Assess Accessibility to Pediatric Healthcare Services of San Francisco County

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1. Introduction

Accessibility means the degree of ease for residents to approach a facility or environment. The increasing uneven distribution of pediatricians and the changing demographics of children have resulted in a large geographic disparity in access to pediatricians. In 2019, the under-18 population accounted for 13 percent of San Francisco's total population, and 8,331 children were born that same year. Compared to the previous decade, this number of births has dropped significantly. In 2011, San Francisco's population under the age of 18 accounted for 13.4% of the total population. Women in San Francisco gave birth to 8,691 babies in 2011(BARMANN, 2021). So far, San Francisco still remains the county with the lowest proportion of children in the Bay Area. As the population of children in San Francisco changes, the availability of pediatricians is an important factor in measuring the quality of their children's medical care.

To examine the current spatial accessibility of pediatricians in San Francisco, the US Census dataset and HealthCare Facilities dataset were applied. Through ArcGIS Pro, a 15-minute driving catchment was created and the pediatrician's location accessibility was estimated using the 2 step Floating Catchment Area method (2SFCA) for each population centroid area. The objective of this project is to assess spatial accessibility to pediatric services in San Francisco.

2. Study area

Children population density pattern and pediatric services distribution are shown in Figure 1. Generally speaking, San Francisco has a smaller percentage of children. Also, the children population is unevenly distributed in San Francisco, with more children in the north and south of San Francisco than in central San Francisco. Hospitals in the dataset are mostly located in the northeast of San Francisco. Also, hospitals in the Northeast are more dense, while pediatric hospitals south of San Francisco are sparse.

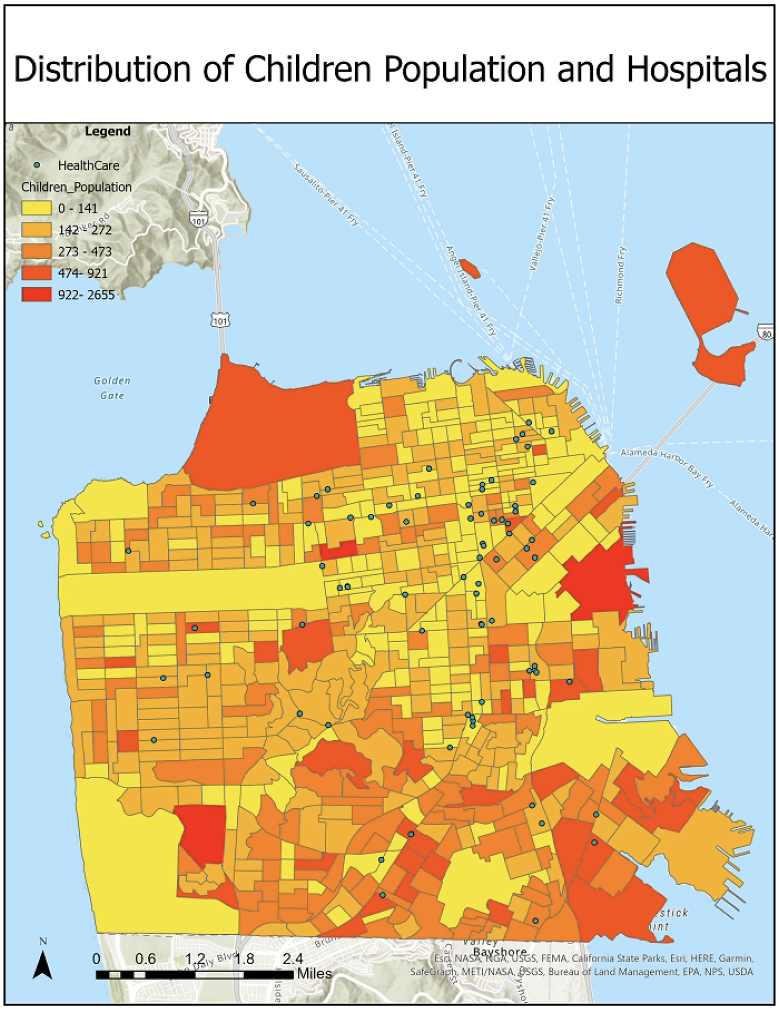


Figure. 1 Distribution of children population and hospitals

3. Methods

a. Data Preparation

Table 1. Datasets used in this project.

Datasets	Description	Source
SF_BlockGroups_Sex_Age_2019 ACS	This data set gives the population number within each census block in San Francisco.	US Census
SF_Health_Care_Facilities	This data set gives the location and type of the	DataSF

	medical institutions in San Francisco.	

