

Potential geographic accessibility to municipal medical services (Cruz Verde) in the municipality of Guadalajara, Jalisco, Mexico

Accesibilidad geográfica potencial a los servicios médicos municipales (Cruz Verde) del municipio de Guadalajara, Jalisco, México

Ortiz-Curiel, Yaireth Deyanira^a, Niño-Gutiérrez, Naú Silverio^{*b}, Andrade-García, María Dolores^c and Macías-Huerta, María del Carmen^d

^a ROR Universidad de Guadalajara • • 10.1111/1018115 • 10.1111/1018115

^b ROR Universidad Autónoma de Guerrero • • 10.1111/1018115 • 10.1111/1018115

^c ROR Universidad de Guadalajara • • 10.1111/1018115 • 10.1111/1018115

^d ROR Universidad de Guadalajara • • 10.1111/1018115 • 10.1111/1018115

CONAHCYT classification:

Area: Social Science

Field: Geography

Discipline: Regional Geography

Subdiscipline: Urban Geography

<https://doi.org/10.35429/EJROP.2024.10.18.1.15>

Article History:

Received: January 25, 2024

Accepted: December 31, 2024

* [nsninog@uagro.mx]

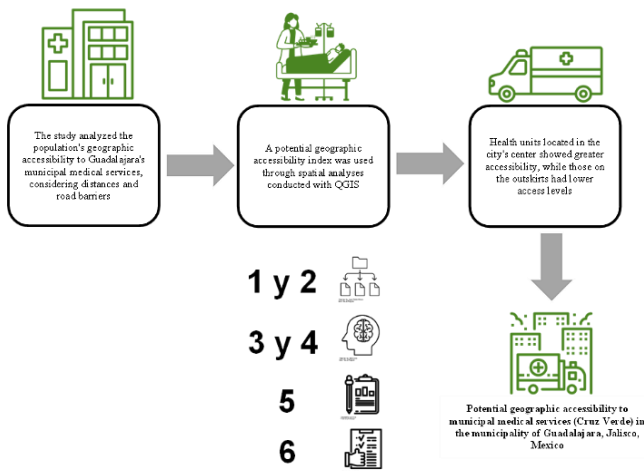


Abstract

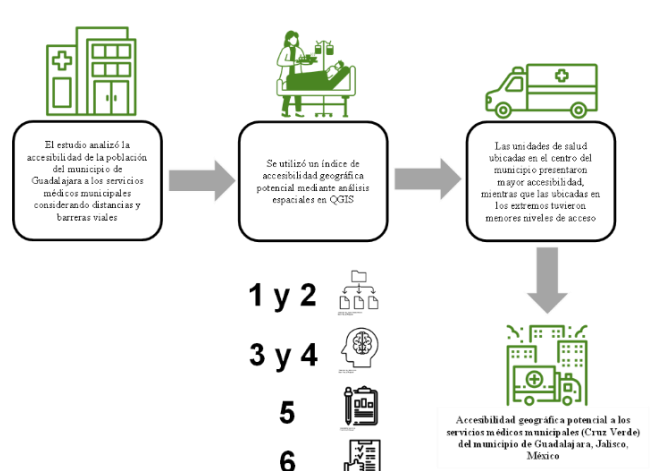
This research evaluated the potential geographic accessibility of the population in the municipality of Guadalajara to the municipal medical services units, considering distances and road barriers. The central objective was to analyze how the location of health units and road infrastructure influenced the population's access to these services. A quantitative approach was adopted, using a potential geographic accessibility index based on spatial analyses conducted with QGIS. The results showed that units located in the center of the municipality, such as Dr. J. Jesús Delgadillo Araujo, had greater accessibility, while those located on the outskirts, such as Dr. Leonardo Oliva Alzaga and Dr. Mario Rivas Souza, showed lower levels of access. It was concluded that the planning of health services must consider both geographic distribution and road infrastructure to improve equity in health access.

Resumen

Esta investigación evaluó la accesibilidad geográfica potencial de la población del municipio de Guadalajara a las unidades de servicios médicos municipales, considerando distancias y barreras viales. El objetivo central fue analizar cómo la ubicación de las unidades de salud y la infraestructura vial influyeron en el acceso de la población a dichos servicios. Se adoptó un enfoque cuantitativo, utilizando un índice de accesibilidad geográfica potencial basado en análisis espaciales realizados con QGIS. Los resultados mostraron que las unidades ubicadas en el centro del municipio, como la Dr. J. Jesús Delgadillo Araujo, presentaron una mayor accesibilidad, mientras que las situadas en los extremos, como la Dr. Leonardo Oliva Alzaga y la Dr. Mario Rivas Souza, mostraron menores niveles de acceso. Se concluyó que la planificación de los servicios de salud debe considerar tanto la distribución geográfica como la infraestructura vial para mejorar la equidad en el acceso a la salud.



Health services, Municipal medical services, Spatial analysis



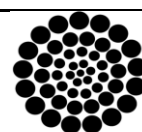
Análisis espacial, Servicios médicos municipales, Servicios de salud

Citation: Ortiz-Curiel, Yaireth Deyanira, Niño-Gutiérrez, Naú Silverio, Andrade-García, María Dolores and Macías-Huerta, María del Carmen. [2024]. Potential geographic accessibility to municipal medical services (Cruz Verde) in the municipality of Guadalajara, Jalisco, Mexico. ECORFAN Journal-Republic of Paraguay. 10[18]-1-15: e11018115.



ISSN 2414-4827/© 2009 The Author[s]. Published by ECORFAN-Mexico, S.C. for its Holding Republic of Paraguay on behalf of ECORFAN Journal-Republic of Paraguay. This is an open access article under the CC BY-NC-ND license [<http://creativecommons.org/licenses/by-nc-nd/4.0/>]

Peer Review under the responsibility of the Scientific Committee MARVID® - in contribution to the scientific, technological and innovation Peer Review Process by training Human Resources for the continuity in the Critical Analysis of International Research.



RENIECYT
Registro Nacional de Instituciones y
Empresas Científicas y Tecnológicas

1702902 CONAHCYT

Introduction

The term “accessibility” can encompass various meanings, including the ease of access to technology, commerce, education, services, buildings, information, recreation, and work, among others. However, in this context, the focus is on the scientific aspect of the concept, particularly in its applications and processes aimed at public health.

[Donabedian \(1988\)](#) identified two ways to measure accessibility: socio-organizational and geographical. Socio-organizational accessibility relates to the characteristics of both the user and the service, which can either facilitate or hinder access to the service. Factors influencing this dimension include both formal and informal admission policies that may exclude individuals based on their economic capacity, diagnosis, addictions, contagious diseases, mental disorders, religious preferences, and educational levels, as well as the patient's reluctance to consult a physician or choose a health unit, and service hours, among others. On the other hand, geographical accessibility examines the physical distances between the user and the service, including linear distance, travel time and cost, as well as the total associated costs.

