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Multiscale evaluation of an urban deprivation index: Implications for quality of life and healthcare accessibility planning

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ABSTRACT

Deprivation indices are widely used to identify areas characterized by above average social and/or material disadvantages. Especially spatial approaches have become increasingly popular since they enable decision makers to identify priority areas and to allocate their resources accordingly. An array of methods and spatial reporting units have been used to analyze and report deprivation in previous studies. However, a comparative analysis and assessment of the implications of the choice of the reporting unit for quality of life and health care accessibility planning is still missing. Based on a set of ten socioeconomic and health-related indicators, we constructed a weighted deprivation index for the urban area of Quito, Ecuador, using four different reporting units, including census blocks, census tracts, and two units based on the automatic zoning procedure (AZP). Spatial statistics and metrics are used to compare the resulting units, and a participatory expert-based approach is applied to evaluate their suitability for decision making processes. Besides structural differences regarding their size and shape, no strongly marked statistical or qualitative differences were found in the four analyzed spatial representations of deprivation. The four representations revealed similar spatial patterns of deprivation, with higher levels of deprivation in the peripheries of the city, especially in the southern and north-western parts. The study also suggests that census blocks, due to their fine spatial resolution, were considered most useful for quality of life and health care accessibility planning by local stakeholders.

1. Introduction

Deprivation indices are practical measures that can be used to identify areas characterized by socioeconomic marginalization and limited access to services, including inadequate access to clean water, household overcrowding, unemployment, lack of formal education, etc. (Cabrera Barona, Murphy, Kienberger, & Blaschke, 2015; Havard et al., 2008; Townsend, 1987). Evidence has also shown that people living in areas with a higher quality of life have a lower risk of developing health problems (Pampalon & Raymond, 2000; Stjärne, Ponce de Leon, & Hallqvist, 2004). Therefore, area-based deprivation indices, generally constructed from census data, have proven to be closely related to the health status of the population (Boyle, Gatrell, & Duke-Williams, 2001; Carstairs, 1995; Lalloué et al., 2013). The spatial analyses of socioeconomic disadvantages under a multidimensional perspective can hence further support policies and decision making aimed at reducing poverty, enhancing quality of life as well as the health status of the population (Alkire & Santos, 2013; Mideros, 2012; Schuurman, Bell, Dunn, & Oliver, 2007).

A wide range of studies have proposed and utilized different methods and techniques to construct deprivation indices, including principal component and multi-criteria analysis as well as participatory approaches (Bell, Schuurman, & Hayes, 2007; Bell, Schuurman, Oliver, & Hayes, 2007; Cabrera Barona et al., 2015; Folwell, 1995; Lalloué et al., 2013; Pampalon, Hamel, Gamache, & Raymond, 2009; Pasetto, Sampaolo, & Pirastu, 2010). However, less attention has been paid to addressing the influence of the choice of the reporting units or spatial representations of deprivation (Schuurman et al., 2007). However, the choice of the scale and the reporting unit can have both conceptual and practical implications that users should be aware of when taking decisions based on such indices (Hagenlocher, Kienberger, Lang, & Blaschke, 2014).

Oftentimes, neighborhoods have been used to evaluate the local

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place effects on health, and most of the previous deprivation studies have used administrative or census areas as the unit of analysis (Haynes, Daras, Reading, & Jones, 2007). However, since *a-priori* defined units do not capture the real spatial distribution/variability of deprivation, one could also aim to present the information in zones which are as internally homogeneous as possible in terms of deprivation.

One of the challenges when working with such aggregated data is the Modifiable Areal Unit Problem (MAUP) (Openshaw, 1984). The MAUP influences not only the results, but also how these results are interpreted (Marceau, 1999). It has two components: (1) the scale effect, and (2) the zoning effect. The scale effect occurs when the same data is grouped at different spatial resolutions (Openshaw & Taylor, 1979; Arbia & Petrarca, 2013), such as census blocks, districts or regions, etc. (Schuurman et al., 2007). The latter is a result of the fact that a set of spatial units, at the same scale, can be grouped in different ways (Openshaw, 1984; Schuurman et al., 2007) and this effect is not the result of the variation in the size of the units (Schuurman et al., 2007). The scale effect is also related to the population size, whereas the zoning effect is related to the construction of new zones' boundaries at a given scale (Haynes et al., 2007).

These two effects generate different results after a statistical analysis, and hence can have an important influence on decision-making (Schuurman et al., 2007). For this reason, the evaluation of whether the chosen reporting units or spatial representations of deprivation have any meaning for information users (e.g. decision makers, practitioners, etc.) becomes an important issue to consider (Haynes et al., 2007).

