# Manuscript Details

| | |
|---|---|
| **Manuscript number** | JAPG_2019_34_R2 |
| **Title** | Spatial inequality and its relationship with local food environments: the case of Barcelona |
| **Article type** | Full Length Article |

**Abstract**

Unhealthy dietary habits are affecting negatively the health status of citizens throughout the world. Reversing unequal local food environments, in terms of physical accessibility to food stores with healthy items, can be an effective way to mitigate the poor eating habits of the population and contribute to the sustainability of agri-food systems. The main objective of this study is to explore the characteristics of local food environments in the city of Barcelona (Catalonia, Spain), and to analyse the existence of sociodemographic inequalities in the access to food stores with or without supply of organic products. Based on an official database of commercial premises and on additional information, 7,983 food stores have been identified and classified, 471 (5.9%) of which supply organic food. Spearman's Rho correlation and Local Indicator of Spatial Association (LISA) analyses are applied to investigate the global and local relationships between food access and two sociodemographic variables, namely Household Income Index and percentage of non-Spanish inhabitants. Results demonstrate that, even though total food access and organic food access are positively influenced by the socioeconomic level of the neighbourhoods, this is not the case in some areas of the city, where other factors might be more influential. Our findings emphasise the importance of local food environments in shaping health, and the need to promote its equality across different socioeconomically segregated areas to counterbalance negative effects on the health of vulnerable populations.

| | |
|---|---|
| **Keywords** | Local food environments; accessibility; organic food; spatial inequality; Barcelona |

| | |
|---|---|
| **Corresponding Author** | Xavier Garcia |
| **Corresponding Author's Institution** | Institute of Regional and Metropolitan Studies of Barcelona |
| **Order of Authors** | Xavier Garcia, Marta Garcia-Sierra, Elena Domene |

## Submission Files Included in this PDF

**File Name [File Type]**

Cover letter.docx [Cover Letter]

responsetoreviewers_191203.docx [Response to Reviewers (without Author Details)]

Highlights.docx [Highlights]

Title page.docx [Title Page (with Author Details)]

food_env_BCN_191203.docx [Manuscript (without Author Details)]

Author statement_191203.docx [Author Statement]

To view all the submission files, including those not included in the PDF, click on the manuscript title on your EVISE Homepage, then click 'Download zip file'.

# Spatial inequality and its relationship with local food environments: the case of Barcelona

Xavier Garcia, Marta Garcia-Sierra, Elena Domene

Institute of Regional and Metropolitan Studies of Barcelona, Autonomous University of Barcelona, Plaça del Coneixement, Edifici MRA, planta 2, Campus UAB, 08193 Bellaterra, Spain

Email addresses: xavier.garcia.acosta@uab.cat; marta.garcia.sierra@uab.cat; elena.domene@uab.cat

Author to whom correspondence should be addressed:

Dr. Xavier Garcia

Institute of Regional and Metropolitan Studies of Barcelona, Autonomous University of Barcelona, Plaça del Coneixement, Edifici MRA, planta 2, Campus UAB, 08193 Bellaterra, Spain

Tel.: +34 935 868 862

Email: xavier.garcia.acosta@uab.cat

**Acknowledgements**

This work was supported by Àrea Metropolitana de Barcelona through the Contract Program 2017-2019 AMB-IERMB (action 5.2.1 of project 2018).

**Highlights**

- A total of 7.983 food stores in Barcelona are classified in 11 categories.
- The 5.9% are stores with organic food available.
- Neighbourhoods with a larger proportion of non-natives have better food access.
- Access to organic food is driven by socioeconomic status of neighbourhoods.
- Bivariate LISA shows that there are areas of the city where this is not applicable.

**Abstract**

Unhealthy dietary habits are affecting negatively the health status of citizens throughout the world. Reversing unequal local food environments, in terms of physical accessibility to food stores with healthy items, can be an effective way to mitigate the poor eating habits of the population and contribute to the sustainability of agri-food systems. The main objective of this study is to explore the characteristics of local food environments in the city of Barcelona (Catalonia, Spain), and to analyse the existence of sociodemographic inequalities in the access to food stores with or without supply of organic products. Based on an official database of commercial premises and on additional information, 7,983 food stores have been identified and classified, 471 (5.9%) of which supply organic food. Spearman's Rho correlation and Local Indicator of Spatial Association (LISA) analyses are applied to investigate the global and local relationships between food access and two sociodemographic variables, namely Household Income Index and percentage of non-Spanish inhabitants. Results demonstrate that, even though total food access and organic food access are positively influenced by the socioeconomic level of the neighbourhoods, this is not the case in some areas of the city, where other factors might be more influential. Our findings emphasise the importance of local food environments in shaping health, and the need to promote its equality across different socioeconomically segregated areas to counterbalance negative effects on the health of vulnerable populations.

**Keywords:** Local food environments; accessibility; organic food; spatial inequality; Barcelona

## 1. Introduction

There are renewed social and academic concerns over spatial inequality worldwide. The global financial crisis, which started in 2008, and the growing globalization of labour and capital are major culprit (Wei 2015; Zwiers et al., 2016). On the one hand, the financial crisis has more severely affected disadvantaged households and exacerbated poverty (van Lanen, 2017). On the other hand, globalization and post-Fordist economic restructuring has mostly benefited higher-ranked socioeconomic groups, as they receive a greater proportion of total earnings (Reardon and Bischoff, 2011). These phenomena have thus risen income and wealth disparity and fuelled spatial inequality.

Literature on spatial segregation effects suggests that the mere fact of residing in poverty concentration neighbourhoods may involve negative impacts on their residents' education, occupational status or health (van Ham et al., 2018). Concerning health neighbourhood effects, it has been demonstrated that mortality from preventable death causes is higher in neighbourhoods with low socioeconomic status (Hoffmann et al., 2014) and that poorer dietary habits might be partly responsible (Schwingshackl and Hoffmann, 2015). Among the different neighbourhood effects mechanisms (as classified by Galster [2012]) that can explain this negative eating behaviours, the "Local Market Actors" institutional mechanism is of particular significance. This mechanism would explain the substantial spatial variations in the prevalence of many sorts of market actors whose proximity may influence on health-related behaviours of neighbourhood residents, such as smoking, alcohol consumption, or diet. In this sense, there is a growing body of research that aims to demonstrate that socioeconomically segregated urban areas have unequal local food environments, and that this may imply nutrition-related health issues (Ball et al., 2009; Gordon et al., 2011; Howlett et al., 2016; Morland and Evenson, 2009; Morland et al., 2006; Powell et al., 2007). Local food environments "*comprise the foods available to people in their surroundings as they go about their everyday lives and the nutritional quality*, *safety*, *price*, *convenience*, *labelling and promotion of these foods*" (FAO, 2016). Therefore, local food environments influence the options available to individuals and families, and thus food choices. The objective of this study is to analyse the local food environments of the city of Barcelona (Spain), considering the access to conventional food stores, and those that predominantly or partly sell organic food. In addition, we will explore the influence of sociodemographic factors on access to conventional and organic food. Concretely, and in line with previous research, ethnicity and socioeconomic dimensions of food access in the city are explored.

Subsequently in this introduction, we argue that increasing the access to stores with organic food may increase in consumption of healthy organic foods, support healthy dietary habits and the transition to more sustainable food systems, and thus have a positive impact on both health and the environment. The remainder of this article is structured as follows. Section 1.2 outlines the main motivations to consume organic food. Section 1.3 reviews the literature on inequalities in healthy food access and health implications. Section 2 introduces the methodology. Section 3 presents the results of the empirical analyses. Section 4 discusses these results and their implications, and section 5 concludes.

### *1.1. Reasons for consuming organic food*

Organic farming is a food production system that relies on environmentally sound techniques and avoids the use of synthetic chemicals for the management of nutrients and pests. In the last years, Europe's demand of organic products has continued to increase. From 2015 to 2016, the European organic food market raised up by 11.4% (Willer et al., 2018), and by 10.5% in the following year (Willer et al., 2019). The main factors that explain this growing demand for organic food are the health concerns of the population and the perceived notion that organic food is more natural and healthier (Brantsæter et al., 2017; Nasir and Karakaya, F. (2014); Padel and Foster, 2005). Environmental concerns, animal welfare, sensory appeal or local production, are also important factors that may influence consumption of organic food (Annunziata and Vecchio, 2016; Lockie et al., 2002).

Despite the perceived benefits of consuming organic foods, a number of research studies have been conducted to verify these claims. In this line, it has been proved that there are some compositional differences between organic and conventionally produced food. Organic food has a higher concentration of several nutrients compared to conventional food, such as vitamin C, antioxidants and minerals, among others (Hunter et al., 2011; Orsini et al., 2016). In addition, detectable pesticides residues are more commonly found in conventionally produced food. However, there is still a lack of evidence supporting that these differences can be causally related to any objectively measurable improvement in human health (Brantsæter et al., 2017; Magkos et al., 2006; Williams, 2002). Concerning the environmental benefits of opting for organic consumption, given that the use of most pesticides is prohibited in organic farming, impact on biodiversity caused by ecotoxicity is minimized (Bengtsson et al., 2005).

