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2SFCA Accessibility Analysis for Outpatient Mental Health Facilities

Introduction

Spatial accessibility is a measure of how difficult it is to reach a certain place, person or object, and is one of the top goals for urban planning (Liu et al. 2004). Key facilities and services must be accessible for populations in the surrounding area. Services such as grocery stores, hospitals and in this case mental health facilities should be accessible for the population.

Mental health care is a vital component of overall health and wellness, but many Americans lack access to it. San Francisco, in particular, has been put in the spotlight for the "mental health crisis", with far greater need for mental health care services than providers who can offer it. To add onto the issue, racial minorities tend to have proportionately higher populations with mental health issues (Mongelli et al. 2020) The goal of our 2SFCA analysis is to determine spatial accessibility of outpatient mental health services in the county and city of San Francisco by two different modes of transportation: driving and walking.

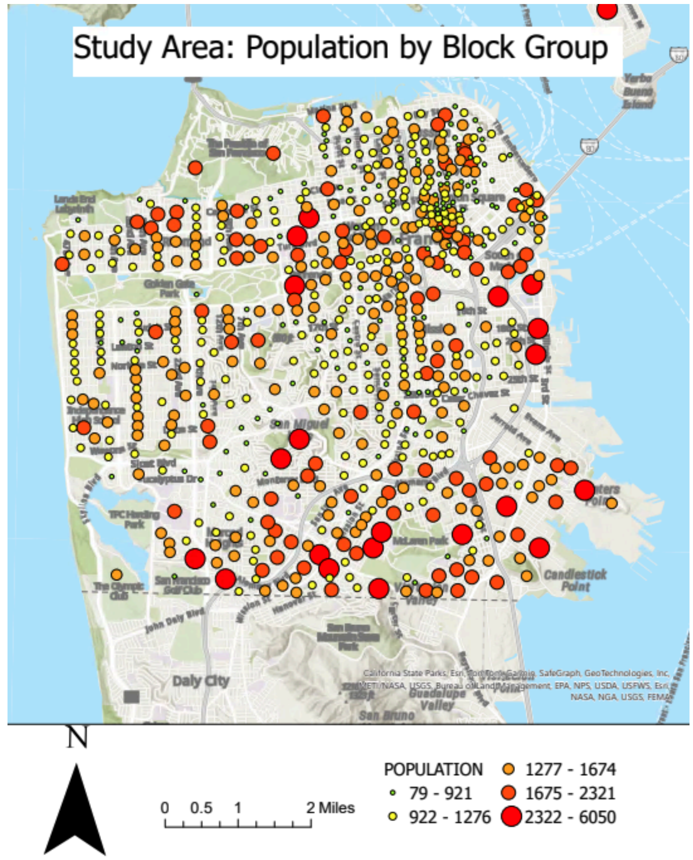
The 2SFCA method and its variants have been used for a variety of purposes ranging from healthcare to green space accessibility. The model captures the real world travel environment and different service needs, providing much more than a simple Euclidean distance model of accessibility (Chen and Pengfei 2019).

Study Area

San Francisco is located on a peninsula between the San Francisco Bay and the Pacific Ocean; it is both a city and county, sharing the same administrative boundaries. It has an estimated population of 808,437 people living within approximately 47 square miles (U.S. Census Bureau 2024). California faces a shortage of mental health care providers, and though San Francisco has a higher share of providers relative to population compared to rural inland counties, San Francisco's challenges providing adequate mental healthcare to its population, many of whom are homeless, have been well publicized (San Francisco Chronicle Editorial Board 2023).

Figures 1 & 2: Study area with mental health facilities locations. Study area with population by block group.

