Title

Assessing Equity in accessibility to haemodialysis services by automobile in Cali, Colombia: cross-sectional analyses using publicly available data.

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Abstract

Objectives: To obtain dynamic spatial-temporal measurements of driving times to haemodialysis services and estimate the benefits of adding new services.

Design: Cross-sectional analyses of dynamic spatial-temporal accessibility, considering traffic congestion. A web-based platform integrated traffic analysis zones, public census and health services datasets, with Google Distance Matrix API big travel-time big data. Predictive and prescriptive analytics identified optimal locations for new haemodialysis services and estimated accessibility improvements.

Setting and participants: Cali, Colombia (2020 population: 2.258 million) using geographic and disaggregated sociodemographic data from the adjusted 2018 Colombian census. Predicted travel times were obtained for 6–12 July and 23–29 November 2020. This study is part of a project measuring accessibility to health services.

Primary and secondary outcomes: Percentage of residents within 20 minutes by car of a haemodialysis service at peak- and free-flow traffic congestion. Locations where new services maximise accessibility and estimated improvements. Findings were disaggregated by sociodemographic characteristics, providing an equity perspective.

Results: Accessibility was lower in July, without COVID-19 traffic restrictions. Traffic congestion reduces accessibility to haemodialysis, hurting more less-educated people, residents of low-income housing and outlying neighbourhoods, and specific ethnic groups.

For 6-12 July, free-flow and peak-traffic accessibility were 95.2% and 45.0%, respectively; 19.9% at peak-traffic for the lowest-income stratum. Adding services in the Agua Blanca district and southern Cali would increase peak traffic accessibility to 70.2% and 62.4% for the lowest-income stratum. Accessibility for 23–29 November was better.
Conclusions: New haemodialysis services in eastern Cali would improve accessibility and reduce inequities. Dynamic accessibility measures improve health services and land-use planning.

RESEARCH IN CONTEXT

- **What is already known on this topic** – *Urban and health services planning do not yet systematically integrate dynamic accessibility measures, which are superior to travelled distance or static assessments. Typically, accessibility studies are sophisticated and geared towards specialised audiences.*
- **This study adds**: dynamic *assessments of urban travel times, the impact of congestion on health equity and accessibility, and the conclusion that new haemodialysis services can improve accessibility for low-income populations and residents from outlying neighbourhoods of Cali. Findings are presented using cartography, simple graphs, and descriptive statistics that different stakeholders can share and interpret with peers and counterparts.*
- **How this study might affect research, practice, or policy** – *This study shows the potential and value of integrating dynamic spatial-temporal accessibility measurements into land-use and health services planning and creating win-win situations. It offers a practical approach to obtaining actionable information and developing a new strategy to improve public policy. Information is suitable for seeking social appropriation of knowledge and integrated knowledge translation.*

Strengths and limitations of this study:

- This study provides affordable, dynamic accessibility measurements for haemodialysis services for urban Cali, with an equity perspective.
- The study uses a web-based platform with a person-centred design that communicates findings using basic descriptive statistics, graphics and cartography.
- Dynamic spatial-temporal analysis measurements account for traffic congestion and offer a proxy for travel costs (i.e., distance, travel cost, and time).
- Models need to be retrained if conditions change.
- Reducing inequities in accessibility requires adding new services accessible to all who need them.

Introduction

Background/rationale

Accessibility to essential health services advances sustainable development goals (SDGs), improves health and well-being (SDG 3), reduces inequalities (SDG 10) and makes cities and communities more sustainable (SDG 11). Accessibility measures how easily and quickly people can reach a particular location, such as a health service facility. It is a dynamic attribute because it can change over time due to factors such as changes in transportation infrastructure, traffic patterns, and population density. This study measures accessibility in terms of the travel time from a residence to a health service location. This information helps us understand how long people need to travel to access healthcare and can be used to identify areas where access to healthcare may be limited.[1,2]

This study is part of the AMORE Project, a proof of concept evaluating new approaches to place-based dynamic spatial-temporal accessibility measures (DSTAM) to health services by integrating publicly available data. Using existing data facilitates fast, affordable assessments of DSTAM, and the AMORE Project seeks to deliver granular information for an entire city with an equity perspective.[1–3] An earlier report assessed accessibility in urban Cali to tertiary care emergency services, which are essential to all residents.[4] This study assesses accessibility to haemodialysis services. It identifies the approximate location(s) where new services would place most of the urban population of Cali within 20 minutes of a haemodialysis service by car and the population in the catchment area of those locations. This study thus provides a proxy measurement and new data to inform health services planning and a strategy for reducing inequities in accessibility.[1]

Haemodialysis is an expensive, life-saving treatment usually administered three times weekly for about four hours. Regular use and adherence usually improve the quality of life of people with end-stage renal disease (ESRD).[5–7] Roughly three of every four people requiring kidney replacement therapy in Colombia are in haemodialysis. There are 516 patients per million population (PMP) in haemodialysis and 103 new PMP yearly.[8] Home haemodialysis is not widely available in Colombia,[9] and travel time to haemodialysis might be associated with higher mortality rates and lower health-related quality of life.[10] People in outlying areas of Cali seeking haemodialysis have described the challenges they face in video testimonies.[11]

Colombia offers universal health coverage through a two-tier health services system and special regimes that cover insured and uninsured populations.[12] Nonetheless, travel times and their associated direct and indirect costs represent access barriers to care. In 2019, the Colombian Constitutional Court ruled that the national health insurance program must cover transportation costs, but Colombian insurers still need to comply with this order fully.[13]

The direct and indirect costs of frequent commutes to haemodialysis can impoverish patients and their families. A family member usually accompanies the patient to haemodialysis sessions, often missing work or the chance to seek a new job or a promotion.[14,15] We did not find an analysis or assessment of the financial burdens of haemodialysis, but obtained personal accounts of how haemodialysis can impact patient and family finances, including video testimony of patients from outlying areas of Cali.[11] Haemodialysis causes changes that can impair physical capacity and mobility, and patients need endurance training to counter these changes, but that training is not a standard practice.[16,17] Such mobility issues add to the challenges of long journeys.

DSTAM account for traffic congestion delays and are becoming available for cities where traffic congestion impact accessibility and health equity.[2,18–21] Unlike most accessibility studies, which use sophisticated methods requiring specialised expertise, the AMORE Project follows knowledge translation good practices by engaging a broad range of stakeholders with a person-centred strategy. That approach aims to translate integrated knowledge and deliver information that stakeholders can communicate to their peers and the public.[1,22–26]

DSTAM can inform health services and land-use planning from an equity perspective. In this project, DSTAM rely on simple metrics like time-to-destination to monitor and address accessibility, health equity, and social justice factors.[2]

This study assessed accessibility by car to haemodialysis services in Cali, the third-largest city in Colombia by population and the largest in the Colombian Pacific region. A 20-minute travel-time threshold was set to predict the effects of adding new services in one or two new locations that would optimise accessibility. [1] An interface of the web-based AMORE Platform is available for readers to test assumptions, modify parameters, and draw conclusions.[22,27,28] This study advances the global research priorities for urban health.[29]

Objectives

This study characterises geographical accessibility to haemodialysis services in urban Cali and its relationship with sociodemographic factors and health equity. It also suggests locations where new services would maximise accessibility if all patients could use them and predicts how much accessibility would increase. This study also benchmarks potential improvements that could be reassessed as conditions change and addresses these questions:

- What accessibility to haemodialysis did urban Cali dwellers have in 2020, depending on their sociodemographic characteristics?
- Did accessibility vary according to socioeconomic status in urban Cali?
- What improvement would result from strategically adding new haemodialysis services in one or two new neighbourhoods in Cali?

Methods:

Study Population and setting

The rationale and methods for this study are published.[1–4] This study assesses accessibility by car to the service with the shortest travel time among the 11 haemodialysis services, which together had 370 haemodialysis chairs in 2020. According to an international traffic scorecard, Cali was the fifth-most congested city in South America and 76th globally.[30] It has been a magnet for migration, and it was an epicentre for social unrest in 2021, during the COVID-19 pandemic.[31–33] Traffic congestion fluctuated widely in 2020 due to COVID-19 pandemic-related quarantines, stay-at-home orders, and traffic restrictions, such as those implemented in November.[4,34–36]

ESRD has increased in Cali in recent years, affecting 128 per 100,000 people in 2020. Rates increase with age, especially after age 30. In 2020, 1545 people underwent haemodialysis in Cali, with the vast majority being adults.[37,38] Patients typically travel by car (private or for hire) with a family member to haemodialysis appointments. In Colombia, insurers contract with health-providing institutions (IPS in Spanish), and these contracts define which health services patients access. We did not match patients with insurance and provider contracts.