In any case, a growing body of academic opinion suggests that betting for more technologically advanced and multifunctional organic farming systems will be vital to reduce the environmental impacts of food production, and to achieve food security in the near future

(Guzmán et al., 2011; Ponisio et al., 2015; Seufert et al., 2012). Hence, encouraging the consumption of organic food might be a rational health and environmental policy initiative in urban areas. In addition, if this initiative gives preference to the consumption of organic healthy items, such as fruits and vegetables, indirect health benefits will be gained as well (Slavin and Lloyd, 2012). However, there are barriers to its consumption. The price premium of organic food products influences negatively on the purchase frequency of this kind of produce (Vittersø and Tangeland, 2015). Another principal barrier to the development of organic food markets is the lack of access to organic products (Aertsens et al., 2009; Li et al., 2018; Vittersø and Tangeland, 2015). Therefore, enhancing the access to these products can significantly contribute to increase their consumption, and even lead to lower prices due to more competition in the sector.

### *1.2. Food access inequalities and health implications*

A large body of academic studies have focused on the role of physical accessibility to food on nutrition and health. According to these studies, mostly conducted in US cities, unsuitable access to food stores with healthy products is related to poorer dietary habits (Black et al., 2014; Caspi et al., 2012; Laraia et al., 2004;). This limited access to food and its consequent negative dietary behaviours can adversely affect citizens' health (Howlett et al., 2016; Morland and Evenson, 2009; Morland et al., 2006; Powell et al., 2007). This issue is aggravated in the areas called "food deserts". Food deserts might be simply described as areas with poor access to food stores with healthy options (Clarke et al., 2002; Yeager and Gatrell, 2014), or involve a sociodemographic component, namely access being modulated by socioeconomic status or ethnicity (Cummins and Macintyre, 2002; Smoyer-Tomic et al., 2006).

Research has shown that often low income or ethnic minority neighbourhoods have significantly poorer access to healthy food in comparison with predominantly white and wealthier neighbourhoods. Consequently, this may be inhibiting their residents from making health dietary choices (Ball et al., 2009; Gordon et al., 2011; Powell et al., 2007). Moreover, it has also been found that disadvantaged neighbourhoods have significantly more access to stores with less healthy food available (e.g. convenience stores), so-called "food swamps", with possible negative effects on their health (Galvez et al. 2010; Hager et al., 2017). However, the relationship between the socioeconomic status of a neighbourhood and accessibility to supermarkets or other stores with healthy food options has not always been consistent, particularly outside the US. The less pronounced residential segregation of non-US cities can be an explanation for the similarity in the access to supermarkets in neighbourhoods with

different ethnical and socioeconomic backgrounds (Helbich et al., 2017; Macdonald et al., 2009; Smoyer-Tomic et al., 2006).

Lastly, gentrification processes could have enhanced the access to supermarkets and other specialty format stores in poorest inner-city neighbourhoods (Smoyer-Tomic et al., 2006). Yet, in these areas food prices can be a factor of exclusion and social divide since these expensive stores would be unaffordable for low-income families (Breyer & Voss-Andreae, 2013). Either way, increasing access to food stores offering greater availability and variety of healthy foods, such as organic food stores, can have a positive impact on healthy eating habits of the population (Morland and Filomena, 2007; Menezes et al., 2017; Weatherspoon et al., 2015; Zenk et al., 2009).

## 2. Method

The city of Barcelona was selected as case study. Barcelona is the second most populated city in Spain with over 1.6 million inhabitants. In addition, it is visited annually by 8.3 million tourists.

As in other cities of the Mediterranean region (CIHEAM/FAO, 2015), unhealthy dietary habits have also emerged in Barcelona. A recent local study has revealed that only 11.7% of citizens comply with the dietary recommendation of eating five or more portions of fruits and vegetables per day (ASPB, 2016), an indicator of adherence to a Mediterranean diet. This percentage decreases to 6.6% (ASPB, 2016) for children under 14 years of age. Another recent study in Catalonia (the region where Barcelona is located) has shown that higher socioeconomic groups tend to adopt a proper Mediterranean diet and consume less energy-dense foods (GENCAT, 2018). The findings of these studies highlight the need to implement measures that encourage greater consumption of healthy foods in the city (i.e. fruits, vegetables and other products commonly used in the Mediterranean diet), instead of increasingly providing energy-dense and nutrient-poor foods, especially in socially deprived areas.

Barcelona is a traditional Mediterranean compact city characterized by high population densities and mixture of urban land uses (Monclús, 1998). This may imply more equal physical accessibility to food stores than in US cities, but no research has yet been conducted to corroborate it. In addition, recent statistics point to the influence on dietary behaviour of local food environments in Barcelona. For instance, it has been reported that 85.5% of the citizens of Barcelona walk to buy fresh food (AB, 2017a). Also, between 91-97% (depending on the

food type) do their main food shopping in proximity, that is, in stores within the neighbourhood of residence (AB, 2017b).

The city of Barcelona is administratively divided into 10 districts and 73 neighbourhoods (Fig. 1), which present wide sociodemographic disparities as pointed out by recent studies (Lara Navarro-Varas et al., 2018). The districts of Ciutat Vella (the old city) and Eixample are considered the centre of the city.

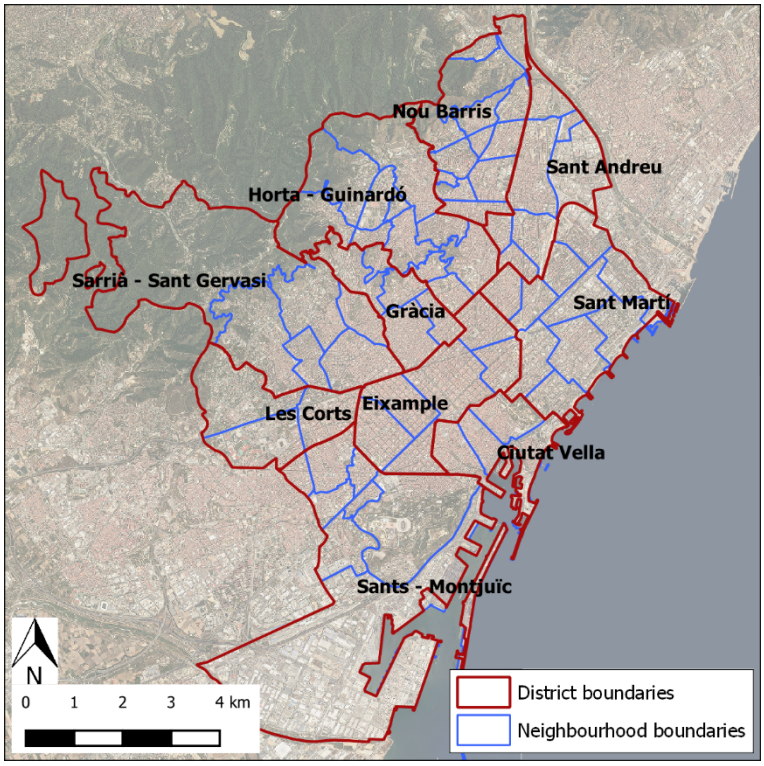



**Figure 1. District and neighbourhood boundaries of Barcelona.**

### *2.1. Food stores data source and classification*

Data on food stores location in the city of Barcelona for 2016 was obtained from the *Commercial premises' inventory of Barcelona* (AB, 2016). This database provides information, as well as the spatial location, of all the existing ground floor commercial premises in the city (n = 78,033). Based on this information and other complementary sources, 11 food store categories were created depending on the size, the opening hours, and the availability of fresh organic products. Table 1 offers a summarised description of these food store categories. These were: *convenience stores*, *small specialized stores*, *municipal market stands*, *small organic stores*, *supermarkets*, *supermarkets with organic*, *organic supermarkets*, *hypermarket*, *hypermarkets with organic*, *weekly markets*, and *organic weekly markets*.

To an important extent, *small organic stores* and *organic supermarkets* classification was based on the information from a participatory GIS project carried out by the City Council of Barcelona (BS, 2018). Additionally, when classifying food stores, we followed a sequential process consisting of the subsequent steps: (1) we searched for the terms “eco”, “bio”, “natur” and “organic” in the store’s name field of the database; (2) we applied a direct search with Google® engine using the key terms “food” OR “supermarket” OR “store” AND “organic” OR “bio” OR “natural”, both in Catalan and in Spanish languages; and (3) we applied a deductive search based on the store name (e.g. unusual names such as “Monmax” or “Giotiga”). The existence and location of each of the stores was subsequently confirmed using Google® and Google Street View®, using the function of selection of images from the past.

