Applied Geography 100 (2018) 30–38

Contents lists available at ScienceDirect

Applied Geography

journal homepage: www.elsevier.com/locate/apgeog

Improving the measurement of the Korean emergency medical System's spatial accessibility

Kyuhyeon Shin*, Taesik Lee

Department of Industrial and Systems Engineering, Korea Advanced Institute of Science and Technology, 291 Daehak-ro, Yuseong-gu, Daejeon, 34141, Republic of Korea

ARTICLE INFO

Keywords:
Geographical accessibility
Spatial accessibility
Floating catchment area method
Distance decay function
Emergency medical service

ABSTRACT

Measuring spatial accessibility for healthcare service is an important prerequisite for public health policy decision. While existing literature offers spatial accessibility measures, applying those measures to healthcare services reveals some weaknesses for improvement. In this study, we propose an improved accessibility measure. The proposed measure is based on the floating catchment area method but improved in some aspects. We use two distance decay functions to distinguish their respective effects in measuring accessibility. A local distance decay function, expressed as a logistic cumulative density function, accounts for region-specific patient visit patterns. A global distance decay function, also defined as a logistic density function, incorporates patients' inherent resistance to travel in the measure. To address the problem of potential demand estimation, which distorts the resulting accessibility values, we introduce effective potential demand which is defined as the ratio of potential demand to total nearby capacity by care providers as an adjustment factor. To examine the effectiveness, we apply the measure to identify the medically underserved areas in Korea for emergency medical services. Compared with the existing floating catchment area measure, the proposed measure provides more proper spatial accessibility information.

1. Introduction

One of the important goals of public health policy is to provide equitable health care access to all their citizens. A critical piece of information for public health authorities to achieve the goal is the accessibility to health care services in different regions in their countries. For example, ensuring appropriate accessibility to primary care is an important public health concern as it contributes to health outcomes of ambulatory care sensitive conditions. As such, accessibility measures for primary care have received much attention by many researchers (Bauer & Groneberg, 2016; Delamater, 2013; Guagliardo, 2004; Joseph & Bantock, 1982; Luo & Qi, 2009; Luo & Wang, 2003; Luo & Whippo, 2012; McGrail, 2012; McGrail & Humphreys, 2009; Wan, Zou, & Sternberg, 2012). Another important area in public health provision is the emergency medical service (EMS) – emergency medical conditions cannot be completely prevented by primary care (Kobusingye et al., 2006). In spite of its importance in public health, few studies have examined the spatial accessibility for EMS with sufficient rigor. Studies on the EMS accessibility often examine geographical accessibility to EMS by using a simple coverage definition, e.g., the number of emergency departments (EDs) within 30 min, 45 min, and 60 min (Carr, Branas, Metlay, Sullivan, & Camargo, 2009; Hameed et al., 2010; Lawson, Schuurman, Oliver, & Nathens, 2013).

Developing effective health care policies to achieve equitable access to health care requires credible measures of spatial accessibility that is based on accurate assessment of supply and demand for health care services. Unfortunately, spatial accessibility is often measured from a care supplier (i.e., government) perspective, when health care consumers' perspective of spatial accessibility may be quite different. For example, public health policy makers may perceive 30-min distance to a hospital to present same accessibility to residents in urban area or in rural area. Yet, a hospital located 30 min away is probably much less attractive to urban residents than to rural residents. In addition, patients may prefer larger hospitals to smaller hospitals even when the larger hospital is located farther away. Thus, the geographical distance alone is not sufficient for properly assessing the spatial accessibility to health care services.

This study aims to develop a measure for spatial accessibility for health care services. We build upon a widely used accessibility measure, floating catchment area methods, and improve it in a few aspects. First, we introduce two separate distance decay functions – local and global decay functions. A local decay function captures the characteristics associated with region-specific visit patterns. A global distance decay function, on the other hand, reflects the patients' willingness to travel

* Corresponding author.
E-mail addresses: shinkyuhyeon@kaist.ac.kr (K. Shin), taesik.lee@kaist.edu (T. Lee).

https://doi.org/10.1016/j.apgeog.2018.08.009
Received 9 January 2018; Received in revised form 5 August 2018; Accepted 25 August 2018
0143-6228/ © 2018 Elsevier Ltd. All rights reserved.

which are global to all patients. These two distance decay functions are formulated into the measure in a way their distinct effects are appropriately incorporated. In addition, we address the problem of over- or under-estimation of potential demand for service providers in the existing method. To do so, we take into account service capacities of other service providers to produce the effective potential demand of a service provider.

2. Background

2.1. Literature review

Measuring accessibility is a relevant question in design and analysis of service provision in many domains including transportation, retail as well as health care services. In this section, we first review the previous development on accessibility measure in general, and discuss some studies on spatial accessibility in the particular context of emergency medical services.