In this project, we used two datasets (see Table 1). During this process, we used the **Select by Attributes tool** to filter out the data we don't need to use in the following steps. The output layer is SF_Health_Care_Facilities_selected.Our project is to assess spatial accessibility in San Francisco Pediatrics. For the population layer, we removed all data except those under the age of 18. For the healthcare layer, we found that there is only one youth hospital in San Francisco, which is clearly not enough. Considering that general clinics/hospitals also have pediatrics, we expanded the selection of medical services. Therefore, we removed Women Hospital, Senior Hospital, Drug Treatment, Mental Hospital, and Cultural General Hospital. There are 26 hospitals left.

Table 2. Number of pediatricians in twenty-six healthcares.

<table>
<tr><th>Favcility Name</th><th>Favcility Service</th><th>Number of Pediatricians</th></tr>
<tr><td>California Pacific Med Ctr-california West</td><td>Hospital</td><td rowspan="7">74</td></tr>
<tr><td>California Pacific Med Ctr-pacific Campus</td><td>Hospital</td></tr>
<tr><td>California Pacific Med Ctr-california East</td><td>Hospital</td></tr>
<tr><td>California Pacific Med Ctr-davies Campus</td><td>Hospital</td></tr>
<tr><td>California Pacific Medical Center - St. Luke's Campus</td><td>Hospital</td></tr>
<tr><td>St. Luke's Health Care Center - Pediatric Clinic</td><td>Youth Health</td></tr>
<tr><td>St. Luke's Health Care Center - Adult Clinic</td><td>General Health</td></tr>
<tr><td>Lifeways Pace At The Coronet</td><td>General Health</td><td>0</td></tr>
<tr><td>Ucsf Medical Center</td><td>Hospital</td><td>0</td></tr>
<tr><td>Ucsf Medical Center At Mount Zion</td><td>Hospital</td><td>0</td></tr>
<tr><td>Chinese Community Health Services</td><td>General Health</td><td>2</td></tr>
<tr><td>Chinese Hospital</td><td>Hospital</td><td>3</td></tr>
<tr><td>Chinese Hospital's Excelsior Health Services</td><td>General Health</td><td>1</td></tr>
<tr><td>Planned Parenthood Golden Gate</td><td>Family General Health</td><td>0</td></tr>
<tr><td>Planned Parenthood San Francisco Center</td><td>Family General Health</td><td>0</td></tr>
<tr><td>Haight Ashbury Integrated Care Center</td><td>Free General Health</td><td>0</td></tr>
<tr><td>Haight Ashbury Free Medical Clinic</td><td>Free General Health</td><td>0</td></tr>
<tr><td>San Francisco Free Clinic</td><td>Free General Health</td><td>0</td></tr>
<tr><td>South Of Market Health Center</td><td>General Health</td><td>0</td></tr>
<tr><td>St. Mary's Medical Center, San Francisco</td><td>Hospital</td><td rowspan="2">12</td></tr>
<tr><td>St. Francis Memorial Hospital</td><td>Hospital</td></tr>
<tr><td>St. Anthony Medical Clinic</td><td>Free General Health</td><td rowspan="2">Average</td></tr>
<tr><td>Glide Health Services</td><td>General Health</td></tr>
<tr><td>Laguna Honda Hospital And Rehabilitation Center</td><td>Hospital</td><td>0</td></tr>
<tr><td>Kaiser Fnd Hosp - San Francisco</td><td>Hospital</td><td>67</td></tr>
<tr><td>San Francisco General Hospital</td><td>Hospital</td><td>37</td></tr>
</table>

Consider that the service capacity of each hospital or clinic varies. We checked the number of pediatricians at each hospital on their website (See Table 2). What we found is that pediatrics is basically only available in large hospitals. Among them, seven hospitals in the dataset belong to Sutter Health company. The total number of pediatricians at Sutter Health in San Francisco is 74, but we didn't find the specific number of pediatricians of each hospital. Therefore, we imputed the number of pediatricians in each of the seven hospitals using the mean of 10.75. The estimation was also the same for St.Mary's Medical Center and St.Francis Memorial Hospital, which belong to Dignity Health company. Each of these two hospitals was imputed with an average of 6 pediatricians. Kaiser Fnd Hosp has 67 pediatricians. Zuckerberg San Francisco General Hospital and Trauma Center has 37 pediatricians. The number of pediatricians for Chinese Community Health Services, Chinese Hospital and Chinese Hospital's Excelsior Health Services is 2, 3 and 1 respectively. We did find on the websites of St. Anthony Medical Clinic and Glide Health Services that they have pediatric services, but no specific data on the number of pediatricians. Therefore, we imputed these two hospitals with the average pediatrician number of the total 26 hospitals. As for the remaining 14 hospitals, most of them are small-scale hospitals, and we did not find any pediatric services on their official websites. Then we added a field named pediatrician_num to the SF_Health_Care_Facilities layer and entered the pediatric number to each hospital.