Supermarkets of well-known supermarket chains operating in Spain were identified in the store’s name field of the database. Besides, other less-known supermarkets of smaller chains were identified by searching stores with their name repeated in the store name’s field three or more times. Subsequently, the existence of less known local and regional supermarket stores was confirmed in Google®. In total, 37 supermarket chains were identified, of which four were classified as *organic supermarkets*. The category *supermarkets with organic* was formed based on the availability of fresh organic products in 2016, concretely fruits and vegetables. This information was obtained and confirmed by contacting the supermarket chain’s customer service. When this previous step was not possible, we contacted by telephone up to three stores of the same chain. If we still could not confirm the offer of fresh organic products (fruits and vegetables), at least one store of the chain was visited, and the shopkeeper enquired. In total 10 out of 33 supermarket chains were classified as *supermarkets with organic*.

The identification of *convenience stores* was also based on a systematic procedure. This is a relatively new typology of store that has surged with the last immigration wave to Barcelona (Güell, 2017). The stores that had foreign names were entered in this category (e.g. “Ahmed Groceries” or “Malik Foods” [in Catalan]). Complementarily, a deductive search based on the store’s name was also applied (e.g. simple names such as “Supermarket 24 H”, or “Mini Supermarket” [in Catalan]). The classification was further verified based on the aesthetics of the store facade viewed through Google Street View®, using again the function of selection of images from the past.

*Hypermarkets* and *municipal market stands* already had a category defined in the database. The rest of food stores in the database were classified as *small specialised stores*. Finally, the information about location and type of *weekly markets* or *organic weekly markets* were

obtained from another participatory GIS project (Mercatsetmanal.cat, 2018), and added to the spatial dataset.

| Food store categories | Description |
|---|---|
| *Convenience stores* | Small sized and generalist (wide and shallow assortment) food stores mostly managed by non-Spanish. It is also characterized by very broad opening hours. |
| *Small specialized stores* | Small sized and specialised food stores (e.g. bakeries, butcher shop, fish shop, etc.). It also includes delis, ready-made food stores and ethnic food stores. |
| *Municipal market stands* | Small sized and specialised food stores but located within a municipal market. |
| *Small organic stores* | Small sized and generalist organic food stores |
| *Supermarkets* | Medium sized and generalist food stores |
| *Supermarkets with organic* | Medium sized and generalist food stores with organic food available |
| *Organic supermarkets* | Medium sized generalists organic food stores |
| *Hypermarket* | Large sized and generalist food stores |
| *Hypermarkets with organic* | Large sized and generalist food stores with organic food available |
| *Weekly market* | Outdoor market in a public space that take place once a week. |
| *Organic weekly market* | Outdoor organic market in a public space that take place once a week. |

**Table 1. Food store categories and description.**

### 2.2. *Food access of Barcelona neighbourhoods*

Spatial accessibility to the different food store categories was measured by applying kernel density estimations. This is a commonly used method to evaluate the local density of geographically referenced point data (in this case food stores), in which density estimations are weighted by distance from the point of interest within the search radius (Menezes et al., 2017; Moore et al., 2008). The selected Kernel function was quartic and the bandwidth was fixed to 650 meters. In the particular context of Barcelona, this distance has been defined for short journeys, that is, those that can be covered walking in less than 10 minutes (assuming an average speed of 4 km/h) (Marquet and Miralles-Guasch, 2014). The spatial unit of analyses is the neighbourhood (in Barcelona n = 73). This is the smallest administrative unit with updated sociodemographic information available.

The sum of the kernel density estimates in the raster cells within the boundaries of the neighbourhoods was calculated for each food store category. However, since Barcelona is a Mediterranean city with a quite heterogenous distribution of land uses, this sum was only applied in residential land use covers within the neighbourhood boundaries. In high-density urban areas, food stores spatial distribution is strongly determined by population density (Morland and Filomena, 2007). Thus, the sum of the kernel density estimates in each neighbourhood was divided by the number of inhabitants in order to obtain more realistic estimates of accessibility to food stores.

Apart from kernel densities, food store categories were weighted differently according to two other relevant food access criteria in urban areas, namely opening hours and store surface. Opening hours are a very important aspect of accessibility, especially in Spain, due to its well-known unbalanced work-life routine characterized by long work shifts that can end at 8-9 pm (Medina et al., 2012). Surface, on the other hand, reflects the capacity of the store to sell a wider variety of food items. Indeed, previous studies have shown that the surface of food stores is a good *proxy* of availability and variety of healthy food items (Farley et al., 2009). Other food access studies have applied similar weighting systems in order to consider access variability of different food stores (Dai and Wang, 2011; Yeager and Gatrell, 2014). Table 2 shows the opening hours and the surface differences between the various categories, as well as the final weight applied according to both criteria. After applying the corresponding final weights, two aggregated food access variables were calculated: *organic food access* (*OrganicFA*) and *total food access* (*TotalFA*). The former only aggregates the access values of the food store categories with organic food items available, that is; *small organic stores*, *supermarkets with organic*, *organic supermarkets*, *hypermarkets with organic*, and *organic weekly markets*. The later includes the access values of the organic food stores, as well as the food stores without organic food items available, that is all the categories listed in table 1.

| Food store categories | Surface | | Opening hours | | Final weight* |
|---|---|---|---|---|---|
| | Approx. $m^2$ | Weight | Hours/week | Weight | |
| *Convenience stores* | 40 – 400 | 2 | 98 | 14 | 2.31 |
| *Small specialized stores* | 40 – 400 | 2 | 48 | 6.86 | 1.61 |
| *Municipal market stands* | 20 – 100 | 1 | 38 | 5.43 | 1.00 |
| *Small organic stores* | 40 – 400 | 2 | 48 | 6.86 | 1.61 |
| *Supermarkets* | 400 – 2500 | 7 | 72 | 10.29 | 4.29 |
| *Supermarkets with organic* | 400 – 2500 | 7 | 72 | 10.29 | 4.29 |
| *Organic supermarkets* | 400 – 2500 | 7 | 72 | 10.29 | 4.29 |
| *Hypermarkets* | > 2500 | 15 | 72 | 10.29 | 8.05 |
| *Hypermarkets with organic* | > 2500 | 15 | 72 | 10.29 | 8.05 |
| *Weekly markets* | 400 – 2500 | 7 | 7 | 1 | 3.39 |
| *Organic weekly markets* | 400 – 2500 | 7 | 7 | 1 | 3.39 |

Note: Surface and opening hours information has been obtained from the Catalan Government Law 18/2017, of August 1, on trade, services and fairs. Also, expert knowledge was required.

* The final weight is applied with a weight of 8/10 to the surface criterion and 2/10 to the opening hours criterion.

**Table 2. Surface and opening hours of the different food stores and applied access weights.**

### *2.3. Data analysis*

To test if there are ethnicity or socioeconomic inequalities in food access in the city of Barcelona, two variables were obtained at the neighbourhood level from the Department of Statistics and Dissemination of Data of the Barcelona City Council (AB, 2018). One is the Households Income Index (*HI_index*) for 2016. This is an estimated indicator of average households' income based on the weighting of different variables, which allows to know the socioeconomic position of each one of the neighbourhoods in relation to the city average (Barcelona *HI_index* value is set at 100). The second is the percentage of non-Spanish inhabitants (*perc_nonS*) living in the neighbourhood in 2016. In Barcelona, non-Spanish residents (*perc_nonS*) represented 16.6% in 2016.

The nature and magnitude of the correlation of these two sociodemographic variables and the food access variables (*OrganicFA* and *TotalFA*) was tested by means of Spearman's Rho non-parametric test, given the non-normal distribution of most of the variables. We defined r values higher than |0.5| as representing strong correlations, r values between |0.5| and |0.3| as representing moderate correlations, and r values lower than |0.3| as representing weak correlations.

Furthermore, this study was also aimed at exploring the spatial distribution of food access across the city, and more concretely, the existence of spatial clusters of neighbourhoods with similarly high or low values of the food access estimates, with and without relation to the sociodemographic characteristics of the neighbourhoods. For this purpose, the univariate and bivariate version of the Local Indicator of Spatial Association (LISA) analyses were applied. Univariate LISA, based on local Moran's I index, is used to identify either spatial clusters or outliers in a given variable (Anselin, 1995). This analysis was applied with both the *OrganicFA* and *TotalFA* variables. This spatial autocorrelation analysis was used to identify neighbourhoods with a high food access value in a high food access area (*High-High*) or neighbourhoods with a low food access value in a low food access area (*Low-Low*). On the other hand, spatial outliers can also be found, that is, cases of neighbourhoods with a high food access value in a low food access area (*High-Low*) or neighbourhoods with a low food access value in a high food access area (*Low-High*).

