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IS ACCESSIBILITY IN THE EYE OF THE BEHOLDER? SOCIAL INEQUALITIES IN SPATIAL ACCESSIBILITY TO HEALTH-RELATED RESOURCES IN MONTRÉAL, CANADA.

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Highlights

- Traditional measures of spatial accessibility overlook neighbourhood experiences.
- Social gradient in resource accessibility vary with neighbourhood definition.
- Half-mile buffers mask social variations observed in neighbourhood experiences.
- Self-defined neighbourhoods are larger for higher social groups.
- Resource accessibility is more socially patterned for self-defined neighbourhoods.

Abstract

Neighbourhood resources are often considered to be spatially accessible to people when they are located close to their place of residence, a perspective which overlooks individuals' unique lived experience of their neighbourhood and how they define it. Drawing on the relational approach to place and on Sen's capability approach, we explore spatial accessibility to health-related resources, and the social gradient therein, in light of people's place experiences. Using data from 1,101 young adults from Montreal (Canada) who participated in the Interdisciplinary Study of Inequalities in Smoking (ISIS), we compare the social gradients in the presence of health-related resources located (i) within uniform areas (defined as circular buffers and road-network buffers) around participants' place of residence; and (ii) within participants' self-defined neighbourhoods. Social inequalities in accessibility to a diversity of health-related resources (grocery stores, fruit and vegetable stores, eating and drinking places, recreational sports centres, civic, social, and fraternal organizations, bike paths, parks, social services, libraries, dental offices, physician offices) were more pronounced in self-defined neighbourhoods than in uniform buffer areas. Neglecting the variability in people's place experiences may distort the assessment of social inequalities in accessibility, and ultimately, of neighbourhood effects on health inequalities.

Keywords

accessibility; capability approach; perceived neighbourhood; place experiences ; proximity; relational approach; social inequalities

INTRODUCTION

In health-related social sciences, there is a tendency to treat spatial components of accessibility to resources from a utilitarian perspective: spatial accessibility is generally measured in terms of distance, with shorter distance meaning greater accessibility. Despite metric distance or resource density within a defined perimeter being the two most common measures used to describe spatial accessibility to health-related resources (Estabrooks et al., 2003; Moore et al., 2008; Pearce et al., 2007; Powell et al., 2006; Richardson et al., 2012; Todd et al., 2015), they exclusively depend on the spatial distribution of resources. Even when measures are based on road-network buffers which inherently integrate aspects of accessibility by limiting measures to locations that can be reached within a given distance along the road network (eg., Duncan et al., 2013; Sparks et al., 2011; Thornton et al., 2011), they neglect the fact that individuals perceive, experience and use places differently.

Integrating people's neighbourhood experiences of place in measures of resource accessibility speaks to two theoretical perspectives. First, we rely on the relational approach to place which views places and the resources they provide as shaped by political powers, social networks, regulation of various actors, and local interactions with people. In relational geography, the structure-agency dichotomy is rejected. Places are contemplated from a non-Euclidean perspective where place boundaries are fluid and distances are relative (Cummins et al., 2007; Jones, 2009). Second, we use Amartya Sen's capability approach (Abel and Frohlich, 2012; Sen, 1992) as a way of moving beyond a conceptualization of spatial accessibility based only on resource location, by focusing instead on what people are actually able to extract from available resources given their particular needs, abilities, and desires. Following Sen's idea, we argue that rather than basing the evaluation of equity on metric distances to available resources alone, we should view citizens' choices as being structured by the situation in which they find themselves. Comparing metric-based resource densities between social groups is therefore insufficient for assessing equity. What is required, instead, is an understanding of people's capacity to convert *available* resources into *accessible* ones. By distinguishing itself from utilitarianism, Sen's capability theory allows us to ask not only if health-related resources are equally distant from people, but also if people are equally able to access them. Drawing on both relational and capability perspectives, we suggest viewing spatial accessibility to resources as a hybrid notion combining people's place experiences and the distribution of resources across space.

