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Measuring spatial accessibility to primary health care services: Utilising dynamic catchment sizes

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ABSTRACT

The two-step floating catchment area (2SFCA) method continues to be a popular measure of spatial accessibility, especially in relation to primary-level health care. Despite its popularity, most applications of the 2SFCA method are limited by the utilisation of only a single catchment size within a small geographic area. This limitation is significant to health policies which are mostly applied at the state or national scale. In this paper, a five-level dynamic catchment size was trialled within the 2SFCA method to all of Australia, with a population's remoteness used to delineate increasing catchment sizes. Initial trial results highlighted two perverse outcomes which were caused by sudden changes in catchment sizes between each level. Further refinement led to trialling an additional three-level catchment sub-type to the 2SFCA method, which created a smoother transition between remoteness levels. This study has demonstrated an effective approach to dynamically apply variable and more appropriate catchment sizes into different types of rural areas, which for the first time enables the 2SFCA method to be suitable for national-level access modelling and its potential application to health policy.

Introduction

Good access to health care for all populations, regardless of geography, remains a key goal of governments and societies internationally (Dussault & Franceschini, 2006; World Health Organization, 1978, 2010). Rural communities, despite being characterised by poorer health status and increased need for health care, often experience the greatest access barriers (Australian Institute of Health and Welfare, 2008; Humphreys & Solarsh, 2008). These barriers faced by rural communities include reduced service availability, limited choice of preferred characteristics of both services and providers, and the need for greater travel to access health care (Russell et al., 2013; Wakerman & Humphreys, 2012).

Access to health care services is often modelled using catchments to define regions where utilisation of health care services occurs (Guagliardo, 2004; Luo & Whippo, 2012; McGrail, 2012). Catchment sizes delimit how far geographically services are delivering health care to patients, and, at the same time, determine how far populations are prepared to travel to access the services on offer. Catchment limits are especially important for primary health care (PHC), the key health service entry point for residents of rural communities. Generally, residents are free to choose where they access PHC services from. However, increased travel distance to access more service options often leads to a trade-off between convenience and choice. Distance and geographical isolation are foremost health care access barriers (Arcury, Gesler, Preisser, & Sherman, 2005; Chan, Hart, & Goodman, 2006; Sibley & Weiner, 2011), and most residents prefer not to travel further than required. Whilst many studies suggest that individuals in more remote settings accept lengthy travel as a routine part of their lives (Kwan & Weber, 2003; Sherman, Spencer, Preisser, Gesler, & Arcury, 2005), few have specifically investigated the variability of distance tolerance of rural residents in relation to accessing their usual PHC service (Buzza et al., 2011; Shannon, Lovett, & Bashshur, 1979; Tanser, Gijsbertsen, & Herbst, 2006).

The two-step floating catchment area (2SFCA) method has grown in prominence in the last 10 years, notably as a measure of

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spatial access to PHC (Luo & Qi, 2009; Luo & Wang, 2003; McGrail & Humphreys, 2009a). A key feature of the 2SFCA method is its use of catchments that are centred on actual population and service locations (Luo & Whippo, 2012; McGrail, 2012; McGrail & Humphreys, 2009b; Wan, Zou, & Sternberg, 2012). This improvement notwithstanding, however, most applications of the 2SFCA method are limited by their utilisation of only a single catchment size. Furthermore, most demonstrations of the 2SFCA method have been contained to small geographical areas such that limitations of using a single catchment size could be ignored (Bell, Wilson, Bissonnette, & Shah, 2013; Ngui & Apparicio, 2011; Wang & Tormala, 2014). The aim of this paper is to critically appraise how dynamic catchment sizes can be employed in the 2SFCA method. Moreover, this paper aims to demonstrate that dynamic catchment sizes are a critical component of the 2SFCA method for large scale access modelling.

Background

Improved access measurement through the 2SFCA method

Access to healthcare is multidimensional, with access barriers consisting of both spatial and aspatial dimensions (Khan & Bhardwaj, 1994; Russell et al., 2013; Wang & Luo, 2005). Spatial accessibility in healthcare refers to the ease that populations can utilise health services, with an emphasis on proximity and population demand (Joseph & Bantock, 1982; Luo & Wang, 2003). Spatial accessibility measures capture both the geography separation between the population and services and the size of the population competing for limited available services. Historically, three approaches dominate measures of spatial accessibility. Firstly, travel impedance (distance or time) to the nearest service is a simple approach (Rosero-Bixby, 2004) but ignores the common behaviour in healthcare access of bypassing (Hyndman, Holman, & Pritchard, 2003) as well as not accounting for demand. Secondly, the gravity model introduces the two concepts of diminishing 'attractiveness' with increased distance, and demand from the population for limited services (Guagliardo, 2004; Joseph & Bantock, 1982; Luo & Wang, 2003), but its decay function is questionable and difficult to define.

