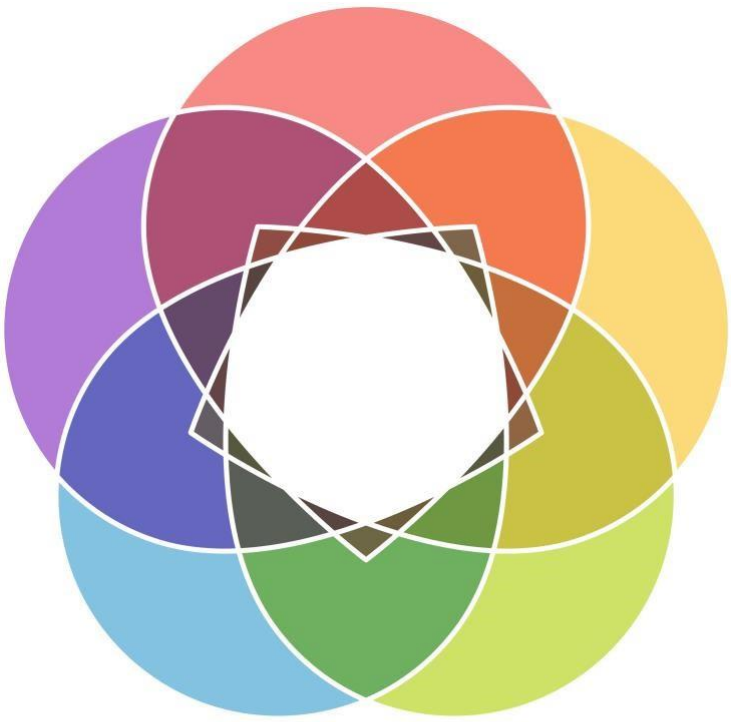
Dynamic geographical accessibility assessments to improve health equity: protocol for a test case in Cali, Colombia

[Evaluaciones dinámicas de accesibilidad geográfica para mejorar la equidad: prueba en Cali, Colombia: protocolo de investigación]



AMORE Project

Contents

Administrative information

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What if data from mobile applications allowed more people to reach health services using fewer resources? *"El reto para las ciudades de Latinoamérica y el Caribe es que la tecnología visualice las necesidades de sus ciudadanos, sobre todo las de los más vulnerables." ["**The challenge for the cities of Latin America and the Caribbean is for technology to visualize the needs of its citizens, especially those of the most vulnerable**"] Anasella Acosta, Smart Cities & Inequidad, Forbes Centroamérica, Issue 82, July–August, 2021, Page 12.*

Summary

This protocol proposes an approach to assessing the place of residence as a spatial determinant of health in cities where traffic congestion might impact health services accessibility. The study will explore the use of dynamic travel times, instead of traveled distance, to inform urban and health services planning and evaluation. It aims to present data in ways that help shape decisions and spur action by diverse stakeholders and sectors.

Equity assessments in geographical accessibility to health services typically rely on static metrics, such as distance or average travel times. [1–3] This protocol explores a new approach to assess equity by using dynamic travel times from residence to the location of the relevant health service with the shortest travel time journey. The study results will show the interplay between traffic congestion, accessibility, and health equity and should be used to inform urban and health services monitoring and planning.[4]

Datafication, digitization, and data sciences enable affordable assessments of accessibility to health services while offering adequate accuracy and efficiency for urban and health services monitoring and planning. This can be done by applying data analytics to publicly available sources that describe populations, health services, and travel times to assess accessibility from an equity perspective.[1,5,6] Dynamic assessments consider variations in urban traffic and their effect on travel times, equity, and accessibility.[1,7–11]

This research aims to (1) provide dynamic measurements of travel times to selected health services used for urgent or frequent care (i.e., repeated ambulatory care). Cross-sectional assessments will study accessibility and equity for the studied health services in the entire city; (2) assess potential improvements from optimizing the location of up to two new health services representing urgent care and frequent care scenarios; (3) provide insights and recommendations for future studies exploring their value in reframing healthy urbanism and health services planning in response to new knowledge.[12–14]

This study will use visualizations and descriptive statistics to allow non-specialized stakeholders to understand the effects of accessibility on populations and health equity. For this, the study will use well-established metrics, such as “time-to-destination,” or the proportion of the people that can reach a service within a given travel time threshold from the place of residence. These times will be estimated for travel by car (private or for hire) for this demonstration. [1,9,13,15,16]

The study is part of the AMORE Collaborative Project, in which a diverse group of stakeholders seeks to address equity for accessibility to essential health services. The Collaborative Project

involves the participation of over two dozen contributors representing health service users and providers, authorities, and community members, including academia.

Introduction

Equitable accessibility is central to the United Nations Sustainable Development Goals and targets like universal health coverage and quality of care.[16–20] A common definition of accessibility is the relative ease (travel time by car) by which a destination (health service) can be reached from a given location (residence).[11,21,22] Equity assessments in geographical accessibility to health services typically rely on static metrics, such as distance or average travel times.[1–3]

Measuring equitable accessibility has several challenges. Accessibility studies assess distance or the shortest average travel time to the nearest facility; they seldom assess equity and are typically geared towards field experts. [23–25] These studies usually explore broad service categories without focusing on specific services people might need. They are lengthy, costly, and rarely address the dynamic temporospatial nature of accessibility, such as its links to traffic congestion. [11,26,27]

Reliable data on equity of accessibility to urban health services has been elusive for most cities due to limitations in sampling techniques, extrapolations, and the use of complex methods to capture temporospatial variations associated with traffic congestion. Stakeholders, including urban and health service planners, have relied on indirect fixed assessments that fail to address the impact of traffic congestion on equity.[1,11,26,28]

These challenges were understandable because assessments were cumbersome and required detailed origin-destination studies with small samples from home surveys, traffic corridor speed cameras, or extrapolations from average traffic in selected corridors, with limited intersectoral and multistakeholder participation.[11,27,29–37] Results would turn irrelevant given the rapid changes in conditions, including traffic congestion, populations, or infrastructure.[5]

Travel times affect geographic accessibility and the quality of care.[16,38,39] Poor accessibility can lead the most socially disadvantaged populations to pay the highest share to reach health services, an aberration of social justice known as the “inverse care law.” Lengthy travel times hurt people; they are detrimental to health, well-being, and family finances.[38,40–45] Measuring travel times might reveal problems hiding in plain sight. Addressing accessibility might help people unable to choose a better place of residence overcome structural barriers to health.[46]

Travel time assessments have been widely available for commodities and commerce and powered consumer apps. These developments have yet to translate into a systematic integration of dynamic equity assessments into urban and health services planning or public sector debates about land use and how to put health services within reach of the broadest population possible.

Measurements have proven difficult, and this project explores a new approach to making measurements feasible, scalable, and adaptable to urban sprawl and lengthening journeys. This new line of research explores if market forces and land use plans achieve service accessibility and if this holds for populations in situations of vulnerability.[1,23,39]

The Need for This Study

This proposal spurs the scaling up and replicating of accessibility analyses to health services in urban centers while promoting accessibility indicators based on dynamic travel times. The research demystifies the use of big data and analytics that reveal the needs of citizens, including the most vulnerable.[6,47–51] The project will lay the basis for subsequent studies that assess the value and use of dynamic accessibility and equity assessments in urban and health services planning.

This project explores a new approach to making such measurements feasible, scalable, and adaptable to urban sprawl and long journeys. This new line of research examines whether market forces and land use planning achieve services' accessibility and if this holds for populations in situations of vulnerability.[39,52]

Using reliable data that is systematically updated and publicly available could be a game-changer.[6,9,11,53] This study tests a new approach for assessing dynamic accessibility to health services, providing an equity perspective and using digital data sources. [1,9,54]

Using data readily available in the public domain allows these assessments to be completed in a shorter time and with a lower budget. When combined, the growing millions of measurements of travel times (big data) passively collected by mobile apps, the digitalized georeferenced sociodemographic data from the census, and the geolocation of health services, provide a dynamic assessment of accessibility that accounts for temporospatial variations related to traffic congestion.[11,54] Big data provides millions of measurements that allow identifying unexpected correlations with a level of detail and accuracy that surveys and inferences cannot match.[53]

This study aims to overcome the limitations of regular accessibility assessments by prioritizing dynamic travel times and adopting recommended knowledge production and use practices.

The following section details some key features and good practices that contribute to addressing present challenges:

- **Multistakeholder engagement:** a diverse intersectoral team of stakeholders contributes to the AMORE Project throughout the research process, and their inputs also informed the AMORE Platform conceptualization and development.[13,55–57] Contributors to the AMORE Project Collaborative Group represent the government, community, health service providers, and end users (consumers) who may directly or indirectly shape decisions, policies, plans, and programs.[12,13,58,59]
- **Measurement** of dynamic travel times using "time to destination" is a universal and comparable metric used by urban dwellers and users of navigation and travel apps.[9]
- **Digitization and datafication** by using anonymized publicly available georeferenced data of housing, people, and services, including disaggregated sociodemographic characteristics.[5,6,11]

- **Using analytics and modeling** to obtain reasonable estimates and maintain efficiencies and affordability while still delivering valid and reliable forecasts.
- **Disaggregating sociodemographic data** to deliver an equity analysis of accessibility.[60–62]
- **Scalability and replicability** using sources increasingly available to low- medium, and high-income settings. The approach can be scaled, adapted, and replicated to other locations, transportation means, services, or sectors.

Subsequent research will explore if revealing territorial inequities in urban and health services planning could catalyze intersectoral responses.[40,63–67]

Intersectoral collaborations rarely occur naturally and are challenged by the lack of consensus on issues and metrics. Using metrics and methods that all parties understand and facilitate direct communication could contribute to intersectoral action; assessing this will require additional research and is the subject of a separate proposal.[1,15,64,68–71]

Objectives

General objective

To assess dynamic accessibility assessments for selected healthcare services in urban Cali, Colombia, and predict the maximum improvements possible if new services were added.