[Butler \(1986\)](#) emphasized that the contributions of the pioneers of Location Theory—Von Thünen, Alfred Weber, and Walter Christaller—laid the foundation for what is now known as “geographical accessibility”. Thünen focused on the agricultural context, Weber on manufacturing industry, and Christaller on the distribution and functions of urban settlements. Although each model applies to different fields, they share key variables such as distance, monetary costs, time, and the difficulties in overcoming distance.

The study of geographical accessibility from a health perspective is the subject of this research. For this purpose, it has been deemed appropriate to employ the concept defined by Brian Goodall in the Dictionary of Human Geography, which states that “accessibility is the ease with which a certain site (destination) can be reached from other points in the territory (origins)” ([Garrocho & Campos, 2006, p. 353](#)).

The primary objective is to describe the potential geographical accessibility of Municipal Medical Services (Cruz Verde) for the population of the municipality of Guadalajara ([Salinas Escobar *et al.*, 2012](#)), as well as to identify its limitations. The relevance of applying a potential geographical accessibility index lies in its ability to perform a spatial analysis of varying intensities of accessibility within a defined geographic area. This analysis is fundamental for health service planning, contributing to the development of planning, management, and evaluation tools that reflect the international priorities established by the World Health Organization ([OMS, 2015](#)), as well as for fulfilling the objectives stipulated in the Political Constitution of the United Mexican States, the General Health Law, the State Health Law, and the Sectoral Health and Human Rights Program.

Article 4 of the Political Constitution of the United Mexican States that “Every person has the right to health protection. The law will define the bases and modalities for access to health services and will establish the concurrence of the Federation and the federal entities in matters of general health”.

Similarly, the General Health Law establishes the bases and modalities for access to health services; Article 5 expresses the commitment of the National Health System, “constituted by the federal and local public administration agencies and entities, as well as physical or moral persons from the social and private sectors that provide health services, along with the coordination mechanisms for actions, aimed at fulfilling the right to health protection” ([General Health Law, 2020, p. 5](#)).

Likewise, Article 15 of the State Health Law defines the coordination and collaboration mechanisms for health service planning, establishing that the State Health System, with the involvement of the Jalisco Health Secretariat and the State Development Planning Committee, “will define the coordination and collaboration mechanisms for health service planning in the State, to fulfil the right to health protection, in accordance with the provisions of this law and those that may be applicable” ([State Health Law, 2018, p. 5](#)).

The Sectoral Health Program 2019-2024 also emphasizes as a strategy to “improve and expand health infrastructure and equipment, creating adequate and accessible conditions to provide quality services to the entire population at all levels of care”. Meanwhile, the World Health Organization (WHO) notes that the right to health includes timely, acceptable, and affordable access to health care services of sufficient quality.

In Guadalajara, Jalisco, as in the state and other regions of the country (Niño-Gutiérrez et al, 2023), disparities are observed in the distribution of the population and the even distribution of public health services. These services are typically located near areas with higher population concentrations, leaving more remote and sparsely populated localities with fewer public services. This forces residents to travel long distances to access a health unit, increasing travel time and costs.

The potential geographical accessibility index developed by Garrocho & Campos (2006) for Mexican cities is considered applicable to both rural and urban areas. Using Geographic Information Systems (GIS), mathematical models for spatial analysis can be implemented, utilizing open-source software such as QGIS version 3.16.0. Additionally, tools like the calculation of centroids for Basic Geo-Statistical Areas (AGEB) and ORS Tools facilitate processes such as mapping and calculating the shortest distance via the road network from the centroid to the Municipal Medical Services unit, which is essential information for applying the potential geographical accessibility index.

The municipality of Guadalajara, Jalisco, has five Municipal Medical Services (Cruz Verde) units to provide emergency care to the population: “Dr. J. Jesús Delgadillo Araujo”, “Dr. Ernesto Arias González”, “Dr. Francisco Ruíz Sánchez”, “Dr. Leonardo Oliva Alzaga”, and “Dr. Mario Rivas Souza”. These units have 29 consultation rooms, 5 emergency rooms, 23 ambulances, and 5 motorcycle ambulances.

The “supply” variable is defined as the number of consultation rooms registered in the Unique Key of Health Establishments for each Municipal Medical Services unit. Meanwhile, the “demand” corresponds to the total population of the municipality of Guadalajara, which amounts to 1,385,629 inhabitants according to the 2020 Population and Housing Census, distributed across 442 Basic Geo-Statistical Areas (AGEB).

Additionally, the distance in kilometres via the road network from the centroid of each AGEB to the municipal medical services units was considered.

For the preparation of the matrix, the application of the geographical accessibility index, and the creation of the maps, it was crucial to locate the municipal medical services units, referenced in the Universal Transverse Mercator (UTM) coordinate system.

One of the main challenges in a city like Guadalajara is the high density of vehicles in circulation. According to the Jalisco Institute of Statistical and Geographic Information (IEG), in its report of August 31, 2020, the Guadalajara Metropolitan Area concentrates 64.3% of the state's total vehicular load, with Guadalajara being the second municipality with the highest vehicle rate, at 63.8 per 100 inhabitants.

Moreover, lines 1 and 3 of the Urban Electric Train System (SITEUR) interfere with traffic, as they are not fully constructed underground, creating areas where street crossings are spaced apart or do not allow turns, forcing motorists and pedestrians to take alternative routes or detours that increase travel time.

Traffic, terrain, and communication routes are factors that limit the efficiency and fluidity of emergency unit movement in the city, affecting their ability to quickly reach the event location or return to their base unit for care.

According to the Population and Housing Census by the National Institute of Statistics and Geography (INEGI, 2020), the municipality of Guadalajara had 1,385,629 inhabitants, of which 70.06% are affiliated with some form of health service. The distribution is as follows: 58.78% with the Mexican Social Security Institute (IMSS), 5.11% with the Institute of Health for Well-being (INSABI), 2.94% with private institutions, 2.76% with the Institute of Security and Social Services for State Workers (ISSSTE), 0.19% with the State ISSSTE, 0.15% with PEMEX, SEDENA, or SEMAR, 0.18% with IMSS Bienestar, and 1.10% with other institutions. However, 29.50% of the population has no affiliation with these health institutions, forcing this segment to seek medical care through other means. It is worth noting that INSABI was founded in 2020 with the goal of providing health services to those not affiliated with IMSS.

Although most of the population is affiliated with a health service, they may also access or request Municipal Medical Services in case of emergencies.

The World Health Organization (WHO) establishes that one ambulance is required for every 25,000 inhabitants (Cruz, 2018). Considering Guadalajara's population of 1,385,629 people, the city should have at least 56 ambulances, but it only has 23 units and 5 motorcycle ambulances, indicating limited accessibility per unit.

Approximately 89.9% of the terrain in the municipality of Guadalajara is flat, with slopes of less than 5°. The remaining 10.1% has uneven terrain, which has led to modifications in road infrastructure to accommodate water bodies like the Atemajac River or the San Juan de Dios River. However, certain communication routes affect traffic due to the lack of continuous crossings, forcing detours to continue or make turns on a street, as seen with avenues such as Lázaro Cárdenas, Calzada Independencia, and Periférico, among others.