b. GIS workflow

Based on the existing literature and the size of San Francisco. We think the 15-minute driving time is an appropriate scale for the catchment. A threshold of 20 to 50 minutes was applied in Luo and Wang's article (Wang & Luo, 2005) to analyze healthcare spatial accessibility in Chicago, where the boundary is wide. However, when we drew the catchment centered at hospital locations, we found the output of the 20 minute catchment polygon covered almost the entirety of San Francisco. In San Francisco, it only takes 20 minutes to drive from the east coast to west coast. If we use 20 minutes catchment, the accessibility outcome may be the same for all the census tracts. Then our analysis would be meaningless.Hence, a 15-minute drive is used in our analysis. The workflow of spatial accessibility operations using the 2SFCA method through ArcGIS Pro is shown in Figure.2.

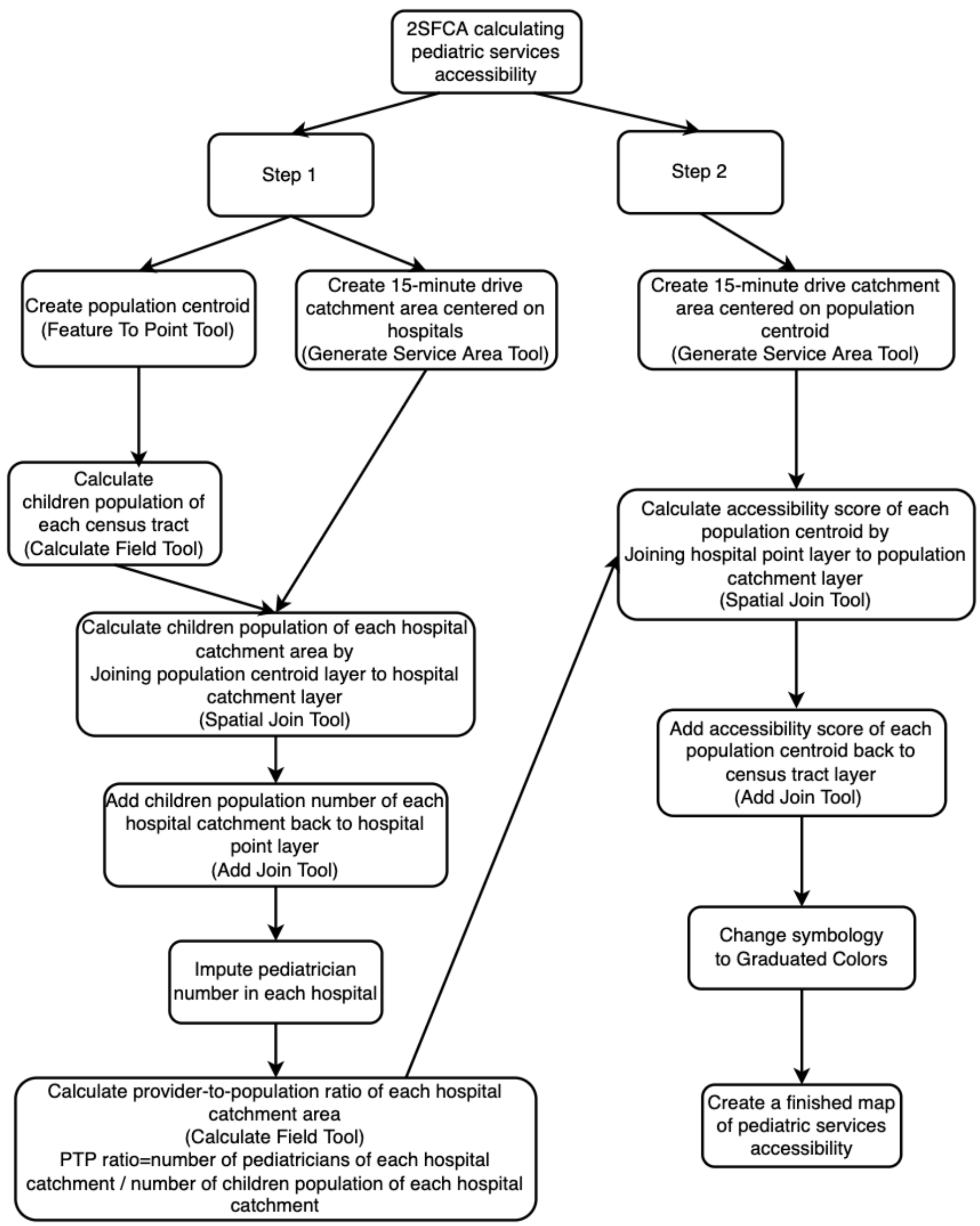


Figure 2. Workflow of spatial accessibility operations

i. 2SFCA Step1

We used the **Feature To Point** tool to create population centroids of each census tract. The input layer is the filtered SF_BlockGroups_Sex_Age_2019 ACS layer. As for the output layer, we named it SF_CentroidXY. Then we created the 15-minutes drive catchment area centered on 26 selected hospitals, using the **Generate Service Areas** tool. We selected the filtered SF_Health_Care_Facilitie layer under **Facilities**, and entered 15 under **Break Values**, and left the other settings as default. We also changed the output layer name to hospital_15min_ServiceArea.

Next, we calculated the children population, people under or equal to 19 years old, of each census tract in the SF_CentroidXY layer, using the **Calculate Field** tool. After that, the **Spatial Join** tool was used to join the SF_CentroidXY layer to the hospital centered catchment layer. We chose the hospital_15min_ServiceArea layer as **Target Features**, and selected the SF_CentroidXY layer as **Join Features**. For the **Match Option**, **Completely Contains** and the **Sum Merge Rule** was applied in the total_ppl field to calculate the total children population of each catchment area. Then we got the output layer named hospital_centroid with children population data in hospital catchment.