Specific objectives

- To assess the temporospatial characteristics of equity and accessibility to hemodialysis, radiation therapy (radiotherapy), and tertiary care emergency services when traveling by car in urban Cali, Colombia.
- To provide dynamic assessments based on selected (arbitrary) travel time thresholds.
- To assess if populations in a situation of vulnerability needing hemodialysis, radiotherapy, and tertiary care emergency services will likely incur longer journeys when traveling by car in urban Cali, Colombia.
- To identify common variations of dynamic accessibility at two moments of the COVID-19 pandemic from an equity perspective.
- Assess the magnitude of absolute and relative accessibility variations attributed to traffic congestion.
- To estimate potential improvement for accessibility gained by expanding services.

Materials and Methods:

This cross-sectional study uses a research design of GIS modeling applied to case studies based on analyses of publicly available secondary data. This study will conduct paired cross-sectional assessments comparing equity in health services accessibility for July 6 – 12, 2020, and the week of 23 – 29 November 2020.

Reporting of study results will follow the STROBE Guideline for cross-sectional observational studies and incorporate elements from other guidelines, such as those on equity assessments (CONSORT-E

and PRISMA-E equity extensions), public health and policy interventions (TIDieR-PHP), reporting of analytical models (e.g., SPIRIT-AI extension), and multistakeholder engagement with patient and public participation in research (GRIPP2).[61,72–77]

Context and Study Population

The study is a proof-of-concept for implementation in Cali (est. 2,258 million in 2020), the third largest and most populous city in Colombia and the dominant urban center of Colombia's southwest and pacific regions (approx. 564 km^2). The study includes the entire urban population. Nearly half of Cali's population lives in low-income housing, 41% in medium income, and 9% in high-income housing. About 84% of the population identifies as white descent, and 14% identify as afro-descendent, with a small proportion identifying as Indigenous or Rrom. [78–80]

The COVID-19 pandemic severely impacted the local economy. By January 2021, unemployment rates in Cali rose to 23.2% for women and 14.6% for men, a one-year increase of 8.1% and 3.1%, respectively. The situation was worse for the youth, with an estimated 52% of women and 47.2% of men dependent on the informal economy. One in 5 people was unemployed, and unemployment rates were substantially higher for those living in lower socioeconomic areas. Cali absorbed 139,000 migrants from Venezuela over the past five years, with more than 25,000 in 2020.[79,81]

For the reports, contextual data will be obtained to provide an overview of the use and demand of services. Sources include reports and platforms such as the "Cuentas de Alto Costo."[82–84]

In preparatory dialogues with contributors, we learned about plans to transform Cali into a Special District with its 22 communes converted into six to eight minor districts to be led by minor district mayors.[85] This new political and administrative layout might raise interest in this topic as new authorities might want to discuss accessibility and equity issues with their constituents and in power-brokering negotiations, noting the equity implications of the concentration of health services in a few sectors of the city.

Data Sources

The study will use anonymized, aggregated data from the following data sources :

- Microdata of Colombia's National Census for Cali 2018 was downloaded from the official public website of the National Department of Statistics– DANE.[86] This provides sociodemographic data of the populations at the block level for the entire city. The census population had a 28.1% adjustment estimated for 2020 to account for intercensal growth, under-registration, and migration.[78,79,81,87]
- The city's transportation analysis areas (TAZ) and census administrative sectorization for urban Cali were obtained from the IDESC portal.[88] This data allows linking TAZs with city blocks. TAZs are adequate to estimate travel times and less detailed than blocks, thus reducing the number of travel time measurements and adding anonymity to the population.
- Approved health services relevant to the chosen scenarios, obtained from the National Special Registry of health services providers – REPS from the Ministry of Health and Social Protection. The services geolocation was verified with Google Maps. Approved services were checked in June and October 2020 and January 2021, finding they remained unchanged. This

protocol will assess accessibility to the entire city's fourteen tertiary care hospitals with emergency services (REPS Code "Alta complejidad" + 501); eleven hemodialysis units totaling 370 chairs (REPS code 733); five radiotherapy services (REPS code 711).

- Google's Distance Matrix API provides big data measurements of travel times from the origin (TAZ for the residence) to the destination (TAZ of the health service). It allows the identification of travel time changes during the assessed weeks.

Data Integration: The AMORE Platform

Secondary data will be integrated into the AMORE Platform, a web-based digital platform developed with inputs and feedback from stakeholders and piloted by the AMORE Project.[89–91] The Platform is hosted by IQuartil SAS. See https://www.iquartil.net/proyectoAMORE.

The AMORE Platform was developed and tested following a design-thinking approach between June and August 2020.[55,92–95] The final version was completed in February 2022. The digital web-based platform was developed for this project by the principal investigator with input from experts in data science, public health, logistics, and mobility and a wide range of stakeholders (A description of the development and piloting phases of the AMORE Platform can be provided).

Figure 1, Figure 2, and Figure 3 display examples of the AMORE Platform's interface or "front-end" panels (presentation layers) with its zoomable choropleth maps and graphics that integrate multiple layers of data. Filters activated by tapping on the graphs act on sociodemographic variables, travel times, and health services to offer a descriptive analysis. The front-end has been developed with Microsoft's Power BI™. The back end (data access layer) is written in Python™ open-source software from the Python Software Foundation – PSF and in the Konstanz Information Miner – KNIME, a free and open-source data analytics, reporting, and integration platform.

Study Variables

Reports will describe the people and percentages for the entire population able to reach services within a set threshold with peak and free-flow traffic conditions for each scenario. The variations in these accessibility figures will be disaggregated by sociodemographic characteristics such as gender, ethnicity, the socioeconomic stratum of housing, maximum education attainment, and marital status. These reports will contrast the statistics for peak and free-flow traffic conditions. These reports will use an arbitrary 15-minute threshold for accessibility by car to tertiary care emergencies and 20-minutes for hemodialysis and radiotherapy.

Graphs will be used to present variations in accessibility as traffic congestion increases for different travel time intervals (e.g., 10-minute intervals vs. accessibility for each socioeconomic stratum), as shown in Figure 4

The contrast will be drawn between results obtained for July and November 2020.

Reports will include the location(s) maximizing accessibility if one or two new services are added, contrasting predicted accessibility vs. measured accessibility for July and November 2020, and the recommended services locations. For an example, see Figure 3

All estimates in this test case use travel by car. Reports will include visualizations from the AMORE Platform, tables, and simple graphs with descriptive statistics.

Figure 1 Cali, accessibility to tertiary care emergency service late morning to early afternoon Mon-Sat. North to the right and west at the top

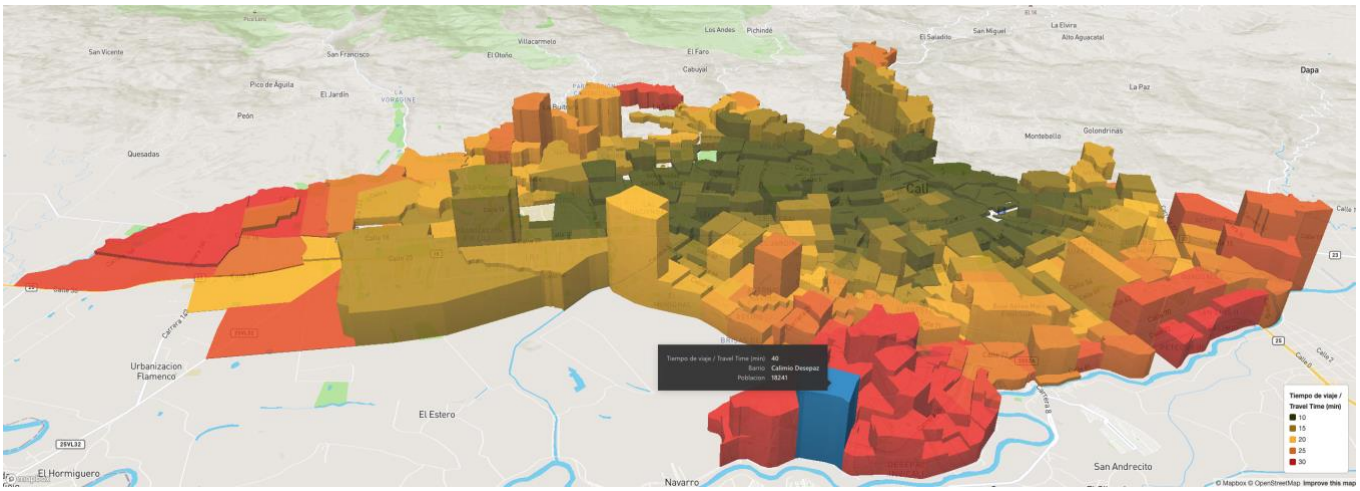


Figure 2 AMORE Platform Interface for situational analysis for tertiary care emergencies

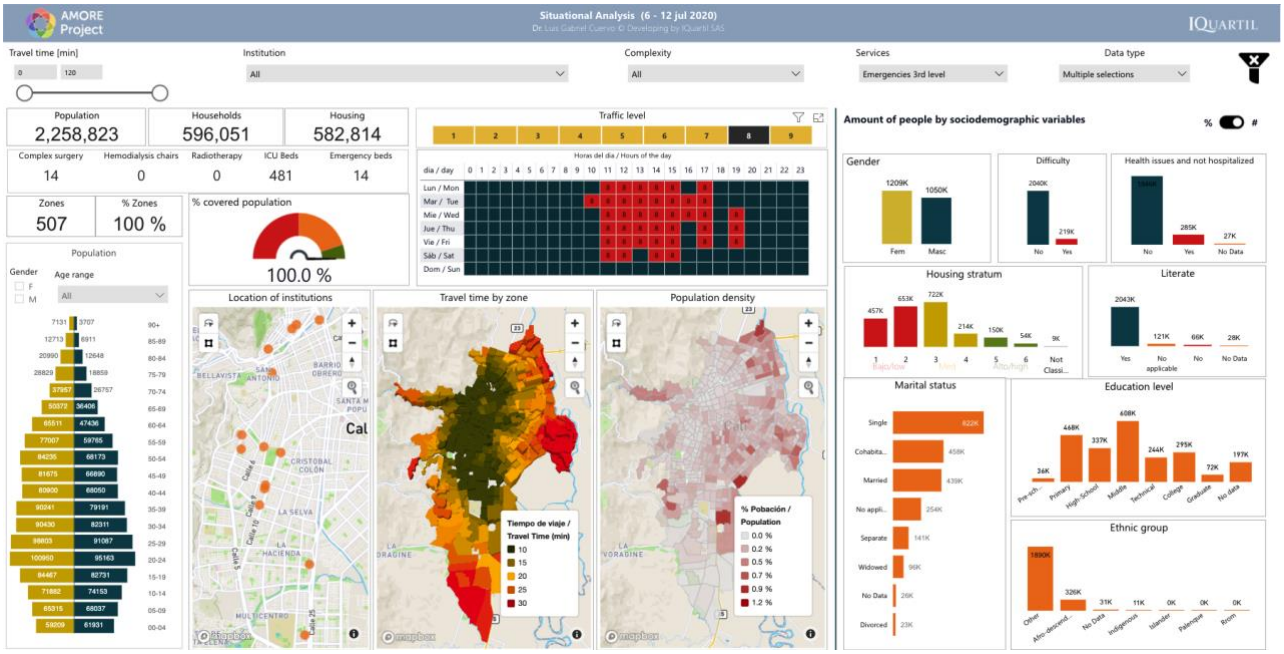


Figure 3 AMORE Platform with predictive analyses of adding two new tertiary care emergency services