Despite the strong evidence of MAUP effects in different spatial representations of deprivation, there has not been much focus on the evaluation of their implications in deprivation literatures. We argue that understanding the MAUP effects in different regionalizations of deprivation is relevant for several practical issues, including the identification of ecological fallacies, the choice of the optimal scale of analysis, and the correct interpretation of the phenomenon of deprivation.

Against the background of the above described challenges, this study aims to analyze the effects of four different spatial representations of deprivation, including census blocks, census tracts and two Automated Zoning Procedure (AZP)-based zones. The overall goal of this work is hence to analyze whether important multiscale differences exist between different spatial representations of deprivation. To achieve this the following research questions are addressed: (1) do important statistical and structural differences exist between different spatial representations (reporting units) of deprivation?, and (2) do the different spatial representations of deprivation generate important differences regarding their interpretation by local experts?

To answer these questions, a mixed-methods approach is applied, consisting of a quantitative and a qualitative (participatory, expert-based approach) analysis of the four different representations of deprivation.

2. Methods

The study was carried out in Quito, the capital city of Ecuador (Fig. 1). Quito is located approximately 2800 m above sea level in the northern Ecuadorean Andes. The administrative urban area of the city comprises 34 urban Parishes and is home to more than 1.5 million inhabitants (INEC, 2010). Socioeconomic marginalization is still prevalent in some areas of Quito (Cabrera Barona et al., 2015). Even though significant improvements have been made in Ecuador in the field of healthcare compared to the past decades (Rasch & Bywater, 2014), socioeconomic disparities continue to exacerbate health inequalities, especially in marginalized communities (Parkes et al., 2009).

Fig. 2 shows the overall workflow of our study from the conceptualization of deprivation to its spatially explicit assessment based on a set of normalized, weighted indicators while using different reporting units. As indicated above, we selected two groups of units to represent deprivation in Quito: administrative units (census blocks and census tracts) and units based on zone design. The latter includes zones generated by applying the Automated Zoning Procedure (AZP) (Openshaw, 1977; Cockings & Martin, 2005), an approach that can be used to maximize the internal homogeneity of information within zones and the heterogeneity between them. The objective of using AZP-based zones is to have areas designed taking into consideration specific real phenomena, creating zones with different structural characteristics as compared to pre-defined artificial administrative areas. The AZP was considered useful for this study since the spatial datasets available are aggregated at census block and census tract level. Alternative regionalization methods that we could have used, such as the geon approach (Lang, Kienberger, Tiede, Hagenlocher, & Pernkopf, 2014) are based on the integration and analysis of gridded datasets.

2.1. Index construction at census block and census tract level

A deprivation index was constructed using a set of ten socioeconomic and health-related indicators (Table 1). They were chosen following a rights-based perspective that considers basic living conditions for human wellbeing (Cabrera Barona et al., 2015; Mideros, 2012; Ramírez, 2012) and their affinity to material and social deprivation as documented in previous deprivation studies (Cabrera Barona et al., 2015; Lalloué et al., 2013; Pampalon & Raymond, 2000; Pasetto et al., 2010; Stjärne et al., 2004). Four indicators represent population characteristics in the study area: i.e. (1) *percentage of the population that is disabled for more than a year*, (2) *percentage of the population that does not have any level of formal education or instruction*, (3) *percentage of the population that has no public social insurance (incl. health insurance)*, and (4) *percentage of the population that works without payment (unpaid jobs)*. Five additional indicators representing household conditions were also included in the analysis: (5) *percentage of households with four or more persons per dormitory (overcrowding)*, (6) *percentage of households without access to drinking water from the public system*, (7) *percentage of households without access to the sewerage system*, (8) *percentage of households without access to the public electricity grid*, and (9) *percentage of households without garbage collection service*. Finally, (10) the *distance to the nearest primary healthcare service (in meters)* was used as an indicator for access to healthcare. Data for these indicators were extracted from the 2010 Ecuadorian Population and Housing Census (INEC, 2010) at the census block level. Since the raw data were expressed in absolute numbers, the datasets were transformed into percentages. After normalizing the indicators using min–max normalization, multicollinearities in the data were evaluated based on variance inflation factors (VIF) (OECD, 2008). All VIF values obtained were smaller than five, indicating that all indicators could be used for the construction of the deprivation index. Indicator weights were calculated by means of principal component analysis (PCA) following guidelines published by the OECD (2008). The significance of the Bartlett's test of sphericity was lower than 0.05, which enabled us to run the PCA. The final weights were re-scaled to sum up to one (Table 1).

In addition to collecting data at census block level, we also extracted data for the above mentioned indicators at the census tract level. A census tract area is formed by the union of census blocks. For both levels, i.e. census blocks and census tracts, the