The extended bivariate version of LISA has been developed to analyse spatial correlations between one variable at a location and a different variable at the neighbouring locations (Anselin et al., 2002). We also used this methodology to analyse access inter-neighbourhood inequalities based on sociodemographic characteristics. The resulting maps show neighbourhoods with significant spatial correlations between food access and

sociodemographic variables, either in the same vein of the general correlation or showing contrasting local associations between both types of variables. For instance, a neighbourhood with a high value of *TotalFA* where values of *HI_index* are high will be depicted as *High-High* in the map. A neighbourhood with a low value of *OrganicFA* where values of *perc_nonS* are high will be showed as *Low-High*.

When analysing the spatial relationship between neighbourhoods through LISA, it was necessary to establish the limits of what is considered "neighbouring" neighbourhoods. In this case, and due to the spatial isolation of certain neighbourhoods, we used a Queen's approach from Thiessen polygons obtained from the centroids of the neighbourhoods (Anselin and Rey, 2014).

## 3. Results

In 2016, Barcelona had 7,983 food stores that can be classified according to the proposed categories (see Table 1). The most frequent category corresponds to *small specialized stores* (43.48%), followed by *municipal market stands* (26.09%) (Table 3). The least frequent categories are *hypermarkets* (n = 3) and *weekly markets* (n = 7). Concerning stores with organic products (n = 471; 5.90%), there were 233 *supermarkets with organic* (2.92%), 166 *small organic stores* (2.06%), and 48 *organic supermarkets* (0.60%). In what refers to supermarkets and hypermarkets (i.e. *supermarkets*, *supermarkets with organic*, *organic supermarkets*, *hypermarkets*, *hypermarkets with organic*), we listed 882 stores. Supermarkets and hypermarkets are the most commonly reported categories of stores in the literature on food environments, and their density allows comparison with results from other case studies.

| Food store categories | n | % |
|---|---|---|
| *Convenience stores* | 1,366 | 17.11 |
| *Small specialized stores* | 3,471 | 43.48 |
| *Municipal market stands* | 2,083 | 26.09 |
| *Small organic stores* | 166 | 2.08 |
| *Supermarkets* | 582 | 7.29 |
| *Supermarkets with organic* | 233 | 2.92 |
| *Organic supermarkets* | 48 | 0.60 |
| *Hypermarket* | 3 | 0.04 |
| *Hypermarkets with organic* | 16 | 0.20 |
| *Weekly market* | 7 | 0.09 |
| *Organic weekly market* | 8 | 0.10 |

**Table 3. Frequency and percentage of food store categories in Barcelona in 2016.**

With respect to food access variables *OrganicFA* and *TotalFA* (Fig. 2), the city centre (especially in the districts of Eixample and Gràcia) is the area that concentrates the highest values of *OrganicFA* (quintile 5). On the contrary, the western, eastern and northeaster areas show very low values of *OrganicFA* (quintile 1) (Les Corts, Nou Barris, Sant Andreu and Sant Martí). The spatial distribution of total food access (*TotalFA*) is similar. However, the highest values (quintile 5) are instead found on the coastal neighbourhoods from the city centre (Ciutat Vella and Example). Regarding *HI_index*, it can be appreciated in the map that most affluent neighbourhoods are located in the centre-west area of Barcelona and the centre-east coastal areas (Sarrià-Sant Gervasi, Les Corts, Eixample and Gràcia). Most deprived neighbourhoods are located in the north (Nou Barris and Sant Andreu). Most non-Spanish residents inhabit centre-south areas, eastern and northern areas of the city (Sants-Montjuïc, Eixample, Ciutat Vella, Sant Martí and Nou Barris).

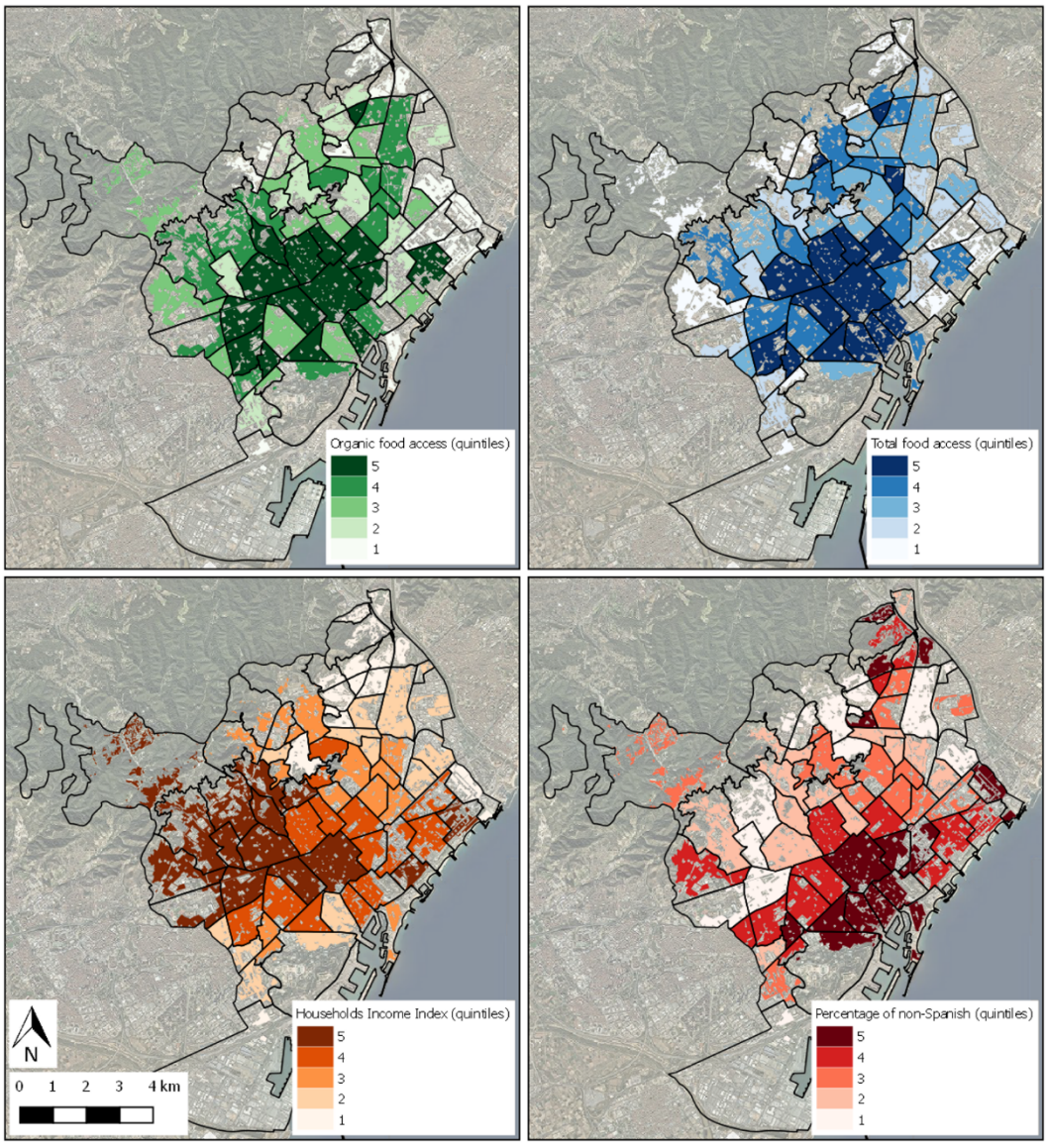


**Figure 2. Food access and sociodemographic variables' values at neighbourhood scale. The variables' values are represented in quintiles.**

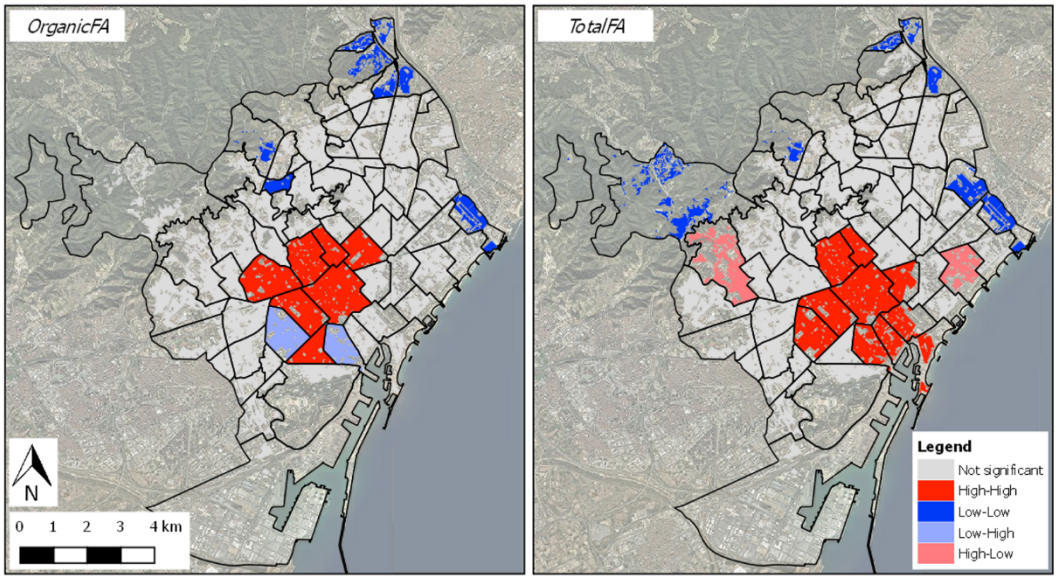
The bivariate (Spearman's rho) correlation analyses (Table 4) confirms that the two food access variables are strongly correlated, which is understandable because *TotalFA* includes *OrganicFA*, although the correlation is not perfect. This fact denotes that *OrganicFA* spatial distribution is led by some different drivers. *HI_index* is strongly correlated with *OrganicFA*, but only weakly correlated with *TotalFA*. This result confirms that access to food stores with organic products is unequally distributed in the city, and that it is driven by socioeconomic status of neighbourhoods. Concerning ethnicity, *perc_nonS* is moderately and positively correlated with *TotalFA*, and uncorrelated with *OrganicFA*. This indicates that, contrary to what other studies have shown, neighbourhoods with a larger proportion of non-native residents have better access to food stores, but not especially to organic ones.