About 75% of Cali households rely on the informal economy, mainly the most vulnerable. Unemployment rates in 2020 were 17.3% for men, 24% for women, 24.2% for young men (15-28 years), and 34.3% for young women. About 11.7% of the population lives in multidimensional poverty, and 82.2% of urban Cali residents have health insurance. [39,40]

Targeted sites/participants

We identified all 11 haemodialysis services in Cali using the Ministry of Health Special Registry of Health Services Providers (REPS in Spanish), which remained unchanged between July 2020 and January 2021. These services are all located along a corridor in north-central Cali that follows a major street, Calle Quinta, and appear on Map 1.[41]

Map 1 Location of haemodialysis units in Cali, 2020 (order in which REPS displayed them)[41]

Study design

We did two cross-sectional analyses by integrating public data sources in the web-based AMORE Platform, which displays DSTAM for each Traffic Analysis Zone (TAZ) to the TAZ hosting the haemodialysis services with the shortest travel time. TAZs are geographic units commonly used in transportation planning and are usually built on census blocks. Travel times are typically short within a TAZ, but populations are not evenly distributed in TAZs. Therefore, travel times from each of 507 TAZs in Cali were measured from the population-adjusted geometric centroids. [42] The 11 haemodialysis services in Cali are concentrated in six TAZs.

Data for the cross-sectional analyses was obtained from the web-based AMORE Platform (https://www.iquartil.net/proyectoAMORE), hosted by iQuartil SAS and developed under the leadership of the principal investigator (LGC) and analytics adviser (DC).

The AMORE Project explores whether dynamic travel times to specific services can be easily analysed using public data sources. The platform shows the populations within reach of the service with the shortest travel time and disaggregates sociodemographic variables to provide an equity perspective.

The AMORE Platform integrates these data sources:

- 2018 National Census Data for Cali, obtained from the official public databases of the Colombian National Department of Statistics (DANE in Spanish), and adjusted to 2020.[43,44]
- The administrative divisions of Cali were obtained from government sources: the IDESC Geoportal, Traffic Analysis Zones (TAZ), and census block sectors. [45,46]
- Google's Distance Matrix API. For this test case assessment of urban Cali, data were downloaded on July 3, for the week of 6 – 12 July 2021. Predicted times were downloaded on 27 October for the week of 23 – 29 November 2020.
- The 11 haemodialysis services in Cali were identified using the REPS registry.[41] These services were in six TAZs, with one TAZ hosting four services and another TAZ hosting three.

Data for this case study were a subset of the data used by the AMORE Project to measure accessibility to 30 health services: 14 tertiary care emergency departments, 11 haemodialysis services, and five radiotherapy services. These 30 services were in 15 TAZs, with one TAZ hosting seven services, another TAZ four, six TAZ hosting two, and seven hosting a single service. Had the project focused on haemodialysis only, the eleven services would have been studied by assessing travel times to six TAZs.

Measuring DSTAM for the three types of services (tertiary care emergencies, haemodialysis, and radiotherapy), using traffic congestion clusters and TAZs brought efficiencies and reduced travel time data download cost and complexity. Measurements were reduced from 43.1 million data points (507 origins to 506 destinations for 168 hours weekly) to a sample of 68,445 (507 origins to 15 destinations for 9 traffic congestion clusters) for each week analysed.[1,4] Using predictive analytics based on the sample, an estimation was made for 2.3 million travel times (507 origins to 506 destinations in 9 traffic congestion clusters) for each week analysed.

Variables

The main study outcome was the proportion of urban dwellers likely to reach a haemodialysis service within 20 minutes by car. Data were disaggregated by age, self-reported sex, education level attained, literacy, marital status, and household economic stratum based on electricity bill stratification. Other study outcomes include 10-minute accessibility intervals, up to an hour, by household economic stratification.

Travel-time thresholds were based on expert advice from contributors to the AMORE Project collaborative group, including patient advocates. We found no international standards, and we only assessed travel time by car (private and for hire), which will likely be unevenly distributed across socioeconomic groups.

Data are displayed using graphs with disaggregated figures and colour-coded choropleth maps, presenting travel times and population density for each TAZ. For the predictive and prescriptive analyses, one or two TAZs where new services would optimise accessibility were identified, and results were disaggregated by sociodemographic characteristics. Figures 1 and 2 are screenshots from AMORE Platform interfaces showing the variables reported for the situational and predictive analyses.

Traffic clusters range from free-flow (level 1) to peak traffic (level 9).[1,4]

Figure 1. AMORE Platform interfaces with situational and predictive analyses, 6–12 July 2020
Figure 2. AMORE Platform interfaces with situational and predictive analyses, 23–29 Nov 2020

These data are also displayed in colour-coded choropleth maps presented in 3D, with each choropleth representing a TAZ and their height representing its population density. These maps reveal the relationship between population density and geographic location with travel times. The colour code should help stakeholders and sector leaders agree on a common goal, such as "painting the city green" or putting all people within a 20-minute travel-time threshold from a service.

Figure 3. Choropleth maps comparing accessibility if services were added in new TAZs, for 6-12 July 2020
Figure 4. Choropleth maps comparing accessibility if services were added in new TAZs, for 23-29 November 2020

Household socioeconomic stratification in Colombia has an incremental range from 1 to 6, with six representing the highest-income household group. Household socioeconomic stratum was categorised into Low (levels 1 and 2), middle (3 and 4), and high (5 and 6).

Earlier publications have described the definition of traffic levels and subgroup variation measurement.[3,4,42]

Results / Outcomes

Cali has substantial traffic congestion and remains congested through most of the day and evening, even on weekends. Traffic level 8, the second highest, accounts for 40/168 (24%) hours of the week. Traffic clusters are skewed, with most activity hours having high-traffic congestion levels.

Figures 1 and 2 are screenshots from AMORE Platform interfaces that display the variables and disaggregated data for the situational and predictive analyses for the July and November assessments. These analyses include baseline data and estimate accessibility after adding services in one or two additional TAZs.

Figure 3, Figure 4, and Supplemental File 1 illustrate the impact of traffic congestion on accessibility under real and predicted scenarios. These results point to the locations where new services would maximise urban accessibility and provide overall and disaggregated estimates and variations for the July and November assessments.

Supplemental File 1. Traffic congestion and accessibility to haemodialysis, Cali 6-12 July 2020. Animation

Population characteristics are presented in Table 1. About half of Cali residents live in low-income housing, 40% live in middle-income households, and about 9% live in high-income housing, including domestic workers. The southern end of Cali is inhabited mainly by high-income households living in villas. The choropleth map shows that most of the population and the most densely populated areas are towards the periphery of Cali and far from haemodialysis services. Travel-time comparisons between 6–12 July and 23–29 November 2020 show that traffic was notably lighter in November, when COVID-19 traffic restrictions were in place. The effect of these measures varied throughout city sectors.

The images and data revealed that services are concentrated, and most of the population incurs long journeys, particularly the poorest and those from minority ethnic groups.

Placement of new services to optimise equitable accessibility

The optimal location for maximising accessibility changed between neighbouring TAZs between July and November but remained close and within minutes. For July, the best TAZ was in the Alirio Mora Beltrán neighbourhood; for November, it was in the neighbouring Marroquin III TAZ. Both TAZs are in the eastern Agua Blanca district (Figure 5). If services were added in two TAZs, the TAZ initially identified would remain the same. The second recommended TAZ was for Parcelaciones del Pance in July and San Joaquín in November; these southern neighbourhoods are adjacent (*Figure* 5).

Figure 5. TAZs where new services optimise accessibility

Adding new haemodialysis service(s) to the recommended locations — in Alirio Mora Beltran or Marroquin III TAZ in the eastern district of Agua Blanca, with access to all patients — would greatly improve accessibility for the entire city. In this scenario, we estimated that accessibility for July 2020 rose from 45.0% to 70.2% for July 2020 and from 69.7% to 91.4% for November. These results levelled accessibility specifically by benefiting the lowest-income residents of Cali. For example, in the July estimates, accessibility for the lowest-income group (i.e., stratum 1) rose from 11.4% to 64.9%. Populations living in the southernmost high-income suburban areas benefited the least from the new service.