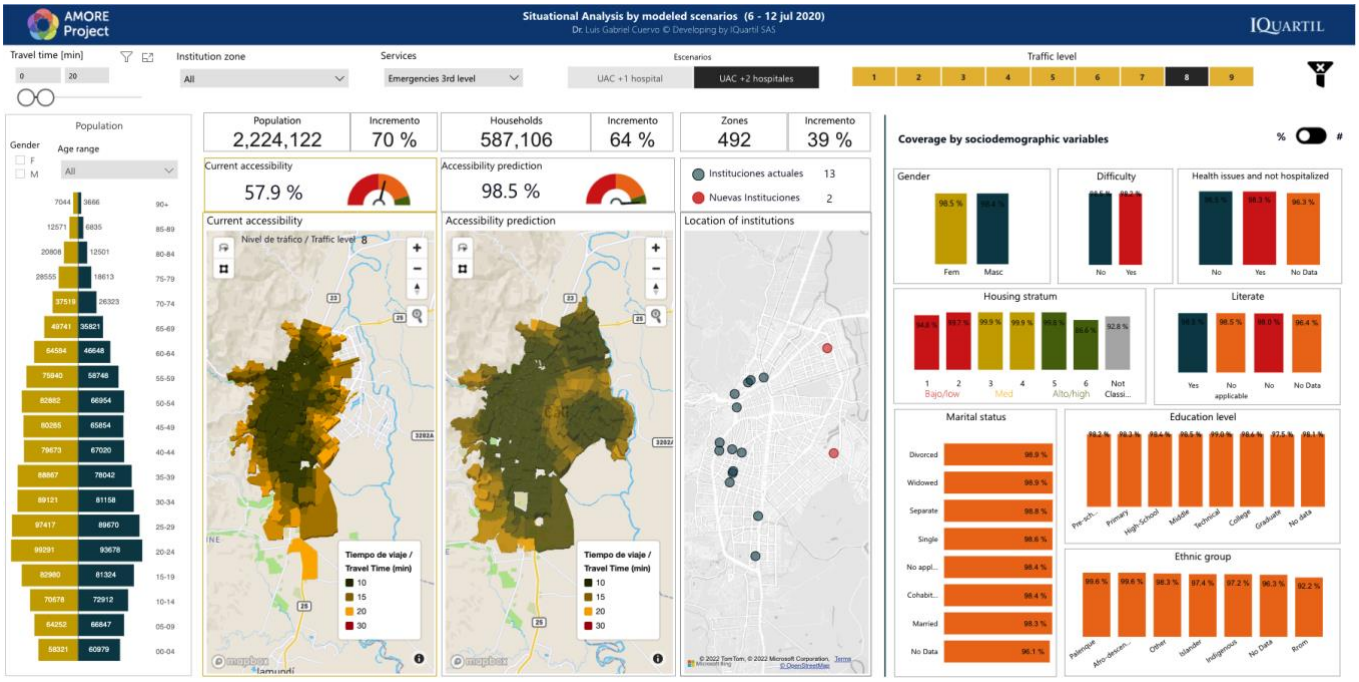
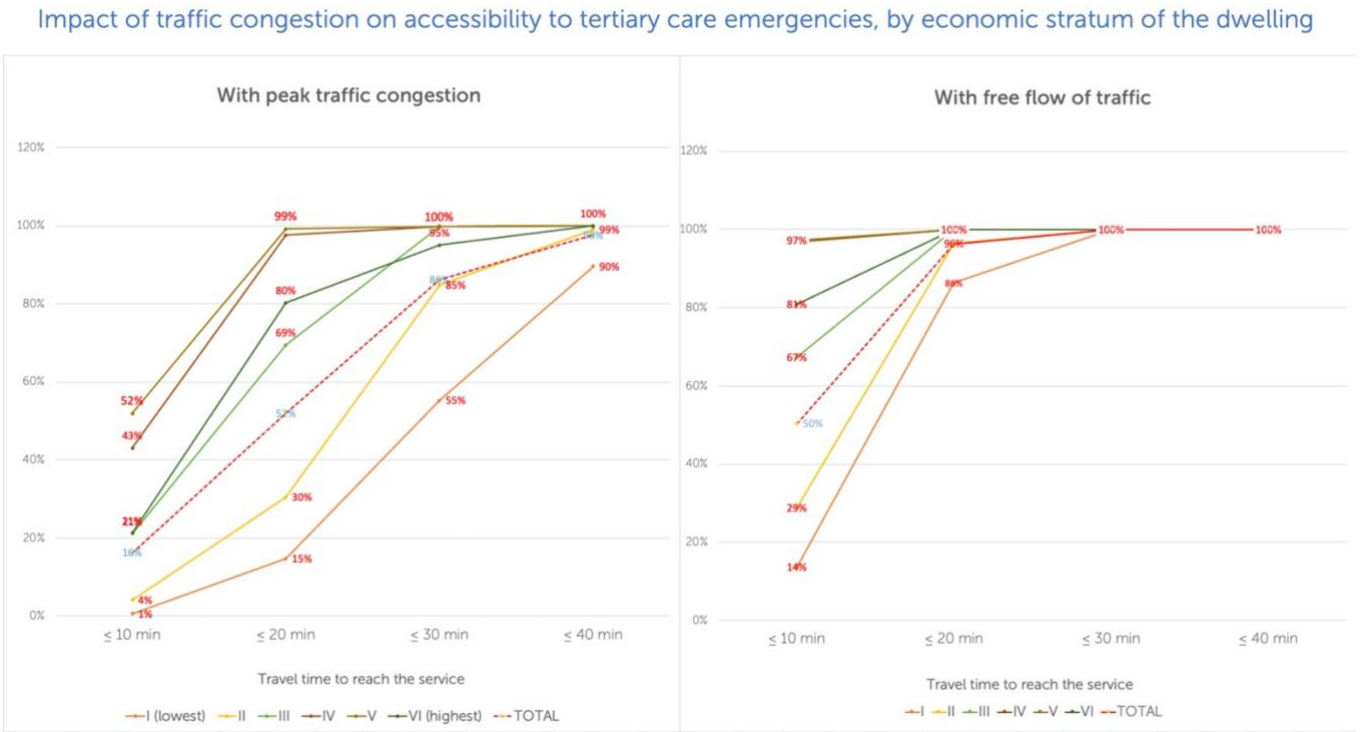


Figure 4 Comparing accessibility by socioeconomic stratum, tertiary care emergencies.[96]



Data Analysis

Data and images for analyses will be obtained from the AMORE Platform and presented using descriptive statistics for absolute figures (people) and relative (percentage of population), as shown in Figure 2 and Figure 3.

The use of relatable and commonly used metrics (i.e., time to destination), descriptive statistics (percentage of a population that can reach the services within a travel time threshold), visualizations, and simple graphs (e.g., Figure 2, Figure 3, Figure 4) and maps (e.g., Figure 1) are chosen to allow non-specialized stakeholders to understand the effects of accessibility on populations and health equity.

The study will deliver (1) situational analyses of accessibility to a selection of urgent or frequent health care services scenarios in urban Cali, Colombia, and (2) predictions of potential improvements to the accessibility of adding services under changing assumptions.

Arbitrary travel-time points will be used (15 minutes for urgent care; 20 minutes for frequent care services); we found no standards for travel time thresholds.

The situational analyses of accessibility will consider the following study scenarios:

1. **Urgent care,** assessing travel times to the health emergency department with the shortest journey by car, among the 14 hospitals with tertiary care emergency departments.
2. **Frequent care,** assessing travel times to ambulatory services that require regular use. The analyses will investigate the shortest journey to five radiation therapy services and eleven hemodialysis units.

    For these case studies, the project will deliver a:

    - **Situational analysis** uses descriptive and diagnostic analytics to assess accessibility under traffic conditions. Choropleth maps mark the boundaries of travel times Figure 1. The blocks building the map represent Traffic Analysis Zones (TAZ), and their height in the 3D choropleth map represents population density. By pointing to a TAZ, identification, population, and travel time to the nearest facility are displayed, and the sociodemographic characteristics of the people are presented in a dashboard (Figure 2). The dashboard also includes a choropleth map with the density of the population being analyzed.

Optimization analysis using predictive and prescriptive analytics for modeling. Using heuristic techniques, the research will predict accessibility with different service schedules or when adding up to two new services in locations that maximize accessibility. Case studies will focus on hemodialysis and radiotherapy, which are used to treat high-cost conditions and must be accessed repeatedly for prolonged periods. For example, hemodialysis usually requires 3-5 weekly sessions, and radiotherapy may require daily sessions for weeks. Predicted accessibility with new services will be compared with measured accessibility (Figure 3).