| | *OrganicFA* | *TotalFA* | *HI_index* |
|---|---|---|---|
| *TotalFA* | 0.728** | | |
| *HI_index* | 0.516** | 0.230* | |
| *perc_nonS* | 0.167 | 0.329** | 0.020 |

Note: *Variable significant at the 0.05 level; **Variable significant at the 0.01 level.

**Table 4. Correlations between food access and sociodemographic variables. Spearman's rho correlation coefficients r ≥ |0.5| (indicating strong correlation) are depicted in dark grey, |0.3| ≤ r < |0.5| (indicating moderate correlation) are shown in light grey, and cells containing r ≤|0.3| (indicating weak correlation) are not filled.**

The results of the univariate LISA analyses (Fig. 3) show that, despite some slight differences, food access of both categories, *OrganicFA* and *TotalFA*, are higher in central areas of the city of Barcelona (especially in the districts of Gràcia and Eixample). Still, the neighbourhoods surrounding these clusters enjoy moderate access in both cases. This causes that *Low-Low* neighbourhood clusters are located in the outermost and hilly parts of the city, especially in the north (Nou Barris and Sant Andreu). The most notable difference between *OrganicFA* and *TotalFA* distribution, apart from some outliers, is that the latter is overrepresented in coastal neighbourhoods in Ciutat Vella, one of the most tourist districts of Barcelona.

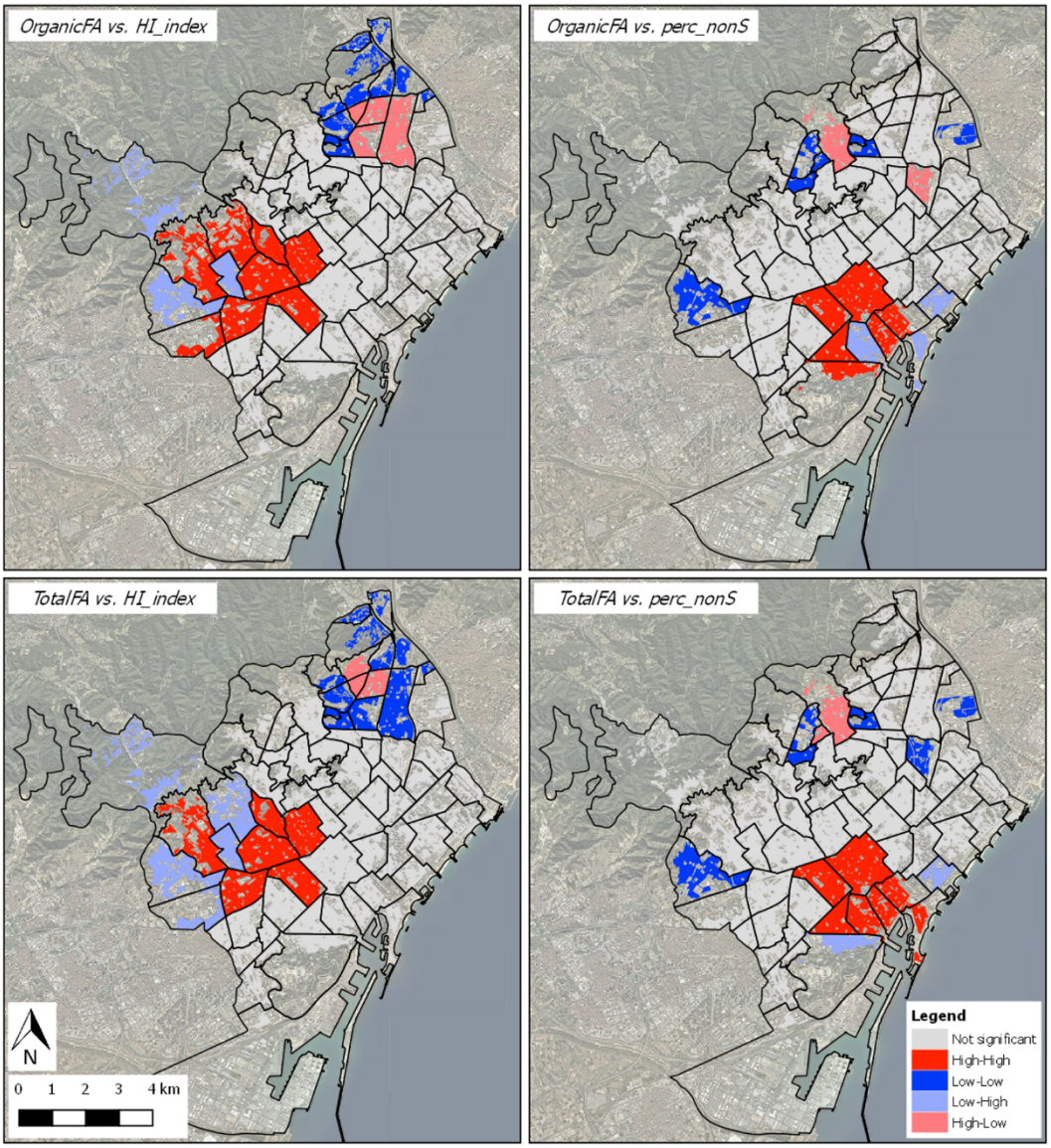



Note: Moran's I significance at the 0.05 level.

**Figure 3. Univariate LISA analyses results for the two food access variables.**

Concerning the bivariate LISA analyses (Fig. 4), it can be corroborated that the highest access to stores with organic food options is in the western and more affluent neighbourhoods of the city (especially in the districts of Sarrià-Sant Gervasi, Les Corts, and Gràcia), with few exceptions. On the contrary, access to organic food is the lowest in the northern neighbourhoods (Nou Barris and Sant Andreu), although there is a group of them with significantly high access independently of their low-income characteristics. There are also central areas of the city (Eixample and Ciutat Vella) that show high percentages of non-Spanish inhabitants and high access to organic food stores.

High *TotalFA* is also associated with *HI_index* in the affluent western neighbourhoods (Sarrià-Sant Gervasi, Les Corts, and Gràcia), but to a lesser extent than *OrganicFA*. Disadvantaged neighbourhoods in the north of the city (Nou Barris and Sant Andreu) are consistently related to low values of *TotalFA*, with few (*High-Low*) exceptions. High *TotalFA* values in areas with high percentage of non-Spanish citizens occur in the centre, especially in the old town neighbourhoods (Eixample and Ciutat Vella). This trend does not occur in the eastern and northern neighbourhoods of the city (Les Corts, Horta-Guinardó, Nou Barris and Sant Andreu), with high percentages of non-Spaniards and seemingly low access to food stores.




Note: Moran's I significance at the 0.05 level.

**Figure 4. Bivariate LISA analyses results for the food access and sociodemographic variables.**

## 4. Discussion

Local food environments should ensure an equitable access to food stores offering healthy foods to support healthy dietary habits. In addition, improving access to stores selling organic food can enhance organic food consumption, especially of fresh fruits and vegetables, thus contributing to the health status of the resident population as well as the environment. The main aim of this study was to investigate the characteristics of local food environments in the city of Barcelona, and to explore the existence of sociodemographic inequalities in access to food stores with or without organic products.

373 Just considering the offer of supermarkets and hypermarkets, Barcelona had a good general
374 food access of 8.63 stores/km$^2$. Studies conducted in Amsterdam (Helbich et al., 2017),
375 Glasgow (Macdonald et al. 2009) or Bratislava (Križan et al., 2015) reported densities of only
376 0.56, 0.38, and 0.63 stores/km$^2$, respectively. If density is measured in (n) stores/1,000
377 inhabitants, the estimates for these European cities (0.15, 0.12 and 0.17, respectively) were
378 way below the 0.55 average value for Barcelona. However, this result does not imply that food
379 access is equally and fairly distributed throughout this city.