Neglecting people's differential abilities to access resources is problematic, particularly for those concerned with social inequalities in health, given that place experiences may be socially patterned (Shareck et al., 2014). At the residential neighbourhood scale, it may also lead to inaccurate estimations of the number and types of resources people may actually have access to in their neighbourhood, and of the magnitude of the social gradient in resource accessibility, what has been called the 'constant size neighbourhood trap' (Vallée et al., 2015). Social inequalities in spatial accessibility to health-related resources can be seen as resulting from the overlap between inequalities in the spatial distribution of resources (a first source of inequality) and in people's experiences of neighbourhoods (a second source of inequality).

At the residential neighbourhood scale, the question of neighbourhood experiences has a rich history in neighbourhood and community studies and environmental psychology. One way to explore neighbourhood experiences empirically has been to ask respondents to draw and discuss their self-defined neighbourhood. These studies show that even when living in close proximity, people locate their neighbourhood boundaries differently (Campbell et al., 2009; Lee, 1968). Self-defined neighbourhoods, however, remain under-studied in quantitative research since the tight interrelationships between individuals and contexts are not easy to capture (Cummins et al., 2007). In the few cases where such studies have been performed, they have largely focused on how self-defined neighbourhoods (sometimes called 'perceived neighbourhoods') differ in size and shape from standard census units and according to population subgroups and urban form (Charreire et al., 2016;

Coulton et al., 2013; Lee and Campbell, 1997; Orford and Leigh, 2014; Sastry et al., 2002; Vallée et al., 2015).

Few studies have assessed how resources located in self-defined neighbourhoods compared to those found in more traditional spatial units, and consequently, how individuals' spatial accessibility to neighbourhood resources might differ (Vallée et al., 2015) . Self-defined neighbourhoods can yet be seen as reflecting both past spatial behaviours and future possibilities: they capture an individual's effective past access as well as potential future access to neighbourhood resources (Campbell et al., 2009; Colabianchi et al., 2014; Mondschein et al., 2006). In line with this idea, it seems valuable to rely on self-defined neighbourhoods to integrate people's neighbourhood experiences within quantitative studies, and assess social inequalities in potential access (ie., accessibility) to health-related resources.

In the heath literature, some studies indirectly address neighbourhood experiences by comparing subjective, resident-perceived neighbourhood attributes and more objective neighbourhood attributes issued from administrative, commercial, or direct observation databases (Haynes et al., 2007; Pampalon et al., 2007). However, these studies do not explore how differences between subjective and objective neighbourhood attributes vary according to social profile and may lead to social inequalities in health behaviours. Recent studies also consider place experiences in link with daily mobility: activity locations were seen as a way of capturing accessibility to resources beyond the residential neighbourhood (Kestens et al., 2010; Shearer et al., 2015; Sherman et al., 2005; Zenk et al., 2011). These studies, nonetheless, can still be seen as being metric-based since they rely on fixed distances around activity locations or GPS tracks.

We explore and compare the social gradients in spatial accessibility to a wide range of health-related resources where spatial accessibility is: (1) uniformly defined as the number of health-related resources found within fixed radius distance around participants' place of residence (using either circular or road-network buffers); and (2) based on place experiences and expressed as the number of health-related resources found within participants' self-defined neighbourhood.

METHODS

Study design and population

Data used for this study came from the second wave of the Interdisciplinary Study of Inequalities in Smoking (ISIS) (Montreal, Canada). Between January and June 2014, 1,457 young adults participating in a cohort study aged 20-27 years old and living in the Greater Montreal Region completed a questionnaire. The majority completed an online questionnaire (96.3%), with a minority completing either a paper copy (0.5%), or one administered over the phone with a research assistant (3.2%). Sampling, recruitment, and data collection procedures are described in detail elsewhere (Katherine L Frohlich et al., 2015). Ethical approval was obtained from the Research Ethics Committee of the Université de Montréal's Faculty of Medicine and participants provided informed consent prior to questionnaire completion.

Measures

Social variable

Participants' socio-economic status (SES) was operationalized using their mother's level of education, which was reported by choosing one of 12 pre-defined categories ranging from no schooling (only kindergarten) to doctoral studies. Four categories were created: very low education (less than High school; equivalent to <11 years of schooling), low (High school; 11 years of schooling); intermediate (CEGEP/trade school (CEGEP refers to post-secondary educational institutions found only in Québec, Canada); 12-13 years of schooling) and high education (University; 14+ years of schooling).