Adding services in the southern Pance neighbourhood would reduce differences for most subgroups, raising urban accessibility to 75.1% in July and 97.2% in November. Both results represent dramatic improvements over baseline assessments.

Applying the city's prevalence of haemodialysis (128 per 100,000 people) to July's estimations shows that adding services in Alirio Mora Beltrán would put 700,472 people within the 20-minute threshold of those services, with an estimated 897 requiring haemodialysis; the figure could be higher considering that ESRD is more prevalent in low-income communities.

Adding services in Parcelaciones del Pance would put an additional 122,665 people within the 20-minute threshold, which could result in an estimated 157 requiring haemodialysis. The two services would bring a population of 823,137 within the 20-minute threshold, and about 1054 require haemodialysis. While these estimations are simplistic and a proper one more would have more nuances, they give an insight into the opportunities and possibilities of refining these tests case to guide decision making.

The strategic location of new services will specially benefit populations in outlying areas and vulnerable groups such low-income households, some ethnic groups, and people whose education attainment isn't high. It will also likely reduce the workload and need for night schedules for existing services.

Choropleth maps show that offering haemodialysis in the eastern district of Agua Blanca would make haemodialysis accessible to densely populated areas of the city. These additions would nearly double overall urban accessibility and level accessibility rates in sociodemographic groups, reducing most inequities (Figure 3 and Figure 4; Table 2 and Table 3).

Table 1. 20-minute accessibility to haemodialysis in Cali by socio-demographic group

The 10-minute interval assessments by housing socioeconomic stratum (Figure 6) also revealed links between income and accessibility, except for the highest-income households living in south-end villas. For these households, accessibility would only improve if services were added in the thinly populated south end of the city. Differences between income groups were noticeable throughout and worsened with traffic congestion. Adding services in the proposed TAZs reduced inequities even though these persisted for the shorter 10-minute journeys (Figure 1, Figure 2, Figure 6).

The analysis found that during peak traffic congestion and at most hours of the day (traffic levels 8 and 9), most people in the lowest-income stratum could not reach a haemodialysis service within 20 minutes. This was true in both the July and November assessments (11.4% and 39.6%, respectively).

Data indicates that accessibility is an access barrier for low-income households, specifically in areas with high population density and outlying urban sectors (Supplemental File 1 and 2). The situation is worse than the study found because we did not consider service restrictions providers impose, which further reduce accessibility.

Data for the predicted accessibility to the haemodialysis service with the shortest travel times are provided in Table 2 (absolute figures) and Table 3 (relative subgroup proportions).

Haemodialysis services are concentrated in areas distant from most of the population. Even during the early morning (5 AM) or late evening (11 PM) on weekdays, almost one-fifth of the population is beyond the 20-min travel threshold, including some of the poorest people and those living in outlying areas.

The 20-minute threshold used in this study was deemed sound and appropriate for context by collaborative group members, including patient representatives. We found no benchmarks for travel times to haemodialysis. Time is a continuous variable; an arbitrary threshold was chosen. An interactive interface enables stakeholders, including decision-makers, to test different assumptions and variables, assess the resulting data, draw conclusions and challenge current thinking.[22] The haemodialysis sections of the AMORE Platform will be available at https://www.iquartil.net/proyectoAMORE/ for at least two years from the date of this publication.

Discussion

This proof-of-concept study focuses on urban Cali, Colombia, and similar studies could include entire metropolitan areas and their broader service catchment areas.

The studied scenarios considered transportation by car, commonly used and deemed convenient by those seeking haemodialysis services.[5] Future studies could explore other means of transportation, link services with insurance, and integrate prevalence and incidence data or appointment availability to provide more refined information. Future studies could also determine availability with the shortest travel time and expand coverage to suburban and rural areas or other communities accessing these services. These objectives, and examining different health services, are beyond the scope of this report.

In terms of cost, if each travel time measurement were charged at 0.08 USD, obtaining measurement for every origin-destination combination in 168 hours of a week would be 3.45 million USD. The efficiencies introduced by clustering and predictive modelling would reduce this cost to 5476 USD.

Other studies have shown that socioeconomic characteristics and distance are associated with accessibility. This study provides accurate granular measurements, identifies travel time as a barrier to access, and corroborates that those most in need generally pay a higher share of their family income to access services.[47–51]

The most vulnerable populations are most likely to require haemodialysis and face higher direct and indirect costs, even if national insurance covers the treatment (Figure 1, Figure 2, and Figure 6). Moreover, insurance agreements likely restrict access to some haemodialysis services offering the shortest travel times. This report does not include an economic analysis, but low-income families might rely on just one or two minimum wages. Frequent long trips can hurt these families by consuming most of the minimum wage in direct travel costs. This burden will likely affect families in outlying areas of Cali, where much of the population lives and some of the poorest residents concentrate. Low-income families are likely to live with three or fewer minimum wages and can easily incur catastrophic health costs, well above 15% of their family income.[52,53]

Patient stories show that getting to services is challenging and physically demanding for patients living in outlying city areas. One haemodialysis patient explained, "I spent four hours in haemodialysis. Many other patients would spend hours just commuting to and from haemodialysis, whether on their car or shared rides arranged by health providers. Long travel times added to treatment duration, taking most of the time patients and companions had for other activities." (Personal communication, Felipe Piquero, November 2022).[5,11] The situation was worse and riskier for those relying on public transportation.

Key results

Accessibility figures varied substantially between the July and November assessments, but the ideal locations for new haemodialysis services did not. These assessments suggest the need for adding haemodialysis services accessible to all people in the eastern Agua Blanca district. These locations in eastern Cali were consistent when independent assessments explored adding services in one or two TAZs.

A potential application of this data is prioritising transportation or subsidising travel costs for people with longer travel times and vulnerable populations; data could be used to determine subsidy rates.[54]

Traffic congestion consistently burdened people in outlying areas of Cali, including most low-income populations. Traffic congestion remains high and impacts accessibility most of the day (Figure 7). Readers can explore different assumptions in the interactive platform.[4,22]

Limitations

While all people should be within a short travel time of service, travel time to the nearest service alone does not guarantee accessibility. Haemodialysis patient services are covered by health insurance, but the extent of coverage depends on agreements with service providers, and coverage only sometimes includes transportation. The ideal scenario would be for all patients to access a service in each of the six TAZs hosting these services. Services would also need the capacity to absorb the demand. The geographic, ethnic, and socioeconomic distribution of haemodialysis patients in Cali is unknown to the research team.[38]

Bias

The study shows travel times to the TAZ hosting the haemodialysis service(s) with the shortest travel times. Because accessibility to services sometimes depends on insurance affiliation, findings will likely show a favourable result despite services being concentrated in six TAZs. Some patients may not be eligible to use the services in the TAZ with the shortest travel time.

We measured travel times twice during the COVID-19 pandemic, and variations are likely due to changes in travel restrictions and stay-at-home orders in effect in November 2020. Both assessments were done in weeks with no holidays.

This study does not adjust the socioeconomic stratum for low-paid, domestic homeworkers who live and work in middle or high-income households.

Travel time between TAZs follows diverse patterns and directions throughout the day. For example, commuting impacts TAZs differently. Traffic clusters were sorted in incremental order for each TAZ, and it was found that the sorting switched the order of contiguous clusters in fifteen cases. This has a minimal impact as variations between adjacent clusters are small.

The concentration of the eleven units in the central west end of the city (near Calle Quinta, see Map 1 or Platform) might mitigate differences in service arrangements, and refining those measurements is beyond the scope of this report. This study also did not assess appointment availability in services, a refinement that could be developed for the AMORE Platform.

Haemodialysis travel times varied substantially during the COVID-19 pandemic, and it is still unknown how this influenced Google Distance Matrix algorithms.[55] Empirical and anecdotal reports suggest they remained accurate.[56]

Poor road conditions can add to travel times and are not evenly distributed throughout the city.[57] Impactful road conditions and infrastructure changes, for example, road enhancements and new traffic light corridors controlled by artificial intelligence, might justify reassessing travel times.

