Using consumer and public service data for determine accessibility to healthy places in Great Britain

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Summary

Our study details the creation of a series of national open source low-level geographical measures of accessibility to health-related features of the environment. There are three main domains across our indicators: retail services, health services and the physical environment. Using the network analysis process of Routino, this study analyzed postcode accessibility to retail and health services in the whole of Great Britain. The three domains combined to form an overall '*Index of Accessibility to Healthy Choices*' which highlights access to 'healthy' areas. We find the most accessible healthy areas are concentrated in the periphery of the urban cores, whilst the least accessible healthy areas are located in the urban cores and the rural areas.

KEYWORDS: Accessibility; Healthy Geography; Network Analysis; Open Data.

1. Introduction

Geographical inequalities in health outcomes have been long observed, and research has shown that neighbourhoods themselves may also contribute to these inequalities. Developing indicators to measure the multidimensional features for how geography may influence health is important for informing future research and policy applications. Data limitations usually limit analyses to a subset of indicators taken in isolation, large geographical zones, or a specific city/region. Our study builds on previous research through detailing the development of a set of national low-scale open source indicators for measuring the 'healthiness' of areas. There are three main domains across our indicators: retail services, health services and the physical environment which are combined to form an overall Index of Accessibility to Healthy Choices (IAHC).

2. Background

2.1. Retail services

Poor diets and alcohol misuse represent important determinants for ill health. Numerous studies have demonstrated an association between the density of fast food outlets and poor dietary behaviours and/or obesity (Burgoine et al., 2014), as well as similarly for the density of alcohol outlets and alcohol-related harms (Livingston, 2011). As such, we include indicators of accessibility to 'fast food outlets' and 'pubs, bars and nightclubs'. We also include other retail services that provide access to both healthy and unhealthy choices including 'supermarkets' and 'gambling outlets'.

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2.2. Health services

Health care services provide important point of care services for diagnosis, treatment and maintenance of health. However, there are spatial inequalities in their location (Macintyre et al., 2008) and accessibility has been demonstrated to be associated with the utilisation of a service (McLafferty, 2003). We include measures of accessibility to GPs, A&E hospitals, pharmacies and dentist practices to cover primary and secondary health care. We also include accessibility to leisure services, which while are not health services, offer individuals the opportunity to exercise which is important for promoting healthy lifestyles.

2.3. Physical environment

We measure three aspects of the physical environment which have demonstrated consistent associations to health and health-related behaviours: green space, air pollution, and walkability. Access to green space has shown to be associated with improved mental wellbeing, higher levels of physical activity and lower mortality rates (Mitchell and Popham, 2008). Air pollution is associated with respiratory health and forms an important determinant of geographical inequalities (Richardson et al., 2013). We include DEFRA estimates of PM10, NO2 and SO2 levels. Finally, features of the built environment such as the street networks have been shown to encourage walking and levels of physical activity which promote health (Sallis et al., 2016).

3. Data and Methodology

Data on all retail businesses throughout Great Britain were provided by the Local Data Company (LDC). The data includes records for every operating retail business including a classification of retail type (e.g. fast food outlets, pubs, bars and nightclubs, gambling outlets, supermarkets) and the postcode of the store. The LDC dataset was found to undercount supermarkets and to address any bias we acquired missing supermarket locations from a open dataset provided by the Geolytix for. Openly available data from NHS Digital, Information Services Division (ISD) in NHS Scotland and DEFRA were collected for information on the location of health services (GP Practices, A&E hospitals, Pharmacies and Dentists) and air pollution (air pollutants: NO2, PM10 and SO2) respectively. Finally, we acquired information on park locations from the Open Street Map (OSM) and road networks from OS Open Roads. The density of road networks was used as proxy measures of walkability based on previous research (Sallis et al., 2016).

Accessibility to each of our indicators (other than some features of the physical environment which are less relevant) have been created using the Routino open source tool. Routino[†] is an application for finding a route between two points using the OSM road network and takes into account restrictions on roads as well as tagged speed limits and barriers. In this study, we measured the network distance between the centroid of each postcode in Great Britain and the coordinates of the nearest service (e.g. postcode centroid of GP practice). The overall process of calculating network distances for about 2 million postcodes in Great Britain is cpu-intensive. Therefore, we have implemented a parallelization framework using 10 Docker containers which run Routino instances in parallel for subsets of 200,000 GB postcodes. This way, we archived a significant decrease of the processing time to about 8 hours per indicator.