Then we used the **Add Join** tool to add the youth population field in the hospital_centroid layer to the filtered SF_Health_Care_Facilities layer. Finally, we calculated the provider-to-population ratio in the filtered SF_Health_Care_Facilities layer using the **Calculate Field** tool. The ratio is equal to the number of pediatricians in each hospital divided by the total youth population within that catchment.

ii. 2SFCA Step2

We created a 15-minute driving time catchment area centered at children population centroids through the **Generate Service Areas** tool**.** We selected the filtered

SF_Blockgrps_Age_Sex_Data layer under **Facilities**, and entered 15 under **Break Values**, and left the other settings as default. We also changed the output layer name to ppl_15min_ServiceArea.

Then the **Spatial Join** tool was applied to join the updated SF_Health_Care_Facilities layer to the population catchment layer. We chose the ppl_15min_ServiceArea layer as **Target Features**, and selected the updated SF_Health_Care_Facilities layer as **Join Features**. For the **Match Option**, **Completely Contains** and the **Sum Merge Rule** was applied in the provider-to-population ratio to calculate the accessibility score of each population centroid. The accessibility score of one centroid equals the sum of the provider-to-hospital ratios of every hospital which is within a 15-minute driving time catchment of that centroid. We also changed the output layer name to spatial_accessilibity_ppl layer.

Finally, we used the **Add Join** tool to add the spatial accessibility ratio field from spatial_accessilibity_ppl layer back to the filtered SF_BlockGroups_Sex_Age_2019 ACS layer. And we change to **Graduated Colors** in **Symbology** so that we can see the spatial accessibility level of each census tract clearly.

4. Results

A 15-minute drive centered at providers and demand locations were created in Figure 3 and Figure 4. It is noted that a 15-minute driving time from hospital locations covered almost the entirety of San Francisco. Likewise, a 15-minute driving time from children locations also spread to all parts of San Francisco. The size of San Francisco is quite small compared to other cities. Ideally, a 20-minute drive can cross from west to east of San Francisco. According to our survey, U.S. 101 northbound and I-80 eastbound in San Francisco are the most congested routes. In fact, traffic congestion information is also a significant factor that needs to be considered when drawing a catchment.