The third approach of 'crude' provider-to-population ratios (PPRs) has long been used to differentiate access to health care between regions (Primary Health Care Research & Information Service, 2012; World Health Organization, 2013). PPRs are calculated for pre-defined regions (such as Local Government boundaries or Counties) such that residents are assumed to access services only from within their region. However, PPRs are often condemned as highly-simplistic measures lacking specificity and accuracy. In particular, PPRs are criticised because they ignore any effect of increased distance on reduced access and because they assume that population demand will only occur within their region (Guagliardo, 2004; McGrail & Humphreys, 2009b).

Elements of all three approaches are brought together in the two-step floating catchment area (2SFCA) method. A key additional feature of the 2SFCA method is that catchments used in its calculation are centred on each individual service and population location. Within Step 1 (which focuses on service catchments), the 2SFCA method calculates potential service demand by identifying all population locations with potential access to that service. These populations are identified by measuring a fixed radius (maximum time or distance) from the service location and aggregating all population locations that fall within its catchment. Similarly, Step 2 (which focuses on population catchments) calculates potential utilisation by identifying all service locations that fall within a fixed radius (maximum time or distance) from the population location. In combination, Steps 1 and 2 measure the "fit" between services and the population. However, whilst these "floating catchments" undeniably improve access methodology by using more accurate points of access origin and destination, the 2SFCA method still suffers from limited evidence as to the most appropriate catchment size(s) to apply.

Although not part of the original 2SFCA method, there is now almost universal agreement that a distance-decay function is an essential additional component of the 2SFCA method (Luo & Qi, 2009; McGrail, 2012). These additional components ($f(d_{jk})$ in Step 1 and $f(d_{ij})$ in Step 2) infer that the likelihood of access between a population and a service diminishes as distance separation increases up to the catchment border and is assumed to be zero for anywhere beyond this. A brief summary of the 2SFCA method (Steps 1 and 2), with the inclusion of a distance-decay function, is given below and its calculation follows the general process detailed elsewhere (Luo & Qi, 2009; McGrail, 2012; Wang & Luo, 2005).

Step 1. Calculate service catchments – for each provider or service location (j) of volume S_j, determine what population size (summed P_k) can potentially access that provider (up to the catchment border = d_{max}) and calculate the ratio of providers to the population (R_j).

$$R_j = S_j \Big/ \sum k \in \left[d_{jk} < d_{max}\right] P_k * f\left(d_{jk}\right)$$

Step 2. Calculate population catchments – for each population location (i), determine what services (j) can potentially be accessed by that population (up to the catchment border = d_{max}), and aggregate the PPRs for these services (R_j) as calculated in Step 1. A_i = access score for each location (i).

$$A_i = \sum j \in \left[d_{ij} < d_{max}\right] R_j * f\left(d_{ij}\right)$$

Distance decay functions $f(d_{jk})$ and $f(d_{ij})$ are additionally shown here (range: between 1 = no distance decay/full access, and 0 = full distance decay/no access).

Applying dynamic catchment sizes to the 2SFCA method

Besides distance-decay, a second additional component for the 2SFCA method is the use of multiple or dynamically-defined catchment sizes – that is, different sized catchments within the same model for different regions or population subgroups. Only a few studies so far have tested the use of any dynamic catchment sizes (Luo & Whippo, 2012; McGrail, 2012) within the 2SFCA method. Unfortunately, these studies have either only split the population into two types, rural or metropolitan, or applied dynamic catchments only within metropolitan areas. Notably, these simple approaches to dynamic catchments mean that all rural populations are assumed to be one homogeneous group in their propensity to utilise health services with respect to distance barriers. This assumption of homogeneous behaviour has not been a major concern, to date, because most studies using the 2SFCA method have only investigated small geographic regions or metropolitan-only populations.

Many authors of studies utilising the 2SFCA method have concluded with recommendations their method better identifies low access areas and should be used in government health policies (Luo & Whippo, 2012; McGrail & Humphreys, 2009c; Wan et al., 2012; Wang & Luo, 2005). However, most health policies target a