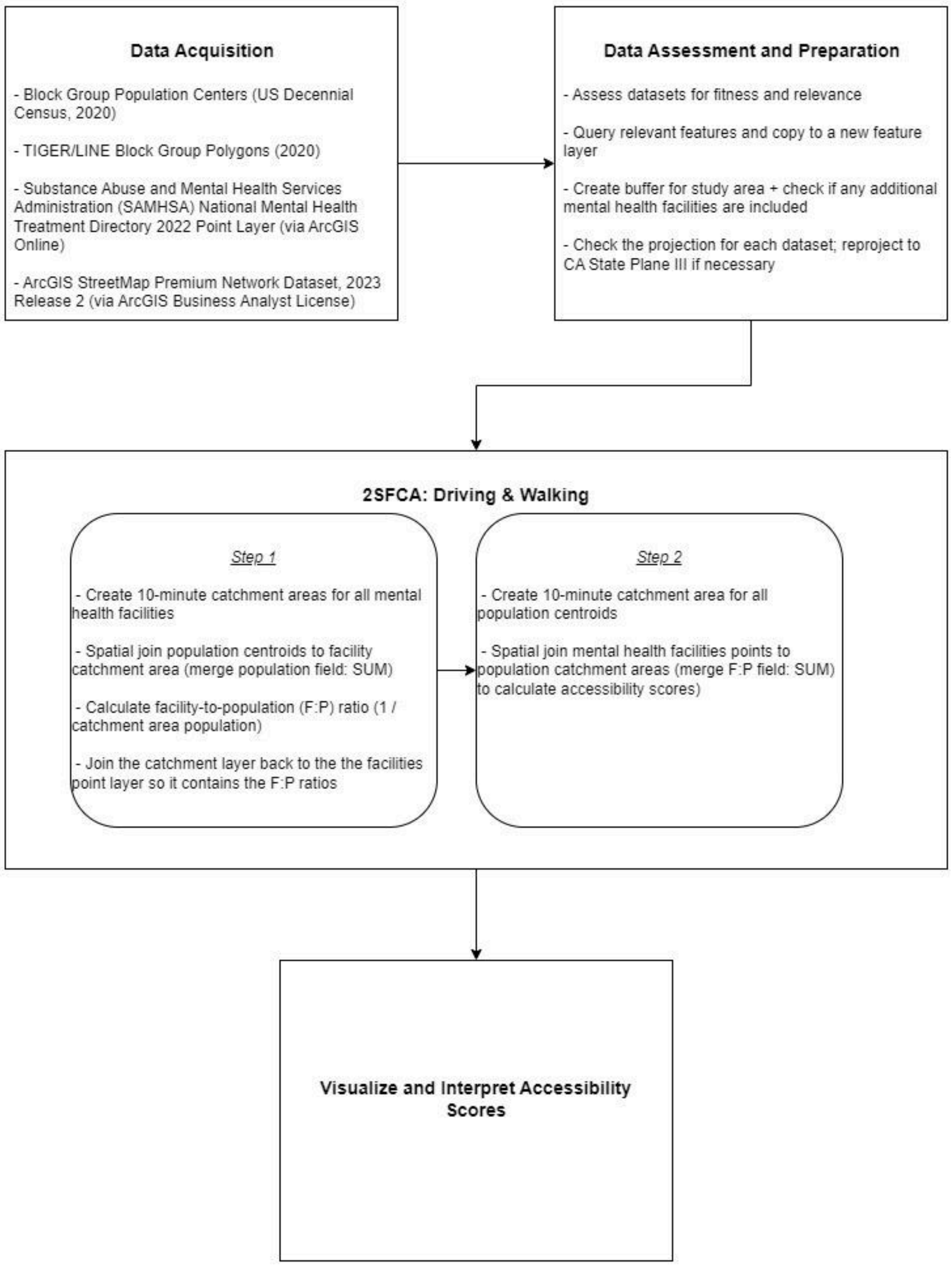

Study Area: San Francisco
Richmond
Western Addition
San Francisco
Union Square
South of Market
Mission
Golden Gate Park
San Miguel Hills
Merced Heights
Hunters Point
Candlestick Point
Visitacion Valley
Daly City
N
0 0.5 1 2 Miles
Mental Health Facilities


Study Area: Population by Block Group
N
0 0.5 1 2 Miles
POPULATION
79 - 921
922 - 1276
1277 - 1674
1675 - 2321
2322 - 6050

Methods

An overview of the workflow followed for this accessibility analysis is shown below, in Figure 3, and expanded upon throughout the section.