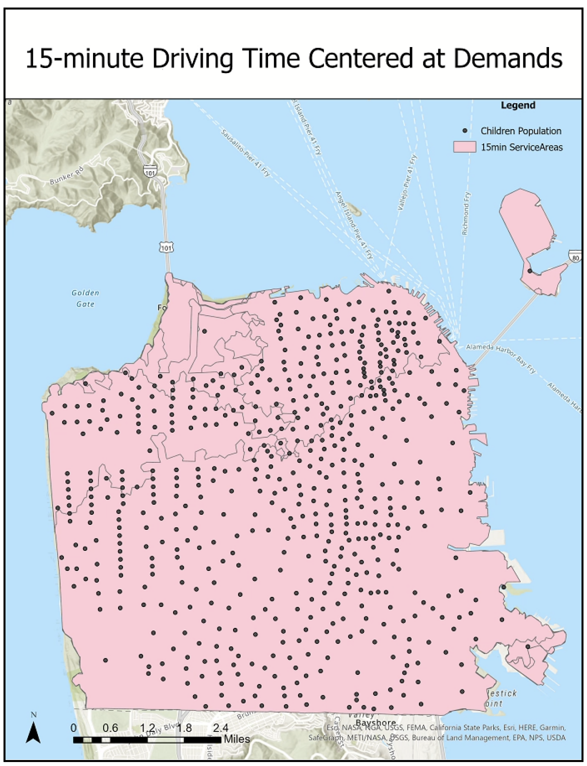


Figure 3. 15-minute threshold time centered at pediatric services.

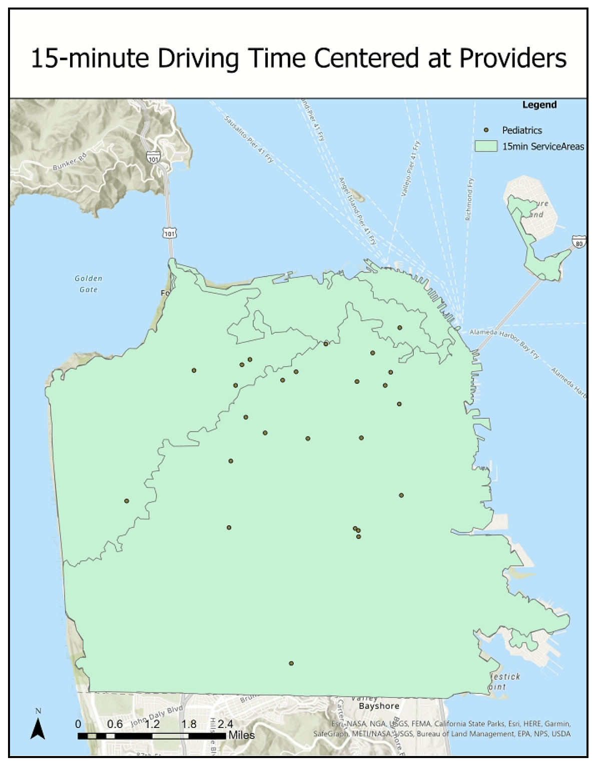
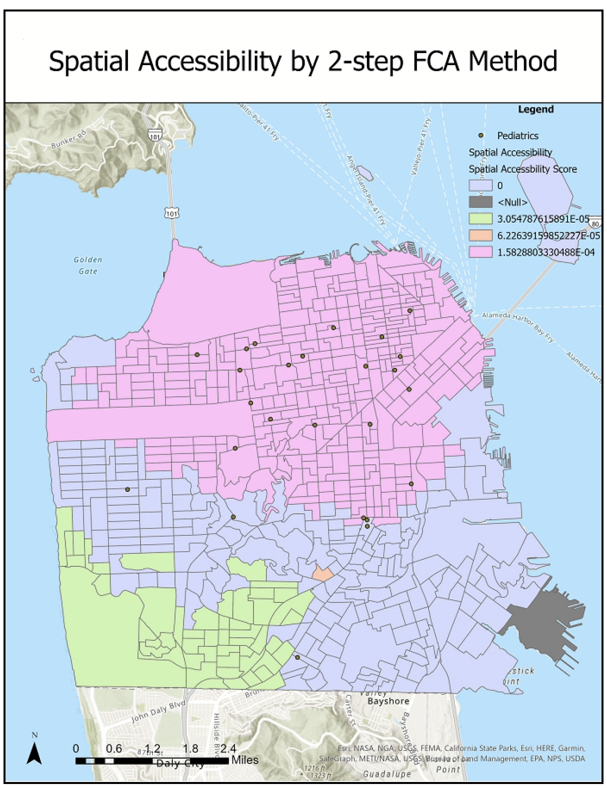


Figure 4. 15-minute threshold time centered at children locations.