380 Regarding the access to stores offering organic items, results confirmed that a higher
381 socioeconomic status of neighbourhoods conveyed a greater access to this kind of stores.
382 Considering that organic food is regarded as healthier than conventional (Brantsæter et al.,
383 2017), this result is consistent with findings from Black et al. (2012) who proved that affluent
384 neighbourhoods might have greater access to a variety and quality of healthy foods. A
385 plausible explanation for the positive relationship between income and organic food access
386 could be the positive association between socioeconomic status and a greater demand for
387 healthy food products (Lynch et al., 1997).

388 Parallelly, research conducted in different contexts had pointed out that price was one of main
389 barriers to the purchasing of organic food (Lockie et al., 2002; Padel and Foster, 2005; Vittersø
390 and Tangeland, 2015). A recent study that sampled households in the study region, reported
391 that price was the main barrier to increase the consumption of this kind of products (DARPA,
392 2015). Therefore, it can be deduced that, in this case also, higher food prices of organic food
393 products could also explain why wealthier neighbourhoods had better access to these stores.
394 However, recent research in this field contradicts this finding and showed that income was not
395 significantly associated with presence of organic food stores (Li et al., 2018). Still, the authors
396 of the later study justified this by arguing that lower food prices offered in farmers markets
397 enabled their location in low-income neighbourhoods. The *organic weekly markets* category of
398 the present study also included farmer markets with organic products. Despite their possible
399 lower prices, there were only 8 stores of this category in Barcelona; a small number to
400 influence the results.

401 Other studies have reported that socioeconomic status can influence healthy eating habits as
402 much as personal preferences and values (Johansson et al., 1999), and that these personal
403 preferences and values are shared among individuals belonging to different socioeconomic
404 groups (Lockie et al., 2002). Therefore, personal preferences and values can be an important
405 factor for organic food demand beyond the socioeconomic status of individuals. This may

406 explain why the bivariate LISA detected a group of neighbourhoods with significantly low
407 incomes and high access to stores with organic food in the northern area of the city. As a
408 matter of fact, these neighbourhoods are acknowledged by their active civil movements to
409 achieve good access to public services and environmental justice (Sempere, 2004; Masjuan et
410 al., 2008). In addition, these neighbourhoods are also characterised by having an important
411 presence of other alternative food supply elements, such as food consumer cooperatives and
412 public urban vegetable gardens (BS, 2018, Domene et al., 2016). People in these movements
413 show strong preferences for alternative food systems (socially and environmentally
414 sustainable) and are consequently willing to pay higher prices for certified organic food.

415 Despite the existing socioeconomic and ethnic heterogeneity in Barcelona, access to food
416 stores is only weakly positively correlated with socioeconomic level at the neighbourhood
417 scale, and moderately and positively correlated with percentage of non-Spanish residents.
418 Besides that, bivariate LISA results have identified a cluster of neighbourhoods in the northern
419 area of Barcelona where lower food access values were spatially correlated with lower
420 socioeconomic levels. In light of these results, it can be concluded that in Barcelona, similarly
421 to what happens in other developed non-English-speaking countries, there might be deprived
422 neighbourhoods with poorer food access (Helbich et al., 2017; Križan et al., 2015; Shaw, 2012).
423 A study conducted by the Public Health Agency of Barcelona identified one neighborhood,
424 namely Ciutat Meridiana (in the district of Nou Barris), where poor nutrition among the young
425 and the elderly was one of the main health problems according to the residents (ASPB, 2009).
426 All these evidences highlight the need to further investigate if the comparatively lower food
427 access in these neighborhoods is actually limiting the healthy dietary habits of their residents,
428 or there are other limiting factors such as affordability, food culture, lifestyles, among others.

429 The investigations carried out in the US have more often indicated limited access to food in
430 neighbourhoods with ethnic minorities (Walker et al., 2010). On the other hand, a study
431 conducted in New York (US) found that predominantly Latino neighbourhoods had better food
432 access, but only if compared with predominantly Black/African-American neighbourhoods
433 (Gordon et al., 2011). In the present study, neighbourhoods with a larger proportion of non-
434 native residents have better access to food stores. One reason for this contradictory result
435 may be related to the higher food access in central neighbourhoods, the most touristic areas
436 of the city, which host a greater number of non-Spaniards, as has been observed in the
437 bivariate LISA results. A large number of *small specialised stores* and *convenience stores* are
438 located in this area, especially in the old town neighbourhoods. Many of these stores are
439 hosted by both Asian and European origin residents who have considered these businesses as

a good way of life in the context of economic crisis (Güell, 2017). They may benefit from the large number of visitors and workers coming to the area daily. In this context, another phenomenon that must be taken into account is the appearance of "food mirages", that is, areas where access to food stores with healthy items is good, but the average prices of these products are so high that their residents cannot easily purchase them (Breyer & Voss-Andreae, 2013). Future research should assess the magnitude of food mirages in these central neighbourhoods with low income immigration and food prices adapted to the visitors' purchasing power.

As previously mentioned, facilitating greater access to stores with organic food items can promote changes in dietary habits and provoke significant health benefits to citizens and potential positive environmental impacts. However, previous studies have demonstrated that securing sufficient access to healthy food stores in socially disadvantaged neighbourhoods, may not be sufficient by itself to make a significant impact on dietary choices and health outcomes. For instance, a natural experiment study conducted in Philadelphia (US) demonstrated that enhancing food access by opening a supermarket in a food desert was not enough to influence the dietary behaviour of the community. They concluded that access-focused initiatives should be complemented with other measures to stimulate dietary changes, for instance, through price and availability, in order to bridge the gap between perception and behaviour change (Cummins et al., 2014). Similarly, the opening of a new hypermarket in Glasgow (UK) caused that approximately 30% of the sample of residents switched to this new store for their main food shopping, but this was not enough to increase their intake of fruits and vegetables (Cummins et al., 2005). Other studies have shown that, even in supermarkets, the shelf space dedicated to unhealthy snacks items is often larger than the shelf space for fresh fruits and vegetables (Farley et al., 2009). These evidences call to deepen on the relationship between access to healthy food and dietary habits of Barcelona dwellers, so as to study the effectiveness of food access-oriented measures.

## 5. Conclusions

Although the city of Barcelona has an abundant number of food stores possibly selling healthy food items such as fresh products, this study has demonstrated that there are inequalities in access to organic food between neighbourhoods of different socioeconomic conditions. For instance, some deprived neighbourhoods in the northern part of the city may have more limited access to food stores. When it comes to stores with organic food products, results have demonstrated that wealthier neighbourhoods have significantly higher access than low-income

neighbourhoods. In light of this evidence, local authorities should promote the creation of affordable alternatives (e.g., farmer markets or organic food cooperatives) in these neighbourhoods with deficient access to healthy organic food, so that they have equal opportunities to make food choices.

The spatial autocorrelation analysis, concretely bivariate LISA, has also shown that socioeconomic status is positively related to organic food access. Yet, there are areas of the city where this is not applicable. This result reveals that in some neighbourhoods the demand for organic food may be more determined by personal values (i.e., health and pro-environmental motivations) than by purchasing power. This proves that there is still room for increasing the demand for organic products, as well as other options that support alternative food systems, by means of truthful campaigns informing about the actual social and environmental benefits of its consumption. Enhancing the development of organic food consumer cooperatives, which support sustainable sourcing for their products, and educate consumers about responsible consumption, can prove an effective complementary strategy.

Cities across the world are enduring the consequences of nutrition-related health issues boosted by spatial intra-urban inequality. Improving knowledge and understanding of the configuration of local food environments in a broad sense, including all kinds of food alternatives, and their impact on changing dietary habits, is essential in order to inform the design of targeted interventions and policies that mitigate these negative neighbourhood effects.

## References


AB - Ajuntament de Barcelona (2016) Inventari de locals de Barcelona. Available at: http://opendata-ajuntament.barcelona.cat/data/ca/dataset/cens-activitats-comercials (accessed 25 April 2018).

AB - Ajuntament de Barcelona (2017a) Enquesta Òmnibus Municipal: Direcció de Serveis de Comerç. Available at: https://ajuntament.barcelona.cat/comerc/sites/default/files/arxius/omnibus_municipal_desembre_2017.pdf (accessed 10 September 2018).

AB - Ajuntament de Barcelona (2017b) Hàbits de consum i polaritat comercial de la ciutat de Barcelona. Available at: https://ajuntament.barcelona.cat/comerc/sites/default/files/arxius/habits_consum_polarits_barcelona_2017_0.pdf (accessed 01 July 2018).

AB - Ajuntament de Barcelona (2018) Departament d'Estadística i Difusió de Dades. Available at: http://www.bcn.cat/estadistica/angles/index.htm (accessed 10 April 2018).

