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An individual-based rurality measure and its health application: A case study of Latino immigrants in North Florida, USA

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ABSTRACT

Rurality has been frequently noted by researchers as pathways to understand human health in rural and remote areas. Current measures of rurality are mostly oriented to places, not individuals, and have not accounted for individual mobility, thus inappropriate for studying health and well-being at an individual level. This research proposed a new concept of individual-based rurality by integrating personal activity spaces. A feasible method was developed to quantify individuals' rural experience using household travel surveys and geographic information systems (GIS). For illustration, the proposed method was applied to understand the well-being and social isolation among rural Latino immigrants, who had participated in a community-based participatory research (CBPR) study in North Florida, USA. The resulting individuals' rurality indices were paired with their scores of well-being and social isolation to identify potential associations. The correlation analysis showed that the proposed rurality can be related to the social isolation, mental and physical well-being of individuals in different gender groups, and hence could be a suitable tool to investigate rural health issues.

1. Introduction

The worldwide rural population face considerable risks to poor health and well-being, as they are more likely than their urban counterparts to be poor, have lower education, less employment opportunities and unequal access to healthcare (AIHW, 2015; Alfero et al., 2013; Van Dis, 2002). There are, for example, lower rates of hospital surgical procedures and general practice consultation in remote areas than in major cities (Jordan et al., 2004; Laditka et al., 2009). People from remote areas tend to be more likely than their major city counterparts to smoke and drink alcohol in harmful or hazardous quantities (Coomber et al., 2011; Lutfiyya et al., 2008). Further, living in rural areas may adversely affect the mental health of residents, particularly for minority groups who have limited language proficiency, work in low-paying jobs and are spatially segregated (Warren and Smalley, 2014). Thus, the concept of 'rurality' has been widely acknowledged in regional planning, health policy making, and resource allocation (Judd et al., 2002; Smith et al., 2008).

To date, a variety of methods have been proposed to define 'rurality' qualitatively and quantitatively (Hall et al., 2006), but most definitions are constrained by the fact that they are placed-based. That is, rurality is often measured as a property of places, which are identified as administrative units, such as counties, census tracts, or postal-code areas (Hart et al., 2005). There are two limitations for those place-based definitions. First, many health outcomes are measured at the individual level, for instance, blood pressure, smoking behavior, and mental status. Previous studies had to aggregate these individual measures by place to accommodate placed-based rurality, and thus potential associations can only be investigated at the place level. Due to the ecological fallacy, results from such ecological analysis should not be used to infer individual experiences (Kwan, 2009; Wong and Shaw, 2011). Second, individuals are mobile and could visit multiple places on a daily, weekly, or monthly basis to carry out a range of activities. The rurality of one place is not adequate to fully portray the rural environment an individual is exposed to, which could in turn

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mislead the relationships between rurality and human health.

To address these limitations, this research proposed that measurements of rurality need to be individualized and be capable of considering individual mobility. The following literature review shows that limited studies have been undertaken along this line of thinking. This article describes the development of a new individual-based rurality index, and illustrates its application in studying the social isolation and well-being of rural Latino immigrants in North Florida, USA.

2. Literature review

2.1. Development of rurality measures

Like concepts such as truth, beauty, or justice, everyone knows the term 'rural', but no one can precisely define the term (Weisheit et al., 2005). In the literature, there have been a number of attempts to define and measure rurality, but no consensus has been reached so far (Hewitt, 1989; Weinert and Boik, 1995). The US Census uses a dichotomous taxonomy: an area is either urban or rural. An urban area is composed of contiguous census blocks or block groups that has, in its core, a population density of at least 1000 persons per square mile and has a total population of 2500 or more residents (USCensus, 2010). All areas outside of urban areas are defined as rural. The definition is limited to represent the rural–urban transition or capture the breadth of variation in rural areas.

