulty of access”, “with moderate difficulty of access”, and “with significant difficulty of access”. These categories were defined based on the

time it takes to travel the distance to the EBAIS and the population's ability to travel. The category "with the significant difficulty of access" corresponds to the MGUs with a low percentage of households that have a motorcycle or car and that are 20 minutes or more on foot from the EBAIS (Table 1). The category "with moderate difficulty of access" corresponds to the

MGUs with a low percentage of households with a motorcycle or car and that is located between 10 to 20 minutes or more walking distance from the EBAIS or with an intermediate percentage of households with a motorcycle or car and that are 20 minutes or more walking distance from the EBAIS. The category "no access difficulty" corresponds to the rest of the MGUs.

Table 1. Characterization of the minimum geostatistical units according to the population's ability to travel by motor vehicle and walking distance to the EBAIS, Costa Rica

	<i>High</i>	<i>Intermediate</i>	<i>Download</i>
Walking time to EBAIS	<i>more than 53% with a motorcycle or a car</i>	<i>from 34% to 53% with a motorcycle or a car</i>	<i>less than 34% with a motorcycle or a car</i>
<i>Less than 10 minutes</i>	Without difficulty	Without difficulty	Without difficulty
<i>From 10 to 20 minutes</i>	Without difficulty	Without difficulty	Difficulty moderate
<i>20 minutes or more</i>	Without difficulty	Difficulty moderate	Difficulty important

Maps

The maps were made using the QGIS program and the OpenStreetMap layer to identify the different neighborhoods based on the points representing the centroids of each EBAIS. Three maps were made with the classification by "difficulty of access to EBAIS", one for each canton.

Statistical Analysis

The main indicator was the percentage of people living in each of the three EBAIS access categories according to the 2011 Census data. This indicator was presented by canton, in the general population, and there was a focus on the population living in MGUs with low and intermediate travel capacity.

The average distance to the EBAIS (in minutes and meters) in each canton was also estimated by weighting the distance between each MGU and its respective EBAIS by the population of the MGU, according to the 2011 Census.

Ethical principles

This work is part of research project B7365 entitled "Development of a model and methodological guide for the analysis of health inequities in selected cantons of Costa Rica: An approach from the analysis of theories and methodologies used globally for their approach" registered at the School of Public Health, University of Costa Rica. No additional approval from the Scientific Ethical Committee was required.

Results

The characteristics of the MGU and the population of the cantons studied are described in Table 2. The three cantons studied have different socioeconomic characteristics. In Escazú, only 9.2% of the population lives in a MGU with low population displacement capacity. In Curridabat and Desamparados, this figure reaches 28.9% and 28.7%, respectively. In Curridabat, 52.3% of the population lives in a MGU with a high population displacement capacity, compared to 63.2% in Escazú and only 31.4% in Desamparados. The three cantons studied also differ concerning the distance to the EBAIS. In Escazú, the average time to travel the distance between the MGU centroid and the EBAIS was 17.4 minutes walking (1301 m) versus 14.0 minutes in Desamparados (1088 m) and 13.7 minutes in Curridabat (1091 m). As a result, in Escazú, 31.0% of the population lives 20 minutes or more from their EBAIS, compared to 18.7% in Desamparados and 18.5% in Curridabat.

A correlation was observed between the distance in minutes it takes to get to the EBAIS walking and the percentage of people who own a car or a motorcycle ($r=0.25$, $p<0.01$); people residing in more favored areas live on average farther away from the EBAIS in the cantons studied. The average distance that a person residing in a MGU with low population traveling capacity must travel is equivalent to 12.7 minutes on foot, compared to 13.9 minutes for a person in a MGU with intermediate population traveling capacity and 16.2 minutes for a person in a MGU with high population traveling capacity.

Finally, 65 of the 2014 MGUs were located more than a 20-minute walk from the EBAIS and were made up of a population with low traveling capacity, namely: 49 in Desamparados, 13 in Escazú and 3 in Curridabat (Table 2). Thus, 3.4% of the population studied lived in a MGU classified as “with the significant difficulty of access”. This proportion reached 4.4% in the canton of Desamparados, 2.7% in the canton of Escazú, and 1.4% in the canton of Curridabat. In addition, 16.5% of the population studied lived in a MGU classified as “with the moderate difficulty of access”. This proportion reached 21.4% in the canton of Desamparados, 7.7% in the canton of Escazú, and 11.4% in the canton of Curridabat.