Figure 3. Accessibility analysis workflow diagram



Data Preparation

The accessibility analysis carried out in this study used four datasets, described below in Table 1; a further explanation of data sources and data preparation follow the table.

Table 1: Data table

Name	Attributes	Source
Block Group Centers of Population (2020)	Point data with the population centers at the block level group (WGS 1984)	2020 Decennial Census
TIGER/LINE Boundaries - Block Group (2020)	Polygon shapefile (WGS 1984)	U.S. Census Bureau
National Mental Health Treatment Center Directory (2022)	Point data of all national mental health facilities (NAD 1983)	Substance Abuse and Mental Health Services Administration, via ArcGIS Online
ArcGIS StreetMaps Premium USA Routing Network	Network dataset (nodes and edges)	Esri, from ArcGIS Business Analyst 2023, Release 2

Mental health issues can impact any demographic group; as such, the entire 2020 census dataset for population centers (i.e., population weighted centroid) by block group was used. The census centroids data was initially downloaded in the form of a .txt file, so the extension was changed to .csv and imported to ArcGIS Pro. The XY point to table tool was used to create a weighted population centroids feature class.

It is also important to note the implications of MAUP with regard to the population centers that were used for this analysis. With different areal units, the geometric centroid would be in a completely different location, which will affect our analysis. There are multiple potential approaches to this problem. In a study assessing food deserts, representative addresses were chosen which were large areas near high population density areas and tended to be around the middle of each desert, such as a large apartment building, parks or a school (Sisk et al. 2023). Another potential method was using the feature to point tool, which takes the geometric centroid of each block group or areal unit. However, this does not accurately represent where the population is and this is highly susceptible to MAUP. Our chosen methodology was to take the center of population at the block group level (i.e., population weighted centroid), which was calculated by the US Census from individual-level data. Though this still has MAUP implications, as the population of a block group must be counted as fully in or out of a catchment, the impact is reasonably minimized (given available data).

The 2022 mental health treatment center dataset from the Substance Abuse and Mental Health Services Administration is a national dataset, so facilities within the study area (the City and County of San Francisco) and a surrounding 2 mile buffer were queried. As described in Luo and Wang (2003), this buffer was created to determine if there were any nearby mental health facilities that would impact the accessibility of our population that is towards the border of our study area. No additional mental health facilities that were located in the buffer.

Because the study is focused on outpatient services, 24 hour inpatient and residential treatment centers were removed, as were VA health centers, which do not provide services to the general public. Only outpatient mental health facilities were included in the analysis. Some of these facilities were different clinics at the same location; these were kept as separate facilities for the purposes of more accurately reflecting overall provider capacity within the analysis. Unlike a traditional healthcare 2SFCA, which uses the ratio of providers to population, this study used a facility:population ratio due to data limitations. (We were unable to find data on the number of providers at each facility).

The ArcGIS StreetMap Premium Routing Network Dataset for the United States was used to create the travel time catchment areas for the 2SFCA (described in further detail below in the 2SFCA Section)

All data was projected into NAD 1983 California State Plane III US Ft (2011) before continuing on.

2SFCA Analysis

For the first step of the two-step floating catchment, 10-minute travel time catchment areas for mental health facilities and for population centers were created using the Service Area tool in ArcGIS Pro's Network Analyst. Though 30 minutes is a more widely recognized limit for travel-time accessibility, used both in previous literature and by state healthcare programs such as Medi-Cal (Disability Rights California 2018; Wang & Ariwi 2021), the travel-time impedance limit was lowered to 10 minutes, commonly used as the smallest isochrone for E2SFCAs, to reflect our significantly smaller study area and high population density. Two modes of transportation were used to run two separate 2SFCA analyses: driving and walking. These modes of transport were chosen because they are the two most popular modes of transportation in San Francisco, with 56% of residents using privately owned vehicles as their primary mode of transportation and 29% of residents walking as their primary mode of transportation (San Francisco Municipal Transportation Agency and Corey, Canapary & Galanis Research 2021). Parameters to create the catchment areas were set to: 10 minutes travel, traveling away from facilities, to create a standard precision overlapping polygon output. The 'date and time' parameters were set to "not using time."