Preparation for the Project

Beginning on June 12, 2020, interviews were conducted with key informants, local authorities, and experts to inform the project, assess feasibility, and develop a protocol. These interviews offered contextual insights and ideas for the AMORE Platform to address the needs of data users and stakeholders. Discussions helped identify contributors and provided valuable contextual information. They also revealed how stakeholders approached health equity and accessibility and the relationship to urban and health services planning and land use. Stakeholders offered insights into the elements and processes of urban and health services planning, public policy, and advocacy.

Interviewed key informants included:

- Members of the SIGELO Project on vulnerability, accessibility, and logistics in the context of the COVID-19 pandemic, Universidad del Valle
- Health equity and public health experts at the Bruyère Institute, University of Ottawa • Contributors to Cali's Administrative Department of Municipal Planning (DAPM)
- Advisors and staff working with Cali's local government, including the secretariats of Health, Mobility, Urban planning, and Emergency response and preparedness.
- Data Science for All Team33 and IQuartil SAS analysts.
- Former local government and education authorities
- Urban observatories, urbanists, and networks on urbanism, mobility, and public health.
- Innovators and advisors working with health services and systems
- Service providers, including managers and science advisors
- Health services and accessibility data users
- Doctoral and professional networks
- Designers, graphic and science communications professionals, and artists
- Researchers and research sponsors.

Twenty-eight meetings were held with key informants and stakeholders between July 2020 and March 2022, when the advanced prototype of the AMORE Platform was completed. Two presentations were made to the Follow-up Commission of the Doctoral Program on Research Methodology for Biomedical Research and Public Health of the Universitat Autònoma de Barcelona.

During the preparatory phase, the project was also debated in international fora such as the Global Health Learning Network of the University of Ottawa, The 4th Urban Forum "Lima Cómo Vamos," the CEDEUS-REDEUSLAC II International Symposium of Doctoral Candidates on Urban Development and Sustainability for Latin America, and the Caribbean (Chile), and with urban observatories (Cali, Bucaramanga).[89,97,98]

These interviews shaped the AMORE project and platform. The objectives and platform were discussed from a theoretical perspective. Once the prototypes of the AMORE Platform became available, tests and demonstrations were made as part of the validation.

Data downloads and sources were stored in a dedicated repository using CSV formats to adhere to data sharing and reuse good practices. They will be made public with the publication of relevant research reports. Similarly, the AMORE Platform hosted by IQuartil SAS is made accessible with the completion of non-disclosure agreements. We expect to make platform sections publicly available

as relevant results are published.[99] Information of the project is stored in a protected area on the Open Science Framework website (https://osf.io/ypg5a/)

Fidelity/adaptation

The fidelity of the AMORE Platform is based on data validation and verification exercises, comparing the findings from the AMORE Platform using the two data downloads and the two development teams.

The results of the platform will likely be optimistic for several reasons. For example, people do not always travel to the service with the shortest journey for known (e.g., lack of coverage from the insurance in the institution) and unexpected reasons (familiarity, poor navigation aids, reputation). The potential for improved accessibility would be accurate if all people were entitled to access those services.

The census includes respondent-reported data that is subject to interpretation. For example, variables like disability and health status are self-reported, and the question is unspecific. Respondents may not find a suitable response option. For example, ethnicity has no category for Caucasian or mestizo populations representing a substantial part of the population. People with mixed backgrounds may find no suitable option to represent them.

The census is still well suited for this study: the data has been digitized, and sociodemographic data are linked with the residential block. The place of residence is a common starting point for people undergoing hemodialysis or radiotherapy, children, the elderly, and those not engaged in formal employment.

Mobile phone data is impractical because it cannot be accurately tied to reliable sociodemographic data; coverage varies among the population and excludes those unregistered as users or without a phone. It also has technical limitations.[100]

Accessibility and spatial equity have been studied in Cali by the Research Group on Transport, Transit and Roads (GITTV) of the Faculty of Engineering of the Universidad del Valle. Members of this group contributed to the validation of the AMORE Platform, and the preliminary findings of the AMORE Platform are consistent with those of the GITTV and other authors.[101–106]

Harms, risks, and ethical considerations

This observational study addresses the impact of mobility on health equity without researching human subjects and by integrating anonymized coded secondary data obtained from openly available records.

The study does not involve human subjects' research. The AMORE Platform and dynamic geospatial analyses expose social justice issues and potential solutions of benefit to society by enabling informed decisions relevant to policies, plans, and procedures for improving health equity. This data can also predict or monitor changes in urban accessibility. The data used is anonymized and publicly available. Under Colombian law, this component fits the definition of research without risk, as described in Resolution 008430-1993 of the Ministry of Health.[107] This was corroborated on July

25, 2022, by the Research Ethics Committee of the School of Engineering of the Universidad del Valle, which declared the project “without risk” per Colombian law (Ref: CEIFI 010-2022). The project was cleared on September 16, 2022 by the Commission on Ethics in Animal and Human Experimentation (CEEAH), and the Vice-Rector for Research, Universitat Autònoma de Barcelona (Ref: CEEAH-6100) on September 20, 2022.

The study can challenge current thinking with data and disrupt traditional approaches to land use and health services planning that may perpetuate pervasive inequalities that could fuel social strife and corruption.[101–104,108–114]

The ethical approach of this study follows the broader principles and considerations of public health ethics and health systems ethics; it generates population data valuable to address inequity and social injustice, is helpful for accountability and is relevant to intersectoral action.[115,116] The need for further guidance on these issues remains a challenge for cross-sectoral collaboration. It is part of the ongoing discussions on stakeholder engagement in global health.[73,117]

Accessibility is a determinant of health on the supply side of health equity.[118] Useful, valid equity assessments in accessibility matter to health systems and social justice. Having action-oriented data to challenge established thinking might contribute to various SDGs, such as improving good health and well-being (SDG 3), reducing inequalities (SDG10), having sustainable cities and communities (SDG11), improving infrastructure (SDG 9), and facilitating partnerships to achieve the SDGs (SDG17). [12,13,18,64,115]

These ideals are synergic with other urban development and planning initiatives on a human scale: Smart City, the 15-minute City, the Caring City, and the Committed City. Having data is the first step for technology to serve the needs of urban dwellers and inform public policy regularly or when facing health emergencies and pervasive inequities.[12,119–121]

The risks of this study are especially those associated with data science and artificial intelligence. Travel time data providers do not disclose the algorithms they use. These are empirically known to be accurate and are expected to be more accurate for the areas most traveled by people with network-engaged smartphones and sites where infrastructure and conditions remain stable; accuracy may vary across the city.[5,122]

There is a risk of errors in programming or labeling data; to control this risk, the validity of the data was tested, repeatedly reviewed, and found sensible by experts and local contributors. The chance that inaccuracies result from clustering traffic and times is low and is unlikely to change the overall picture the project analyzes.

The project reveals accessibility levels for populations and sectors of the city. It uses heuristic analysis to identify areas in which new services would significantly impact accessibility. These areas, like traffic conditions, may evolve. However, the data provided to inform decisions gives an overall idea of the locations that would optimize accessibility. It is unlikely that conditions and populations would change fast enough to make those broad estimations suddenly irrelevant. Regular updating of the AMORE

Platform would allow assessing these variations and would be the subject of further studies after this test case.

Additional factors influence the use of a service, including insurance coverage entitlements. Exploring this would require different data layers and funding that exceeds the purpose and scope of the test case and would be a matter of subsequent implementation.

There is an inherent risk of revealing social injustices or inequities that can lead to discomfort, alienation, or corrective action.

Dissemination, promotion, and implementation of findings

As part of the project, communication tools such as animations, infographics, videos, summaries, and logos were developed.

The research team seeks to publish its reports in open-access impactful journals and present them to diverse audiences, including observatories, networks, and intersectoral groups.

The planned reports include:

- Accessibility of health services for the urban population of Cali, 2020: urgent care and frequent care
- Predicted accessibility of health services for the urban population of Cali with the addition of health services in areas that would maximize accessibility (urgent care and frequent care scenarios) or changes in service schedules (frequent care)
- Editorials and methodological articles.

General

Declarations

This project has no human subjects' research; it uses anonymized, openly available data sources seeking quality improvements in health services. This version of the protocol was completed and prepared for publication following the approval by ethics review committees, and includes a graph published in Figure 4 from the first published reports.[96]

The Follow-up Commission of the Doctoral Program on Biomedical Research Methodology and Public Health of the Universitat Autònoma de Barcelona reviewed the study in September 2020 and 2021.

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Conflicts of interest / confluent interests

LGC is contributing his time in his personal capacity and as part of his part-time doctoral studies. His contributions and reports do not necessarily reflect the policies or decisions of his employer, the Pan American Health Organization (PAHO/WHO).

IQuartil SAS was commissioned to develop the backend and front end of the AMORE Platform and to host the platform. DCA was part of Team 33, where he led the team in developing the prototype of the AMORE Platform in coordination with the principal investigator. DCA is also a partner in IQuartil SAS and guided the company's technical support and coordination with the principal investigator. LFP worked with IQuartil SAS until March 2021.

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Annex: Theory of change https://doi.org/10.6084/m9.figshare.20485404.v2.[123]

What is already known on this topic – dynamic travel times are not available for most cities, including Cali, and are not integrated into urban and health service planning; dynamic geospatial analyses reveal the effects of traffic congestion on health equity and accessibility to health services, a determinant of health.

What this study adds – it will provide estimates of accessibility with an equity perspective using simple methods and metrics that concerned stakeholders might find familiar. This will test if dynamic accessibility assessments can be done with existing data. The study adds an approach to analyzing dynamic geographic accessibility by tapping into hundreds of thousands or millions of observations to analyze, predict, improve geographic accessibility to health services, and identify new correlations.

How this study might affect research, practice, or policy – This study will provide a new metric and data source to address inequities aggravated by poor accessibility offering new perspectives on land use and the expansion of health services. The study prioritizes travel times over distance, accounting for the temporospatial variations caused by traffic congestion. Subsequent examinations can explore stakeholders' valuing of the data and their communication of the methods and findings with peers and counterparts.

