Method Name: Two-Step Floating Catchment Area (2SFCA)

Measure(s) Using This Method:

Mental Health Treatment Facility Access, Substance Use Treatment Facility Access

Overview:

The Two-Step Floating Catchment Area (2SFCA) method is used to determine spatial accessibility for the Mental Health Treatment Facility Access and Substance Use Treatment Facility Access measures. It calculates ratios of treatment facilities-to-residents within a service area centered at a facility's location (step 1) and subsequently sums the ratios for residents located in areas where different provider services overlap (step 2). The larger the summed proportion is, the better the facility accessibility in a geographic location.

FCA Method Description:

The 2SFCA method is derived from the floating catchment area (FCA) method, which computes physician accessibility in any given geographical area as the physician-to-population ratio within its catchment area.[1,2] In this context, our definition of a catchment area is a circle with a radius of the threshold travel distance around the centroid of a geographical area (e.g., census tract). For example, if there is one physician and 20,000 residents within a catchment area for a given census tract, the physician-to-population ratio is 1/20,000 for that census tract. An underlying postulation for this method is that physicians that fall within a catchment area will be completely accessible to residents within that catchment area. This is a limitation of the FCA method, as distances between physicians and residents may exceed threshold travel times. Another byproduct of this limitation is that physicians must serve residents in multiple catchments, creating the possibility that physicians are not fully available to every resident within a catchment area.

2SFCA Method Description:

The 2SFCA method addresses these weaknesses by calculating ratios of physicians to residents within a catchment area centered at a physician's location (step one) and subsequently summing the ratios for residents located in areas where different provider services overlap (step two).[3] This method also uses travel times as opposed to distance thresholds. More pragmatically, the mathematical approach of the 2SFCA method is as follows:

1) *Step One*: For each location *j*, search all population locations (*k*) that are within a threshold travel time (d_0) from location *j*, and compute the physician-to-population ratio (R_j) within the catchment area (centered on location *j*). S_j is the number of physicians at location *j*, d_{kj} is the

[1] Peng Z. (1997). The Jobs-Housing Balance and Urban Commuting. *Urban Studies, 34*(8), 1215–1235. https://doi.org/10.1080/0042098975600

[2] Wang, F., & Minor, W. W. (2002). Where the jobs are: Employment access and crime patterns in Cleveland. Annals of the Association of American Geographers, 92(3), 435–450. https://doi.org/10.1111/1467-8306.00298

[3] Radke, J., & Mu, L. (2000). Spatial decompositions, modeling and mapping service regions to predict access to social programs. Geographic Information Sciences, 6(2), 105–112. https://doi.org/10.1080/10824000009480538

travel time between *k* and *j*, and P_k is the population of the geographic location whose centroid falls within the catchment.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} P_k}$$

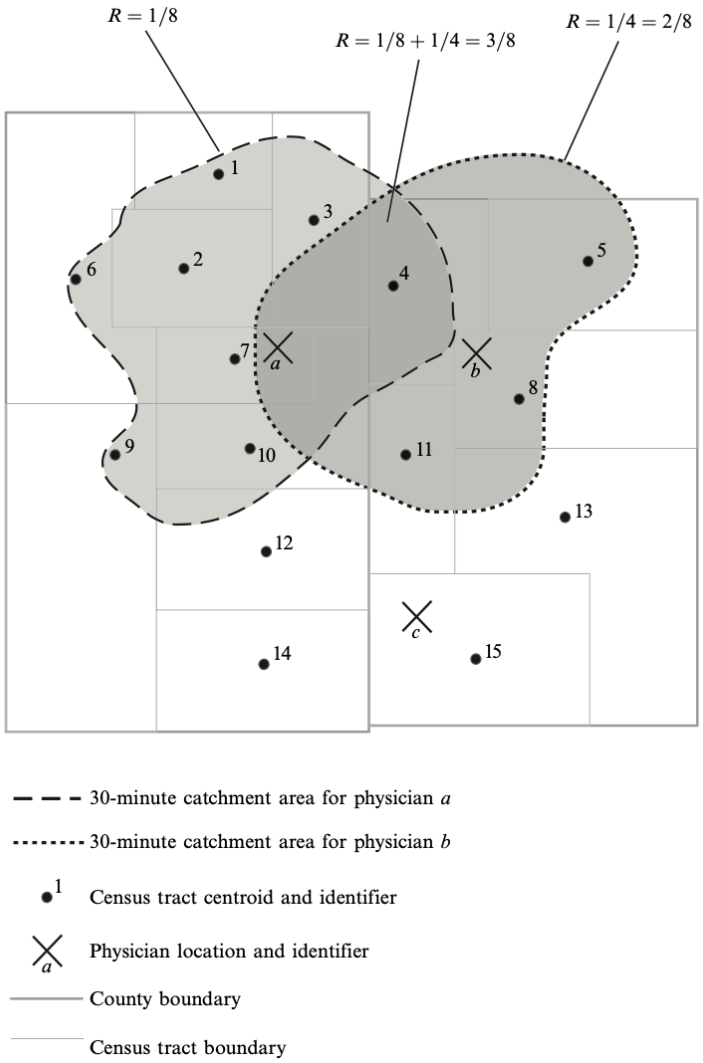
2) *Step Two*: For each population location *i*, search all physician locations (*j)* that are within the threshold travel time (d_0) from location *i*, and sum the physician-to-population ratios (R_j) at these locations. A_i^F is the accessibility at resident location *i*, while *Rj* is the physician-to-population ratio at physician location *j* whose centroid falls within the catchment centered at *i* ($d_{ij} \leq d_0$), and d_{ij} is the travel time between *i* and *j*.