In Desamparados, several areas “with significant access difficulties” can be observed (Figure 1). The two main ones are the northern part of Desamparados 1 (Barrio Río Jorco, Barrio San Jerónimo, Barrio Loto), and west of Los Guido (Barrio Balcón Verde, Urbanización Benjamín Núñez). To a lesser extent, there are Barrio Lomas de Jorco and Barrio Maiquetía. In Escazú, there are several isolated neighborhoods, “with significant access difficulties”, in the north and south of the canton (Figure 2). In Curridabat, the only area “with significant access difficulty” is the Barrio Nuevo (Figure 3).

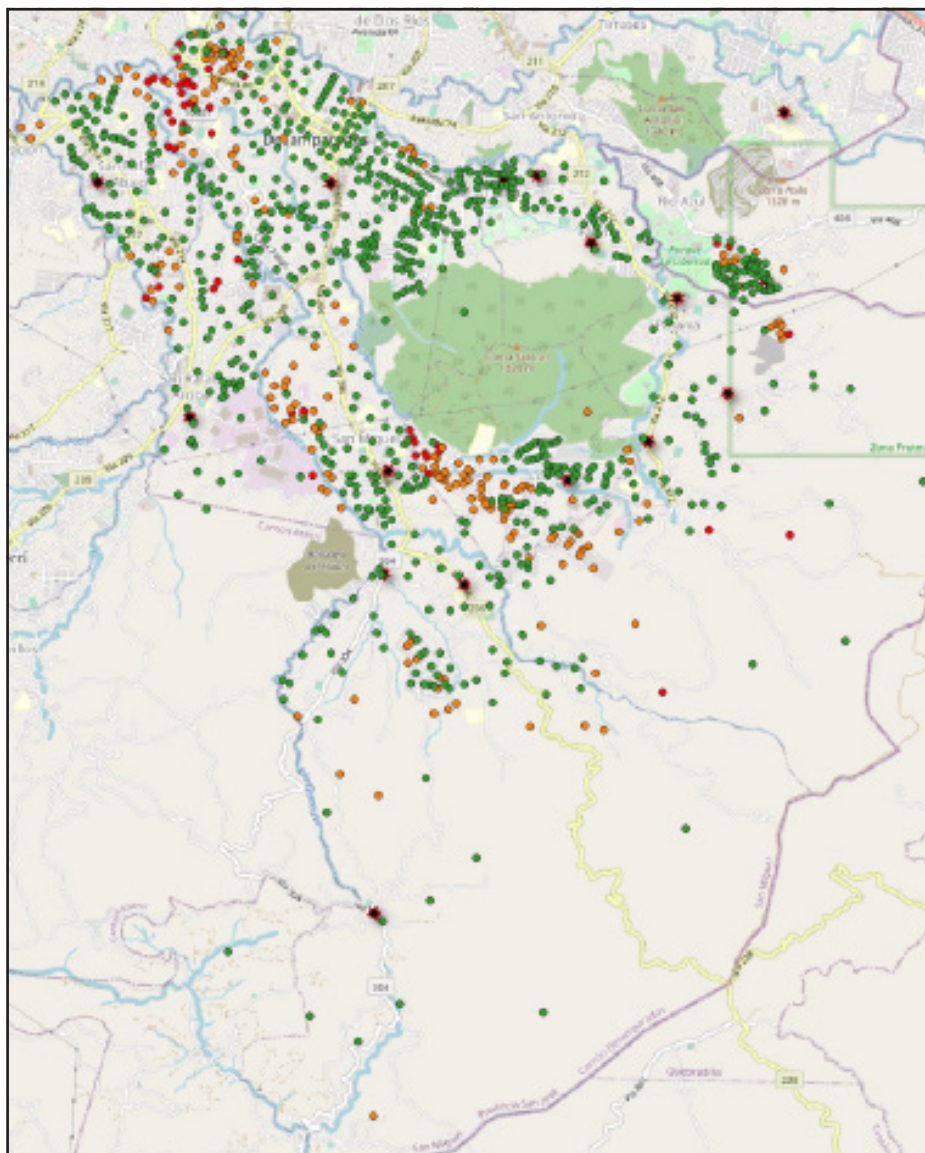


Figure 1. Level of difficulty in accessing the EBAIS of the population of Desamparados, by minimum geostatistical unit (★ EBAIS. Difficulty of access of the population of the minimum geostatistical unit to the EBAIS: ● No difficulty, ● Moderate difficulty, ● important difficulty. Scale 1/32000. OpenStreetMap and Qgis).