Measured network distances for each indicator for postcodes were aggregated to the LSOA level providing average network distances for each indicator (as a measure of accessibility). All other indicators were also summarised for LSOAs. The indicators within each domain were standardised by ranking and transformed to the standard normal distribution. The direction of each variable was dictated by the literature (e.g. accessibility to fast food outlets were identified as health negating, whereas accessibility to parks was health promoting see Table 1). The maximum likelihood factor analysis

[†] https://www.routino.org/

technique was used to generate the weights to combine the indicators into the domain score.

To calculate our overall index (and domain specific values), we followed the methodology of the 2015 IMD (Smith et al., 2015). For each domain, we ranked each domain R and any LSOA scaled to the range [0,1]. R=1/N for the most 'health promoting' LSOA and R=N/N for the least promoting, where N is the number of LSOAs in Great Britain. Exponential transformation of the ranked domain scores was then applied to LSOA values to reduce '*cancellation effects*' (Smith et al., 2015). So, for example, high levels of accessibility in one domain are not completely cancelled out by low levels of accessibility in a different domain. The exponential transformation applied also puts more emphasis on the LSOAs at the end of the health demoting side of the distribution and so facilitates identification of the neighbourhoods with the worst health promoting aspects. The exponential transformed indicator score X is given by:

$$X = -23 \ln \left(1 - R(1 - exp^{-100/23})\right)$$

where *'ln'* denotes natural logarithm and *'exp'* the exponential transformation.

The main domains across our indicators: retail services, health services and the physical environment then were combined to form an overall 'Index of Accessibility to Healthy Choices' (IAHC).

Table 1. Indicator weights generated by factor analysis for each domain of IAHC index.

Domain	Indicator	Indicator weight	Health promoting	
			Low value	High value
Retail Services	Accessibility to Fast food outlets	0.24	-	+
	Accessibility to Gambling outlets	0.30	-	+
	Accessibility to Supermarkets	0.20	+	-
	Accessibility to Pubs, bars and nightclubs	0.26	-	+
Health Services	Accessibility to GP practices	0.25	+	-
	Accessibility to A&E hospitals	0.10	+	-
	Accessibility to Pharmacies	0.24	+	-
	Accessibility to Dentist practices	0.26	+	-
	Accessibility to Leisure services	0.15	+	-
Physical Environment	Street junctions' density	0.07	-	+
	Accessibility to Green spaces (Parks)	0.08	+	-
	Nitrogen Dioxide (NO2)	0.46	+	-
	PM_{10} Particles	0.26	+	-
	Sulphur Dioxide (SO2)	0.13	+	-

4. Results

Figure 1 illustrates the quintiles of the three domains (retail services, health services and physical environment) and the overall '*Index of Accessibility to Healthy Choices*' where the 1st and 5th quintiles highlights better and worse access to services respectively. The domain quintiles for access to retail services (map 1a) show the greatest access to retail services in urban areas particularly city centres where there is a concentration of fast food outlets, gambling outlets and bars. The pattern contrasts with the outer suburbs and rural areas which have poorer access and hence are identified as 'heathier'. Accessibility to health services (map b) follows a similar pattern, albeit the interpretation is reversed as city centres have good accessibility which is health promoting. The final domain, physical environment (map 1c), demonstrates healthier areas are located in the outer suburbs, with city centres performing poorly again. The overall index (map 1d) combines the information from each domain, showing that the 'healthiest' areas are concentrated in the periphery of the urban cores, whilst the least accessible healthy areas located in the urban cores and the rural areas.

5. Conclusions

Our study details the creation of a series of national open source low-level geographical measures of accessibility to health-related features of the environment. These measures combined to create an index of 'healthiness' for areas ('*Index of Accessibility to Healthy Choices*') and help summarise the complex geographical patterns demonstrated across our indicators. The importance of the index, and each subsequent domain and input, will be investigated to understand the contribution of neighbourhood features to influencing the health of individuals.