Aertsens J, Verbeke W, Mondelaers K and Van Huylenbroeck G (2009) Personal determinants of organic food consumption: a review. *British food journal* 111(10): 1140-1167.

Annunziata A and Vecchio R (2016) Organic farming and sustainability in food choices: an analysis of consumer preference in Southern Italy. *Agriculture and agricultural science procedia* 8: 193-200.

Anselin L (1995) Local indicators of spatial association—LISA. *Geographical analysis* 27(2): 93-115.

Anselin L, Syabri I and Smirnov O (2002) Visualizing Multivariate Spatial Correlation with Dynamically Linked Windows.'' In Anselin L and Rey SJ (*eds*) *New Tools for Spatial Data Analysis: Proceedings of the Specialist Meeting*. Santa Barbara, CA: Center for Spatially Integrated Social Science, University of California

527 Anselin L and Rey SJ (2014). Modern Spatial Econometrics in Practice, a Guide to Geoda,
528 Geodaspace and Pysal. Chicago: GeoDa Press.
529
530 ASPB - Agència de Salut Pública de Barcelona (2009). Salut als Barris. Diagnòstic. Torre Baró,
531 Ciutat Meridiana i Vallbona. Available at: http://www.aspb.cat/wp-
532 content/uploads/2016/07/Diagnostic_salut_ZNord_2009.pdf (accessed 10 September
533 2018).
534
535 ASPB - Agència de Salut Pública de Barcelona (2016). La salut a Barcelona 2016. Available at:
536 http://www.aspb.cat/wp-content/uploads/2018/04/Informe-Salut-2016-Web-DEF.pdf
537 (accessed 10 October 2018).
538
539 Ball K, Timperio A and Crawford D (2009) Neighbourhood socioeconomic inequalities in food
540 access and affordability. *Health & place* 15(2), 578-585.
541
542 Baudry J, Allès B, Péneau S, Touvier M, Méjean C, Hercberg S, Galan P, Lairon D and Kesse-
543 Guyot E (2017) Dietary intakes and diet quality according to levels of organic food
544 consumption by French adults: cross-sectional findings from the NutriNet-Santé Cohort
545 Study. *Public health nutrition* 20(4): 638-648.
546
547 Bengtsson J, Ahnström J and Weibull AC (2005) The effects of organic agriculture on
548 biodiversity and abundance: a meta-analysis. *Journal of applied ecology* 42(2), 261-269.
549
550 Black C, Ntani G, Kenny R, Tinati T, Jarman M, Lawrence W, Barker M, Inskip H, Cooper C,
551 Moon G and Baird J (2012) Variety and quality of healthy foods differ according to
552 neighbourhood deprivation. *Health & place* 18(6): 1292-1299.
553
554 Black C, Moon G and Baird J (2014). Dietary inequalities: what is the evidence for the effect of
555 the neighbourhood food environment?. *Health & place* 27: 229-242.
556
557 Brantsæter AL, Ydersbond TA, Hoppin JA, Haugen M and Meltzer HM (2017) Organic food in
558 the diet: exposure and health implications. *Annual review of public health* 38: 295–313.
559
560 Breyer B and Voss-Andreae A (2013) Food mirages: Geographic and economic barriers to
561 healthful food access in Portland, Oregon. *Health & Place* 24: 131-139.

562
563 BS - Barcelona més Sostenible (2018) Mapa Barcelona + Sostenible. Available at:
564 http://www.bcnsostenible.cat/es/mapa/index (accessed 01 May 2018).
565
566 Caspi C E, Sorensen G, Subramanian S V and Kawachi I (2012) The local food environment and
567 diet: a systematic review. *Health & place* 18(5): 1172-1187.
568
569 CIHEAM/FAO (2015) Mediterranean food consumption patterns: diet, environment, society,
570 economy and health. a White Paper Priority 5 of Feeding Knowledge Programme, Expo
571 Milan 2015. CIHEAM-IAMB, Bari/FAO, Rome. Available at: http://www.fao.org/3/a-
572 i4358e.pdf (accessed 01 October 2018)
573
574 Clarke G, Eyre H and Guy C (2002) Deriving indicators of access to food retail provision in
575 British cities: studies of Cardiff, Leeds and Bradford. *Urban Studies* 39(11): 2041–2060.
576
577 Cummins S and Macintyre S (2002) A systematic study of an urban foodscape: the price and
578 availability of food in greater Glasgow. *Urban Studies* 39(11): 2115-2130.
579
580 Cummins S, Petticrew M, Higgins C, Findlay A and Sparks L (2005) Large scale food retailing as
581 an intervention for diet and health: quasi-experimental evaluation of a natural experiment.
582 *Journal of Epidemiology & Community Health* 59(12), 1035-1040.
583
584 Cummins S, Flint E and Matthews SA (2014) New neighborhood grocery store increased
585 awareness of food access but did not alter dietary habits or obesity. *Health affairs* 33(2):
586 283–291.
587
588 Dai D and Wang F (2011) Geographic disparities in accessibility to food stores in southwest
589 Mississippi. *Environment and Planning B: Planning and Design* 38(4): 659–677.
590
591 DARPA - Departament d'Agricultura, Ramaderia, Pesca i Alimentació (2015) Baròmetre 2015
592 de Percepció i Consum dels Aliments Ecològics. Available at:
593 http://pae.gencat.cat/web/.content/al_alimentacio/al01_pae/05_publicacions_material_re
594 ferencia/arxius/15_Barometre.pdf (accessed 01 June 2018).
595

596 Domene E, García-Sierra M, Coll F and Marull J (2016) L'agricultura metropolitana: funcions
597 productives, ecològiques i socials. Anuari Metropolità de Barcelona 2016. Available at:
598 https://iermb.uab.cat/es/anuari/repensar-la-metropoli-nuevas-claves-para-un-proyecto-
599 colectivo/ (accessed 10 September 2019).
600
601 FAO - Food and Agriculture Organization of the United Nations (2016) Influencing food
602 environments for healthy diets through food safety. Rome: FAO.
603
604 Farley TA, Rice J, Bodor JN, Cohen DA, Bluthenthal RN and Rose D (2009) Measuring the food
605 environment: shelf space of fruits, vegetables, and snack foods in stores. *Journal of Urban*
606 *Health* 86(5): 672–682.
607
608 Galster GC (2012) The mechanism (s) of neighbourhood effects: Theory, evidence, and policy
609 implications. In: *Neighbourhood effects research: New perspectives*. Springer, Dordrecht.,
610 pp. 23-56.
611
612 GENCAT (2018) Enquesta de salut de Catalunya: L'estat de salut, els comportaments
613 relacionats amb la salut i l'ús de serveis sanitaris a Catalunya. Available at:
614 http://salutweb.gencat.cat/web/.content/_departament/estadistiques-
615 sanitaries/enquestes/Enquesta-de-salut-de-Catalunya/Resultats-de-lenquesta-de-salut-de-
616 Catalunya/documents/resum-executiu_esca_2017.pdf (accessed 15 October 2018)
617
618 Gordon C, Purciel-Hill M, Ghai NR, Kaufmanc L, Graham R and Van Wyea G (2011) Measuring
619 food deserts in New York City's low-income neighborhoods. *Health & place* 17(2): 696–700.
620
621 Güell B (2017) *L'empresariat ètnic des de l'enfocament del mixed embeddedness: els negocis*
622 *pakistanesos a la ciutat de Barcelona*. PhD Thesis, Universitat Autonoma de Barcelona,
623 Spain.
624
625 Guzmán GI, de Molina MG and Alonso AM (2011) The land cost of agrarian sustainability. An
626 assessment. *Land Use Policy* 28(4): 825–835.
627
628 Hager ER, Cockerham A, O'Reilly N, Harrington D, Harding J, Hurley KM and Black MM (2017)
629 Food swamps and food deserts in Baltimore City, MD, USA: associations with dietary

