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Primary Health Care Accessibility in Zomba, Malawi: A Spatial Modelling Approach

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Abstract:

Access to primary health care (PHC), as the first point of care, is an essential factor in influencing the health status of a society. In Malawi, an individual is considered to have access to health care if they are within an 8 km radius to a health facility. Based on this, the Health Sector Strategic Plan (HSSP) II, 2017-2022 puts access to PHC in Malawi at 90 %. However, a Demographic Health Survey (DHS) reports that 56 % of women find distance as a major barrier. As such the aim of the study was to model spatial access to health of households in the district. The study used the 2 Step Floating Catchment Area (2FCSA) with Gaussian decay function method to model health care access and the greedy algorithm to find optimal locations for new facilities. The study found that 62% households have the potential of walking 60 minutes to the facility, a figure 28 % lower than the one reported by HSSP. With 2SFCA scores ranging from 0 to 0.19, the results show that 98 % and 57 % of the households scored between 0.031 to 0.046 for urban and rural areas respectively. These scores imply that urban households have better spatial accessibility than rural households. The results provide a spatially objective PHC accessibility data to inform policy direction.

Keywords: Spatial Accessibility Modelling, Primary health care, accessibility, 2SFCA

1. Introduction

Health care plays an essential role in the development process of a country as it is only a healthy population that can actively contribute to the development activities of a country. It is, therefore, essential for governments to ensure the provision of equal and easy access to fundamental health care services to all citizens. However, uneven distribution of population, health facilities and transport infrastructure has led to spatial inequalities in accessing health care (Kaur Khakh et al., 2019; W. Luo & Wang, 2003). This, in turn, results in disadvantaged locations and communities having poor accessibility to needed health care facilities

Primary health care (PHC) is a framework of services within the district in which healthcare is promoted and delivered (Ramela, 2009). According to Alma-Ata declaration, 1978 “Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination” (WHO, 1978). PHC is usually the first point of contact people have with the health care system throughout their life (*WHO | Primary Health Care (PHC)*, 2008). It is thus an essential factor in maintaining population health and preventing disease progression on a large scale and also death (Guagliardo, 2004a; Starfield et al., 2005). Effective PHC can prevent or reduce unnecessary expensive medical specialist care hence ensuring good access to PHC is an important factor in any country (Guagliardo, 2004a; W. Luo & Qi, 2009; McGrail, 2012).

To ensure good health, easy access to PHC services is an important factor (McGrail, 2012). In developing countries like Malawi, most of the population have challenges in accessing health services. Distance to health facilities can be considerable, particularly in rural areas, and the transport system is poor. In Malawi where 85% lives in rual areas, an individual is considered to have access to health care if he is within 8 km radius to a health facility. From this policy, 90% of Malawians are considered to have access to health care (Ministry of Health, 2017). Despite this, demographic health survey found that 56% of women have challenges in accessing health services, particularly in the rural areas citing distance as the main deterrent (National Statistical Office/Malawi & ICF, 2017). As such, there are contradicting facts about the state of health care accessibility in Malawi. Apart from that, considering that women and children are in the majority in rural areas, such a discrepancy in policy and practice has a huge impact on the health status of the population. It is, therefore, the main goal of this study to spatially analyse access to health care services using the case of Zomba.

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2. Literature Review

Health care access is defined as an opportunity or ease with which consumers or communities can timely use appropriate services in proportion to their needs (Daniels, 1982; Levesque et al., 2013; McLafferty, 2003; Peters et al., 2008). Access to health care includes the following main dimensions: availability, geographic accessibility, affordability, accommodation and acceptability (Peters et al., 2008). Availability and Geographic accessibility are geographic in nature because they are more dependent on the location and together define spatial accessibility, whereas affordability, accommodation and acceptability are non-spatial (Guagliardo, 2004a; Kaur Khakh et al., 2019). Availability is the relationship between the volume and type of existing services (and resources) to the number of clients and types of needs (Penchansky & Thomas, 1981). Geographic accessibility, on the other hand, is the relationship between the location of supply of available services, the location of clients and the characteristics of the networks linking the two locations (Vickerman, 1974).