To explore the social gradient in spatial accessibility to resources, maternal education was preferred over participants' own education level since it reflects young adults' past socio-economic conditions as well as current ones, especially in the ISIS sample where two thirds of participants (67%) were still living with their parents and often had not completed their studies yet. Moreover, maternal education was better distributed than participants' own education level since 60.7% of respondents had attained the highest level possible (University).

Health-related resources

We sought to study a diversity of resources having a potential influence on social inequalities in health. We chose resources (i) for which the spatial location is decided by various types of public or private operators who may have different, or even contradictory, motivations (e.g., profitability, spatial justice), and (ii) to which access results from different rules: proximity, price, rights, and informal reciprocity as conceptualized by Bernard *et al*. (2007) following Godbout's theory (2003).

Twelve health-related resources were selected: grocery stores, drug stores, fruit and vegetable stores, eating and drinking places, private recreational sports centres, civic, social, and fraternal organizations, bike paths, large parks, social services, libraries and two health services (dental offices and clinics, and physician offices and clinics).

Health-related resource data came from the 2013 DMTI Spatial® Enhanced Points of Interest (EPOI) dataset (www.dmtispatial.com) which provides, for each business or service listed, a name, postal address, geographic coordinates, and between one and six Standard Industrial Classification (SIC) and North American Industry Classification (NAICS) codes based on the economic activities they declare (OSHA, 2008). We extracted data from the EPOI database for each selected resource first using SIC codes (Table 1). For the 'fruit and vegetable stores' category, we included those which had 'fruit and vegetable markets' as well as grocery stores which had 'fruit' or 'vegetable' or 'farm' in their business name. With regards to 'eating and drinking places', we also used information from the NAICS to exclude caterers and establishments providing food services to institutions. Information about parks was obtained by combining DMTI and 'Communauté Métropolitaine de Montréal' (CMM) land use databases; only large parks (with an area superior to 20,000 m^2) were kept for analysis. Resource data sets were cleaned by removing duplicates, head offices, and resources with poor spatial precision (less than 6-digit postal code). Geodatabase information about bike paths was extracted from OpenStreet Map 2016 using overpass-turbo (Ferster et al., 2018).

Table 1. List of selected health-related resources in the Montreal Metropolitan Area (Canada)

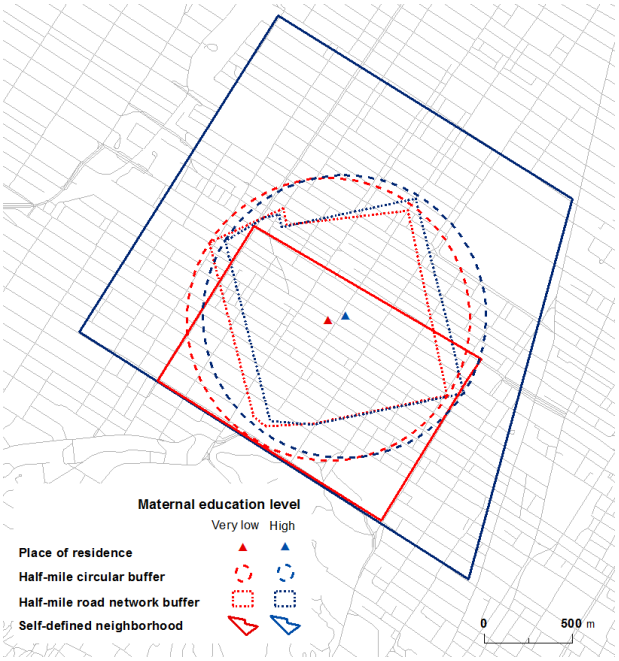
Resource	GIS source	Selection criteria	Geometrical type	N on island of Montreal
Grocery stores	EPOI DMTI 2013	SIC Code 5411 [Grocery Stores]	Point	1507
Drug stores	EPOI DMTI 2013	SIC Code 5912 [Drug Stores and Proprietary Stores]	Point	381
Fruit and vegetable stores	EPOI DMTI 2013	SIC Code 5431 [Fruit and Vegetable Markets] + 5411 [Grocery stores] if name mention "'fruit' or 'vegetable' or 'farm'	Point	163
Eating and drinking places	EPOI DMTI 2013	SIC Code 5812 [Eating Places], 5813 [Drinking Places] excluding NAICS 72231 and 72232	Point	4406
Recreational sports centres	EPOI DMTI 2013	SIC Code 7991 [Physical Fitness Facilities], 7997 [Membership Sports and Recreation Clubs], 7933 [Bowling Centers]	Point	353
Civic, social and fraternal organizations	EPOI DMTI 2013	SIC Code 8641 [Civic, Social, and Fraternal Associations]	Point	1335
Bike paths	OpenStreetMap, 2016	Extraction from overpass-turbo	Line	717 km
Large parks	DMTI, 2013 CMM, 2014	DMTI : code prr "Parks and Recreations reg" AND CMM: code 600 AND area>20000 m^2	Polygon	60,5 km^2 (379 entities)
Social services	EPOI DMTI 2013	SIC Code 8322 [Individual and Family Social Services]	Point	351
Libraries	EPOI DMTI 2013	SIC Code 8231 [Libraries]	Point	35
Physician offices and clinics	EPOI DMTI 2013	SIC Code 8011 [Offices and Clinics of Doctors of Medicine]	Point	826
Dental offices and clinics	EPOI DMTI 2013	SIC Code 8021 [Offices and Clinics of Dentists]	Point	948