630 behaviours among urban adolescent girls. *Public health nutrition* 20(14): 2598–2607.
631
632 Helbich M, Schadenberg B, Hagenauer J and Poelman M (2017) Food deserts? Healthy food
633 access in Amsterdam. *Applied Geography* 83: 1 – 12.
634
635 Hoffmann R, Borsboom G, Saez M, Mari Dell'Olmo M, Burström B, Corman D, Costa C,
636 Deboosere P, Domínguez-Berjón MF, Dzúrová D, Gandarillas A, Gotsens M, Kovács K,
637 Mackenbach J, Martikainen P, Maynou L, Morrison J, Palència L, Pérez G, Pikhart H,
638 Rodríguez-Sanz M, Santana P, Saurina C, Tarkiainen L and Borrell C (2014) Social differences
639 in avoidable mortality between small areas of 15 European cities: an ecological study.
640 I*nternational journal of health geographics* 13(1): 8.
641
642 Howlett E, Davis C and Burton S (2016) From food desert to food oasis: The potential influence
643 of food retailers on childhood obesity rates. *Journal of business ethics*, 139(2): 215-224.
644
645 Hunter D, Foster M, McArthur JO, Ojha R, Petocz P and Samman S (2011) Evaluation of the
646 micronutrient composition of plant foods produced by organic and conventional agricultural
647 methods. *Critical Reviews in Food Science and Nutrition* 51:571–82
648
649 Johansson L, Thelle DS, Solvoll K, Bjørneboe GEA and Drevon CA (1999) Healthy dietary habits
650 in relation to social determinants and lifestyle factors. *British Journal of Nutrition 81*(3):
651 211-220.
652
653 Križan F, Bilkova K, Kita P and Horňák M (2015) Potential food deserts and food oases in a post-
654 communist city: Access, quality, variability and price of food in Bratislava-Petržalka. *Applied*
655 *Geography* 62: 8-18.
656
657 Navarro-Varas L, Porcel S and Pons M (2018). Pobresa i desigualtat social a la ciutat de
658 Barcelona: la configuració de l'escenari post-crisi, 2016-17. Available at:
659 https://ajuntament.barcelona.cat/dretssocials/sites/default/files/arxius-
660 documents/pobresa-i-desigualtat-social-2018.pdf (accessed 01 September 2019).
661
662 Laraia BA, Siega-Riz AM, Kaufman JS and Jones SJ (2004) Proximity of supermarkets is
663 positively associated with diet quality index for pregnancy. *Preventive Medicine* 39(5): 869–
664 875.

Li C, Ghiasi A, Li X and Chi G (2018) Sociodemographics and access to organic and local food: A case study of New Orleans, Louisiana. *Cities* 79: 141–150.

Lockie S, Lyons K, Lawrence G and Mummery K (2002) Eating "green": motivations behind organic food consumption in Australia. *Sociologia ruralis* 42(1): 23–40.

Lynch JW, Kaplan GA and Salonen JT (1997) Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse. *Social science & medicine* 44(6): 809-819.

Macdonald L, Ellaway A and Macintyre S (2009) The food retail environment and area deprivation in Glasgow City, UK. *International Journal of Behavioral Nutrition and Physical Activity* 6(1): 52.

Magkos F, Arvaniti F and Zampelas A (2006) Organic food: buying more safety or just peace of mind? A critical review of the literature. *Critical reviews in food science and nutrition* 46(1),: 23–56.

Marquet O and Miralles-Guasch C (2014) Walking short distances. The socioeconomic drivers for the use of proximity in everyday mobility in Barcelona. *Transportation research part A: policy and practice* 70: 210-222.

Masjuan E, March H, Domene E and Saurí D (2008) Conflicts and struggles over urban water cycles: the case of Barcelona 1880–2004. *Tijdschrift voor economische en sociale geografie* 99(4): 426-439.

Medina JA, Aguilera JC, Poza AM and Sánchez FR (2012) El tiempo de trabajo y la jornada laboral en España. Madrid: Fundación 1o de Mayo.

Menezes MC, Costa BVL, Oliveira CDL and Lopes ACS (2017) Local food environment and fruit and vegetable consumption: An ecological study. *Preventive medicine reports* 5:13–20.

Mercatsetmanal.cat (2018) Mercats Setmanals de Catalunya. Available at: https://www.mercatsetmanal.cat (accessed 15 May 2018)

Monclús F (1998) Suburbanización y nuevas periférias. Perspectivas geográfico urbanísticas. In: Monclús F (ed) *La ciudad dispersa. Suburbanización y nuevas periferias*. Barcelona: Centre de Cultura Contemporània de Barcelona.

Moore LV, Diez Roux AV, Nettleton JA and Jacobs Jr DR (2008) Associations of the local food environment with diet quality-a comparison of assessments based on surveys and geographic information systems: the multi-ethnic study of atherosclerosis. *American journal of epidemiology* 167(8): 917–24.

Morland KB, Diez Roux AV and Wing S (2006) Supermarkets, other food stores, and obesity: the atherosclerosis risk in communities study. *American Journal of Preventive Medicine* 30(4): 333–339.

Morland KB and Filomena S (2007) Disparities in the availability of fruits and vegetables between racially segregated urban neighbourhoods. *Public health nutrition* 10(12): 1481–1489.

Morland KB and Evenson KR (2009) Obesity prevalence and the local food environment. *Health & Place* 15(2): 491–495.

Nasir V A, and Karakaya F (2014) Underlying motivations of organic food purchase intentions. *Agribusiness* 30(3): 290-308.

Orsini F, Maggio A, Rouphael Y and De Pascale S (2016). "Physiological quality" of organically grown vegetables. *Scientia horticulturae* 208:131-139.

Padel S and Foster C (2005) Exploring the gap between attitudes and behaviour: Understanding why consumers buy or do not buy organic food. *British food journal* 107(8): 606–625.

Ponisio LC, M'Gonigle LK, Mace KC, Palomino J, de Valpine P and Kremen C (2015) Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society of London B* 282(1799): 20141396.

Powell LM, Auld MC, Chaloupka FJ, O'Malley PM and Johnston LD (2007) Associations between access to food stores and adolescent body mass index. *American Journal of Preventive Medicine* 33(4 Suppl): S301–S307.

Reardon SF and Bischoff K (2011) Income inequality and income segregation. *American Journal of Sociology* 116(4): 1092-1153.

Schwingshackl L and Hoffmann G (2015) Diet quality as assessed by the Healthy Eating Index, the Alternate Healthy Eating Index, the Dietary Approaches to Stop Hypertension score, and health outcomes: a systematic review and meta-analysis of cohort studies. *Journal of the Academy of Nutrition and Dietetics* 115(5): 780-800.

Sempere J (2004) La guerra del recibo del agua. Una movilización popular atípica en el área metropolitana de Barcelona, 1992-2002. *Revista Internacional de Sociologia* 62(38): 169-187.

Seufert V, Ramankutty N and Foley JA (2012) Comparing the yields of organic and conventional agriculture. *Nature* 485(7397): 229.

Shaw H (2012) Access to healthy food in Nantes, France. *British Food Journal* 114(2): 224-238.

Slavin JL and Lloyd B (2012) Health benefits of fruits and vegetables. *Advances in nutrition* 3(4): 506-516.

Smoyer-Tomic KE, Spence JC and Amrhein C (2006) Food deserts in the prairies? Supermarket accessibility and neighborhood need in Edmonton, Canada. *The Professional Geographer* 58(3): 307–326.

van Ham M, Tammaru T and Jannsen HJ (2018) A multi-level model of vicious circles of socio-economic segregation. In: OECD, *Divided Cities: Understanding Intra-Urban Inequalities*. Paris: OECD, pp. 135–149.

van Lanen S (2017) Living austerity urbanism: space–time expansion and deepening socio-spatial inequalities for disadvantaged urban youth in Ireland. *Urban Geography* 38(10): 1603-1613.

Walker RE, Keane CR and Burke JG (2010) Disparities and access to healthy food in the United States: A review of food deserts literature. *Health & place* 16(5) 876-884.

Weatherspoon D, Oehmke J, Dembele A and Weatherspoon L (2015) Fresh vegetable demand behaviour in an urban food desert. *Urban Studies* 52(5): 960-979.

Wei YD (2015) Spatiality of regional inequality. *Applied Geography* 61: 1-10.

Willer H, Meredit S, Moeskops B and Busacca E (2018) Organic in Europe: Prospects and Developments. In: Willer H and Lernoud J (eds) *The World of Organic Agriculture Statistics and Emerging Trends 2018*. Bonn: Research Institute of Organic Agriculture FiBL, Frick and IFOAM – Organics International

Willer H, Moeskops B, Busacca E and De la Vega N (2019) Organic in Europe: Recent developments. In: Willer H and Lernoud J (eds) *The World of Organic Agriculture Statistics and Emerging Trends 2019*. Bonn: Research Institute of Organic Agriculture (FiBL) and IFOAM – Organics International

Williams CM (2002) Nutritional quality of organic food: shades of grey or shades of green? *Proceedings of the Nutrition Society* 61(1): 19–24.

Yeager CD and Gatrell JD (2014) Rural food accessibility: an analysis of travel impedance and the risk of potential grocery closures. *Applied Geography* 53; 1–10.

Zenk SN, Lachance, LL, Schulz A J, Mentz G, Kannan S and Ridella W (2009) Neighborhood retail food environment and fruit and vegetable intake in a multiethnic urban population. *American Journal of Health Promotion* 23(4): 255-264.

Zwiers M, Bolt G, Van Ham M, and Van Kempen R (2016) The global financial crisis and neighborhood decline. *Urban Geography* 37(5): 664-684.

**Author statement**

**Xavier Garcia:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization.

**Marta Garcia-Sierra:** Conceptualization, Investigation, Writing - Review & Editing.

**Elena Domene:** Conceptualization, Investigation, Writing - Review & Editing, Supervision, Project administration, Funding acquisition.