The combination of availability and geographic accessibility form spatial accessibility. This is essential in finding the relationship between the available health care services and population targeted to access the services. Spatial accessibility modelling provides a picture of the current health system in terms of demand and supply. On one hand, high availability of services does not guarantee high accessibility because it depends on the proximity of the population to those services. On the other, close proximity does not guarantee high accessibility because it depends on the size of the population competing for available services (McGrail & Humphreys, 2009). Spatial accessibility is, therefore, an important step in policymaking and improved decision making.

2.1 Spatial accessibility methods

There have been a number of methods used to model and analyse spatial accessibility to health care and a variety of other disciplines. Some of the notable approaches are the ratio of supply to demand in an area, distance to the closest provider, the average distance to a set of providers, gravity model, kernel density (KD) and two-step floating catchment area (2SFCA) methods (Guagliardo, 2004a; Yang et al., 2006). Although the first three are easy measures for spatial accessibility, they do not consider interactions between patients and providers (Yang et al., 2006) hence not considered in this study. Kernel density (KD) estimation, Gravity model and two-step floating catchment area (2SFCA) method are the common comprehensive methods used to measure spatial accessibility (Mao & Nekorchuk, 2013; Xiong et al., 2016; Yang et al., 2006). These methods provide a better understanding of the relationship between the supply of resources and the available demand for such resources including competition.

Kernel density estimation is used to estimate a smooth probability density function from univariate or multivariate data (Silverman 1986) cited in (Schuurman et al., 2010a). Two kernel density surfaces in the form of raster layers both of the same cell size are created (W. Luo & Qi, 2009; Schuurman et al., 2010a). These surfaces are one for the physician/service location and the other one for the population centroids. Then, physician/service location raster is divided into population raster to form physician/service to population raster using a straight-line distance referred to as radius or bandwidth to define a catchment area. While this does suffice in some contexts, it fails to take into consideration the actual distances and the physical conditions involved in accessing health care. Apart from that density distribution does not show much information about the distribution of services; it merely shows that services near the middle of an area are close to more services in the area than services near the periphery (Schuurman, et al., 2010a).

The gravity model is based on Newton's Gravitation law which says the attraction between particles is directly proportional to the size of the particles and inversely proportional to the distance between them. This model predicts that the attractiveness of a service diminishes with distance or associated increasing travel impedance (McGrail & Humphreys, 2009a). One of the significant benefits of this model is that it accounts for all the possible alternatives within the travelling distance. Although this is the case, initial version of this method was argued that it only models supply, and not demand. Apart from that, the distance or travel impedance coefficient (β) is unknown and it takes many mathematical forms, it's form and magnitude can vary significantly with population under study and may be region-specific (Guagliardo, 2004b; Schuurman et al., 2010a; Xiong et al., 2016).

2.1.1 *Two-Step Floating Catchment Area*

Two-Step Floating Catchment Area (2SFCA) is another method used to model spatial accessibility to health care. This method creates two floats (catchments): service catchment and population catchment within specified time travel or distance. The service catchment area looks at, for each service at a location, how many people can possibly reach it in a specified distance or time while population catchment searches for all service points that can be reached from a given population location. Each step creates an area of coverage called catchment and are eventually floated on each other to calculate accessibility (W. Luo & Wang, 2003). The result of this is a score also known as accessibility index that represents the levels of the accessibility of a particular household.

The 2SFCA was then adopted in this study for the reasons that: i) it is easy to use, modify, interpret, and works well independent of the region of application like the gravity model (W. Luo & Qi, 2009; W. Luo & Wang, 2003; Mao & Nekorchuk, 2013). More so when the study area is a dynamic environment of both rural and urban households; ii) it helps

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to identify population proportion served by each individual health centre, population service deficient area and can be modified to simulate scaling up the health system (Mao & Nekorchuk, 2013); and iii) it produces better ratios than the Kernel density measure (Yang et al., 2006).

3. Methodology

3.1 Study area and data requirements

Zomba is one of the 31 districts in Malawi located in the southern region of Malawi. In terms of health administration, Zomba is in the southeast zone with a population of about 851,737 people (NSO, 2018), with aobut 746,724 (87.7 %) of these people living in rural areas. Part of the district is covered by Zomba plateau and Zomba forest reserve and the other part is covered by lake Chirwa as shown in Figure 3.1. The district has 841 enumeration areas each with an average of 241 households per enumeration area and an average of 4 people per household (National Statistical Office (NSO) & - Ministry of Economic Planning and Development (MoEPD), 2018). There is no government-owned public transport in Zomba with few of the roads paved.