References

1. Cuervo LG, Martínez-Herrera E, Cuervo D, Jaramillo C. Improving equity using dynamic geographic accessibility data for urban health services planning. Gac Sanit [Internet]. [cited 2022 Jun 11];(ePublication ahead of print). Available from: http://www.gacetasanitaria.org/en-improving-equity-using-dynamic-geographic-avance-S0213911122001108

2. Neutens T. Accessibility, equity and health care: review and research directions for transport geographers. J Transp Geogr [Internet]. 2015 Feb 1 [cited 2022 Jan 20];43:14–27. Available from: https://www.sciencedirect.com/science/article/pii/S0966692315000034

3. Kong X, Liu Y, Wang Y, Tong D, Zhang J. Investigating Public Facility Characteristics from a Spatial Interaction Perspective: A Case Study of Beijing Hospitals Using Taxi Data. ISPRS Int J Geo-Inf [Internet]. 2017 Feb [cited 2022 Jan 20];6(2):38. Available from: https://www.mdpi.com/2220-9964/6/2/38

4. Bimpou K, Ferguson NS. Dynamic accessibility: Incorporating day-to-day travel time reliability into accessibility measurement. J Transp Geogr [Internet]. 2020 Dec 1 [cited 2022 Apr 21];89:102892. Available from: https://www.sciencedirect.com/science/article/pii/S0966692320309698

5. Mayer-Schönberger V, Cukier K. Big data: a revolution that will transform how we live, work, and think. Boston, Mass.: Houghton Mifflin Harcourt; 2013. 242 p. (An Eamon Dolan book).

6. Ashford LS. “Demystifying Big Data for Demography and Global Health,” Population Bulletin 76, no. 1 (2022). Popul Bull [Internet]. 2022;76(1):34. Available from: https://www.prb.org/resources/demystifying-big-data-for-demography-and-global-health/

7. Ahuja R, Tiwari G. Evolving term “accessibility” in spatial systems: Contextual evaluation of indicators. Transp Policy [Internet]. 2021 Nov 1 [cited 2022 May 27];113:4–11. Available from: https://www.sciencedirect.com/science/article/pii/S0967070X21000688

8. Zhou X, Yu Z, Yuan L, Wang L, Wu C. Measuring Accessibility of Healthcare Facilities for Populations with Multiple Transportation Modes Considering Residential Transportation Mode Choice. ISPRS Int J Geo-Inf [Internet]. 2020 Jun [cited 2021 Nov 14];9(6):394. Available from: https://www.mdpi.com/2220-9964/9/6/394

9. Śleszyński P, Olszewski P, Dybicz T, Goch K, Niedzielski MA. The ideal isochrone: Assessing the efficiency of transport systems. Res Transp Bus Manag [Internet]. 2022 Jan 19 [cited 2022 Jan 27];100779. Available from: https://www.sciencedirect.com/science/article/pii/S2210539521001620

10. García-Albertos P, Picornell M, Salas-Olmedo MH, Gutiérrez J. Exploring the potential of mobile phone records and online route planners for dynamic accessibility analysis. Transp Res Part Policy Pract [Internet]. 2019 Jul [cited 2021 Nov 14];125:294–307. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0965856417307292

11. Moya-Gómez B, Salas-Olmedo MH, García-Palomares JC, Gutiérrez J. Dynamic Accessibility using Big Data: The Role of the Changing Conditions of Network Congestion and Destination

Attractiveness. Netw Spat Econ [Internet]. 2018 Jun 1 [cited 2021 Jan 23];18(2):273–90. Available from: https://doi.org/10.1007/s11067-017-9348-z

12. Comprender para transformar, entrevista a Oriol Nel·lo [Internet]. 2018 [cited 2020 Aug 17]. Available from: https://youtu.be/AHw6F72HqGQ

13. Abimbola S. Beyond positive a priori bias: reframing community engagement in LMICs. Health Promot Int [Internet]. 2020 Jun 1 [cited 2021 Apr 3];35(3):598–609. Available from: https://doi.org/10.1093/heapro/daz023

14. Cyril S, Smith BJ, Possamai-Inesedy A, Renzaho AMN. Exploring the role of community engagement in improving the health of disadvantaged populations: a systematic review. Glob Health Action [Internet]. 2015 Dec 1 [cited 2021 Apr 2];8(1):29842. Available from: https://doi.org/10.3402/gha.v8.29842

15. Whitty CJM. What makes an academic paper useful for health policy? BMC Med [Internet]. 2015 Dec 17 [cited 2022 Mar 24];13(1):301. Available from: https://doi.org/10.1186/s12916-015-0544-8

16. Frenk J. The concept and measurement of accessibility. In: White K, editor. Health Services Research: an anthology [Internet]. Washington DC: Pan American Health Organization / World Health Organization; 1992. p. 8–42855. Available from: https://www.researchgate.net/profile/Julio-Frenk/publication/19080047_Concept_and_measurement_of_accessibility/links/5575db2708ae75363751a314/Concept-and-measurement-of-accessibility.pdf

17. United Nations. About the Sustainable Development Goals [Internet]. United Nations Sustainable Development. [cited 2020 Aug 22]. Available from: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

18. 53rd Directing Council, 66th Session of the Regional Committee of WHO for the Americas. Strategy for Universal Access to Health and Universal Health Coverage [Internet]. Pan American Health Organization / World Health Organization; 2014. Available from: https://iris.paho.org/handle/10665.2/28276

19. 57th Directing Council of the Pan American Health Organization, 71st Session of the Regional Committee of WHO for the Americas. Strategy and Plan of Action to Improve Quality of Care in Health Service Delivery 2020-2025 / Estrategia y plan de acción para mejorar la calidad de la atención en la prestación de servicios de salud 2020-2025 [Internet]. PAHO/WHO; 2019. Available from: https://iris.paho.org/handle/10665.2/51621

20. Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health: final report of the commission on social determinants of health. Combler Fossé En Une Génér Instaur Léquité En Santé En Agissant Sur Déterm Sociaux Santé Rapp Final Comm Déterm Sociaux Santé [Internet]. 2008 [cited 2022 Mar 19];247. Available from: https://apps.who.int/iris/handle/10665/43943

21. Luo W, Wang F. Measures of Spatial Accessibility to Health Care in a GIS Environment: Synthesis and a Case Study in the Chicago Region. Environ Plan B Plan Des [Internet]. 2003 Dec [cited 2020 May 10];30(6):865–84. Available from: http://journals.sagepub.com/doi/10.1068/b29120

22. Bureau of Transportation Statistics. Transportation Statistics Annual Report1997: mobility and access [Internet]. US Department of Transportation; 1997 p. 331. Available from: https://www.bts.dot.gov/archive/publications/transportation_statistics_annual_report/1997/index

23. Higgins C, Palm M, DeJohn A, Xi L, Vaughan J, Farber S, et al. Calculating place-based transit accessibility: Methods, tools and algorithmic dependence. J Transp Land Use [Internet]. 2022 Feb 1 [cited 2022 Feb 22];15(1):95–116. Available from: https://www.jtlu.org/index.php/jtlu/article/view/2012

24. Carrasco-Escobar G, Manrique E, Tello-Lizarraga K, Miranda JJ. Travel Time to Health Facilities as a Marker of Geographical Accessibility Across Heterogeneous Land Coverage in Peru. Front Public Health [Internet]. 2020 [cited 2022 Apr 4];8. Available from: https://www.frontiersin.org/article/10.3389/fpubh.2020.00498

25. Buzai GD, Santana Juárez MV. Condicionantes Socioespaciales de la Salud (CSS): bases y alcance conceptual. Annu Div Geogr 2018 [Internet]. 2018;(12):15. Available from: http://ri.unlu.edu.ar/xmlui/handle/rediunlu/626

26. Malhotra S, White H, The Campbell Collaboration, de la Cruz N, Saran A, Eyers J, et al. Evidence and gap map-studies of the effectiveness of transport sector intervention in low and middle-income countries [Internet]. Centre for Excellence and Development Impact and Learning (CEDIL); 2022 Jun [cited 2022 Jul 11]. Available from: https://cedilprogramme.org/publications/evidence-and-gap-map-transport-sector-intervention

27. Al-Taiar A, Clark A, Longenecker JC, Whitty CJ. Physical accessibility and utilization of health services in Yemen. Int J Health Geogr [Internet]. 2010 Jul 21 [cited 2022 Jul 11];9(1):38. Available from: https://doi.org/10.1186/1476-072X-9-38

28. Kajalić J, Čelar N, Stanković S. Travel Time Estimation on Urban Street Segment. Promet - TrafficTransportation [Internet]. 2018 Feb 23 [cited 2022 Apr 20];30(1):115–20. Available from: https://hrcak.srce.hr/195122

29. Hernández Gene FJ, Garnica Berrocal R. Accesibilidad física de la población a servicios de salud pública en San Pelayo y Cereté, Córdoba, Colombia, año 2015. Perspect Geográfica [Internet]. 2017 Dec 19 [cited 2020 May 31];22(2). Available from: http://revistas.uptc.edu.co/revistas/index.php/perspectiva/article/view/7599

30. Guagliardo MF. Spatial accessibility of primary care: concepts, methods and challenges. Int J Health Geogr [Internet]. 2004 Feb 26 [cited 2020 May 7];3:3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC394340/

31. Páez A, Scott DM, Morency C. Measuring accessibility: positive and normative implementations of various accessibility indicators. J Transp Geogr [Internet]. 2012 Nov [cited 2020 Jul 9];25:141–53. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0966692312000798

32. Currie G. Quantifying spatial gaps in public transport supply based on social needs. J Transp Geogr [Internet]. 2010 Jan 1 [cited 2020 Jun 11];18(1):31–41. Available from: http://www.sciencedirect.com/science/article/pii/S0966692308001518

33. Lovett A, Haynes R, Sünnenberg G, Gale S. Car travel time and accessibility by bus to general practitioner services: a study using patient registers and GIS. Soc Sci Med [Internet]. 2002 Jul 1 [cited 2020 May 20];55(1):97–111. Available from: http://www.sciencedirect.com/science/article/pii/S027795360100212X

34. Rosero-Bixby L. Spatial access to health care in Costa Rica and its equity: a GIS-based study. Soc Sci Med [Internet]. 2004 Apr 1 [cited 2020 May 20];58(7):1271–84. Available from: http://www.sciencedirect.com/science/article/pii/S0277953603003228