In Curridabat, the location of the EBAIS, and those of Tirrases and Granadilla, allows 95% of people with low traveling capacity who live a UGM to be located less than 20 minutes walking distance from the EBAIS, compared to 85% in Desamparados and 71% in Escazú. Similarly, in Curridabat, only 9% of the people living in a MGU with intermediate traveling capacity live 20 minutes or more from the EBAIS, compared to 18% in Desamparados and 23% in Escazú.

Discussion

This study made it possible to evidence the existence of 65 MGUs (out of 2014 included in the study) that were located more than 20 minutes walking distance from the EBAIS, with a population with low travel capacity and, therefore, low socioeconomic status. Most of these populations were found in the Desamparados Health Area,

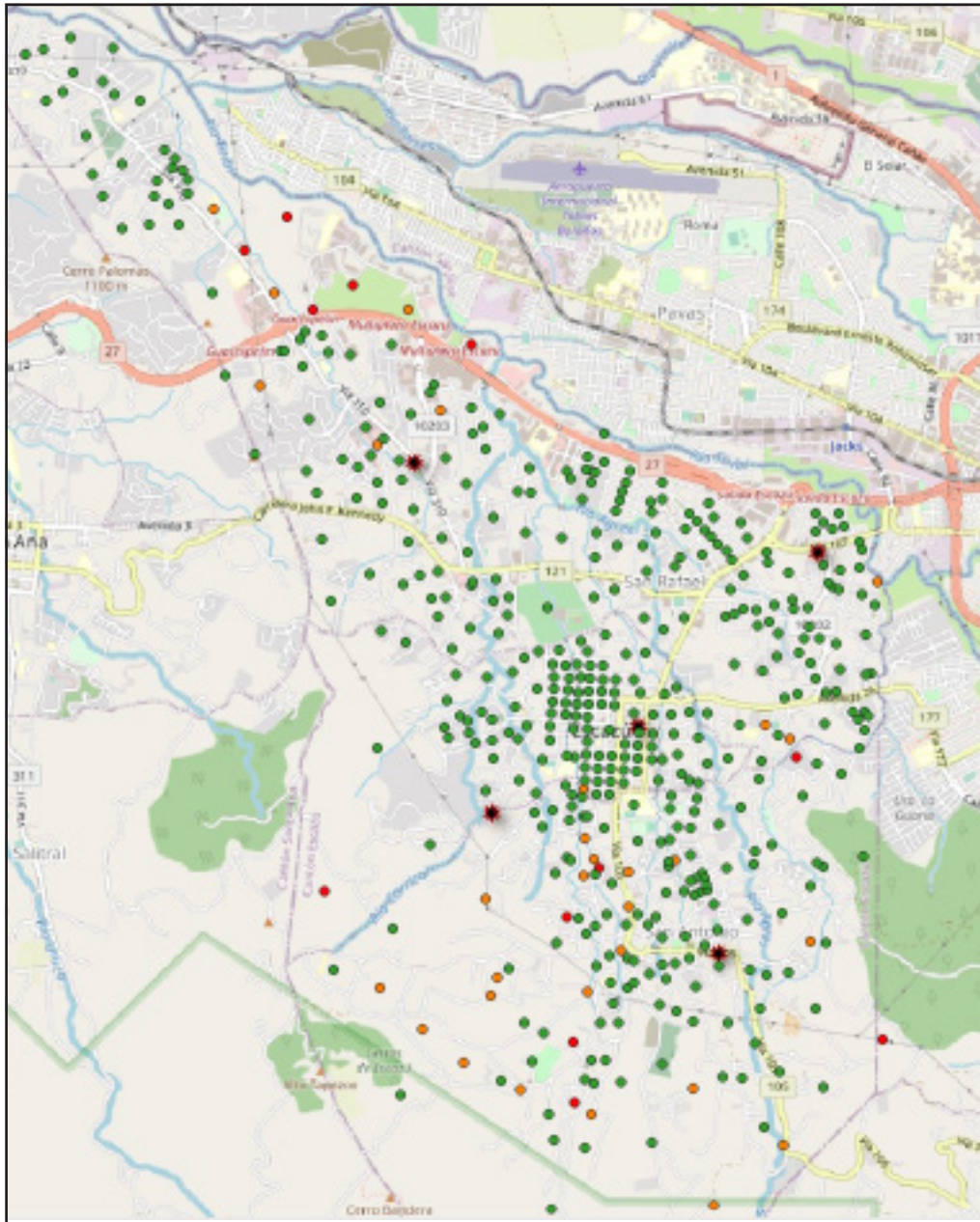


Figure 2. Level of difficulty in accessing the EBAIS of the population of Escazú, by minimum geostatistical unit (★ EBAIS. Difficulty of access of the population of the minimum geostatistical unit to the EBAIS: ● No difficulty, ● Moderate difficulty ● important difficulty. Scale 1/32000. OpenStreetMap and Qgis).

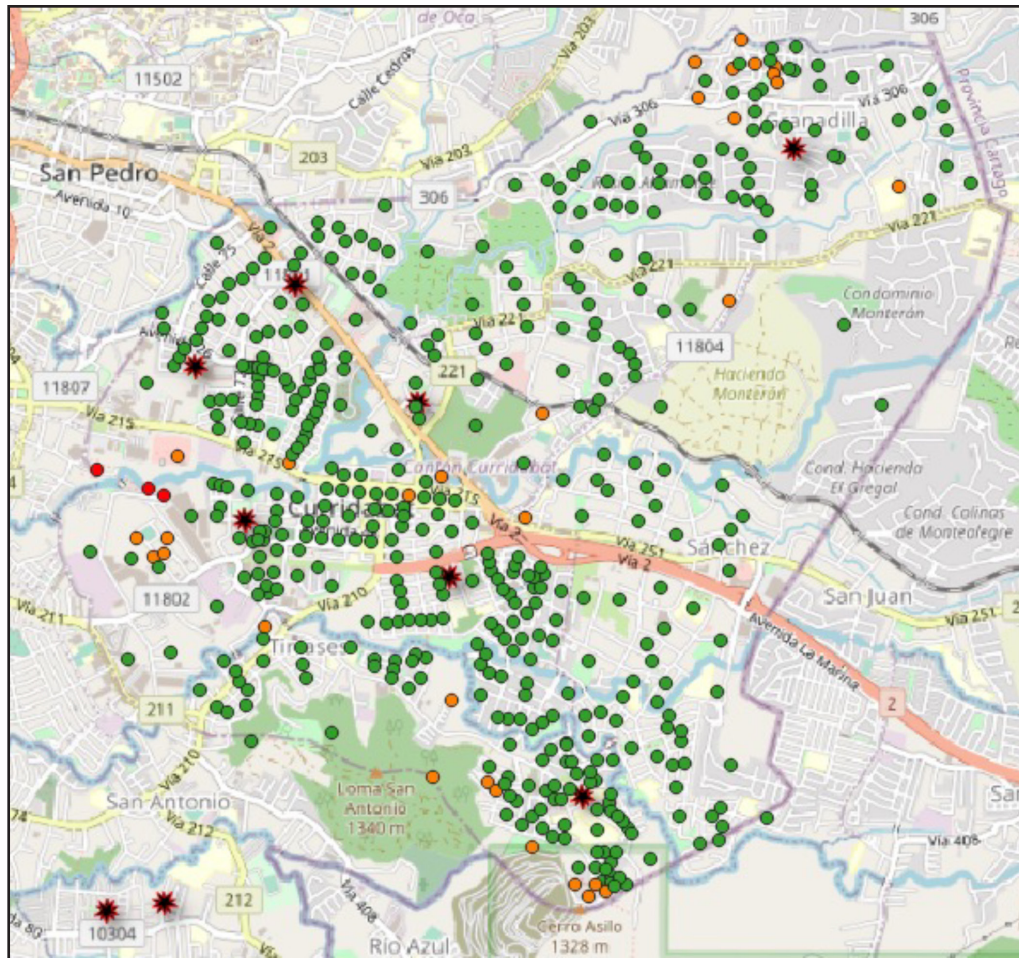


Figure 3. Level of difficulty in accessing the EBAIS of the population of Curridabat, by minimum geostatistical unit (★EBAIS). Difficulty of access of the population of the minimum geostatistical unit to the EBAIS: ● No difficulty, ● Moderate difficulty ● important difficulty. Scale 1/32000. OpenStreetMap and Qgis).