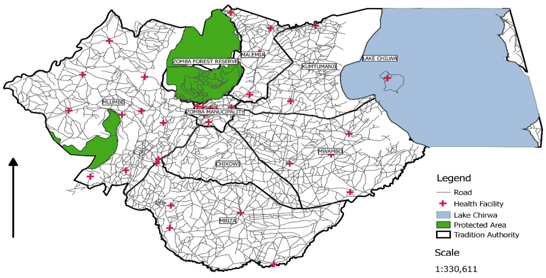

Figure 3.1 Zomba Map

3.2 Data Collection and Preparation

Data for this study was collected using both primary and secondary sources. Primary data was collected using interviews and questionnaires. At the District, level data on methods used to determine accessibility, plan for a new facility, capacity of different type of health facilities and the number of personnel offering the services were collected using face-to-face interviews. Secondary data included enumeration areas from 2018 Population Housing Census, road network shapefiles from MASDAP which is owned by the Department of Surveys, Malawi Digital Elevation Model (DEM), health facility names, type, services offered by health facilities, and location of facilities from Health Management Information System, and number of personnel offering the services. The 2018 population housing census data was used to generate locations of households in the enumeration area to indicate the demand for services at the facility. The health facility positions were linked with the number of health workers at the facilities based on their type.

3.3 Spatial modelling and analysis

Spatial accessibility was assesed using the 2SFCA method with an addition of the Gaussian continuous decaying function $f(d_{ij})$ in equation 1. The continuous decay function removes the assumption that all the population, in this case households, living within a specified threshold have the same accessibility index score (W. Luo & Qi, 2009).

$$f(d_{ij}) = \begin{cases} \frac{e^{0.5\left(\frac{d_{ij}}{d_0}\right)^2} - e^{-0.5}}{1 - e^{0.5}}, d_{ij} \le d_0 \\ 0, d_{ij} > d_0 \end{cases} \quad (1)$$

2SFCA method created two floats (catchments): service catchment and population catchment within a specified time of travel. Each step creates an area of coverage called catchment and are eventually floated on each other [2] The 2SFCA method requires key variables of demand, supply and the cost between the demand and the supply. In this study, the demand was the population of households. The supply was the health facility location, type of health facility and the number of trained personnel at a health facility. The cost between the demand and supply calculated in terms of time based on the existing road, elevation from DEM and mode of transport dominant in the district. The first step in the two-step floating catchment area is calculated as

$$A_i = \sum R_j f(d_{ij}) \quad = \sum \frac{s_j f(d_{ij})}{\sum_{k \in d_{kj} \le do} P_K f(d_{kj})} \quad (2)$$

Where A_i represents the accessibility of household at location i. A larger value of A_i indicates better accessibility to services at that household location. The rest of the parameters are defined as P_k is the population at location k, S_j is the service capacity at location j, d_{ij} is the travel distance between k and j expressed in terms of time, R_j is the service to population ratio at location j that falls within the catchment $(d_{kj} \le d_0)$. f is the Gaussian decay function

The World Health Organisation (WHO) recommends the use of travel time taken to access health services as opposed to distance travelled as a measure of accessibility. This is largely because comparing the distance to a health facility for locations becomes problematic especially when parameters like the geography, mode of transport and transportation infrastructure vary across and within the locations (WHO, 2001). Travel time, on the other hand, does accommodate such parameters making the comparisons objective. In this study, the threshold was 1 hour and the average travelling speed was 5 kilometres per hour (Huerta Munoz & Källestål, 2012; W. Luo & Wang, 2003; Schuurman et al., 2010a).

4. Results and Discussion

4.1 Health facilities and service provision in the district

Zomba has 46 public health facilities that are registered in the national HMIS, thirteen of which are located in the urban areas and the rest in the rural areas. Five health facilities do not have coordinates. Only health facilities with coordinates were included in the study. The number of trained Health

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workers data was obtained from interviews at the DHO level. This was used to determine the minimum human resource required to man the facility. The study included private facilities that are mostly found in the urban areas of the district. In these areas, most of the households could afford to pay for the service due to better economic status as compared to a rural area. Due to the lack of information on the private facilities, in this study, their capacity was considered to be the same as that of the dispensary.