35. Teach SJ, Guagliardo MF, Crain EF, McCarter RJ, Quint DM, Shao C, et al. Spatial Accessibility of Primary Care Pediatric Services in an Urban Environment: Association With Asthma Management and Outcome. Pediatrics [Internet]. 2006 Apr 1 [cited 2020 May 7];117(Supplement 2):S78–85. Available from: https://pediatrics.aappublications.org/content/117/Supplement_2/S78

36. AccessMod 5 | Modelling physical accessibility to health care [Internet]. accessmod. [cited 2021 May 3]. Available from: https://www.accessmod.org

37. Banke-Thomas A, Wong KLM, Collins L, Olaniran A, Balogun M, Wright O, et al. An assessment of geographical access and factors influencing travel time to emergency obstetric care in the urban state of Lagos, Nigeria. Health Policy Plan [Internet]. 2021 Nov 1 [cited 2022 Jun 17];36(9):1384–96. Available from: https://doi.org/10.1093/heapol/czab099

38. Alam K, Mahal A. Economic impacts of health shocks on households in low and middle income countries: a review of the literature. Glob Health [Internet]. 2014 Apr 3 [cited 2022 Jan 8];10(1):21. Available from: https://doi.org/10.1186/1744-8603-10-21

39. Fullman N, Yearwood J, Abay SM, Abbafati C, Abd-Allah F, Abdela J, et al. Measuring performance on the Healthcare Access and Quality Index for 195 countries and territories and selected subnational locations: a systematic analysis from the Global Burden of Disease Study 2016. The Lancet [Internet]. 2018 Jun 2 [cited 2020 Nov 11];391(10136):2236–71. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)30994-2/abstract

40. Hart JT. The inverse care law. The Lancet [Internet]. 1971 Feb 27 [cited 2021 Mar 28];297(7696):405–12. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(71)92410-X/abstract

41. Whitehead M. The concepts and principles of equity and health. Health Promot Int [Internet]. 1991 Sep 1 [cited 2021 Mar 28];6(3):217–28. Available from: https://doi.org/10.1093/heapro/6.3.217

42. Nambiar D, Mander H. Inverse care and the role of the state: the health of the urban poor. Bull World Health Organ [Internet]. 2017 Feb 1 [cited 2021 Mar 28];95(2):152–3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5327938/

43. Cookson R, Doran T, Asaria M, Gupta I, Mujica FP. The inverse care law re-examined: a global perspective. The Lancet [Internet]. 2021 Feb [cited 2021 Mar 28];397(10276):828–38. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0140673621002439

44. Fiscella K, Shin P. The Inverse Care Law: Implications for Healthcare of Vulnerable Populations. J Ambulatory Care Manage [Internet]. 2005 Dec [cited 2021 Mar 28];28(4):304–12. Available from: https://journals.lww.com/ambulatorycaremanagement/Abstract/2005/10000/The_Inverse_Care_Law__Implications_for_Healthcare.5.aspx

45. OECD. Health for Everyone?: Social Inequalities in Health and Health Systems [Internet]. OECD; 2019 [cited 2021 Feb 11]. (OECD Health Policy Studies). Available from: https://www.oecd-ilibrary.org/social-issues-migration-health/health-for-everyone_3c8385d0-en

46. Pineo H. Healthy Urbanism: Designing and Planning Equitable, Sustainable and Inclusive Places. [Internet]. London: Palgrave Macmillan; 2022. Available from: https://link.springer.com/book/10.1007/978-981-16-9647-3

47. Acosta A. Smart Cities & Inequidad: Forbes República Dominicana [Internet]. 2021 Jul 13 [cited 2021 Jul 17];82(julio-agosto 2021):12. Available from: https://issuu.com/forbeslatam/docs/forbes_rd_julio_/12

48. Boeing G, Higgs C, Liu S, Giles-Corti B, Sallis JF, Cerin E, et al. Using open data and open-source software to develop spatial indicators of urban design and transport features for achieving healthy and sustainable cities. Lancet Glob Health [Internet]. 2022 Jun 1 [cited 2022 May 12];10(6):e907–18. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(22)00072-9/fulltext

49. d'Obrenan H van den B, Huxley R. Measuring what matters: supporting cities in tackling climate and health challenges. Lancet Glob Health [Internet]. 2022 Jun 1 [cited 2022 May 12];10(6):e788–9. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(22)00198-X/fulltext

50. Giles-Corti B, Moudon AV, Lowe M, Adlakha D, Cerin E, Boeing G, et al. Creating healthy and sustainable cities: what gets measured, gets done. Lancet Glob Health [Internet]. 2022 Jun 1 [cited 2022 May 12];10(6):e782–5. Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(22)00070-5/fulltext

51. Evidence Aid. Factors affecting patients' ability to access healthcare: overview of systematic reviews [Internet]. Evidence Aid. Evidence Aid; 2022 [cited 2022 Jun 16]. Available from: https://evidenceaid.org/resource/factors-affecting-patients-ability-to-access-healthcare-overview-of-systematic-reviews/

52. Martin. The Sustainable Development Agenda [Internet]. United Nations Sustainable Development. [cited 2020 Aug 22]. Available from: https://www.un.org/sustainabledevelopment/development-agenda/

53. Armstrong K. Big data: a revolution that will transform how we live, work, and think. Inf Commun Soc [Internet]. 2014 Nov 26 [cited 2022 Apr 27];17(10):1300–2. Available from: https://doi.org/10.1080/1369118X.2014.923482

54. Jin T, Cheng L, Wang K, Cao J, Huang H, Witlox F. Examining equity in accessibility to multi-tier healthcare services across different income households using estimated travel time. Transp Policy [Internet]. 2022 Jun 1 [cited 2022 Apr 7];121:1–13. Available from: https://www.sciencedirect.com/science/article/pii/S0967070X22000828

55. Abookire S, Plover C, Frasso R, Ku B. Health Design Thinking: An Innovative Approach in Public Health to Defining Problems and Finding Solutions. Front Public Health [Internet]. 2020 [cited 2022 Jul 18];8. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2020.00459

56. Bazzano AN, Martin J, Hicks E, Faughnan M, Murphy L. Human-centred design in global health: A scoping review of applications and contexts. PLOS ONE [Internet]. 2017 Nov 1 [cited 2022 Jul 18];12(11):e0186744. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0186744

57. Brown T. Design Thinking. 2008.

58. Jull J, Giles A, Graham ID. Community-based participatory research and integrated knowledge translation: advancing the co-creation of knowledge. Implement Sci [Internet]. 2017 Dec 19 [cited 2021 Mar 25];12(1):150. Available from: https://doi.org/10.1186/s13012-017-0696-3

59. Papa E, Coppola P, Angiello G, Carpentieri G. The learning process of accessibility instrument developers: Testing the tools in planning practice. Transp Res Part Policy Pract [Internet]. 2017 Oct [cited 2021 Jan 23];104:108–20. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0965856417302938

60. PROGRESS-Plus | Cochrane Equity [Internet]. [cited 2020 Mar 23]. Available from: https://methods.cochrane.org/equity/projects/evidence-equity/progress-plus

61. Jull J, Graham ID, Kristjansson E, Moher D, Petkovic J, Yoganathan M, et al. Taking an integrated knowledge translation approach in research to develop the CONSORT-Equity 2017 reporting guideline: an observational study. BMJ Open [Internet]. 2019 Jul 1;9(7):e026866. Available from: http://bmjopen.bmj.com/content/9/7/e026866.abstract

62. Welch TF, Mishra S. A measure of equity for public transit connectivity. J Transp Geogr [Internet]. 2013 Dec [cited 2021 Mar 4];33:29–41. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0966692313001762

63. Redman S, Greenhalgh T, Adedokun L, Staniszewska S, Denegri S, Committee on behalf of the C production of KCS. Co-production of knowledge: the future. BMJ [Internet]. 2021 Feb 16 [cited 2021 Apr 23];372:n434. Available from: https://www.bmj.com/content/372/bmj.n434

64. Chircop A, Bassett R, Taylor E. Evidence on how to practice intersectoral collaboration for health equity: a scoping review. Crit Public Health [Internet]. 2015 Mar 15 [cited 2020 Oct 10];25(2):178–91. Available from: https://doi.org/10.1080/09581596.2014.887831

65. Organización Panamericana de la Salud, Organización Mundial de Salud,. Intersectorialidad y equidad en salud en América Latina: una aproximación analítica [Internet]. Washington, D.C.; 2015. 34 p. Available from: https://iris.paho.org/handle/10665.2/33874

66. Geurs KT, van Wee B. Accessibility evaluation of land-use and transport strategies: review and research directions. J Transp Geogr [Internet]. 2004 Jun [cited 2020 May 10];12(2):127–40. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0966692303000607

67. United Nations. Multi-stakeholder partnerships and voluntary commitments [Internet]. Department of Economic and Social Affairs. 2020 [cited 2020 Dec 12]. Available from: https://sdgs.un.org/topics/multi-stakeholder-partnerships-and-voluntary-commitments

68. Hussain S, Javadi D, Andrey J, Ghaffar A, Labonté R. Health intersectoralism in the Sustainable Development Goal era: from theory to practice. Glob Health [Internet]. 2020 Feb 20 [cited 2021 Mar 28];16(1):15. Available from: https://doi.org/10.1186/s12992-020-0543-1

69. Organización Panamericana de la Salud. Hoja de Ruta para el Plan de Acción sobre la Salud en Todas las Políticas [Internet]. OPS; 2016 [cited 2020 Aug 11]. Available from: https://iris.paho.org/handle/10665.2/31314

70. Public Health Institute, Rudolph L, Caplan J, Public Health Institute, Mitchell C, California Department of Public Health, et al. Health in All Policies: Improving Health Through Intersectoral Collaboration. NAM Perspect [Internet]. 2013 Sep 18 [cited 2020 Sep 11];3(9). Available from: https://nam.edu/perspectives-2013-health-in-all-policies-improving-health-through-intersectoral-collaboration/