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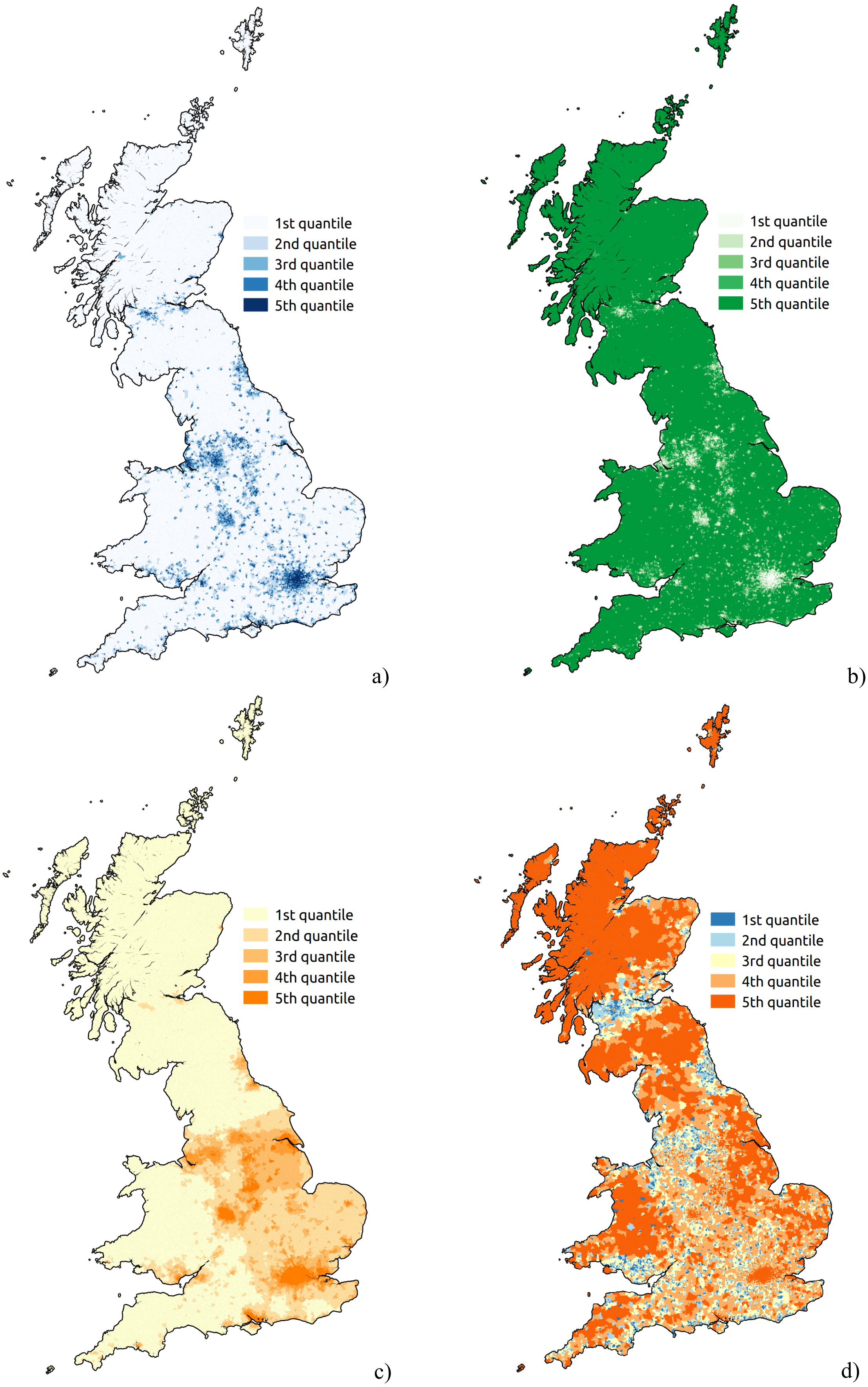

Figure 1 Quintiles of healthy places in GB: a) Retail services domain, b) Health services domain, c) Physical environment domain and d) Index of Accessibility to Healthy Choices.