4.2 8-kilometre radius versus 8-kilometre travel distance

As per Ministry of Health policy, the population of households that are within 8-kilometre radius of any facility is considered served by the current health system or otherwise underserved. In this regard, the study found that 94.4 % of the households are served by the current health facilities with only 5.6 % underserved, as shown in Figure 4.1. With this approach, no household in the urban areas is underserved, i.e. outside the 8 kilometres radius, while only 6% of households in rural areas were underserved. This agrees with a facility mapping showed in HSSP II 2017 -2022 (Ministry of Health, 2017) which found about 95 % of people in the districts are served.

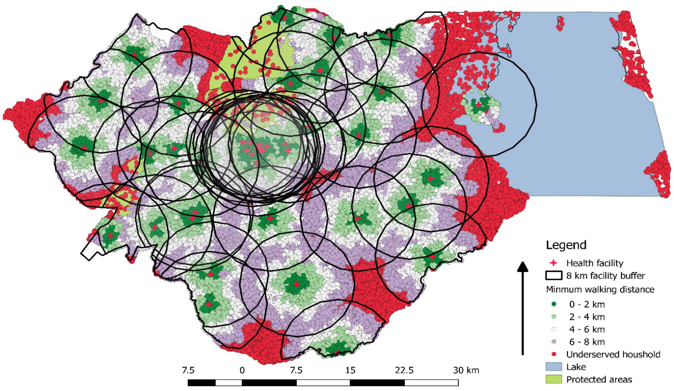

Figure 4.1 8 km radius and 8km traveling distance

The distribution of these facilities is more compact in the urban areas and far apart in rural areas. This implies that more households are within 8 kilometres to one or more facilities in urban areas than in rural areas.

4.2.1 Walking distance

To find the actual distance a household travels to a facility, the 8 kilometres was measured based on the road network travel distance to the facility. Dijkstra's algorithm was used to find the actual distance a household has to travel to access health care. Results from the model showed 87.3 % are within 8 kilometres walking distance to a health facility using the roads which is 7.3 % less than in the 8 kilometres radius result. For the households within 8 kilometres, the average distance to the facility was 3.5 kilometres, with a minimum of 0.05 kilometresThe independent t-test to compare the mean travel distance to the nearest facility is significant with a p-value of < 0.001. This means that the mean travel distance is significantly different in urban and rural areas, which agrees with the calculated average walking distance. Hence, rural households walk significantly longer distances to access health care than urban households. Long-distance also implies that the transport cost or the cost of fuel will be high to reach the hospital. In rural areas, the distances to health care facilities and the poor condition of roads result in substantial time to reach a point of care negatively affecting health care utilization (O'Donnell, 2007).

8 kilometres radius and 8 kilometres travelling distance models show that there is a difference in the accessibility of PHC services for urban and rural households. When the radius is used, it masks out some locations that are underserved due to the actual travel distance as shown in Figure 4.1. There is a notable difference in the underserved population of 5.6 and 11,8 % when 8 kilometres radius and 8 kilometres travelling distance is used respectively. The use of radius in evaluating accessibility introduce substantial errors in rural or sub-metropolitan areas thereby negatively affecting accessibility (Apparicio et al., 2008).

4.3 Travel time and 2 Step Floating Catchment Area (2SFCA)

In this implementation, travel time was calculated by taking into consideration the elevation and mode of transport. Walking speed was determined to be 5 kilometres per hour (dos Anjos Luis & Cabral, 2016; Huerta Munoz & Källestål, 2012; J. Luo et al., 2018; Schuurman et al., 2010b). Elevation, road network distance and the point location of the household were used to calculate the time it would take to travel to the nearest healthcare facility. Walking was chosen as a mode of transport as it is the most used mode to access health care.

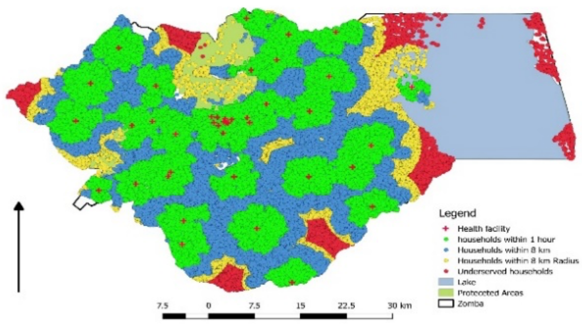

Figure 4.2 8km radius, 8km travelling distance, 1 hour travelling time

The result showed that 66.3% have the potential of walking 60 minutes to the facility in the district with an average of 31.1 minutes and standard deviation of 15.7 and Figure 4.2. This is much lower than the 95% reported in HSSPII where radius was used. This implies, 33.7% of the households are underserved and this is closer to the finding of DHS that reported 56 % of women find difficulties in accessing health care. In the urban areas, almost all (99.8 %) households were

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located within 60 minutes travel time to the health facility unlike in rural areas where only 61.7% are within one hour to at least one closest facility and 38.3 % of underserved households.