71. de Kadt E. Making health policy management intersectoral: Issues of information analysis and use in less developed countries. Soc Sci Med [Internet]. 1989 Jan 1 [cited 2020 Oct 10];29(4):503–14. Available from: http://www.sciencedirect.com/science/article/pii/0277953689901962

72. Petkovic J, Riddle A, Akl EA, Khabsa J, Lytvyn L, Atwere P, et al. Protocol for the development of guidance for stakeholder engagement in health and healthcare guideline development and implementation. Syst Rev [Internet]. 2020 Dec [cited 2021 Jan 3];9(1):21. Available from: https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-020-1272-5

73. Pinnock H, Barwick M, Carpenter CR, Eldridge S, Grandes G, Griffiths CJ, et al. Standards for Reporting Implementation Studies (StaRI) Statement. BMJ [Internet]. 2017 Mar 6 [cited 2020 Jul 6];356. Available from: https://www.bmj.com/content/356/bmj.i6795

74. Campbell M, Katikireddi SV, Hoffmann T, Armstrong R, Waters E, Craig P. TIDieR-PHP: a reporting guideline for population health and policy interventions. BMJ [Internet]. 2018 May 16 [cited 2020 May 7];361. Available from: https://www.bmj.com/content/361/bmj.k1079

75. Rivera SC, Liu X, Chan AW, Denniston AK, Calvert MJ, Ashrafian H, et al. Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension. Lancet Digit Health [Internet]. 2020 Oct 1 [cited 2020 Oct 30];2(10):e549–60. Available from: https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30219-3/abstract

76. Staniszewska S, Brett J, Simera I, Seers K, Mockford C, Goodlad S, et al. GRIPP2 reporting checklists: tools to improve reporting of patient and public involvement in research. BMJ [Internet]. 2017 Aug 2 [cited 2021 Mar 24];358:j3453. Available from: https://www.bmj.com/content/358/bmj.j3453

77. Kpokiri EE, Chen E, Li J, Payne S, Shrestha P, Afsana K, et al. Social Innovation For Health Research: Development of the SIFHR Checklist. PLOS Med [Internet]. 2021 Sep 13 [cited 2021 Sep 29];18(9):e1003788. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1003788

78. DANE. Información técnica y omisión censal 2018, aspectos conceptuales y metodológicos. [Internet]. 2019 [cited 2020 Sep 10]. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/censo-nacional-de-poblacion-y-vivenda-2018/informacion-tecnica

79. DANE, Sistema Estadístico Nacional - SEN. Información del DANE para la toma de decisiones regionales: Cali - Valle del Cauca [Internet]. Colombia - Cali: DANE; 2021 Mar [cited 2021 Apr 24] p. 223. (La información del DANE en la toma de decisiones de las ciudades capitales). Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/informacion-regional/informacion-estadistica-desagregada-con-enfoque-territorial-y-diferencial/informacion-del-dane-para-la-toma-de-decisiones-en-departamentos-y-ciudades-capitales

80. Dirección de Censos y Demografía - DCD,, Departamento Administrativo Nacional de Estadística - DANE. COLOMBIA - Censo Nacional de Población y Vivienda - CNPV - 2018 [Internet]. Bogotá: Departamento Administrativo Nacional de Estadística - DANE; 2020 Feb p. 124. (Microdatos). Report No.: DANE-DCD-CNPV-2018. Available from: http://microdatos.dane.gov.co/index.php/catalog/643/study-description

81. DANE, Sistema Estadístico Nacional - SEN. Información del DANE para la toma de decisiones de las ciudades capitales: Cali - Valle del Cauca [Internet]. Colombia - Cali: DANE; 2020 Jan [cited 2021 Apr 24] p. 79. (La información del DANE en la toma de decisiones de las ciudades capitales). Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/informacion-regional/informacion-estadistica-desagregada-con-enfoque-territorial-y-diferencial/informacion-del-dane-para-la-toma-de-decisiones-en-departamentos-y-ciudades-capitales

82. Gamboa O, Cotes M, Valdivieso J, Henriquez G, Bobadilla I, Esguerra JA, et al. Estimation of the Need for Radiation Therapy Services According to the Incidence of Cancer in Colombia to 2035. Adv Radiat Oncol [Internet]. 2021 Nov 1 [cited 2022 Jul 14];6(6):100771. Available from: https://www.sciencedirect.com/science/article/pii/S2452109421001299

83. de Vries E, Buitrago G, Quitian H, Wiesner C, Castillo JS. Access to cancer care in Colombia, a middle-income country with universal health coverage. J Cancer Policy [Internet]. 2018 May 1 [cited 2022 Jul 14];15:104–12. Available from: https://www.sciencedirect.com/science/article/pii/S2213538317300577

84. Cuentas de Alto Costo - Fondo Colombiano de Enfermedades de Alto Costo. HIGIA - Enfermedad Renal Crónica, Indicadores de Riesgo Demográfico. - Diálisis Adultos y Niños en Cali. [Internet]. Cuenta de Alto Costo. 2022 [cited 2022 Jul 15]. Available from: https://cuentadealtocosto.org/site/higia/erc-indicadores-demografico/

85. Cali Distrito Especial tendría seis localidades [Internet]. [cited 2021 Mar 31]. Available from: http://www.cali.gov.co/publicaciones/148406/cali-distrito-especial-tendria-seis-localidades/

86. Censo Nacional de Población y Vivienda 2018 [Internet]. [cited 2020 Jul 23]. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/censo-nacional-de-poblacion-y-vivenda-2018

87. Grupo Interagencial sobre Flujos Migratorios Mixtos. Página de GIFMM Colombia | R4V [Internet]. 2022 [cited 2022 Jul 20]. Available from: https://www.r4v.info/es/colombia

88. Unión Temporal UT SDG-CNC. Encuesta de movilidad de hogares Cali 2015: Producto 3. Ámbito y zonificación. [Internet]. Steer Davies Gleave; 2015 [cited 2020 May 30]. Available from: https://www.metrocali.gov.co/wp/wp-content/uploads/2019/02/Encuesta-de-movilidad-2015.pdf

89. Proyecto AMORE: mejorando la equidad en la accesibilidad (tiempos de viaje) a los servicios de salud. Prueba de concepto en Cali, Colombia. Sesión 01 Sala B: Ciudad Saludable, Smart Cities y Recursos Críticos [Internet]. Santiago, Chile: Centro de Desarrollo Urbano Sostenible - Chile; 2022 [cited 2022 May 27]. Available from: https://youtu.be/so7qPot48r0?t=1287

90. AMORE Project - to improve health equity by reducing the travel time to essential health services [Internet]. Bethesda, MD, USA; 2021 [cited 2021 Sep 23]. Available from: https://youtu.be/_cDMAULJMTc

91. DS4A Colombia 2020 / Grand Finale [Internet]. 2020 [cited 2020 Aug 16]. Available from: https://youtu.be/sdjJWz9BqiQ?t=7362

92. Hendricks S, Conrad N, Douglas TS, Mutsvangwa T. A modified stakeholder participation assessment framework for design thinking in health innovation. Healthcare [Internet]. 2018 Sep 1 [cited 2021 Apr 2];6(3):191–6. Available from: https://www.sciencedirect.com/science/article/pii/S2213076417301811

93. Brown T, Wyatt J. Design Thinking for Social Innovation. Dev Outreach [Internet]. 2012 Oct 3 [cited 2021 Apr 2]; Available from: https://elibrary.worldbank.org/doi/abs/10.1596/1020-797X_12_1_29

94. Angotti T, Irazábal C. Planning Latin American Cities: Dependencies and “Best Practices.” Lat Am Perspect [Internet]. 2017 Mar 1 [cited 2021 Apr 1];44(2):4–17. Available from: https://doi.org/10.1177/0094582X16689556

95. Zurita I, E C. Revisiting Urban Planning in Latin America and the Caribbean. 2009 [cited 2021 Apr 1]; Available from: https://doi.org/10.7916/D85M6BHX

96. Cuervo LG, Martinez-Herrera E, Osorio L, Hatcher-Roberts J, Cuervo D, Bula MO, et al. Dynamic accessibility by car to tertiary care emergency services in Cali, Colombia, in 2020: cross-sectional equity analyses using travel time big data from a Google API. BMJ Open [Internet]. 2022 Sep 1 [cited 2022 Sep 1];12(9):e062178. Available from: https://bmjopen.bmj.com/content/12/9/e062178

97. Proyecto AMORE: Uso de Análisis Geoespacial para acceso a la Salud | 4º Foro “Ciudades Cómo Vamos” [Internet]. Lima; 2021 [cited 2022 Jul 16]. Available from: https://www.youtube.com/watch?v=J9avNPNa5os

98. Global Health Learning Network- Seminar on Digital app technology to assess equity: Spatial analysis and equity for health services [Internet]. Ottawa; 2022 [cited 2022 Jan 22]. (Global Health Learning Network Seminar Series; vol. 4). Available from: https://uottawa-ca.zoom.us/rec/play/lyT-Vp66Jj-31m2OhM4og3WeeQPslrawRbRPbVUmatxbN6MkzLnW1JdVSDW9M17NP6PxrtOzaMmyh45O.tnj-vla6v-i4299C?continueMode=true&_x_zm_rtaid=qBL0rw-iTMOu8ncExETWeQ.1642867258070.e07076e2ac3e816cb3429bf13b3f2ec8&_x_zm_rhtaid=89

99. Anderson JA, Eijkholt M, Illes J. Ethical reproducibility: towards transparent reporting in biomedical research. Nat Methods [Internet]. 2013 Sep [cited 2022 Jul 16];10(9):843–5. Available from: https://www.nature.com/articles/nmeth.2564

100. Ayesha B, Jeewanthi B, Chitraranjan C, Perera AS, Kumarage AS. User Localization Based on Call Detail Records [Internet]. arXiv; 2021 [cited 2022 Jul 20]. Available from: http://arxiv.org/abs/2108.09157

101. Jaramillo C, Lizárraga C, Grindlay AL. Spatial disparity in transport social needs and public transport provision in Santiago de Cali (Colombia). J Transp Geogr [Internet]. 2012 Sep 1 [cited 2020 Jun 4];24:340–57. Available from: http://www.sciencedirect.com/science/article/pii/S0966692312001263