Three neighbourhood units: self-defined neighbourhoods, circular buffers and road-network buffers

Participants' residential address and self-defined neighbourhood boundaries were obtained using VERITAS, an online web-mapping application (Chaix et al., 2012). Participants were asked to use their computer mouse to draw the boundary lines outlining what they perceived to be their neighbourhood on a map centred on their place of residence and zoomed out to show an area extending 1.3 km from the place of residence to the longest side of the screen. Each individual could then draw her self-defined neighbourhood as many times as she wished until the desired result was obtained. Individuals could also zoom in and out of the map and move it around to comfortably visualize their perceived

neighbourhood boundaries. A short instructional video could be viewed as needed. For 35 participants who completed the questionnaire on paper or over the phone, perceived neighbourhood boundaries were drawn by a researcher following the instructions provided by participants. Prior to being asked to draw their self-defined neighbourhood, participants were asked seven questions as a way to initiate the thought process regarding how they viewed their residential neighbourhood, such as how many people they knew, how safe they felt, or whether they thought there were enough businesses in their neighbourhood (without specifying how that might be delineated). We defined fixed distance neighbourhoods in two different ways : (1) as half-mile circular buffers centred on participants' residential location; and (2) as half-mile road-network buffers centred on participants' residential location. Figure 1 shows the overlap between half-mile circular buffers, half-mile road network buffers and self-defined neighbourhoods for two neighbouring participants whose maternal education level differed.

Figure 1. Illustrative map of half-mile circular buffers, half-mile road network buffers and self-defined neighbourhoods of two ISIS participants living in close proximity, Montreal, Canada.



Note: Residential locations have been slightly moved to protect participant anonymity
Source: ISIS Study, 2014 (ESPUM)

Computing spatial accessibility measures

Three spatial accessibility measures were computed: (1) a 'standard' measure corresponding to the number of resources of each type located in participants' half-mile circular buffers; (2) a 'road network-based 'measure corresponding to the number of resources of each type located in participants' half-mile road-network buffers; and (3) an 'experience-based' measure corresponding to the number of resources of each type located in participants' self-defined neighbourhoods. Spatial accessibility measures were dichotomized as "Yes" (at least one resource present) *vs.* "No".