4.3.1 2SFCA

For all households, the accessibility score was calculated using 2SFCA with a threshold of 60 minutes to find the accessibility levels. The higher the score, the better the accessibility. The first step it to find population to provider ratio. The results show that the population to provider ratio of the district is averaged at 0.004. The lowest ratio was found to be 0.0002, at the State House Clinic and the highest was found to be 0.02 at Chisi Health Centre located at Chisi island. In general, the population-to-provider ratio is generally higher within one hour in rural areas than in urban areas (see Figure 4.3).

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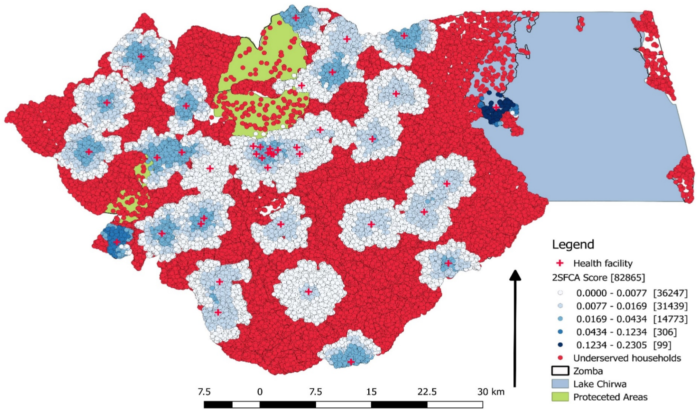

Figure 4.3 2SFCA accessibility score map

The mean 2SFCA accessibility score for the district was 0.0103904 with a standard deviation of 0.00990707, the lowest accessibility score was 2.84262e-08 and the highest was 0.230509 as shown in table 3.1. The highest accessibility score was located around Chisi Health Centre because the area is an island with a relatively low population.

	Rural	Urban	All
Min	4.41 e-08	3.57 e-08	3.57 e-08
Max	0.24638	0.02	0.24638
Mean	0.00458	0.005	0.004
Standard deviation	0.00349	0.00178	0.00326

Table 3.1 2sfca score

Most households in the urban area have good accessibility scores. The average score of urban households was 0.005, which is lower compared to an average of 0.00458 for rural households. The results from the independent t-test show that the mean scores from the urban and rural households are significantly different with a p-value of <0.001. Thus, urban households have significantly higher accessibility score compared to rural households. This implies that urban households have better access to PHC than in rural areas. This result generally agrees with Humphreys, J. S., & Solarsh, G. (2008) cited in (McGrail & Humphreys, 2009a) and contradicts (Samuel & Adagbasa, 2014) finding that a lot of people living in urban areas in sub-Saharan Africa travel long distances to access health care.

Overall there was a negative Pearson correlation between time and score of -0.578, p = ≤ 0.001, n=82862. This implies that as the time to the facility increases accessibility diminishes. This relationship was also observed by (Mokgalaka, 2014; Peters et al., 2008)

5. Conclusions

This study analysed spatial accessibility to primary health care facilities among households in Zomba district. In general, the study found that there are inequalities in terms of spatial accessibility for households in urban and rural areas. Urban households have better spatial access to PHC affirmed by: i) better percentage within 8 kilometre radius, ii) better travelling distance to a PHC facility, iii) better percentage within 1 hour, iv) high number of facilities within 1 hour and v) significantly better 2SFCA score for households.

Although radius is used to evaluating the accessibility of health care, walking distance and time present a realistic picture of how households access health care. Using travel time to access health care, the result can be compared across areas with different elevation and modes of transport.

The spatial accessibility to PHC model in Zomba shows that there is a variation in the measurement of accessibility using radius and network-based routing. Further, as demonstrated in the study, travel distance still does not suffice in capturing the relationship between the household and the facility in terms of time and the available resources. This is important because proximity to a facility does not guarantee the availability of the resource.

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