Table 2. Predicted accessibility to the haemodialysis service with the shortest travel times (absolute figures)

Table 3. Predicted accessibility to the haemodialysis service with the shortest travel times (relative figures)

Interpretation

Accessibility varied substantially between July and November (45.0% vs 69.7%), probably due to traffic restrictions during the COVID-19 pandemic in November. [4] This variation added 557,713 people into the 20-minute threshold, primarily benefitting low- and middle-income populations. Accessibility during peak traffic times rose 31.3% for low-income households (19.9% to 51.2%) and 21.0% for middle-income households (68.9% to 89.9%). Accessibility for high-income households rose just 6.2% (from 72.0% to 78.2%), perhaps because most families live close to services or in south-end villas that will still face long trips.

Subgroup improvements by other sociodemographic characteristics varied between 18% and 29%, with two exceptions. First, accessibility for people with graduate degrees rose 13.2%, reflecting November traffic restrictions and overlap in geographic distribution with high-income households. Second, accessibility rose 79.6% for the small Palenque people population concentrating around a cluster of TAZs.[4]

Considering that the cost of displacement is a function of distance, time, and expenditure, Figure 6 suggests, as presented in some sophisticated time-space maps and the evolving perspective of time-space geography, that strategically adding new services could “shrink the city” by putting such health services within a short travel time of the population.[58]

We suggest updating the data to see how they evolve as the COVID-19 pandemic recedes. We recommend that planning authorities who make decisions using this study rely on the July assessment, which will likely reflect everyday conditions before travel restrictions. Nonetheless, the areas in which new services would optimise accessibility appear to remain consistent. Updating data and checking the models would be ideal, and this unfunded proof of concept indicates that these steps are affordable for a city.

If planning authorities must decide, we recommend adding sufficient services to cope with demand, first in the most impactful recommended location, using the July estimates, which seem to reflect typical conditions in Cali. However, a better option is to update the assessments as the COVID-19 pandemic recedes and updated census data become available in 2023. The overall recommendation to add service(s) accessible to all patients in eastern Cali, near the Alirio Mora Beltrán neighbourhood, might not change. Implementing that recommendation would probably double accessibility and reduce inequities.

Generalisability

Our findings show that it is possible to obtain data on accessibility to health services, such as haemodialysis in Colombia, and deliver it in user-accessible formats for relevant stakeholders and diverse audiences to share. It is likely also possible in other countries with digitised census and services data and where travel-time estimates are available. Multiple travel-time data providers are likely available for other health services in congested cities in Latin America and beyond.

DSTAM might not be as valuable in uncongested areas, such as most rural settings, where travel-time variations are slight.

The study received no external funding and involved a multistakeholder, multidisciplinary group that includes local data scientists and academics. It can likely be replicated with the funding and resources available to cities. Available data provide a general assessment of accessibility. For services such as tertiary care emergencies accessible and relevant to the entire population, findings can be easily generalised.

There is room for refinement by adding layers such as the incidence of ESRD and the availability of haemodialysis chairs. Further improvements require details on insurance agreements, access to providers, and the distribution of insurance coverage in population groups. Still, the recommendation of our study to add services that all citizens can access in the recommended areas might hold. Adding existing public and private infrastructure layers suitable to host new services is another possible refinement.

It might be a sound idea to repeat these studies regularly as infrastructure, traffic conditions, and the population change; there has been significant migration to Cali.

Findings from the AMORE Project suggest that strategically adding new services can dramatically improve accessibility and synergically advance SDG 3, SDG 10, and SDG 11 in Cali.

This test case shows the value of using available data to measure and monitor dynamic geographical accessibility to health services in cities and regions. This information can be useful in achieving the United Nations 2030 Agenda goals, including Goal 3: Good Health and Well-Being (ensuring everyone has access to quality healthcare services). This test case provides inputs for specific indicators, such as coverage for essential health services (3.8.1, the percentage of the population with access to essential health services). This test case shows how dynamic geographical accessibility can be used to help understand and improve access to healthcare.

This test case also highlights the potential for using dynamic geographical accessibility data to support democratic urban planning processes and promote the participation of civil society (SDG indicator 11.3.2). City planners and decision-makers who understand the travel times to different locations and their effects, can make more informed decisions about placing healthcare facilities. They can involve the community in these decisions by providing them with data about accessibility and health equity. Community involvement can help ensure that city planners and decision-makers consider the needs and concerns of residents and can lead to more equitable distribution of resources.[59]

Other information

Funding

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Ethical considerations

This observational study on quality improvement for health services planning does not involve human subjects research. It integrates anonymised coded secondary data sources obtained from publicly available open records. No identifiable private information was used in the study. The Doctoral Programme on Methodology of Biomedical Research and Public Health at the Department of Paediatrics, Obstetrics & Gynaecology and Preventative Medicine at the Universitat Autònoma de Barcelona has provided oversight of the project. Contributors to this study are members of the AMORE Project Collaborative Group and public servants in their official capacity; those who approved are listed in the acknowledgements. The protocol is cited in this article and available from the institutional repository of the Universitat Autònoma de Barcelona (https://ddd.uab.cat/record/266860?ln=ca).[1]

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Map 1 Location of haemodialysis units in Cali, 2020 (order in which REPS displayed them) [41]

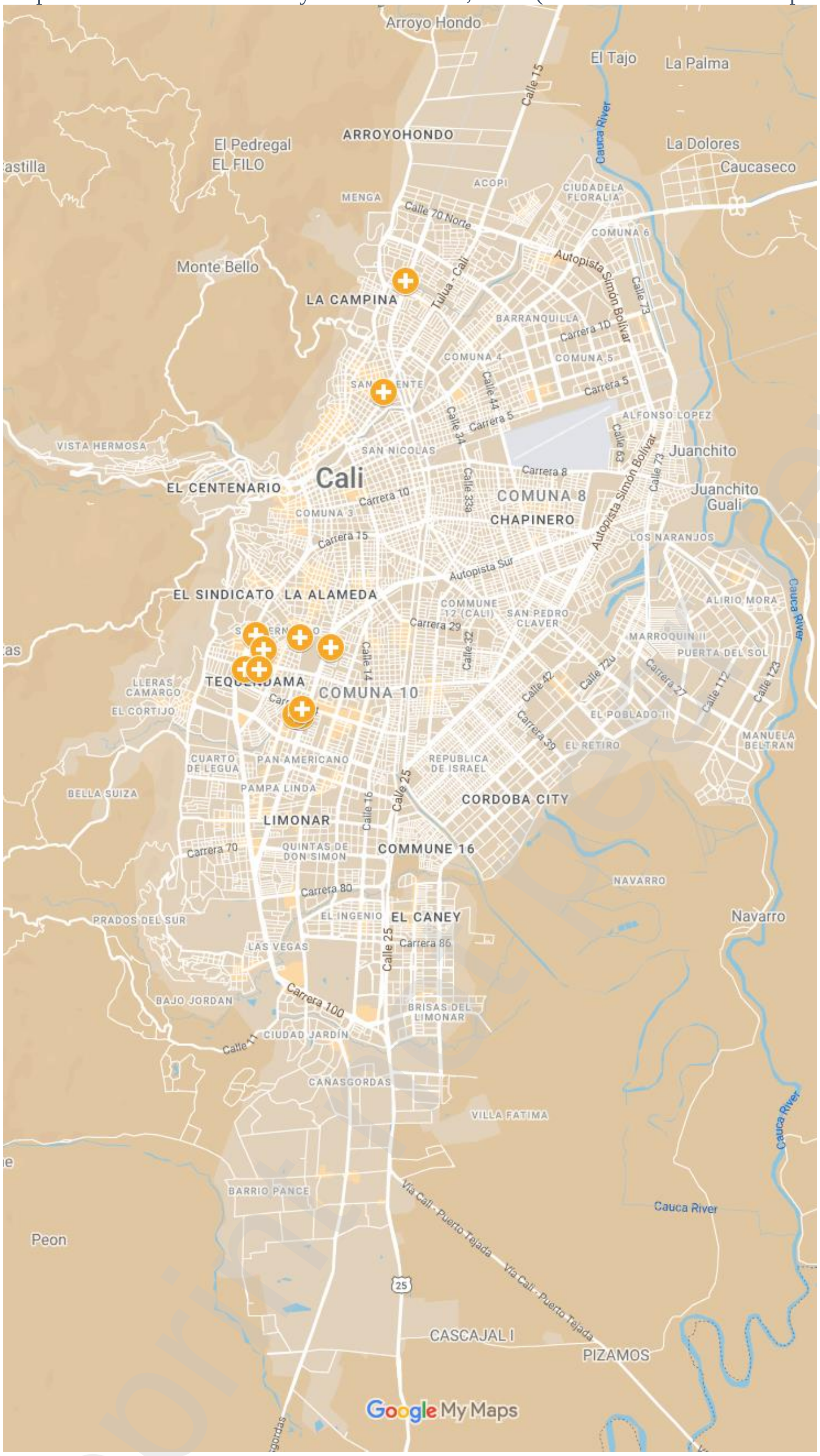


Figure 1. AMORE Platform interfaces with situational and predictive analyses, 6–12 July 2020