Statistical Analyses

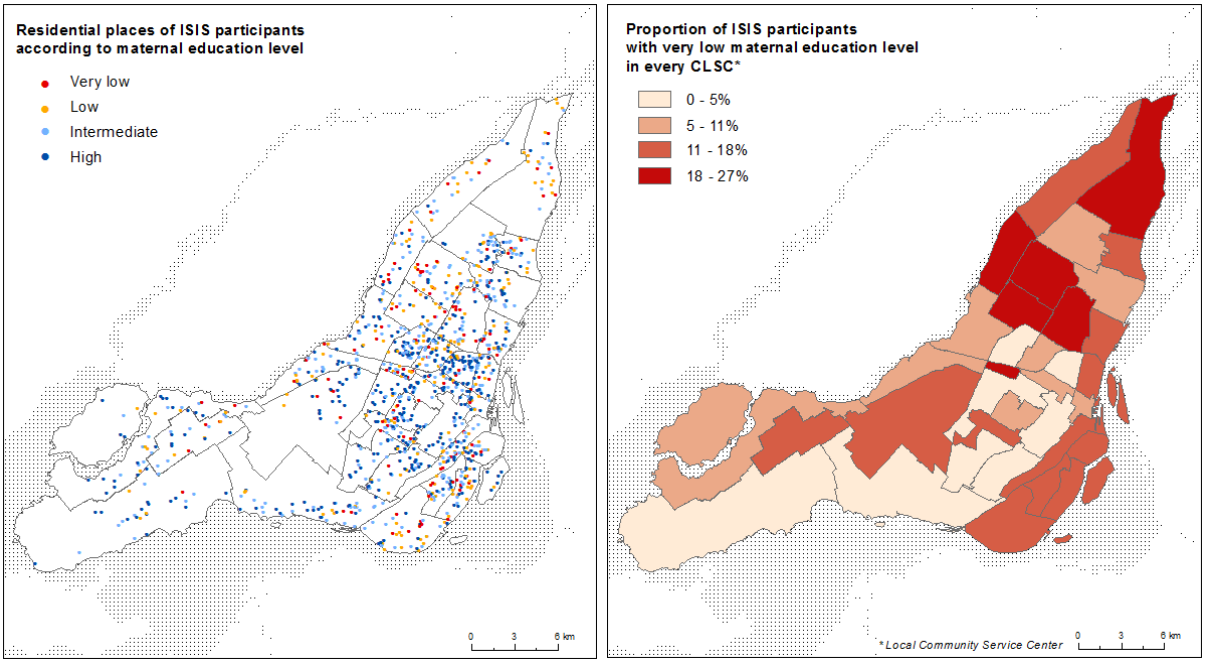
Descriptive statistics were computed for the complete sample and by maternal education level. Mean age, proportion of males, median size of self-defined neighbourhoods and median size of half-mile road network buffers were compared across maternal education levels using ANOVA, Chi2 and Jonckheere

tests respectively. We used logistic regression to model the association between the presence of resources (Yes *vs.* No) in half-mile circular buffers, in half-mile road network buffers or in self-defined neighbourhoods and maternal education level modelled as a continuous variable.

RESULTS

Out of the initial sample of 1,457 participants, those not living on the Island of Montreal (n=35), those who had not drawn their self-defined neighbourhood (n=260), and those without information about maternal education level (n=261) were excluded, for a final analytical sample of 1,101 respondents. Table 2 shows descriptive statistics for the full sample and by maternal education level. The sample was 44% male and mean age was 23.4 years. Based on maternal education level 124 participants (11%) were categorized as very low SES, 216 (20%) as low SES, 343 (31%) as intermediate SES, and 418 (38%) as high SES (see also Figure 2). There were no statistical differences in age or sex by SES (Table 2).

Figure 2. Residential location for 1,101 young adults from the ISIS Study (Montreal, Canada, 2014)



Source: ISIS Study, 2014 (ESPUM)

Social gradient in size of self-defined neighbourhoods

Also shown in Table 2, the median size of participants' self-defined neighbourhood was 196 ha (interquartile range of 346.5 ha). This corresponds to a 791-metre radius circle, which is close to a half-mile buffer (805-metre radius circle) which we used to define distance of circular and road-network neighbourhoods. A positive trend (P=0.03) was observed in the median size of self-defined neighbourhoods according to maternal education level, with median size increasing from 182.3 ha to 212.7 ha as maternal education level increased (Table 2). Besides, no trend (P=0.56) was found in the median size of road network buffers according to maternal education level.

Table 2. Descriptive statistics for 1,101 young adults from the ISIS Study (Montreal, Canada, 2014). Full sample and by maternal education level.