To overcome the dichotomous limitation, there have been efforts to describe the rural–urban transition with discrete coding systems. For example, the US Office of Management and Budget (OMB, 2010) defines metropolitan, micropolitan, and non-core counties, according to the population size and the contiguity between counties. Based on the OMB taxonomy, the United States Department of Agriculture (USDA, 2013c) developed the Urban Influence Codes (UICs) that further divide the three OMB-categories into 12 sub-categories with a set of thresholds concerning the urban populations and adjacency to a metro area. Similarly, the Rural-Urban Continuum Codes (RUCC), previously known as the Beale codes, form a classification scheme that distinguishes the three OMB-categories of counties by 9 sub-categories (USDA, 2013b). The Rural-Urban Commuting Area (RUCA) codes classify U.S. census tracts and ZIP codes into 10 numerical categories using measures of population density, urbanization, and daily commuting(USDA, 2010). In Australia, the Rural, Remote and Metropolitan Areas (RRMA) classification allocates each statistical local areas (SLA) into 7 categories based on population numbers, population density and the straight-line distance to various population centers (McGrail and Humphreys, 2009). Although these classification schemes describe the rurality as numerical codes, they still remain discrete, spatially coarse, and ultimately limiting since they mask rural variations within a geographic unit that are necessary for fine-grained individual analysis. Further, the subjective thresholds between categories can lead to misclassification of geographic units that are similar.

To solve these issues, a number of continuous measures have been developed. These studies have shifted the focus from the question of 'Is a place rural or urban?' to 'What is the degree of rurality for a place?' For instance, Waldorf (2006) structured a continuous index of relative rurality through averaging the normalized scores of population size, density, percentage of urban residents, and distance to the closest metropolitan area. The index was calculated for US counties to understand the spatial-temporal variation of rurality. Caschili et al. (2015) have constructed a Composite Indicator of Rurality (CIR) using principal component analysis and weighted linear combination of demographic, socio-economic, and settlement factors. The CIR was applied to municipalities on an Italian island to examine the relationship between accessibility and rurality. The Accessibility/Remoteness Index of Australia (ARIA) is another continuous index estimated on a 1 km grid of Australia, using road distances from over 12,000 populated localities to their nearest service centers in five categories based on the population size (Dunne et al., 2001). Compared to the discrete coding systems, the continuous degree of rurality offers a more detailed description of urban-rural continuum, and allows more sophisticated numerical analysis on rurality and related social issues from education to poverty, unemployment, and health.

The literature shows that rurality is mostly gauged as a property of places, such as counties, census tracts, and cell locations. Few studies have consider rurality as a property of individuals (Kwan, 2009). There are two limitations for these place-based measures in social/health studies. First, the associations between the rurality and health outcomes can only be explored at the aggregate level, for example the county or tract level. The ecological fallacy can cloud the identification of true relationships at the individual level. Given that many health outcomes are actually obtained at the individual level, a rurality measure of the same level is more appropriate for epidemiologic studies. Second, individuals are mobile and could visit multiple places on a daily, weekly, or monthly basis for a wide range of activities. The rurality of one place (e.g. the home ZIP code) cannot accurately represent the full scale of rural environment an individual is exposed (Farber et al., 2012; Wong and Shaw, 2011). To address the limitations, this research adopted an activity-space approach to define an individual-based rurality.

2.2. Activity-space approach

The concept of activity space has a long history in the geography and transportation literature, and has been extensively used to represent spatial behavior of individuals (Axhausen and Gärling, 1992; Farber et al., 2013; Wang and Cheng, 2001). A widely recognized definition states that an activity space is a set of potential places, such as homes, workplaces, schools, and shops, where an individual may perform routine activities (Golledge and Stimson, 1997). Major data sources to construct individual activity spaces are household travel surveys and individual travel dairies. Recent advance of geo-locating technologies, such as the global positioning system and location-aware smart phones, makes possible the study of activity spaces for a large amount of individuals (Raanan and Shoval, 2014; Silm and Ahas, 2014). Geographic maps are the major tool to depict individual activity spaces, with points, lines, polygons representing locations, travel routes, and spatial extent, respectively (Kwan, 2004). In addition, there is a variety of methods to summarize individual activity spaces (Schönfelder and Axhausen, 2003), such as a two dimensional ellipse (that envelopes all places being visited by an individual), kernel densities (of places being visited), and the minimum distance routes between all locations visited (the minimum spanning tree).

The activity space approach has been used as an individual-level spatial construct in a wide variety of social science studies. For example, Schönfelder and Axhausen (2003) investigated the activity spaces of individuals who may be at risk of social exclusion (female, lower income, elderly) in two German cities, in terms of the ellipses, kernel densities, and minimum spanning trees. Wong and Shaw (2011) devised an individual-based social segregation measure as a function of an individual's exposure to other groups within his/her activity space. The new measure was used to evaluate the social segregation of different ethnic groups in tri-county areas in southeast Florida, USA. Farber et al. (2012) integrated individual activity spaces into the Getis and Ord's *G* statistics, and