The central hypothesis of this research posits that residents in the outskirts of Guadalajara face lower levels of access to municipal medical services units, constrained by the terrestrial communication routes connecting to other municipalities in the state and other states in the country, such as Avenida Lázaro Cárdenas, which links the entry and exit of the highway to Mexico with the highway to Nogales.

The first part of the document presents the general aspects of the project, including the concept of potential geographical accessibility applied to population health and its relevance as a tool and strategy for the planning and evaluation of health services, in accordance with the health laws governing the country. It also discusses the use of Geographic Information Systems, which enable reliable and timely data processing, expediting, and generating results so that the relevant authorities have adequate information to address issues related to health access.

The second part details how the data was obtained and the process followed to apply the Potential Geographical Accessibility Index to the municipal medical services units, breaking down the formula and describing the use of the ORS Tools, which facilitate the calculation of distances in kilometres from the centroids of each AGEB to the health units.

The results describe some characteristics of the municipality of Guadalajara necessary for the application of the mentioned index. This index has two major areas of analysis: from the demand perspective, it is measured from locality centres and AGEBs to health units, revealing urban quality, understood as the advantages that the population has by residing in a specific area of the territory. From the supply perspective, the location of each health unit is evaluated in comparison to its competitors, so that by summing up the accessibility per unit and ordering the results from highest to lowest, the unit with the most advantages relative to the others can be identified.

By summing the Accessibility Index per AGEB for all health units, it is possible to determine which AGEB has the highest or lowest accessibility. Additionally, the total accessibility of the municipality is assessed, allowing for evaluation at the state, regional, or national level, and comparison with other territorial units; although in this case, the analysis is limited to the municipality of Guadalajara.

Finally, the conclusions obtained from applying the Potential Geographical Accessibility Index to the municipal medical services units—Dr. J. Jesús Delgadillo Araujo, Dr. Ernesto Arias González, Dr. Francisco Ruíz Sánchez, Dr. Leonardo Oliva Alzaga, and Dr. Mario Rivas Souza—for the resident population of the municipality of Guadalajara are presented.

Research question

What was the level of potential geographical accessibility for the population of the municipality of Guadalajara to the municipal medical services units of Cruz Verde, considering the existing distances and road barriers?

General objective

To describe and analyse the level of potential geographical accessibility for the population of the municipality of Guadalajara to the municipal medical services units, considering the existing distances and road barriers.

Specific objectives

- To identify the areas within the municipality of Guadalajara with the highest and lowest geographical accessibility to the Cruz Verde municipal medical services units.
- To determine the geographical and road barriers that influenced the population's access to the Cruz Verde municipal medical services units.
- To propose strategies for improving accessibility to health services in areas identified with lower potential geographical accessibility.

Study design

The research was structured as a descriptive, cross-sectional study aimed at analysing the potential geographical accessibility of the population of the municipality of Guadalajara to the municipal medical services units. A quantitative approach was adopted, utilizing spatial analysis tools and geographic information systems (GIS) to evaluate the relationship between the distribution of health units and the population, as well as the road barriers that might affect access.

The study was conducted in several stages. First, geospatial information related to the location of health units and population distribution was collected and processed, using data from the National Institute of Statistics and Geography (INEGI) and the Unique Key of Health Establishments (CLUES). Subsequently, the potential geographical accessibility index, adapted from the model proposed by [Garrocho & Campos \(2006\)](#), was applied to measure the population's opportunities for accessing health services. Distances between the centroids of the Basic Geo-Statistical Areas (AGEB) and the health units were calculated via road routes, using QGIS software and the ORS Tools plugin. The results were represented in thematic maps that visualized areas with varying levels of accessibility.

Finally, a comparative analysis was conducted to identify accessibility patterns based on the location of health units, population density, and characteristics of the road infrastructure. The findings were used to formulate recommendations aimed at improving the planning and distribution of health services in the municipality of Guadalajara.

Methodology

To estimate the potential geographical accessibility of emergency services, specifically the Municipal Medical Services for the population of the municipality of Guadalajara, an accessibility index based on the shortest routes via the road network was employed.

Potential geographical accessibility index

The Potential Geographical Accessibility Index, developed and applied by [Garrocho & Campos \(2006\)](#) in the Metropolitan Area of Toluca, State of Mexico, was adopted for this study. The formula used to estimate this index is as follows:

$$I = \sum_j \frac{S_j}{d_{ij}^b} \quad (1)$$

Where:

- I: Potential Geographical Accessibility Index, representing the relative measure of ease of access that the population has to health units distributed within a defined geographical space. In this case, the population of the municipality of Guadalajara and the distance in kilometres from the centroids of the Basic Geo-Statistical Areas (AGEB) to the municipal medical services units were considered.
- S_j: Magnitude of the services available at each health unit, measured by the number of consultation rooms registered in the Unique Key of Health Establishments (CLUES) in 2021.
- O_j: Total demand of the study area, represented by the total population of the municipality of Guadalajara, according to the Population and Housing Census by the National Institute of Statistics and Geography ([INEGI, 2020](#)).

- dij: Transportation cost, which in this research was considered as the distance in kilometres via the road network between the population's place of residence (AGEB) and the health unit's location.
- b: Distance friction, a parameter obtained by calibration based on user behaviour data. In this study, it was not considered due to the use of road network distances structured by streets, avenues, and thoroughfares, through which the population travels to health units by private vehicle, public transportation, or ambulance.

To conduct this analysis, the municipal boundary of Guadalajara, the AGEBs from the 2020 Geo-Statistical Framework, and the Population and Housing Census data obtained from the official INEGI website were used. Contour lines, watercourses, water bodies, urban structure, roadways, and railways in vector format were obtained from INEGI maps F13D66 and F13D65, at a scale of 1:50,000 (INEGI, 2020).

The location of health units was obtained from the CLUES file provided by the General Directorate of Health Information (DGIS) in 2021 in XLSX format. This file was filtered to extract the Cruz Verde units of Guadalajara, which were then converted to shapefile (shp) format to obtain their location on the map and the number of consultation rooms.

The information was processed using the free software QGIS version 3.16.0, available for download on its official website. The calculation of the centroids of the AGEBs was performed using the AGEB2020 and amg2020 layers, corresponding to the AGEBs located within the municipal boundary of Guadalajara and its neighbouring areas. In the toolbox, the "Centroids" option was used to create the centroid point layer. Once obtained, the points were grouped in sets of 40 to create the routes, due to the tool's point limitation, and a health unit, in this case, Rivas Souza, was added.

Distance calculation

The routing and distance calculation from each AGEB centroid to the municipal medical services units was performed by installing the ORS Tools plugin and creating an account in Open Route Service. A 24-hour valid link was obtained for the tool to use the Open Street Maps service.

The key was entered into the API Key, "Batch Jobs" was selected, followed by "Points (2 Layer)."