Figure 2. AMORE Platform interfaces with situational and predictive analyses, 23–29 Nov 2020

Figure 3. Choropleth maps comparing accessibility if services were added in new TAZs, for 6-12 July 2020

Figure 4. Choropleth maps comparing accessibility if services were added in new TAZs, for 23-29 November 2020

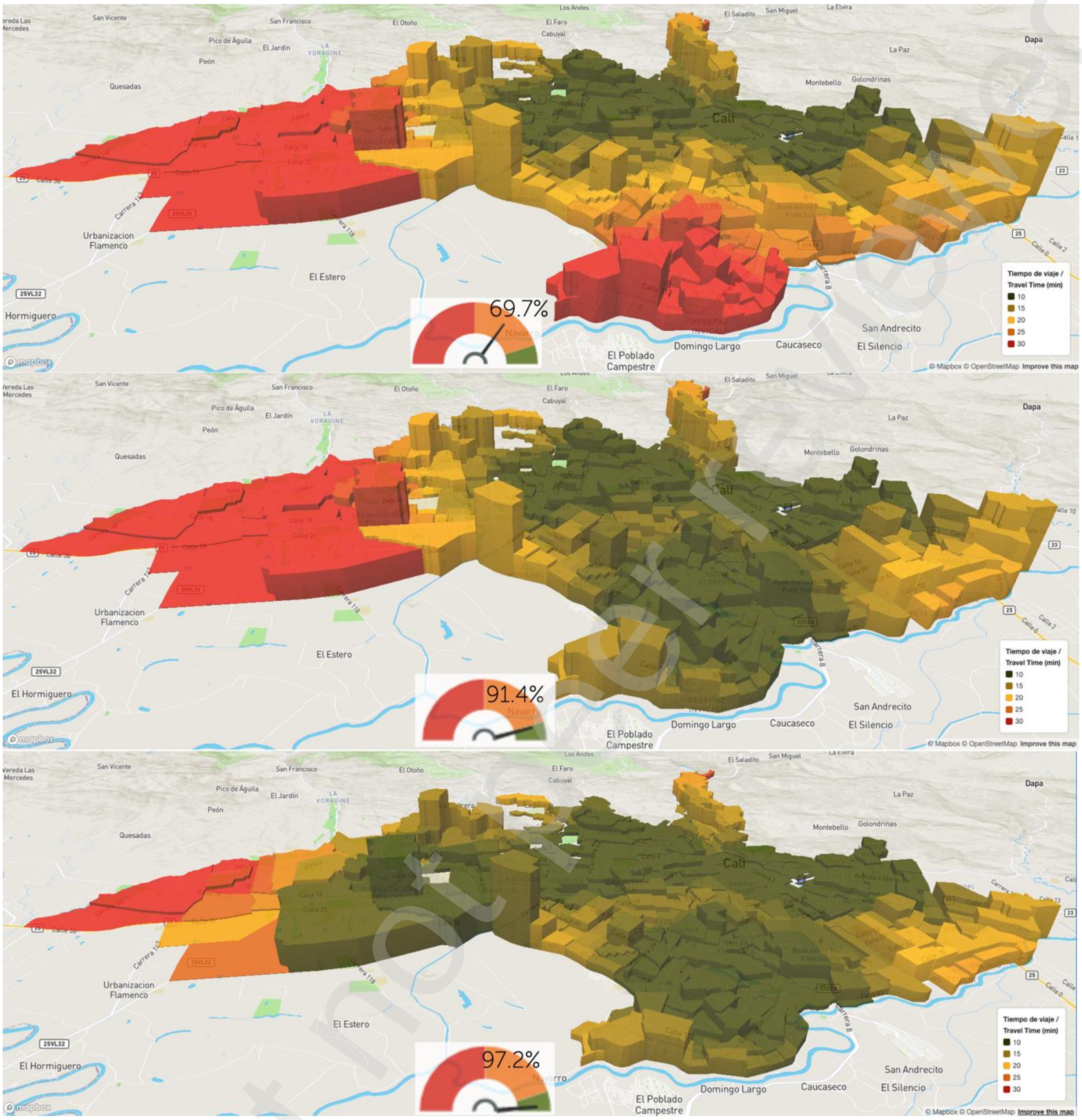


Figure 5. TAZs where new services optimise accessibility

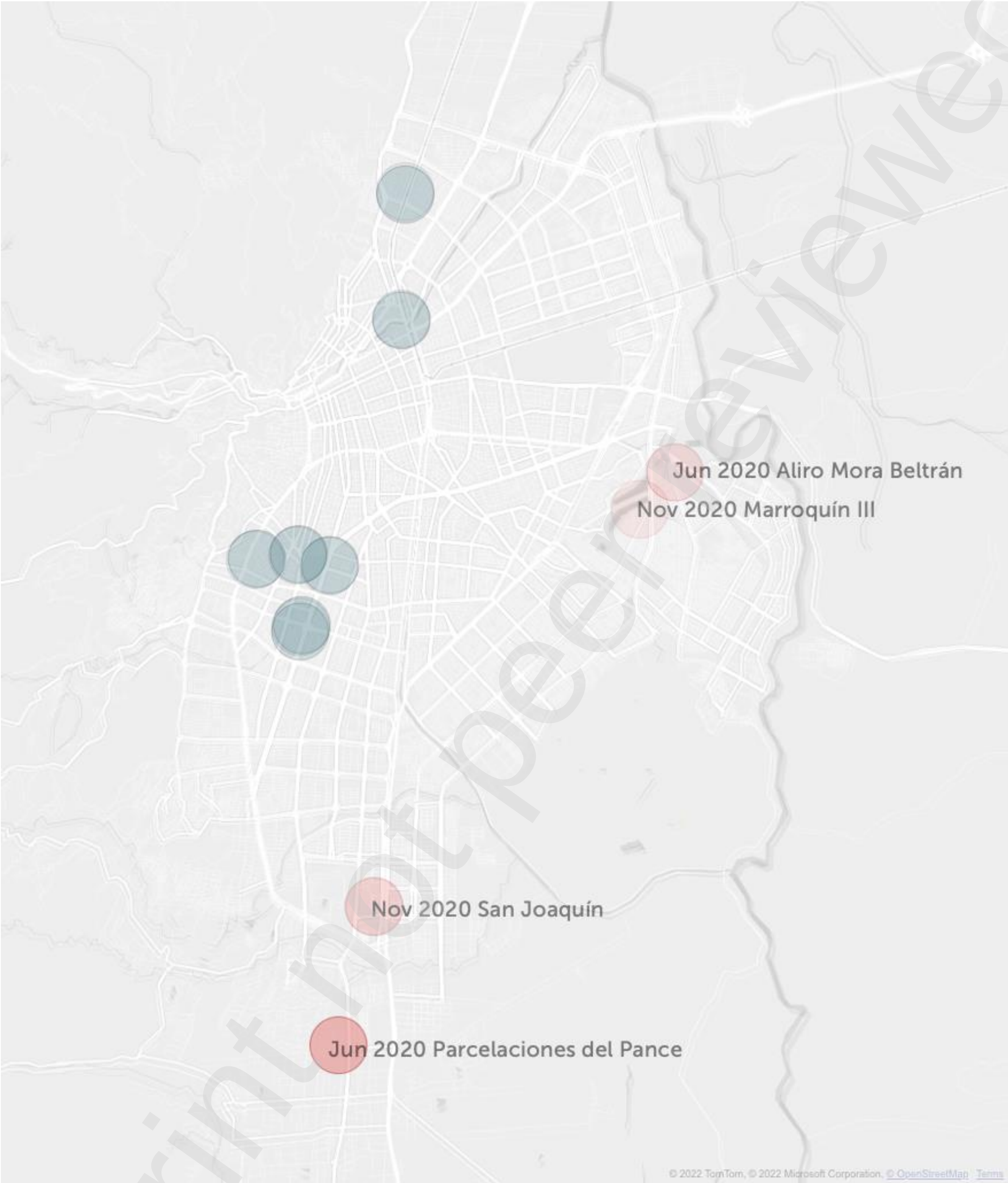


Table 1. 20-minute accessibility to haemodialysis in Cali by socio-demographic group