102. Grindlay AL, Jaramillo C, Lizárraga C. Spatial relationships between mobility opportunities and constraints of transport disadvantages: the case of Santiago de Cali, Colombia. In Rome, Italy; 2017 [cited 2021 Nov 1]. p. 119–29. Available from: http://library.witpress.com/viewpaper.asp?pcode=UT17-011-1

103. Rodríguez Mariaca DA, Vivas Pachecho H, Pinzón MA, Jaramillo Molina C. Accessibility to the Employment Centers in Cali Through the Integrated System of Mass Transportation MIO. El Obs Reg [Internet]. 2017 [cited 2021 Nov 1];(34):1–7. Available from: http://rgdoi.net/10.13140/RG.2.2.29599.87205

104. Wilches Astudillo CA, Jaramillo C, Murillo-Hoyos J. Accesibilidad y equidad espacial al transporte público para pacientes con enfermedad neurodegenerativa en Santiago de Cali, Colombia. Investig Geográficas [Internet]. 2021 May 13 [cited 2021 Jun 4]; Available from: https://www.investigacionesgeograficas.com/article/view/17589

105. Delmelle EC, Casas I. Evaluating the spatial equity of bus rapid transit-based accessibility patterns in a developing country: The case of Cali, Colombia. Transp Policy [Internet]. 2012 Mar 1 [cited 2020 May 19];20:36–46. Available from: http://www.sciencedirect.com/science/article/pii/S0967070X11001338

106. Scholl L. Casos de estudio comparativos de tres proyectos de transporte urbano apoyados por el BID [Internet]. Banco Interamericano de Desarrollo; 2015 Jun [cited 2021 Nov 1]. Available from: http://publications.iadb.org/handle/11319/6967?locale-attribute=es&

107. Ministerio de Salud. Resolución 8430 de 1993: Normas científicas, técnicas y administrativas para la investigación en salud. [Internet]. República de Colombia; 1993. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/DE/DIJ/RESOLUCION-8430-DE-1993.pdf

108. Whitty CJM. What makes an academic paper useful for health policy? BMC Med [Internet]. 2015 Dec 17 [cited 2022 Mar 24];13(1):301. Available from: https://doi.org/10.1186/s12916-015-0544-8

109. Curtis C, Scheurer J. Planning for sustainable accessibility: Developing tools to aid discussion and decision-making. Prog Plan [Internet]. 2010 Aug 1 [cited 2020 Jul 6];74(2):53–106. Available from: http://www.sciencedirect.com/science/article/pii/S0305900610000516

110. Observatorio de Sistemas de Ciudades. Resultados Índice de Ciudades Modernas 2019 [Internet]. 2021 [cited 2021 Jan 16]. Available from: https://osc.dnp.gov.co/index.php/escalafones/sistema-de-ciudades

111. Cali emerges as epicentre of unrest in ongoing Colombia protests | Protests News | Al Jazeera [Internet]. [cited 2021 Oct 11]. Available from: https://www.aljazeera.com/news/2021/5/11/cali-emerges-as-epicentre-of-colombias-ongoing-unrest

112. Colombia protests: UN “deeply alarmed” by bloodshed in Cali. BBC News [Internet]. 2021 May 4 [cited 2021 Oct 11]; Available from: https://www.bbc.com/news/world-latin-america-56983865

113. Castro JES, González JDG. The relationship between corruption and inequality in Colombia: empirical evidence using panel data for the period 2008-2017. Rev Iberoam Estud Desarro Iberoam J Dev Stud [Internet]. 2019 [cited 2021 Apr 26];8(2):28–43. Available from: https://dialnet.unirioja.es/servlet/articulo?codigo=7121071

114. Colombia Corruption Index | 1995-2020 Data | 2021-2023 Forecast | Historical | Chart [Internet]. [cited 2021 Apr 26]. Available from: https://tradingeconomics.com/colombia/corruption-index

115. Krubiner CB, Hyder AA. A bioethical framework for health systems activity: a conceptual exploration applying ‘systems thinking.’ Health Syst [Internet]. 2014 Jun 1 [cited 2021 Jan 1];3(2):124–35. Available from: https://orsociety.tandfonline.com/doi/abs/10.1057/hs.2014.1

116. Cash R, Wikler D, Saxena A, Capron AM, World Health Organization. Casebook on ethical issues in international health research / edited by Richard Cash [... et al]. Estud Caso Sobre Ética Investig Int En Salud [Internet]. 2009 [cited 2021 Oct 30];209. Available from: https://apps.who.int/iris/handle/10665/44118

117. HEARD Project, USAID. Establishing Principles of Stakeholder Engagement in Global Health Implementation Science and Research | HEARD [Internet]. [cited 2021 Jan 7]. Available from: https://www.heardproject.org/resources/establishing-principles-of-stakeholder-engagement-in-global-health-implementation-science-and-research/

118. McCollum R, Taegtmeyer M, Otiso L, Mireku M, Muturi N, Martineau T, et al. Healthcare equity analysis: applying the Tanahashi model of health service coverage to community health systems following devolution in Kenya. Int J Equity Health [Internet]. 2019 May 7 [cited 2021 Apr 23];18(1):65. Available from: https://doi.org/10.1186/s12939-019-0967-5

119. Vida urbana y proximidad – Carlos Moreno [Internet]. Club de Lecturas. [cited 2021 Jul 18]. Available from: https://www.clubdelecturas.com/producto/vida-urbana-y-proximidad-carlos-moreno/

120. BID I. Ciudades inteligentes en América Latina [Internet]. Conexión Intal. 2018 [cited 2021 Jul 18]. Available from: https://conexionintal.iadb.org/2018/11/27/267_e_ideas6/

121. Observatorio de Sostenibilidad de Ciudades [Internet]. [cited 2020 Oct 12]. Available from: https://osc.dnp.gov.co/index.php/escalafones/sistema-de-ciudades

122. Luca M, Kleinberg J, Mullainathan S. Algorithms Need Managers, Too. Harvard Business Review [Internet]. 2016 Jan 1 [cited 2022 Jul 15]; Available from: https://hbr.org/2016/01/algorithms-need-managers-too

123. Cuervo LG, Villamizar CJ, Jaramillo C, Martínez-Herrera E, Cuervo D. Theory of Change for AMORE Project Protocol 2022 [Internet]. figshare. figshare; 2022 [cited 2022 Aug 13]. Available from: https://doi.org/10.6084/m9.figshare.20485404.v2

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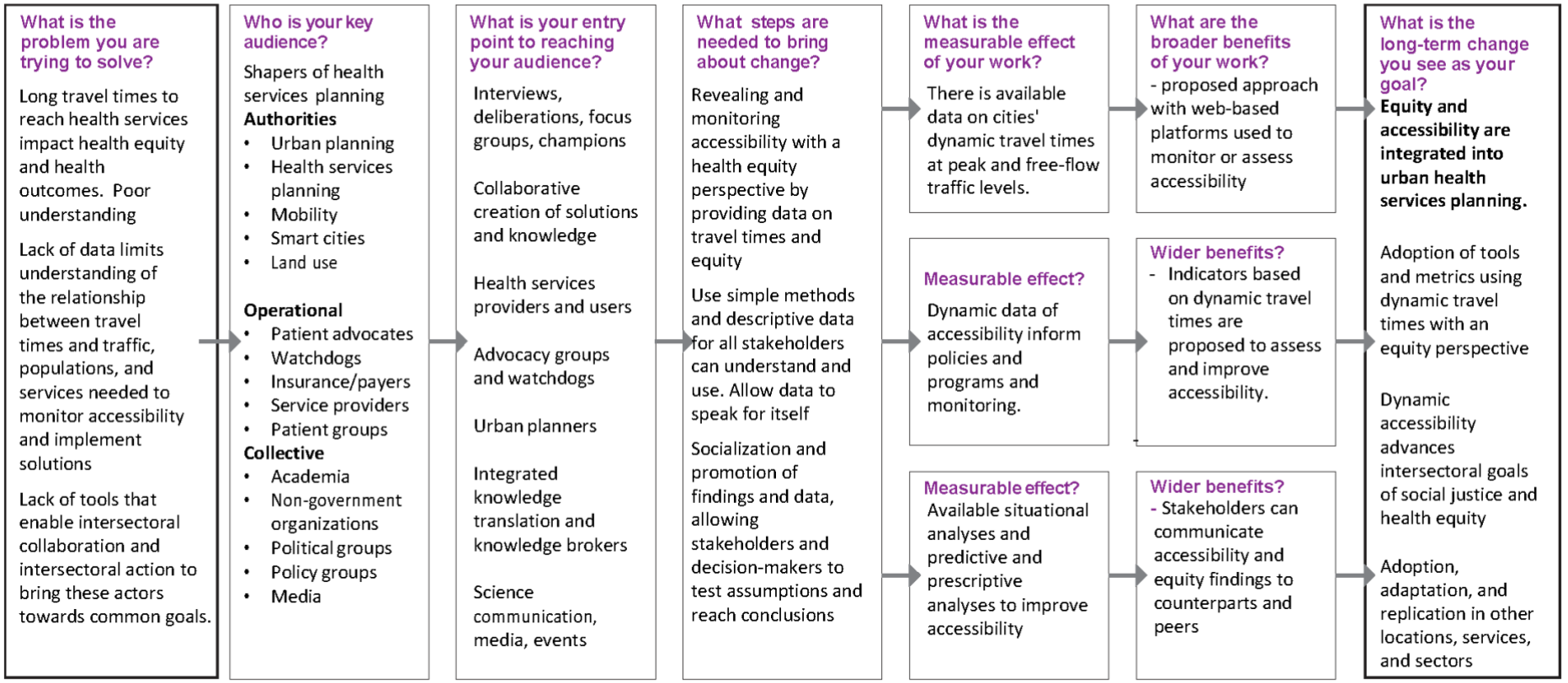
The Theory of Change is provided as an annex in page 31

Annex – Theory of Change

THEORY OF CHANGE — The 2022 goals of the AMORE Project and how they will be achieved



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