Records were captured as follows: the provider was Open route service, Input Start Point Layer was the health unit layer (Mario Rivas Souza), Start ID Field was a column used as an identifier (health unit name), Input End Point Layer was the AGEB centroids layer (in groups of 40), and the AGEB column was used as the identifier. The travel mode selected was "driving-car," the travel preference was "shortest" for shortest routes, the layer mode was "all-by-all," and the directions were stored in a file.

The result was a layer with 40 routes, repeating the procedure for the other 11 layers. The routes were checked using Google Maps to ensure they followed the correct street direction. The 12 layers were then merged into one using the "merge vector layers" tool with the projection EPSG: 32613 WGS84 UTM 13N.

It was verified that the file contained the 442 lines corresponding to the number of AGEBs in Guadalajara, and the process was repeated for the five health units. If any route presented errors, the corresponding distance was recalculated.

Application of the index and map creation

The Potential Geographical Accessibility Index was applied by creating a matrix in Excel 2016, organizing the information as follows:

- A sequential identifier for AGEBs in alphabetical order.
- The AGEB key
- The total population per AGEB.
- The UTM coordinates of the AGEB centroids.
- The health units.
- The design capacity measure (number of consultation rooms).
- The distance in kilometres from each health centre to the AGEB centroids.
- Application of the formula to calculate the index.

For the creation of geographical accessibility maps, based on the index results, ranges were established using the data mean magnitude method, a statistical central tendency method that reveals the position of the values around which the data clusters. Five ranges were defined: lower, below average, average, above average, and upper.

The data were ordered in ascending order, where the median divides the distribution into two subsets of equal frequency: 50% of the values are above, and the other 50% below. Quantiles, which divide the distribution into parts with a certain percentage of the total observations, were used in their decile (10%) form. The resulting five ranges were as follows:

- Lower range / Poor (155 values)
- Below average range / Inadequate (44 values)
- Average range / Acceptable (44 values)
- Above average range / Good (44 values)
- Upper range / Optimal (155 values)

Results

General aspects of the municipality

According to the State Government, the municipality of Guadalajara is located between the coordinates 20° 36' 40" and 20° 45' 00" north latitude, and 103° 16' 00" and 103° 24' 00" west longitude. This municipality is situated in the Central Region of the state of Jalisco and is bordered to the north by the municipalities of Ixtlahuacán del Río and Zapopan, to the east by Tonalá and Zapotlanejo, to the south by San Pedro Tlaquepaque, and to the west again by Zapopan.

Guadalajara covers an area of 150 km², placing it in position 114 in relation to the rest of the municipalities in Jalisco, according to the Jalisco Institute of Statistical and Geographic Information (IIEG, 2019), Figure 1.

Box 1

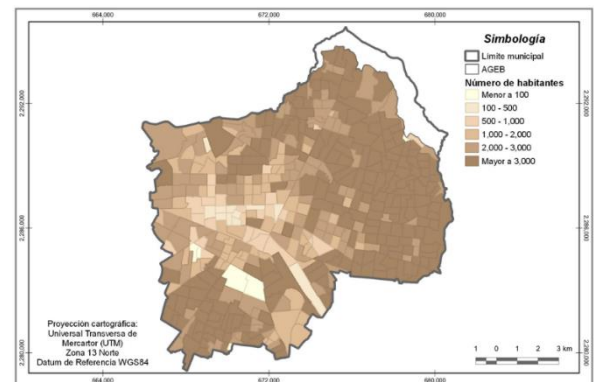


Figure 1

Population as of 2020 in the municipality of Guadalajara

Source: Own elaboration

Regarding the terrain of the municipality, 89.9% of its territory is flat, with slopes less than 5°. About 4.7% of the land consists of hills with slopes between 5° and 15°, while the remaining 5.4% is mountainous, with slopes greater than 15° (IIEG, 2019). The municipality has a Protected Natural Area: the Barranca de Huentitán, which covers a portion of the Barranca del Río Santiago belonging to Guadalajara.

In terms of hydrology, Guadalajara is traversed by the San Juan de Dios River, which is channelled underground through the city; to the northeast, the Verde River joins with the Santiago River. Additionally, the Atemajac Stream marks an inter-municipal boundary. Other water bodies include the San Andrés de los Caños and Osorio streams, the Zoquipan and Hedionda dams, and the Poniente Canal. According to the State Water Commission (CEA), Guadalajara is located in the Lerma–Santiago–Pacific Hydrological Administrative Region VIII, within the Lerma-Santiago Hydrological Region 12, in the RH12-E Santiago–Guadalajara hydrological basin.

Another relevant element for this research is the population distribution. According to the Population and Housing Census conducted by the National Institute of Statistics and Geography (INEGI, 2020), Guadalajara had 1,385,629 inhabitants, of which 48.3% are men and 52% are women. The age group with the highest concentration is 20 to 24 years, representing 4.3% of the men and 4.2% of the women.

The population is primarily concentrated in the eastern and southwestern parts of the municipality, while areas like the centre or industrial zones have lower or no population density. Similarly, areas near the centre and towards the west also show low population density (Niño-Gutiérrez et al, 2018 & Niño-Gutiérrez & Hinojosa, 2016).

The road structure of the municipality is also noteworthy. Access to Guadalajara can be made through various highways, mostly federal, such as 24, 23, 90D, and 15, which in turn connect with the Manuel Gómez Morín Periférico Ring. The city's first ring road was Avenida Circunvalación (Oblatos, División del Norte, Jorge Álvarez del Castillo, López Mateos - up to La Minerva, and Agustín Yáñez), with between 2 and 4 lanes, depending on the section. Guadalajara also has major avenues, such as Calzada Lázaro Cárdenas, which runs from west to southeast and connects the municipalities of Tonalá, Tlaquepaque, and Zapopan. Another important road is Calzada del Federalismo, which has 3 lanes in both directions and runs from north to south (Figure 2).

Box 2

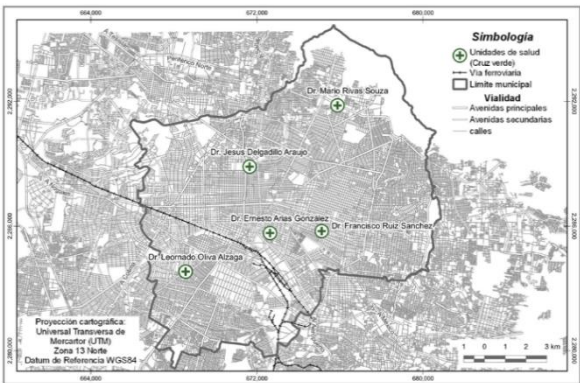


Figure 2
Road network and location of municipal medical services units

Source: Own elaboration

Calzada Independencia, one of the main roads that cross the city from north to south, was originally the San Juan de Dios River channel, crossed by bridges. In 2009, the Calzada underwent a significant change with the operation of the Macrobus, now Mi Macro Calzada, which reduced the existing lanes to two in both directions but allowed for a connection with Avenida Gobernador Luis C. Curiel via an underpass, avoiding detours around the railway tracks and the corresponding station.