	Full sample (n=1101)	Maternal education level				*P-value (statistical test)*
		Very low (n=124)	Low (n=216)	Intermediate (n=343)	High (n=418)	
Age mean (SE)	23.4 (2.3)	23.5 (2.2)	23.6 (2.4)	23.4 (2.3)	23.4 (2.3)	*0.63 (Anova test)*
Male % (n)	44.0 (484)	43.5 (54)	43.1 (93)	43.4 (149)	45.0 (188)	*0.96 (Test chi2)*
Size of self-defined neighbourhood median in ha [Q1-Q3] *(Radius of the corresponding cicular buffer, in metres)*	196.4 [86.7-433.2] *(791)*	182.3 [79.2-432.6] *(762)*	185.5 [61.8-393.2] *(768)*	196.4 [93.0-421.6] *(791)*	212.7 [98.2-455.1] *(823)*	*0.03 (Jonckheere test)*
Size of half-mile road-network buffer median in ha [Q1-Q3]	105.8 [87.9-119.6]	105.8 [94.1 – 120.7]	103.8 [86.3-117.8]	105.7 [90.3-119.8]	107.3 [87.1-119.1]	*0.56 (Jonckheere test)*

Note. For road-networks buffers, distance was fixed at 805 metres (0.5 miles). It corresponds to a 203 ha. circular area, which is close to the median area of 1,101 self-defined neighbourhoods studied

Social gradient in spatial accessibility to resources

Table 3 presents the proportion of participants with at least one resource of each type in their half-mile buffer (circular and road-network) and in their self-defined neighbourhood, for the full sample and by maternal education level. Three quarters (or more) of participants had at least one grocery store, drugstore, eating and drinking place, recreational sport centre, civic, social, and fraternal organization, bike path, large park, social service, dental office or clinic, and physician office or clinic in in their self-defined neighbourhoods. A lower proportion of respondents had a fruit and vegetable store (60.0%) or a library (34.2%) in their self-defined neighbourhoods. Table 3 also presents associations between the presence of health-related resources and maternal education level. For instance, the likelihood that young adults would have at least one fruit and vegetable store in their self-defined neighbourhood increased with maternal education (coefficient of 0.171; *P-value* < 0.01).

When using self-defined neighbourhoods, significant and positive associations were observed (Table 3) between presence of health-related resources and maternal education level for 10 out of the 12 studied resources (with coefficient values from 0.139 to 0.255; *P-values*< 0.10). The two exceptions were drugstores and grocery stores for which associations were less statistically significant (coefficient of 0.118; *P-value*=0.13 and coefficient of 0.139; *P-value*=0.16, respectively). By contrast when using half-mile circular buffers, positive associations were only found for 2 out of the 12 studied resources : library (coefficient of 0.240; *P-value*<0.01) and physician office or clinic (coefficient of 0.179; *P-value*<0.02)). With this 'metric-based' measure of accessibility, no trend were found for 7 out of the 12 resources under consideration (with coefficient values from -0.124 to 0.148; *P-value*s>0.10) while inverse associations were observed for 3 resources: grocery stores (coefficient of -0.397; *P-value*=0.02), bike paths (coefficient of -0.321; *P-value*=0.07) and civic, social and fraternal organizations (coefficient of -0.190; *P-value*=0.07). Measures of association between maternal education and road-network buffer measures tended to lie between those observed for self-defined neighbourhoods and for circular buffers: positive trends were found for 5 out of the 12 studied resources (with coefficient values from 0.103 to 0.323 ; *P-value*s<0.10), no trend for 6 out of the 12 studied resources (with coefficient values from -0.112 to 0.063 ; *P-value*s>0.10) and inverse trends for one out of the 12 studied resources : grocery stores (coefficient of -0.258; *P-value* =0.01).

Table 3. Proportion of ISIS respondents (Montreal, Canada, 2014) with at least one health-related resource in half-mile circular buffers, half-mile network buffers and self-defined neighbourhoods. Analysis for the full sample and by maternal education level.