Situational analysis 20 min accessibility to the nearest hemodialysis service (using Total Pop)	Jul 2020 (#)	Nov 2020 (#)	*Variation (#)*	Total Population	%	Accessibility July	Accessibility November	*Subgroup variation*
	1,017,011	***1,574,724***	*557,713*	***2,258,823***		***45.0%***	***69.7%***	
Socio-economic stratum								
Low	221,296	568,115	*346,819*	1,109,549	49.1%	19.9%	51.2%	*31.3%*
Middle	645,076	841,224	*196,148*	935,699	41.4%	68.9%	89.9%	*21.0%*
High	147,229	160,082	*12,853*	204,589	9.1%	72.0%	78.2%	*6.3%*
N.D.	3,410	5,303	*1,893*	8,986	0.4%	37.9%	59.0%	*21.1%*
Ethnicity								
Afrodescendent	85,481	174,224	*88,743*	325,865	14.4%	26.2%	53.5%	*27.2%*
Rrom (nomadic)	40	58	*18*	102	0.0%	39.2%	56.9%	*17.6%*
Indigenous	4,339	7,394	*3,055*	11,112	0.5%	39.0%	66.5%	*27.5%*
Islander/Raizal	214	276	*62*	382	0.0%	56.0%	72.3%	*16.2%*
Other (Caucasian, Mestizo)	910,535	1,369,069	*458,534*	1,890,491	83.7%	48.2%	72.4%	*24.3%*
Palenque	41	231	*190*	245	0.0%	16.7%	94.3%	*77.6%*
N.D.	16,361	23,472	*7,111*	30,626	1.4%	53.4%	76.6%	*23.2%*
Educational level								
Graduate degree	48,919	57,641	*8,722*	72,441	3.2%	67.5%	79.6%	*12.0%*
Bachelor's Degree	187,250	240,652	*53,402*	295,319	13.1%	63.4%	81.5%	*18.1%*
Technical	123,846	187,591	*63,745*	244,160	10.8%	50.7%	76.8%	*26.1%*
Middle	254,015	409,594	*155,579*	608,429	26.9%	41.7%	67.3%	*25.6%*
High School	132,875	222,293	*89,418*	337,065	14.9%	39.4%	65.9%	*26.5%*
Primary	178,303	304,450	*126,147*	468,206	20.7%	38.1%	65.0%	*26.9%*
Pre-school	13,559	23,360	*9,801*	36,294	1.6%	37.4%	64.4%	*27.0%*
No data	78,244	129,143	*50,899*	196,909	8.7%	39.7%	65.6%	*25.8%*
Literacy								
Literate	935,369	1,436,134	*500,765*	2,043,041	90.4%	45.8%	70.3%	*24.5%*
No literacy	21,864	40,417	*18,553*	66,383	2.9%	32.9%	60.9%	*27.9%*
N.A.	44,609	76,938	*32,329*	121,140	5.4%	36.8%	63.5%	*26.7%*
N.D.	15,169	21,235	*6,066*	28,259	1.3%	53.7%	75.1%	*21.5%*
Gender/Sex								
Fem	547,601	844,077	*296,476*	1,208,617	53.5%	45.3%	69.8%	*24.5%*
Masc	469,410	730,647	*261,237*	1,050,206	46.5%	44.7%	69.6%	*24.9%*
Civil status								
Single	370,444	575,999	*205,555*	821,536	36.4%	45.1%	70.1%	*25.0%*
Married or cohabitation	403,517	624,355	*220,838*	896,958	39.7%	45.0%	69.6%	*24.6%*
Divorced or separated	81,711	118,628	*36,917*	163,980	7.3%	49.8%	72.3%	*22.5%*
Widow	52,705	73,457	*20,752*	95,611	4.2%	55.1%	76.8%	*21.7%*
N.A.	94,566	162,468	*67,902*	254,492	11.3%	37.2%	63.8%	*26.7%*
N.D.	14,068	19,817	*5,749*	26,246	1.2%	53.6%	75.5%	*21.9%*
Age								
0-4	44,609	76,938	*32,329*	121,140	5.4%	36.8%	63.5%	*26.7%*
0-14	150,093	256,909	*106,816*	400,527	17.7%	37.5%	64.1%	*26.7%*
5-14	105,484	179,971	*74,487*	279,387	12.4%	37.8%	64.4%	*26.7%*
15-24	147,838	242,147	*94,309*	363,311	16.1%	40.7%	66.7%	*26.0%*
15-59	657,107	1,027,559	*370,452*	1,482,069	65.6%	44.3%	69.3%	*25.0%*
15-64	716,344	1,111,425	*395,081*	1,595,016	70.6%	44.9%	69.7%	*24.8%*
60+	209,811	290,256	*80,445*	376,227	16.7%	55.8%	77.1%	*21.4%*
65+	150,574	206,390	*55,816*	263,280	11.7%	57.2%	78.4%	*21.2%*
80+	40,103	52,080	*11,977*	64,100	2.8%	62.6%	81.2%	*18.7%*

Table 2. Predicted accessibility to the haemodialysis service with the shortest travel times (absolute figures)