Avenida Javier Mina originates in the eastern part of the city, in the Tetlán neighbourhood, and connects to Federal Highway No. 15. This avenue has three different names: it begins as Francisco Javier Mina in the Libertad sector, changes to Avenida Juárez when crossing Calzada Independencia in the Hidalgo sector, and finally becomes Avenida Ignacio L. Vallarta from Avenida Enrique Díaz de León until its transition in the municipality of Zapopan, where it becomes the exit to Federal Highway 15 to Nogales.

Avenida Alcalde was historically one of the most important roads in the city, being a major route for vehicular traffic and public transportation. However, starting in 2014, with the construction of Line 3 of the Light Rail, several adjacent roads were closed, and a section of the avenue, from Avenida Jesús García to Avenida Niños Héroes, was transformed into a pedestrian walkway and bike path, allowing only local traffic at certain points. Avenida Ávila Camacho also underwent changes due to the construction of Line 3, where the underground route becomes elevated, which required the medians to be extended, blocking some crossings.

To provide medical services to the population, the municipality of Guadalajara has five municipal medical services units: Dr. J. Jesús Delgadillo Araujo, Dr. Ernesto Arias González, Dr. Francisco Ruiz Sánchez, Dr. Leonardo Oliva Alzaga, and Dr. Mario Rivas Souza. According to a statement from the Guadalajara City Council, published on February 25, 2019, these units were renovated, improving their infrastructure, including the adaptation, remodelling, and re-equipment of areas such as operating rooms, central sterilization equipment, emergency rooms, among others.

Potential geographical accessibility by health unit

The application of the potential geographical accessibility index by health unit allows for the identification of the access opportunities available to the population of the municipality of Guadalajara to these health units, as well as the potential capacity of these units to serve the population. This analysis is crucial for spatially visualizing areas with lower access, corresponding to the most vulnerable populations, and thus establishing strategies and actions to mitigate or resolve issues related to access to health services.

Municipal medical services unit Dr. J. Jesús Delgadillo Araujo

The Dr. J. Jesús Delgadillo Araujo Municipal Medical Services unit is located in the Alcalde Barranquitas neighbourhood, in the Central Zone, and has 10 consultation rooms. It offers a variety of services, including emergency medical-surgical care, clinical laboratory, X-rays, tomography, ultrasound, and outpatient consultation in various specialties such as cardiology, general surgery, hypertension clinic, haematology, maxillofacial surgery, general medicine, neurology, dentistry, ophthalmology, orthopaedics, otorhinolaryngology, paediatrics, and psychology.

When applying the potential geographical accessibility index, the results ranged from values of 0.000000643 to 0.000000940, with distances of 7.68 to 11.23 km and a population of 599,611 inhabitants, distributed in 155 AGEBs, placing them in the lowest accessibility range (Poor). In the range below the average, with values from 0.000000940 to 0.000001042, the distance ranges from 6.92 to 7.67 km, covering a population of 177,481 inhabitants distributed in 44 AGEBs (Inadequate).

The accessibility index in the average range varies between 0.000001044 and 0.000001226, with distances from 5.88 to 6.90 km, and a population of 133,735 inhabitants distributed in 44 AGEBs (Acceptable). The range above the average, with values from 0.000001235 to 0.000001414, covers distances from 5.10 to 5.84 km, serving a population of 120,528 inhabitants distributed in 44 AGEBs (Good). Finally, the upper range presents values from 0.000001419 to 0.000011228, with distances from 0.64 to 5.08 km, covering a population of 354,266 inhabitants distributed in 155 AGEBs (Optimal).

AGEBs within the optimal range are located approximately 3 km from the health unit, extending southwest to Avenida Inglaterra and east to Esteban Loera Street. In the good and acceptable accessibility ranges, the unit's influence extends to about 4.5 km, surpassing Calzada Lázaro Cárdenas, westward towards the municipality of Zapopan, and reaching the Industrial Zone and crossing the railway tracks.

AGEBs in the inadequate range are approximately 6 km away in a straight line, some beyond the Periférico Ring and others at its limits. These reach eastward to Avenida Artesanos, which becomes Avenida Plutarco Elías Calles, and southward, beyond Avenida Miguel López de Legazpi. AGEBs with poor accessibility are approximately 8.5 km away in a straight line, located on the outskirts of the municipality, bordering the municipalities of Tonalá and San Pedro Tlaquepaque.

Municipal medical services unit Dr. Ernesto Arias González

The Dr. Ernesto Arias González Municipal Medical Services unit is located in the Las Conchas neighbourhood, in the Central Zone, and has 6 consultation rooms. It offers services such as psychological care (suicide prevention and care), emergency care, traumatology and orthopaedics, general consultation, clinical laboratory, X-rays, and procedures such as medical certificates. Additionally, it houses the Regional Center for Toxicological Information and Care (CRIAT), the only one in the region, covering the Central-West of Mexico. This centre provides interconsultations and medical management of poisoned patients, as well as care for animal bites or stings (Figure 3).

Box 1

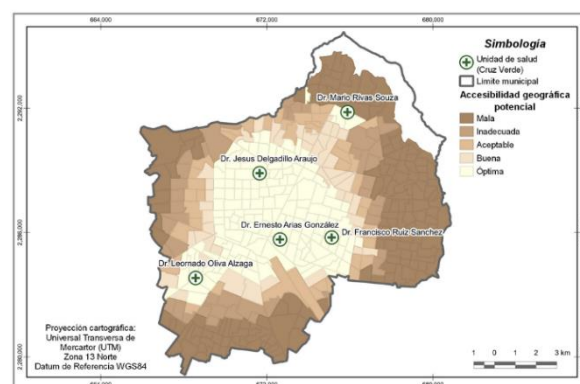


Figure 3

Total potential geographic accessibility of the population of the municipality of Guadalajara to the Municipal Medical Services

Source: Own elaboration

When applying the accessibility index, values between 0.000000417 and 0.000000632 were observed, with distances from 6.84 to 10.39 km, covering a population of 619,905 inhabitants distributed in 155 AGEBs, classifying them in the lowest accessibility range (Poor).

In the range below the average, with values from 0.000000633 to 0.000000679, the distances range from 6.37 to 6.84 km, covering 139,738 inhabitants distributed in 44 AGEBS (Inadequate).

The accessibility index in the average range varies between 0.000000681 and 0.000000754, with distances from 5.74 to 6.35 km and a population of 152,618 inhabitants distributed in 44 AGEBS (Acceptable). In the range above the average, with values from 0.000000754 to 0.000000854, the distances range from 5.07 to 5.74 km, covering 138,313 inhabitants distributed in 44 AGEBS (Good). Finally, the upper range presents values from 0.000000855 to 0.0000007590, with distances from 0.57 to 5.06 km, covering 335,047 inhabitants distributed in 155 AGEBS (Optimal).