Figure 5 shows the variation of spatial accessibility measured by the two-step FCA method using a 15-minute threshold time. As shown in Figure 5, areas with higher accessibility scores – 0.000158 which means having better spatial access. These areas are concentrated in the north of San Francisco, whereas areas with lower accessibility scores, which have poorer spatial access, are mostly located in the southwest of San Francisco. The reason for higher spatial accessibility values in the north is because pediatric services are concentrated there. In the case of Southwest San Francisco, there is a smaller population of children, thereby contributing to a lower score for spatial accessibility. Therefore, we think more youth health care services should be put in the south area. It should be noted that 0 accessibility score represents the area has access to a hospital without a pediatrician within the 15-minute drive threshold. Additionally, there is an area that does not have an accessibility score. This is because the area cannot reach any hospital within the 15-minute threshold. These areas usually suffer from poor pediatric healthcare access.



The results clearly highlight underserved healthcare as a result of inadequate access to pediatric services. However, the question of how to improve access to pediatric services in a better way still needs to be investigated in future studies. Income and education level may also affect accessibility results, if they are put into consideration. More reliable results can be obtained by comparing income and ethnicity data for each census tract with the distribution of accessibility scores. We can see if low-income people are exposed to low accessibility.

5. Discussion

There are several limitations in our study. The dataset is not accurate which demonstrates in two ways. Firstly, Pediatric is defined as providing healthcare service to those who are under 18 years old. However, the datasets we had are grouped by age. The data set SF_BlockGroups_Sex_Age_2019 ACS sets 18 and 19 years old as one group, so we could only obtain the youth population under 19 years old. The accessibility score of San Francisco might be underestimated because of it. Secondly, there are several hospitals affiliated with the UCSF Hospital, but the UCSF Pediatric Department is only set up in the hospital near the eastern coastline, and other UCSF Hospitals do not have the Pediatric Department. However, the SF_Health_Care_Facilities data set does not include this Pediatric Department, whose name is UCSF Benioff Children's hospital. From the UCSF hospital website, we knew that this pediatric department is of big scale. It has many pediatricians. Hence, the accessibility for census tracts in the eastside of San Francisco might be underestimated. In addition, results of spatial accessibility near the edges of the study area requires careful interpretation, as residents may seek healthcare services outside the city. This problem could be solved if data about the distribution of pediatricians in adjacent cities could be obtained and incorporated into the study.

Regarding the MAUP problem, we do find some influence of it. We use the population centroid as the starting point for each census tract, but some census tracts are in the shape of a thin strip. So compared to a tract of a round or square shape, a strip shaped tract may have a less accurate result of accessibility analysis, considering the drive time from the edge location in this tract may be totally different from the centroid point. San Francisco does have such a census tract with strip shape. It is located in the northwest of SF.

From our perspective, the 2SFCA approach can help us understand spatial accessibility in any industry. It is commonly used in the field of healthcare due to the disparities in healthcare services. But the 2SFCA method does have some limitations. When we use the 2SFCA method, we think that we only consider spatial factors such as travel impedance, while ignoring non-spatial factors. The data missing issue in SF_Health_Care_Facilities reminded us that, nowadays people in big cities tend to seek the best health care service for their kids, so they are likely to drive 30 minutes to get to a bigger and better hospital, especially considering that San Francisco is small and it only takes 20 minutes driving from west to east. So these big hospitals may come to a capacity issue, and they may need to find a bigger place to set their pediatric department or dentistry department away from the original hospital site. The UCSF Benioff Children's hospital is an example in this kind of situation. It is the demand from the resident side. The huge number of youth patients requires such a pediatric specialized hospital. If we only consider the drive time barrier, which is also called spatial barrier, the results of accessibility will be biased. Especially in this study, we use a 15 minutes drive time area as catchment area, the results may even be less accurate. But if we can involve non-spatial factors, for example income and education level, in our study and choose a bigger catchment area, our results will be much more accurate. According to Xing's article(Xing et al., 2020) conduct their accessibility analysis using a supply-demand improved 2SFCA (SD2SFCA) method. This method includes some specific demands into consideration. If we can apply this method to our study, several non-spatial factors, such as income, education level, service experience, waiting time, appointment procedure, service price, physicians' professional level and so on will be given different weights. Then we will combine spatial and non-spatial barriers to analyze the accessibility score in each census tract.

To make sense of the results, we need to compare the accessibility results for San Francisco with those based on the previous data set. Cities with similar population sizes and levels of economic development should also be compared. In this way, we can see if the accessibility of adolescent health care in San Francisco has improved and is similar to that in cities of similar size.

6. References

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