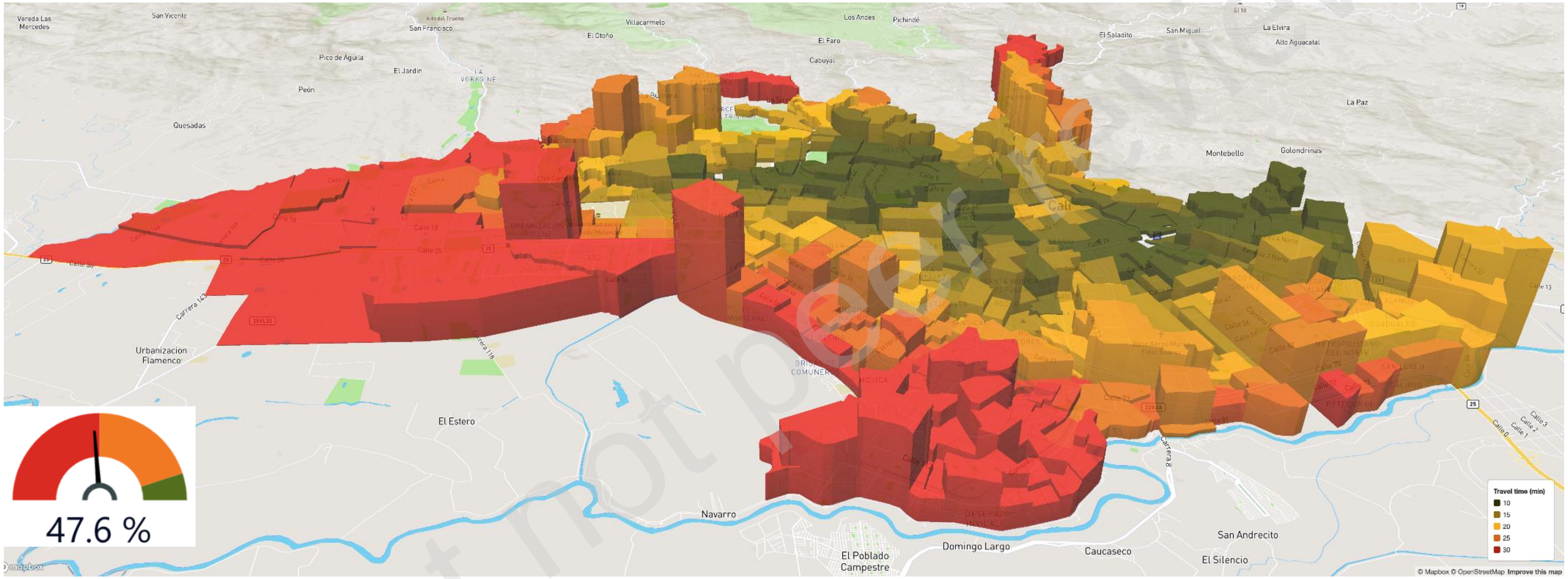
Predicted 20 min accessibility to the nearest hemodialysis service, by subgroup (#)	Jul 2020 (#)	Add 1 Service	*Variation*	Add 2 Services	*Variation*	Benefit of the second service	Nov 2020 (#)	Add 1 Service	*Variation +1 service Nov*	Add 2 Services	*Variation + 2 serv. Nov vs. baseline*	Benefit of the second service
	1,017,011	*1,585,437*	*568,426*	*1,696,205*	*679,194*	110,768	*1,574,724*	*2,063,889*	*489,165*	*2,194,907*	*620,183*	131,018
Socio-economic stratum												
Low	221,296	692,535	*471,239*	708,285	*486,989*	*15,750*	568,115	1,012,179	*444,064*	1,054,841	*486,726*	*42,662*
Middle	645,076	738,967	*93,891*	787,189	*142,113*	*48,222*	841,224	883,232	*42,008*	934,581	*93,357*	*51,349*
High	147,229	147,714	*485*	194,064	*46,835*	*46,350*	160,082	160,448	*366*	197,011	*36,929*	*36,563*
N.D.	3,410	6,221	*2,811*	6,667	*3,257*	*446*	5,303	8,030	*2,727*	8,474	*3,171*	*444*
Ethnicity												
Afrodescendent	85,481	226,665	*141,184*	235,681	*150,200*	*9,016*	174,224	309,773	*135,549*	320,945	*146,721*	*11,172*
Rrom (nomadic)	40	70	*30*	75	*35*	*5*	58	88	*30*	93	*35*	*5*
Indigenous	4,339	7,093	*2,754*	7,661	*3,322*	*568*	7,394	10,023	*2,629*	10,830	*3,436*	*807*
Islander/Raizal	214	287	*73*	308	*94*	*21*	276	339	*63*	366	*90*	*27*
Other (Caucasian, Mestizo)	910,535	1,329,587	*419,052*	1,429,331	*518,796*	*99,744*	1,369,069	1,715,776	*346,707*	1,833,419	*464,350*	*117,643*
Palenque	41	58	*17*	59	*18*	*1*	231	244	*13*	245	*14*	*1*
N.D.	16,361	21,677	*5,316*	23,090	*6,729*	*1,413*	23,472	27,646	*4,174*	29,009	*5,537*	*1,363*
Educational level												
Graduate degree	48,919	51,673	*2,754*	64,274	*15,355*	*12,601*	57,641	59,250	*1,609*	70,683	*13,042*	*11,433*
Bachelor Degree	187,250	214,500	*27,250*	246,213	*58,963*	*31,713*	240,652	259,026	*18,374*	290,113	*49,461*	*31,087*
Technical	123,846	173,029	*49,183*	183,949	*60,103*	*10,920*	187,591	225,703	*38,112*	238,756	*51,165*	*13,053*
Middle	254,015	429,219	*175,204*	449,999	*195,984*	*20,780*	409,594	561,317	*151,723*	589,778	*180,184*	*28,461*
High School	132,875	234,812	*101,937*	245,256	*112,381*	*10,444*	222,293	312,505	*90,212*	326,680	*104,387*	*14,175*
Primary	178,303	323,554	*145,251*	337,279	*158,976*	*13,725*	304,450	433,804	*129,354*	453,532	*149,082*	*19,728*
Pre-school	13,559	24,185	*10,626*	25,912	*12,353*	*1,727*	23,360	32,893	*9,533*	35,018	*11,658*	*2,125*
No data	78,244	134,465	*56,221*	143,323	*65,079*	*8,858*	129,143	179,391	*50,248*	190,347	*61,204*	*10,956*
Literacy												
Literate	935,369	1,439,178	*503,809*	1,540,840	*605,471*	*101,662*	1,436,134	1,867,076	*430,942*	1,986,355	*550,221*	*119,279*
No literacy	21,864	44,390	*22,526*	46,272	*24,408*	*1,882*	40,417	61,347	*20,930*	64,213	*23,796*	*2,866*
N.A.	44,609	81,605	*36,996*	87,318	*42,709*	*5,713*	76,938	110,033	*33,095*	117,422	*40,484*	*7,389*
N.D.	15,169	20,264	*5,095*	21,775	*6,606*	*1,511*	21,235	25,433	*4,198*	26,917	*5,682*	*1,484*
Gender/Sex												
Fem	547,601	849,850	*302,249*	910,080	*362,479*	*60,230*	844,077	1,104,162	*260,085*	1,175,110	*331,033*	*70,948*
Masc	469,410	735,587	*266,177*	786,125	*316,715*	*50,538*	730,647	959,727	*229,080*	1,019,797	*289,150*	*60,070*
Civil status						-					-	-
Single	370,444	576,988	*206,544*	615,450	*245,006*	*38,462*	575,999	754,020	*178,021*	799,355	*223,356*	*45,335*
Married or cohabitation	403,517	625,534	*222,017*	673,554	*270,037*	*48,020*	624,355	813,993	*189,638*	870,343	*245,988*	*56,350*
Divorced or separated	81,711	120,329	*38,618*	127,626	*45,915*	*7,297*	118,628	151,450	*32,822*	160,193	*41,565*	*8,743*
Widow	52,705	2,171	- *50,534*	75,848	*23,143*	*73,677*	73,457	89,402	*15,945*	93,550	*20,093*	*4,148*
N.A.	94,566	171,688	*77,122*	183,663	*89,097*	*11,975*	162,468	231,388	*68,920*	246,543	*84,075*	*15,155*
N.D.	14,068	18,727	*4,659*	20,064	*5,996*	*1,337*	19,817	23,636	*3,819*	24,923	*5,106*	*1,287*
Age			-									-
0-4	44,609	81,605	*36,996*	87,318	*42,709*	*5,713*	76,938	110,033	*33,095*	117,422	*40,484*	*7,389*
0-14	150,093	270,764	*120,671*	289,257	*139,164*	*18,493*	256,909	364,761	*107,852*	387,896	*130,987*	*23,135*
5-14	105,484	189,159	*83,675*	201,939	*96,455*	*12,780*	179,971	254,728	*74,757*	270,474	*90,503*	*15,746*
15-24	147,838	249,309	*101,471*	266,631	*118,793*	*17,322*	242,147	331,487	*89,340*	352,301	*110,154*	*20,814*
15-59	657,107	1,031,825	*374,718*	1,696,205	*1,039,098*	*664,380*	1,027,559	1,349,753	*322,194*	1,439,686	*412,127*	*89,933*
15-64	716,344	1,115,142	*398,798*	1,196,118	*479,774*	*80,976*	1,111,425	1,453,704	*342,279*	1,549,551	*438,126*	*95,847*
60+	209,811	282,848	*73,037*	299,656	*89,845*	*16,808*	290,256	349,375	*59,119*	367,325	*77,069*	*17,950*
65+	150,574	199,531	*48,957*	210,830	*60,256*	*11,299*	206,390	245,424	*39,034*	257,460	*51,070*	*12,036*
80+	40,103	50,570	*10,467*	52,893	*12,790*	*2,323*	52,080	60,472	*8,392*	62,987	*10,907*	*2,515*

Table 3. Predicted accessibility to the haemodialysis service with the shortest travel times (relative figures)