The health unit is approximately 4 km in a straight line from AGEBS that have an optimal range, extending north to Avenida Circunvalación Doctor Atl and southeast to the border with San Pedro Tlaquepaque, crossing Calzada Lázaro Cárdenas and reaching the Industrial Zone. AGEBS with good accessibility are approximately 4.5 km away in a straight line, reaching Avenida Adolfo López Mateos; to the north, up to Avenida Circunvalación Doctor Atl, and to the south, past the Industrial Zone, near the Mercado de Abastos.

The acceptable and inadequate accessibility ranges extend southwest to the border with Zapopan, in the Chapalita neighbourhood, and northward, surpassing Avenida Circunvalación, with some AGEBS reaching Avenida Plutarco Elías Calles, covering an approximate straight-line distance of 5 km. The poor accessibility range reaches the outskirts of the municipality, passing the Periférico Ring and the avenues Adolfo López Mateos, Plutarco Elías Calles, and Patria.

Municipal medical services unit Dr. Francisco Ruíz Sánchez

The Dr. Francisco Ruíz Sánchez Municipal Medical Services unit is located in the Hernández Romo neighbourhood, in the Olympic Zone, and has 5 consultation rooms. It offers services such as emergency medical-surgical care (general surgery and traumatology), general medicine outpatient consultation, traumatology and orthopaedics, nutritional and psychological consultation, clinical laboratory services, and imaging services.

Recent renovations include the modernization of operating rooms, emergency areas, recovery and hospitalization areas, the implementation of a CT scanner for comprehensive diagnostics, improvements in infrastructure and security systems, and the construction of new areas to optimize medical care, such as triage areas and a teaching room.

The accessibility index applied to this unit showed values ranging from 0.000000301 to 0.000000485, with distances from 7.43 to 11.97 km, covering a population of 478,830 inhabitants distributed in 155 AGEBS, classifying them in the lowest accessibility range (Poor). In the below-average range, with values from 0.000000486 to 0.000000525, distances range from 6.87 to 7.41 km, covering 130,780 inhabitants distributed in 44 AGEBS (Inadequate).

The accessibility index in the average range varies between 0.000000529 and 0.000000595, with distances from 6.06 to 6.82 km and a population of 133,561 inhabitants distributed in 44 AGEBS (Acceptable). In the above-average range, with values from 0.000000596 to 0.000000665, distances range from 5.42 to 6.05 km, covering 141,869 inhabitants distributed in 44 AGEBS (Good). Finally, the upper range presents values from 0.000000669 to 0.000000690, with distances from 0.53 to 5.39 km, covering 500,581 inhabitants distributed in 155 AGEBS (Optimal).

The AGEBS with optimal range for this health unit are approximately 4 km away in a straight line, covering a broad area from the boundaries of Guadalajara with Tonalá and San Pedro Tlaquepaque to the north near Panteón Guadalajara, passing through avenues such as Belisario Domínguez, Alcalde, Reforma, Chapultepec, Inglaterra, and Dr. Roberto Michel.

AGEBS with acceptable and inadequate accessibility extend north to the Periférico Ring, reaching the Glorieta de La Normal to the west, and passing Calzada Lázaro Cárdenas and the Industrial Zone, with an approximate straight-line distance of 5.5 km. The range with poor accessibility covers the entire western side of the municipality, reaching the border with Zapopan and part of Tlaquepaque, as well as the Periférico Ring, Avenida Adolfo López Mateos, part of Calzada Lázaro Cárdenas, and Avenida Miguel López de Legazpi.

Municipal medical services unit Dr. Leonardo Oliva Alzaga

The Dr. Leonardo Oliva Alzaga Municipal Medical Services unit, located in the south of the city in the Jardines de la Cruz neighbourhood, has 5 consultation rooms. The main services offered include emergency medical-surgical care, surgery and consultation in traumatology and orthopaedics, surgery and consultation in otorhinolaryngology, anaesthesiology, general surgery, hand surgery, cardiology, paediatrics, outpatient consultation, dentistry, and nutrition.

The unit has undergone several improvements, including the rehabilitation of operating rooms, remodelling and conditioning of the sterilization area, modernization of the laboratory and X-ray area, creation of new spaces for medical care, remodelling of the emergency area with an expansion of beds, and the renovation of water tanks, compressors, emergency power plant, and electrical installations throughout the unit, according to a statement published on February 25, 2019, by the Guadalajara City Council.

When applying the accessibility index, the values obtained ranged from 0.000000236 to 0.000000346, with distances from 10.42 to 15.29 km, covering a population of 516,973 inhabitants distributed in 155 AGEBs, classified in the lowest accessibility range (Poor). The below-average range presented values from 0.000000346 to 0.000000402, with distances between 8.97 and 10.41 km, and a population of 137,798 inhabitants distributed in 44 AGEBs (Inadequate).

The accessibility index in the average range varied from 0.000000404 to 0.000000483, with distances from 7.46 to 8.93 km, covering a population of 138,784 inhabitants distributed in 44 AGEBs (Acceptable). In the above-average range, values ranged from 0.000000484 to 0.000000560, with distances from 6.44 to 7.45 km, and a population of 140,848 inhabitants distributed in 44 AGEBs (Good). Finally, the upper range presented values from 0.000000562 to 0.0000008816, with distances from 0.40 to 6.42 km, covering a population of 451,218 inhabitants distributed in 155 AGEBs (Optimal).

AGEBs within an optimal accessibility range are located at an approximate straight-line distance of 1 to 5 km, covering areas in the south and part of the west of the municipality, reaching Calzada del Ejército, Pedro Moreno Street, and passing through the Ladrón de Guevara neighbourhood (known as Barrio de Santa Tere) to Milán Street.

In the Good and Acceptable accessibility ranges, the AGEBs are approximately 7 km away, reaching Federico Medrano Street, Avenida República, Sierra Morena, Sierra Madre, Avenida Ávila Camacho, and Jardines del Country, ending at Avenida Patria, which marks the boundary with Zapopan.

AGEBs with Inadequate accessibility are approximately 8 km away, extending eastward to Avenida del Chamizal and Avenida San Jacinto, Gigantes Street, Porres Baranda (la 68), Avenida Puerto Melaque, Avenida Circunvalación, Avenida Belisario Domínguez, and neighborhoods like Jardines Alcalde up to Avenida Fidel Velázquez.

Finally, AGEBs with poor accessibility cover part of the east and north of the municipality, with an approximate straight-line distance of 8 to 12 km, passing through avenues such as Plutarco Elías Calles, Artesanos, Circunvalación, Fidel Velázquez, and the Periférico Ring.

Municipal medical services unit Dr. Mario Rivas Souza

The Dr. Mario Rivas Souza Municipal Medical Services unit is located in the Jardines de Santa Isabel neighbourhood, at Anillo Periférico Pte. Manuel Gómez Morin #350, and has 3 consultation rooms. The main services offered include emergency medical care, traumatology and orthopaedics, laboratory, and X-ray services, available 24 hours a day, 365 days a year.