Once the facility and population centroid catchment areas were created, the population centroids were spatially joined to the facility catchment area. In keeping with other 2SFCA studies, the match type option was set to intersect and the merge rule was set to sum in order to obtain the total population within each facility's catchment area (Pervorse, 2020). The facility to population ratio was then calculated by dividing 1 by the population of the service area. This facility:population ratio was then joined back to the mental health facilities point layer in preparation for step two.

For the second step of the two-step floating catchment, the mental health facilities within each population catchment area (i.e., the area accessible to from each population centroid) were spatially joined to the population catchment areas. During this spatial join, the facility-to-population ratios of facilities within each population catchment area were added together using the SUM rule for the field, resulting in the final accessibility score for each population centroid.

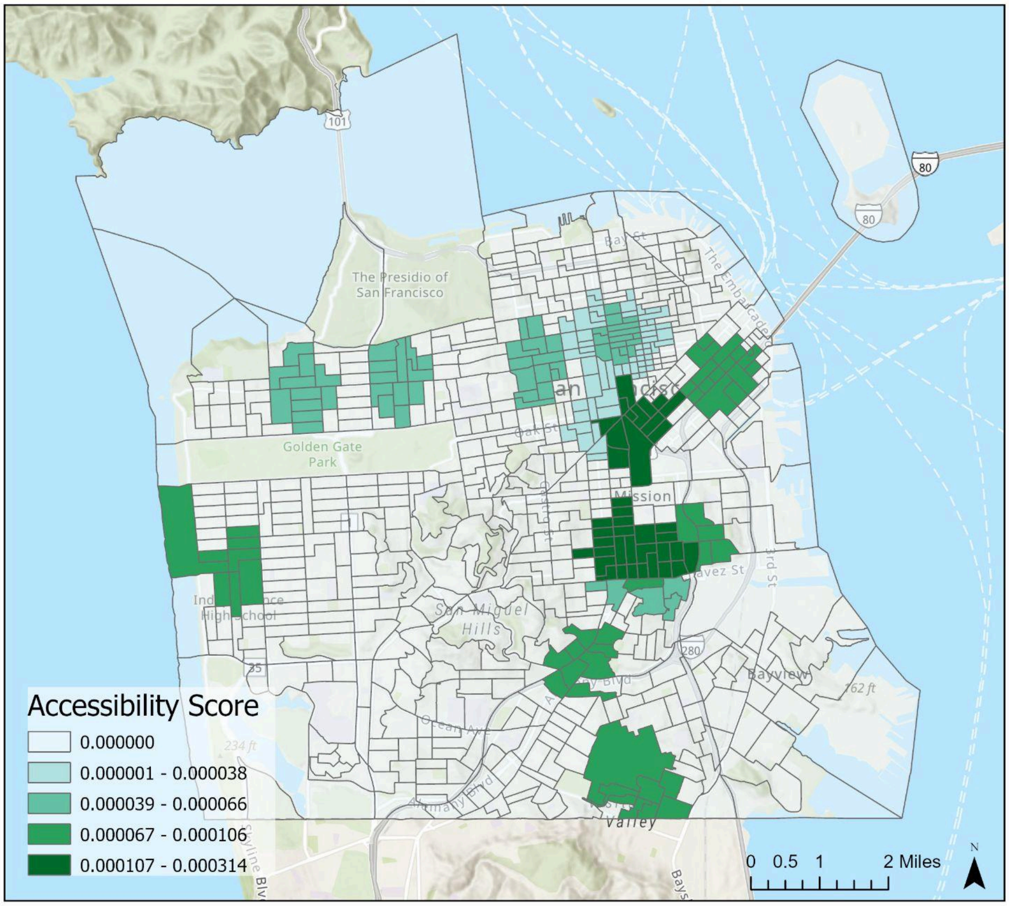
The accessibility scores were then visualized.