Significant research regarding spatial accessibility has been conducted during recent decades. Curl, Nelson, and Anable (2011), Geurs and Ritsema van Eck (2001), and Neutens (2015) have all discussed the existing measures of spatial accessibility, where they are grouped into the following categories: infrastructure-based, cumulative, gravity-based, utility-based, and activity-based measures. These references identify some of the weaknesses of the existing measures. For example, infrastructure-based measures do not consider the relation between supply and demand. Cumulative measures involve the arbitrariness in a cut-off distance or threshold value which is essential in specifying the measure. Gravity-based measures produce an accessibility value that is abstract and do not convey tangible meaning on their own. Utility-based and activity-based measures are weak in their practical applicability due to the complexity and data intensity. Table 1 shows brief descriptions and examples of various accessibility measures discussed in the references.

While each of the existing measures has both strengths and weaknesses in some aspects, gravity-based measures offer a few advantages that make them an attractive option for the purpose of measuring accessibility in the context of equitable health care service provision. First, gravity-based measures consider both care provider- and customer-side factors. In addition, although their accessibility values are abstract and carry little meaning in their absolute magnitude, they are still relevant and useful to compare these values of different areas in relative scale. This helps identify areas of relative lack or shortage of accessibility. Due to these advantages, gravity-based measures are popular choices in health care service accessibility studies. In particular, among the gravity-based measures, Floating Catchment Area (FCA) method is a widely-used measure.

Floating catchment area (FCA) methods, which are the extension of gravity based models, define demand using the population within a predefined distance or travel time (i.e., "catchment") (Luo & Wang, 2003). FCA methods consider competition among local population and border seeking behavior in an understandable manner (Bauer & Groneberg, 2016; Delamater, 2013; Guagliardo, 2004; Luo & Wang, 2003; Luo & Whippo, 2012; Mao & Nekorchuk, 2013; McGrail, 2012; McGrail & Humphreys, 2009; Wan et al., 2012). Among the FCA methods, the most popular is the two-step FCA (2SFCA) method by Luo and Wang (2003) which computes the accessibility value at a demand point as the sum of the provider-to-population ratio of local facilities within the catchment in two steps as follows:

Step 1: determines the population that falls within the catchment of each health care provider to compute the provider-to-population ratio, R_j.

$$R_j = \frac{S_j}{\sum_{k \in \{t_{kj} \le t_r\}} P_k w(t_{kj})} \quad (1)$$

where k is a demand point, j is a hospital, S_j is the service capacity of j, and t_{kj} is the travel time from k to j. $w(t_{kj})$ is the distance decay function that produces the travel time weight, t_r is the catchment, and P_k is the population or number of patients in k.

Step 2: allocates providers to populations by determining which providers fall within the catchment of each population and sum up the provider-to-population ratios obtained in the first step of the procedure.

$$A_i = \sum_{j \in \{t_{ij} \le t_r\}} R_j w(t_{ij}) \quad (2)$$

where i denotes a demand point and A_i is the spatial accessibility of demand point i.

Early versions of 2SFCA methods assign same weights to all population within catchment, that is, $w(t_{ij}) = 1$ for $t_{ij} \le t_r$ in equations (1) and (2). This assumes that a distant population contributes to potential demand for a hospital as much as a close population, which is not consistent with the first law of geography. In addition, a catchment area is arbitrarily defined by a threshold distance t_r as in the cumulative measures. Lastly, potential demand gets overestimated when catchment areas of multiple hospitals overlap each other. These problems are addressed in the subsequent modification of the original 2SFCA method. For example, Enhanced 2SFCA method introduces a step-wise distance decay function. Each step represents a divided zone within a catchment and the weight in each step is given by a corresponding Gaussian function value (Luo & Qi, 2009). McGrail and Humphreys (2009) suggests to use a variable catchment size. They propose to differentiate the size of each catchment by taking into account the population size and provider-to-population ratio, which helps to overcome the demand overestimation. A more recent extension is Modified

Table 1
Classification of accessibility measures (adapted from Curl et al. (2011)).

Measure	Description	Example	Weakness
Infrastructure based (e.g. Church, Frost, and Sullivan (2000))	Relate to the performance of the network and might include measures used in transport modelling.	Congestion across a local authority area	Effects of improved level of services of infrastructure on land use patterns are not considered.
Cumulative (e.g. Casas (2007))	Represent the accessibility at a location to another or set of destinations and are the most easily understood.	Proportion of the population within a time threshold of a GP surgery	Have the arbitrariness involved in the selection of an appropriate cut-off distance.
Gravity based (e.g. Joseph and Bantock (1982))	Extension of cumulative ones, but weight opportunities by impedance and the attractiveness.	Accessibility of schools to the population	Produce the resultant value that does not mean anything on its own.
Utility based (e.g.Niemeier (1997))	Considers travel behavior based on economic principles of diminishing return.	Accessibility based on the expected utility an individual will gain	Are rarely used in practical applications due to the complexity and data intensity, and the difficulties encountered with communicating the outputs to a non-expert audience.
Activity based (e.g. Casas (2007))	Relate to individuals' level of access to spatially distributed activities.	The potential path area, considering destinations, the transport network and the individual's constraints	

Download English Version:

https://daneshyari.com/en/article/11028352

Download Persian Version:

https://daneshyari.com/article/11028352

Daneshyari.com