In a statement published in February 2019 by the Guadalajara City Council, the renovations in the facilities and equipment were highlighted, including the comprehensive rehabilitation of the building, complete renovation of the emergency observation area, acquisition of new X-ray equipment (digital), the addition of 2 consultation rooms, rehabilitation of the waiting room, and improvements to the hydro-sanitary network and electrical installations.

When applying the accessibility index, values ranged from 0.000000135 to 0.000000226, with distances from 9.59 to 16 km, covering a population of 433,901 inhabitants distributed across 155 AGEBs, classified in the lowest accessibility range (Poor). In the below-average range, values ranged from 0.000000226 to 0.000000254, with distances from 8.52 to 9.57 km, covering a population of 116,775 inhabitants distributed across 44 AGEBs (Inadequate).

The accessibility index in the average range varied from 0.000000254 to 0.000000290, with distances from 7.47 to 8.50 km, covering a population of 126,420 inhabitants distributed across 44 AGEBs (Acceptable). In the above-average range, values ranged from 0.000000290 to 0.000000332, with distances from 6.44 to 7.45 km, covering a population of 140,848 inhabitants distributed across 44 AGEBs (Good). Finally, the upper range presented values between 0.000000332 and 0.0000003006, with distances from 0.72 to 6.51 km, covering a population of 591,591 inhabitants distributed across 155 AGEBs (Optimal).

The optimal accessibility of this unit is found within approximately 3 to 5 km, reaching areas to the north of the municipality, near the Barranca de Huentitán, extending to Avenida José María Iglesias, Pablo Valdez Street, Felipe Ángeles, Dionisio Rodríguez, Gigantes, Belén, Avenida Jesús García, Parque Alcalde, Avenida del Federalismo Norte, and reaching the northwest boundary with Zapopan.

In the Good and Acceptable ranges, the AGEBs extend further toward the city center, with 14 light rail stations from the 3 lines of the Urban Electric Train System (SITEUR) covering these areas of influence.

Finally, AGEBs with poor accessibility are mainly located towards the south of the municipality, passing Avenida González Gallo, Avenida Niños Héroes, Avenida de las Américas, and reaching the boundary with the municipality of Zapopan; the approximate straight-line distance is 11.5 km.

Total potential geographical accessibility by health unit

The municipality of Guadalajara has five municipal medical services units, which were analysed by applying the accessibility index to identify which has the highest and lowest accessibility.

The results show that the Dr. J. Jesús Delgadillo Araujo health unit, with 10 consultation rooms, has the highest total accessibility, with a value of 0.000671196. In second place is the Dr. Ernesto Arias González health unit, which has 6 consultation rooms and a total accessibility of 0.000412214.

In third place is the Dr. Francisco Ruíz Sánchez health unit, with 5 consultation rooms and an accessibility of 0.000338818. The Dr. Leonardo Oliva Alzaga health unit, also with 5 consultation rooms, ranks fourth, with an accessibility of 0.000279798. Finally, the Dr. Mario Rivas Souza health unit, with 3 consultation rooms, has the lowest accessibility, with a value of 0.000158141.

Thus, the Dr. J. Jesús Delgadillo Araujo health unit presents the best accessibility index due to its higher number of consultation rooms and its favourable geographical location, which facilitates population access. In contrast, the Dr. Mario Rivas Souza unit has the lowest accessibility, likely due to the scarcity of consultation rooms relative to demand and its location in the northern part of the municipality, along the Periférico Ring, complicating access, especially for the population in the west, which must cross several major avenues (Table 1).

Box 1

Table 1
Total potential geographic accessibility of medical services

Health unit	Number of clinics	Accessibility by health unit
Dr. J. Jesús Delgadillo Araujo	10	0.000671196
Dr. Ernesto Arias González	6	0.000412214
Dr. Francisco Ruíz Sánchez	5	0.000338818
Dr. Leonardo Oliva Alzaga	5	0.000279798
Dr. Mario Rivas Souza	3	0.000158141

Source: Own elaboration

Potential geographical accessibility by AGEB

The analysis of potential geographical accessibility by AGEB was conducted by summing the accessibility of each AGEB from the health units, allowing the identification of AGEBs with the highest and lowest accessibility.

In Guadalajara, the AGEBs with the highest accessibility are primarily located in the city centre, covering four of the five health units. These AGEBs benefit from wide roads that facilitate timely connections with the health units.

On the other hand, the AGEBs with the lowest accessibility are located on the outskirts of the municipality, especially to the east. To the north, the Periférico Ring acts as a road barrier that increases the distance required to access health services. Similar situations are observed to the south, where major avenues also act as social divides, reflecting inequality in access to health services.

Potential geographical accessibility of the municipality

By applying the potential geographical accessibility index to the health units in the municipality, a global index for Guadalajara of 0.001860167 was obtained. This value allows for the comparison of Guadalajara's accessibility level with other municipalities, providing authorities with a tool to evaluate and improve health services in the city.

Discussion

The discussion of this research focused on interpreting and contextualizing the findings obtained from applying the potential geographical accessibility index to the municipal medical services units in the municipality of Guadalajara. The results revealed significant variations in access to health services, largely determined by the geographical location of the units, population density, and existing road barriers.

In relation to previous studies, it was confirmed that the strategic location of health units, particularly in areas with high population density and good road connections, facilitated more equitable access to medical services. This finding aligns with the observations of [Garrocho & Campos \(2006\)](#), who emphasized the importance of proximity and road connectivity in the accessibility of public services. However, it was noted that despite favourable road conditions, some units, such as the Dr. Mario Rivas Souza, exhibited lower levels of accessibility, which was attributed to the scarcity of consultation rooms and their location in peripheral areas of the municipality.

Furthermore, units located in the central part of the municipality, such as the Dr. J. Jesús Delgadillo Araujo, showed significantly higher accessibility, not only due to the greater number of consultation rooms but also because they are surrounded by wide avenues and major roads.

These results underscored the decisive influence of road infrastructure on access to health services, in line with studies that have highlighted the importance of transportation networks in the effective provision of public services.

The units with lower accessibility, such as the Dr. Leonardo Oliva Alzaga and the Dr. Mario Rivas Souza, highlighted the need to consider both the geographical distribution of health units and the adequacy of resources available at each unit. This aspect was particularly relevant for the peripheral areas of the municipality, where the combination of greater distances and lower density of services contributed to the population's vulnerability in terms of access to health.

Finally, the study suggested the implementation of policies aimed at improving equity in the distribution of health services, considering not only the expansion of healthcare infrastructure but also the optimization of access routes and the increase in the number of consultation rooms in units with lower accessibility. Additionally, further studies were recommended that include variables such as travel time on public transportation and the population's perception of the quality and accessibility of health services, to provide a more comprehensive view of the problem.

In summary, the research provided significant evidence on the influence of geographical distribution and road characteristics on access to health services in Guadalajara, highlighting key areas for intervention and improvement in the planning of these services.

Conclusions

Technological advancements, along with the continuous renewal of processors, programs, and tools, have made research processes faster and more reliable, and the representation of results more visually appealing. However, it is crucial to have a solid knowledge base, use available techniques appropriately, and develop projects aimed at improving the living conditions of the population.