Predicted 20 min accessibility to the nearest hemodialysis service, by subgroup (%)	Jul 2020 (% subgroup)	Add 1 Service	*Variation*	Add 2 Services	*Variation adding 2 services*	Benefit of the second service	Nov 2020 (%)	Add 1 Service	*Variation +1 service Nov*	Add 2 Services	*Variation + 2 serv. Nov vs. baseline*	Benefit of the second service	Subgroup's population
Socio-economic stratum													
Low	19.9%	62.4%	*42.5%*	63.8%	*43.9%*	1.4%	51.2%	91.2%	*40.0%*	95.1%	*43.9%*	3.8%	1,109,549
Middle	68.9%	79.0%	*10.0%*	84.1%	*15.2%*	5.2%	89.9%	94.4%	*4.5%*	99.9%	*10.0%*	5.5%	935,699
High	72.0%	72.2%	*0.2%*	94.9%	*22.9%*	22.7%	78.2%	78.4%	*0.2%*	96.3%	*18.1%*	17.9%	204,589
N.D.	37.9%	69.2%	*31.3%*	74.2%	*36.2%*	5.0%	59.0%	89.4%	*30.3%*	94.3%	*35.3%*	4.9%	8,986
Ethnicity													
Afrodescendent	26.2%	69.6%	*43.3%*	72.3%	*46.1%*	2.8%	53.5%	95.1%	*41.6%*	98.5%	*45.0%*	3.4%	325,865
Rrom (nomadic)	39.2%	68.6%	*29.4%*	73.5%	*34.3%*	4.9%	56.9%	86.3%	*29.4%*	91.2%	*34.3%*	4.9%	102
Indigenous	39.0%	63.8%	*24.8%*	68.9%	*29.9%*	5.1%	66.5%	90.2%	*23.7%*	97.5%	*30.9%*	7.3%	11,112
Islander/Raizal	56.0%	75.1%	*19.1%*	80.6%	*24.6%*	5.5%	72.3%	88.7%	*16.5%*	95.8%	*23.6%*	7.1%	382
Other (Caucasian, Mestizo)	48.2%	70.3%	*22.2%*	75.6%	*27.4%*	5.3%	72.4%	90.8%	*18.3%*	97.0%	*24.6%*	6.2%	1,890,491
Palenque	16.7%	23.7%	*6.9%*	24.1%	*7.3%*	0.4%	94.3%	99.6%	*5.3%*	100.0%	*5.7%*	0.4%	245
N.D.	53.4%	70.8%	*17.4%*	75.4%	*22.0%*	4.6%	76.6%	90.3%	*13.6%*	94.7%	*18.1%*	4.5%	30,626
Educational level						0.0%							
Graduate degree	67.5%	71.3%	*3.8%*	88.7%	*21.2%*	17.4%	79.6%	81.8%	*2.2%*	97.6%	*18.0%*	15.8%	72,441
Bachelor Degree	63.4%	72.6%	*9.2%*	83.4%	*20.0%*	10.7%	81.5%	87.7%	*6.2%*	98.2%	*16.7%*	10.5%	295,319
Technical	50.7%	70.9%	*20.1%*	75.3%	*24.6%*	4.5%	76.8%	92.4%	*15.6%*	97.8%	*21.0%*	5.3%	244,160
Middle	41.7%	70.5%	*28.8%*	74.0%	*32.2%*	3.4%	67.3%	92.3%	*24.9%*	96.9%	*29.6%*	4.7%	608,429
High School	39.4%	69.7%	*30.2%*	72.8%	*33.3%*	3.1%	65.9%	92.7%	*26.8%*	96.9%	*31.0%*	4.2%	337,065
Primary	38.1%	69.1%	*31.0%*	72.0%	*34.0%*	2.9%	65.0%	92.7%	*27.6%*	96.9%	*31.8%*	4.2%	468,206
Pre-school	37.4%	66.6%	*29.3%*	71.4%	*34.0%*	4.8%	64.4%	90.6%	*26.3%*	96.5%	*32.1%*	5.9%	36,294
No data	39.7%	68.3%	*28.6%*	72.8%	*33.1%*	4.5%	65.6%	91.1%	*25.5%*	96.7%	*31.1%*	5.6%	196,909
Literacy													
Literate	45.8%	70.4%	*24.7%*	75.4%	*29.6%*	5.0%	70.3%	91.4%	*21.1%*	97.2%	*26.9%*	5.8%	2,043,041
No literacy	32.9%	66.9%	*33.9%*	69.7%	*36.8%*	2.8%	60.9%	92.4%	*31.5%*	96.7%	*35.8%*	4.3%	66,383
N.A.	36.8%	67.4%	*30.5%*	72.1%	*35.3%*	4.7%	63.5%	90.8%	*27.3%*	96.9%	*33.4%*	6.1%	121,140
N.D.	53.7%	71.7%	*18.0%*	77.1%	*23.4%*	5.3%	75.1%	90.0%	*14.9%*	95.3%	*20.1%*	5.3%	28,259
Gender/Sex													
Fem	45.3%	70.3%	*25.0%*	75.3%	*30.0%*	5.0%	69.8%	91.4%	*21.5%*	97.2%	*27.4%*	5.9%	1,208,617
Masc	44.7%	70.0%	*25.3%*	74.9%	*30.2%*	4.8%	69.6%	91.4%	*21.8%*	97.1%	*27.5%*	5.7%	1,050,206
Civil status						0.0%							
Single	45.1%	70.2%	*25.1%*	74.9%	*29.8%*	4.7%	70.1%	91.8%	*21.7%*	97.3%	*27.2%*	5.5%	821,536
Married or cohabitation	45.0%	69.7%	*24.8%*	75.1%	*30.1%*	5.4%	69.6%	90.8%	*21.1%*	97.0%	*27.4%*	6.3%	896,958
Divorced or separated	49.8%	73.4%	*23.6%*	77.8%	*28.0%*	4.4%	72.3%	92.4%	*20.0%*	97.7%	*25.3%*	5.3%	163,980
Widow	55.1%	2.3%	*-52.9%*	79.3%	*24.2%*	77.1%	76.8%	93.5%	*16.7%*	97.8%	*21.0%*	4.3%	95,611
N.A.	37.2%	67.5%	*30.3%*	72.2%	*35.0%*	4.7%	63.8%	90.9%	*27.1%*	96.9%	*33.0%*	6.0%	254,492
N.D.	53.6%	71.4%	*17.8%*	76.4%	*22.8%*	5.1%	75.5%	90.1%	*14.6%*	95.0%	*19.5%*	4.9%	26,246
Age													
0-4	36.8%	67.4%	*30.5%*	72.1%	*35.3%*	4.7%	63.5%	90.8%	*27.3%*	96.9%	*33.4%*	6.1%	121,140
0-14	37.5%	67.6%	*30.1%*	72.2%	*34.7%*	4.6%	64.1%	91.1%	*26.9%*	96.8%	*32.7%*	5.8%	400,527
5-14	37.8%	67.7%	*29.9%*	72.3%	*34.5%*	4.6%	64.4%	91.2%	*26.8%*	96.8%	*32.4%*	5.6%	279,387
15-24	40.7%	68.6%	*27.9%*	73.4%	*32.7%*	4.8%	66.7%	91.2%	*24.6%*	97.0%	*30.3%*	5.7%	363,311
15-59	44.3%	69.6%	*25.3%*	114.4%	*70.1%*	44.8%	69.3%	91.1%	*21.7%*	97.1%	*27.8%*	6.1%	1,482,069
15-64	44.9%	69.9%	*25.0%*	75.0%	*30.1%*	5.1%	69.7%	91.1%	*21.5%*	97.1%	*27.5%*	6.0%	1,595,016
60+	55.8%	75.2%	*19.4%*	79.6%	*23.9%*	4.5%	77.1%	92.9%	*15.7%*	97.6%	*20.5%*	4.8%	376,227
65+	57.2%	75.8%	*18.6%*	80.1%	*22.9%*	4.3%	78.4%	93.2%	*14.8%*	97.8%	*19.4%*	4.6%	263,280
80+	62.6%	78.9%	*16.3%*	82.5%	*20.0%*	3.6%	81.2%	94.3%	*13.1%*	98.3%	*17.0%*	3.9%	64,100

Figure 6. Traffic variations and their effect (July vs November 2020) 6 – 12 July vs 23 – 29 November 2020

Figure 7. characteristic accessibility during day hours, traffic congestion level



Supplemental File 1. Traffic congestion and accessibility to haemodialysis, Cali 6-12 July 2020. Animation

This file is a GIF or MP4. Its DOI: 10.6084/m9.figshare.21699773 will be activated before publication and replace this temporary link: https://figshare.com/s/38142a4a4958b6b054e5

Supplemental File 2. Choropleth maps comparing accessibility 6-12 July and changes as services are added in recommended locations