Results

The resulting visualization of the raw accessibility scores for the 2SFCAs (walking and driving) are shown below (Figures b and c). Though the accessibility scores cannot be directly compared due to how they were calculated, visualizing them can provide insight into patterns of spatial accessibility for the two modes of transportation assessed in this analysis.

As Figure 4 shows, pedestrian accessibility to outpatient mental health services is unequally distributed throughout the city, with access clustered throughout a select neighborhoods (such as the Richmond District, Nob Hill, Union Square, the Mission, and Bernal Heights) that run along the northern and eastern interior of the city. The vast majority of the city, shown in the transparent white, was not within a 10-minute walking distance of any outpatient mental health facility. Low pedestrian accessibility throughout most of the city combined with a high density of facilities in the Mission and South of Market (SoMa) Neighborhoods account for their accessibility scores being the highest.

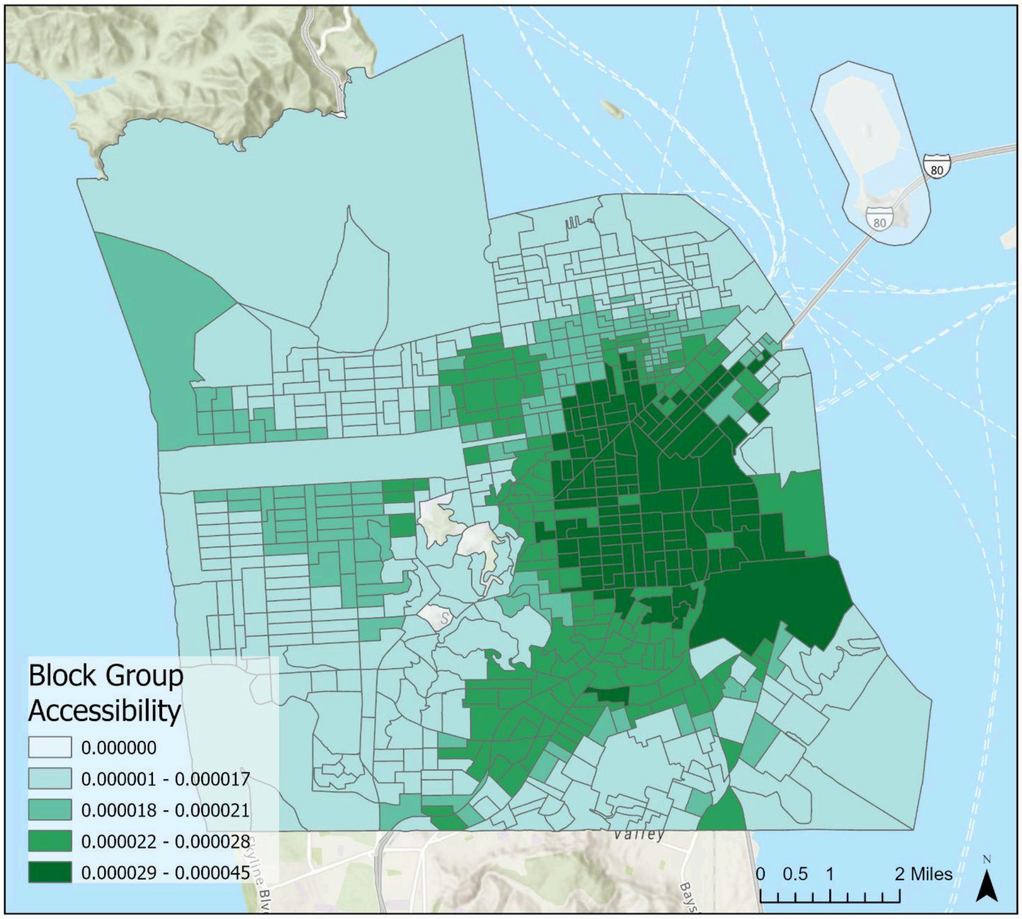
Figure 4. Results of the walking 2SFCA for outpatient mental health treatment centers.