Regarding the results obtained by applying the potential geographical accessibility index and representing them on maps, it has been possible to clearly identify the areas of the population that face challenges in accessing health services.

This information is vital for taking measures that mitigate, reduce, or eliminate access barriers for the most vulnerable populations. Therefore, the index proves to be a valuable tool for health service planning.

In this context, it is concluded that the application of the potential geographical accessibility index to the municipal medical services units (Cruz Verde) Dr. J. Jesús Delgadillo Araujo, Dr. Ernesto Arias González, Dr. Francisco Ruíz Sánchez, Dr. Leonardo Oliva Alzaga, and Dr. Mario Rivas Souza has allowed for the spatial description and analysis of the varying intensities of access among the resident population in the municipality of Guadalajara.

Most health units, such as Dr. J. Jesús Delgadillo Araujo, Dr. Ernesto Arias González, and Dr. Francisco Ruíz Sánchez, exhibit good accessibility. However, this is not the case for other units, where barriers such as distances and roadways significantly limit access, as evidenced by the findings of this research.

The Dr. J. Jesús Delgadillo Araujo unit stands out for its greater accessibility, as it has a larger number of consultation rooms and is surrounded by wide, two-way avenues, such as Avenida Federalismo, Avenida de los Maestros, Mariano Bárcena Street, and Avenida Jesús García, which facilitate access to this unit.

On the other hand, the health units Dr. Leonardo Oliva Alzaga and Dr. Mario Rivas Souza, located at the southern and northern ends of the municipality, respectively, face the greatest accessibility challenges, both due to the longer distances users must travel and the limited number of consultation rooms available.

Based on the results of this research, it is suggested to apply an additional model that incorporates variables such as public transportation and travel times, with the aim of correlating it with the marginalization index. Additionally, it would be advisable to conduct surveys to understand the perceptions and preferences of the population regarding accessibility to health units.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Ortiz-Curiel, Yaireth-Deyanira conducted primary research, preparation, project administration and conceptualization, methodology, QGIS software, visualization, collected data, and drafted sections related to potential geographic accessibility to municipal medical services (Cruz Verde) in the municipality of Guadalajara.

Niño-Gutiérrez, Naú Silverio validation, writing-review and editing, focused on analyzing the transformation of Guadalajara, Jalisco, México, gathering relevant literature, and synthesizing findings.

Andrade-García, María Dolores and *Macías-Huerta, María del Carmen* contributed by providing expertise in urban planning and offering insights into policy implications and recommendations for general aspects of the municipality of Guadalajara, Mexico, formal analysis, investigation, and supervision.

Availability of data and materials

Availability of data: The collected data as well as supplementary materials accompanying the publication of this research are accessible to other users. Trough request to the author.

Availability of materials: The authors specify that the materials are freely available for the users to use without any restrictions or conditioned associated with Access to them. This means that the materials, such as data sets, or other resources, can be accessed and utilized by anyone interested in the research without requiring permission or facing any limitations. This commitment to open Access promotes transparency, reproducibility, and collaboration in research, allowing others to verify findings, replicate experiments, or build upon the work without barriers.

Abbreviations

AGEB = Basic Geo-Statistical Areas

CLUES = Unique Key of Health Establishments

DGIS = General Directorate of Health Information

GIS = Geographic Information Systems

IIEG = Institute of Statistical and Geographic Information

Article

IMSS = Mexican Social Security Institute

INEGI = National Institute of Statistics and Geography

INSABI = Institute of Health for Well-being

ISSSTE = Institute of Security and Social Services for State Workers

PEMEX = Mexican state-owned company

SEDENA = Secretariat of National Defense.

SEMAR = Secretariat of the Navy

SITEUR = Urban Electric Train System

UTM = Universal Transverse Mercator

WHO = World Health Organization

References

Antecedents

Butler, J. H. (1986). *Geografía económica: aspectos espaciales y ecológicos de la actividad económica*. México: LIMUSA.

Dirección General de Información en Salud. (2020). *Catálogo CLUES*. México.

Donabedian, A. (1988). *Los espacios de la salud: aspectos fundamentales de la organización de la atención médica*. México: Fondo de Cultura Económica.

Instituto Nacional de Estadística y Geografía. (INEGI, 2020). *Censo de Población y Vivienda 2020*. México.

Basics

Congreso del Estado de Jalisco. (2018). *Ley de Salud del Estado de Jalisco*. Publicado el 5 de diciembre del 2018.

Garrocho, C. y Campos, J. (2006). *Un indicador de accesibilidad a unidades de servicios clave para ciudades mexicanas: fundamentos, diseño y aplicación*. *Economía Sociedad y Territorio*, 6 (22), 349-397.

Organización Mundial de la Salud. (OMS, 2015). *Derecho a la Salud*. Centro de Prensa de la OMS, 1-5.

Supports

Congreso del Estado de Jalisco. (2018). *Ley de Salud del Estado de Jalisco*. Publicado el 5 de diciembre del 2018.

Instituto de Información Estadística y Geográfica de Jalisco. (IEG, 2019). *Guadalajara Diagnóstico municipal*. Guadalajara, Jalisco, México.

Differences

Cruz, E. (2018). *Requiere la ZMG 189 ambulancias*. Guadalajara, Jalisco, México. *El Diario NTR*.

Discussions

Congreso del Estado de Jalisco. (2018). *Ley de Salud del Estado de Jalisco*. Publicado el 5 de diciembre del 2018.

Niño-Gutiérrez, Naú Silverio; Macías-Huerta, M. del C.; Andrade-García, M. D. & Amaro-López, J. A. (2023). *Conflicts in the land of Tequila: a geographical approach to the socio-spatial challenges in Guadalajara*. *Journal of Social Researches*, 9(23): 1-9.

Niño-Gutiérrez, N. S.; Hinojosa, A. & Galarza, C. A. (2018). *Aporte al turismo cultural en el Centro Histórico de Guadalajara (2014-2016)*. *Topofilia*, IX, XV, 57-67.

Niño-Gutiérrez, N. S. & Hinojosa, A. (2016). *Entorno sustentable del Instituto Cultural Cabañas-Centro Histórico de Guadalajara, Jalisco, México*. En R. M. Velázquez Sánchez; A. L. Ramos Soto y M. V. Hernández Luis (Coords). *Aspectos de innovación y desarrollo en las organizaciones*. (pp. 1-17). Campeche: Universidad Autónoma "Benito Juárez" de Oaxaca.

Salinas Escobar, M. E.; Niño-Gutiérrez, N. S.; Martínez Barragán, H. & Pérez Alcántara, B. (2012). *Función social de la Geografía en México. El caso de la Universidad de Guadalajara*. En B. Pérez Alcántara; Iliana Araya Ramírez y Fernando Carreto Bernal (Coords). *La función social de la Geografía en América Latina*. (pp. 215-232). USA: Editorial Académica Española.