followed by Escazú and Curridabat. It was shown that 3.4% of the population studied lived in a MGU classified as having significant difficulty in accessing health services, as they had both the physical barrier of distance and low socioeconomic status. The areas that presented these access difficulties in Desamparados correspond to the neighborhoods of Río Jorco, San Jerónimo, Loto, and Los Guido (Barrio Balcón Verde, Urbanization Benjamín Núñez are the most affected). To a lesser extent, Barrio Lomas de Jorco and Barrio Maiquetía are also affected. In Escazú, there are several isolated neighborhoods “with significant access difficulties” in the north and south of the canton. In Curridabat, the only area “with the significant difficulty of access” is the Barrio Nuevo precarious area.

Concerning the literature that has studied access to health services, it has different components: population coverage, affordability

of health care, accessibility of health services, and accessibility of health care.¹⁷

The present study focused on the potential impact of distance as a barrier to health services, taking into consideration the ability to travel by car and socioeconomic status as moderating variables of such access. This complements the literature that shows a substantial correlation between unmet needs in terms of health care and travel time.¹⁷ More recent studies have assessed the use of GIS tools to characterize this distance.¹²

One of the main weaknesses of the study is the limited number of health areas included. This is due to both human and technical reasons. Among the human reasons, there is a significant difficulty in accessing the different maps of the health areas since it depends on their level of updating. For example, sometimes the maps do

not include the recent creation of new EBASIS within the Health Areas, which generates a recomposition of the maps. On the other hand, to carry out a nationwide study, funding is required to cover the costs of using the technological tools mentioned in this paper. While some are free of charge, others require payment for each calculation to be performed. In this case, more than 2,000 distance calculations were performed, which would generate a cost if one wished to replicate this study at the national level, for which it is estimated that 38,000 calculations would have to be performed, one for each MGU. Another limitation is the data used to characterize the displacement capacity of the population of each MGU, as these were collected in the 2011 Census and are therefore not up to date. Another limitation is the definition of distance that we used and that, for example, did not contemplate bus services. It was also not possible to incorporate the dimension of quality of access.⁷ Finally, a nationwide study is needed. In this case, we considered cantons in the Greater Metropolitan Area (GAM), which could have superior access conditions when compared to rural areas in different parts of the country. The thresholds used to classify different populations may vary significantly, which should be considered when adapting the methodology for a national study.

Despite these weaknesses, this study also presents strengths. It is the first time, to our knowledge, that a study of this type has been conducted in Costa Rica. The use of different technological tools that allow the systematization of data and the use of specific algorithms for distance analysis, while considering the socioeconomic characteristics and travel capacity of the studied population is of great institutional and national interest. A strength is that this study used a methodology that took into account different variables that could moderate access to services, such as socioeconomic status and the population's ability to travel by automobile; although, indeed, other variables could also be included, such as acceptability of services, perception of the services, people's perceptions, among others. Finally, a great strength of the study lies in the way in which the distances were calculated. Previous studies have been based on straight-line distance calculations, which generate large inaccuracies concerning the actual access for people in general and in urban

areas. In the case of the present study the actual existing routes were used, as well as the topography of the routes and the actual accesses to each of the neighborhoods and health services contemplated.

In conclusion, this study proposes an innovative methodological approach that could be used as a resource for decision-making at the local level when identifying populations with difficulties in accessing health services and to strengthen the extramural actions of the care teams, home visits, or other differentiated actions. This methodology could be replicated in a national study, which would be essential to serving as an input to decision-makers in the prioritization of certain populations, from an objective and evidence-based perspective. This research could contribute to the use of a technological tool for the planning of health services, making the necessary cost-benefit analyses, to locate vulnerable populations with access difficulties to health services due to inadequate geographic conditions. Future research could also include public transportation variables as a possible moderator of these differences in access between populations.

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