$$A_i^F = \sum_{j \in \{d_{ij} \leq d_0\}} R_j$$

The larger the A_i^F value is, the better physician accessibility for a geographic location. Overall, step one assigns an initial ratio to each service area catchment centered around a physician location, and step two sums the initial ratios in the overlapped service areas (where residents have access to multiple physician locations). See
Figure 1 below for a visualization of this process using a 30-minute travel time threshold.[4] In this example, the A value (accessibility at resident location) for each census tract would equal the sum of the R values (physician-to-population ratios) within each census tract. There is no threshold for how much overlap is required between the physician catchment area and the census tract for the corresponding R value to be counted in step 2.

[4] Luo, W., & Wang, F. (2003). Spatial accessibility to primary care and physician shortage area designation: a case study in Illinois with GIS approaches. In Geographic information systems and health applications (pp. 261–279). IGI Global. https://doi.org/10.4018/978-1-59140-042-4.ch015

Figure 1



Method Usage for the Mental Wellness Index:

In the context of the Mental Wellness Index, the 2SFCA method was used to measure the geographic accessibility for treatment facilities. The population weighted centroids of census tracts were used as geographic locations. For each census tract, accessibility scores were created for mental health treatment facilities and for substance use treatment facilities respectively.

The primary difference between our use of the 2SFCA and Radke & Mu's original outline is that accessibility was computed for mental health and substance use treatment facilities rather than general physicians. A second difference in our usage of the 2SFCA method is that distance thresholds were used (as in the standard FCA method) instead of travel time thresholds due to data availability.[5] The distance

[5] Kleinman, J. C., & Makuc, D. (1983). Travel for ambulatory medical care. Medical Care, 543–557. https://doi.org/10.1097/00005650-198305000-00007

thresholds used are based on the county's primary care Medicare Advantage distance thresholds, which vary by micropolitan, metropolitan, and rural areas.[6] A third difference is that catchment areas were used based on distance rather than travel time due to data availability. Therefore, our catchment areas were perfect circles rather than amorphous figures denoted above. So, we computed the ellipsoid (based on the World Geodetic System standard) difference in distance between the facilities and the census tract centroids. If that difference in distance was less than or equal to the distance threshold for a given census tract, it was included in the facility-to-population ratio outlined in steps one and two above. Further, because distances and facilities were used (instead of catchments physicians respectively), the numerator in step one (S_j) is 1 for all calculations to represent the facility for which the calculation is being performed.

Example

To put the usage of this method into context, we can consider an example of calculating a treatment center-to-population ratio and a mental health treatment facility accessibility score for a given census tract.

For the Jane Phillips Medical Center in Bartlesville, Oklahoma, the distance threshold, or reasonable distance to travel to access a treatment facility, for the census tract is 10 miles based on the county's primary care Medicare Advantage distance threshold, which classifies the corresponding census tract as a metropolitan area. There are 12 census tract centroids within 10 miles of this facility. The sum of the populations of those 12 census tracts is 45,573. Using step one of the 2SFCA method, we can calculate the treatment center-to-population ratio below:

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} \leq d_0\}} P_k}$$

$$R_j = \frac{1}{45573}$$

$$R_j = .0000219428170188$$

For census tract 40147000400 in Bartlesville, Oklahoma, the distance threshold is 10 miles (again defined by the county's primary care Medicare Advantage distance threshold). There are three mental health treatment facilities within 10 miles of the census tract. Using step two of the 2SFCA method, we can calculate the treatment facility accessibility score by summing the treatment facility-to-population ratios of each of the three mental health treatment facilities that are within 10 miles:

$$A_i^F = \sum_{\text{j} \in \{d_{ij} \leq d_0\}} R_j$$

$$A_i^F = .00002194282 + .00002194282 + .00002194282$$

$$A_i^F = .00006582846$$

[6] Extracted from the "HSD_2020_Reference_File_updated_2020-06-11 (XLSX)" https://www.cms.gov/files/document/hsd2020referencefileupdated2020-06-11.xlsx. Specifically, data were used from the "Primary Care" section of the "Provider Time & Distance" sheet. Available from https://www.cms.gov/Medicare/Medicare-Advantage/MedicareAdvantageApps.

Strengths:

The primary strength of this method is that it is border-agnostic, meaning that the method would refer populations to facilities based on distance regardless of what geographic entity they reside in and what geographic border the facility is housed in.

Limitations:

The main limitation in our use of this method is that distance thresholds instead of travel time thresholds were utilized, due to data availability. This is a drawback because a facility that is close in physical distance may have a long travel time, while a facility that is physically further away may in fact have a shorter travel time. Due to a lack of data on travel times, we were not able to utilize a more developed version of the 2SFCA, the enhanced two-step floating catchment area (E2SFCA), which is an extension of the 2SFCA that accounts for distance decay by assigning weights to different travel time zones.