Outpatient Mental Health Treatment Center Walking Accessibility in San Francisco by Census Block Group (10 minutes)

In comparison, the map of driving accessibility scores (Figure 5) shows that mental health services are more spatially accessible to almost all San Francisco residents by car. Though the areas with the highest accessibility scores, once again, encompass the Mission and SoMa, the areas of high accessibility are larger and more continuous. There are only four block group population centroids from which no outpatient mental health facilities are accessible within 10 minutes (one of which is the relatively spatially isolated Terminal Island). This highlights a significant discrepancy between car and pedestrian accessibility to outpatient mental health providers.

Figure 5. Results of the driving 2SFCA for outpatient mental health treatment centers.



Outpatient Mental Health Treatment Center Driving Accessibility in San Francisco
by Census Block Group (10 minutes)

Discussion

The 2SFCA analyses performed for driving and walking provide insight into spatial accessibility of outpatient mental health services in San Francisco, assuming all residents are using the same mode of transportation (either walking or driving). Though this assumption is one of multiple significant limitations of this analysis, the results nonetheless suggest that residents of certain neighborhoods, such as the Inner Sunset, San Miguel Hills, and Bayview, who rely on walking as their primary form of transit, face far greater spatial access barriers than residents who live in the southern half of the Mission District or downtown San Francisco (near Union Square).

However, as previously mentioned, it is not possible to directly compare accessibility scores for the two travel modes because of the way accessibility scores are calculated in a traditional 2SFCA, such as the one used here. Accessibility scores for population centers with access to mental health facilities for pedestrians were much higher than for drivers, simply because the total population within an accessible distance of facilities was so much smaller than when all people were assumed to be driving. Z-score transformation and follow-up Getis-Ord Gi* tests, such as those employed by Wang and Ariwi (2021), would allow for comparisons of accessibility across multiple modes of transportation. (These analyses were initially planned in our workflow, but we were unable to successfully complete them.)

We incorporated an edge guard of 2 miles within the block groups of San Francisco looking specifically for mental health facilities. However, a better edge guard could have been to include block groups centroids within 2 miles of our study area as well (Luo and Wang 2003). Residents outside of the area could come into our study area to use the mental health facilities there, which would decrease the accessibility scores among residents towards the edge of our study area.

Additionally, this analysis used a binary determination of "accessible" or inaccessible: either within the relatively short travel time of 10 minutes, or outside of it. Though we felt this was justified given the small study area, it does not reflect individuals' perceptions of spatial (in)accessibility in the real-world. Future analyses could improve upon this by using an enhanced 2SFCA (E2SFCA) which employs a distance decay function, which more accurately reflects how people decide how far a travel time is too far for regular or semi-regular health care such as outpatient mental health services.

There are many non-spatial factors to mental healthcare accessibility that are not accounted for in this analysis, chief among them affordability and insurance coverage. The model could be improved by moving from a facility:population ratio to a more traditional provider:population ratio. The assumption that all facilities are equal is not what the reality is and reflects a limitation of our methods and inability to find a data source for the number of providers at each mental health facility. Additionally, due to the insurance coverage many facilities may not be accessible to lower income residents due to the facility not taking medicaid or medi-cal (Wilkes 2022). A future analysis would also incorporate insurance coverage into accessibility scores, as the supply-demand adjusted 2SFCA methodology by Shao and Luo (2022) does.

Despite the simplicity of the accessibility analyses conducted in this paper, the results emphasize the importance of modeling multiple modes of transportation when assessing and addressing health inequities, which can help policymakers identify areas with the most limited access to vital services.

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