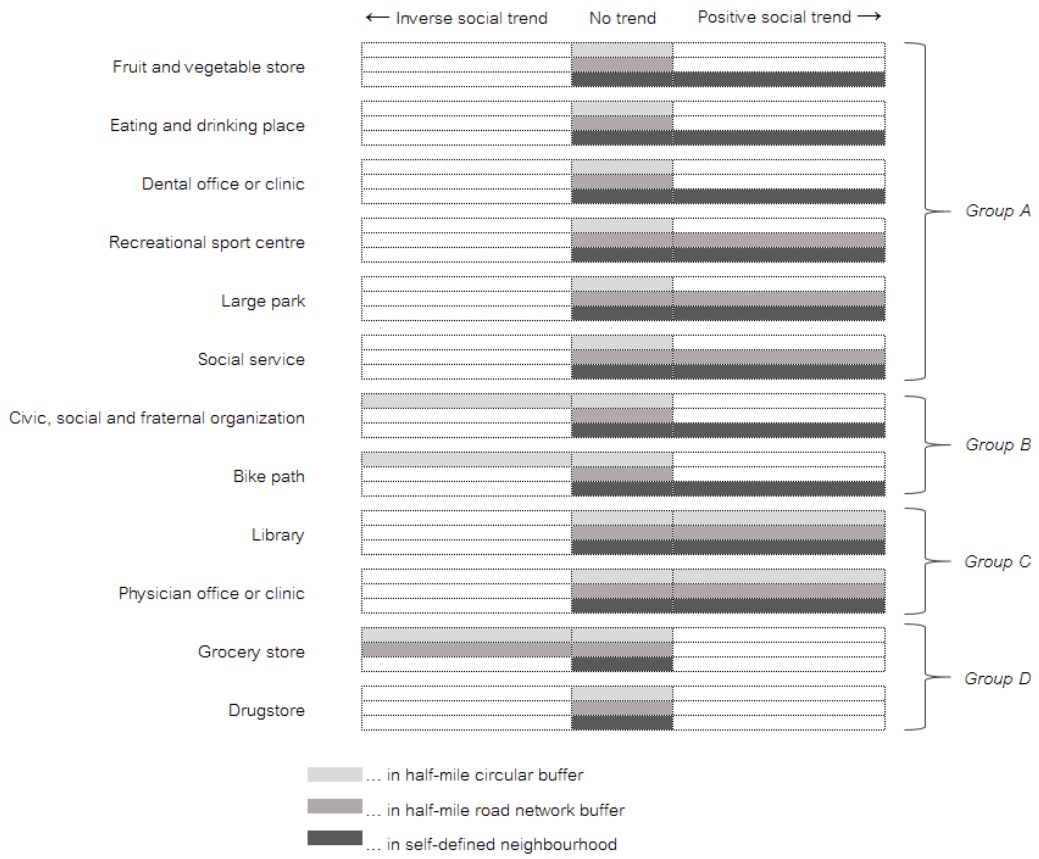
	Proportion of ISIS respondents with at least one health-related resource					**Association between the presence of health-related resources and maternal education level**	
	Full sample (n=1,101)	By maternal education level				Coefficient[1]	*P-value*
		Very low (n=124)	Low (n=216)	Intermediate (n=343)	High (n=418)		
Grocery store							
… in half-mile circular buffer	95.5%	98.4%	96.3%	96.2%	93.5%	-0.397*	*0.02*
… in half-mile network buffer	88.7%	92.7%	90.7%	89.8%	85.6%	-0.258*	*0.01*
… in self-defined neighbourhood	90.6%	90.3%	88.0%	90.4%	92.3%	0.139	*0.16*
Drugstore							
… in half-mile circular buffer	87.6%	87.9%	89.4%	89.5%	85.2%	-0.124	*0.18*
… in half-mile network buffer[1]	73.4%	76.6%	72.7%	74.9%	71.5%	-0.065	*0.34*
… in self-defined neighbourhood	83.7%	83.1%	79.6%	84.3%	85.7%	0.118	*0.13*
Fruit and vegetable store							
… in half-mile circular buffer[1]	58.8%	56.5%	56.5%	57.1%	62.0%	0.088	*0.15*
… in half-mile network buffer[1]	44.7%	41.1%	43.5%	44.9%	46.2%	0.063	*0.29*
… in self-defined neighbourhood	60.0%	54.8%	56.0%	57.1%	66.0%	0.171*	*<0.01*
Eating and drinking place							
… in half-mile circular buffer[1]	95.5%	96.0%	96.8%	93.6%	96.4%	-0.001	*0.99*
… in half-mile network buffer[1]	88.9%	92.7%	88.4%	88.9%	88.0%	-0.112	*0.25*
… in self-defined neighbourhood	91.0%	87.9%	88.9%	89.8%	94.0%	0.257*	*0.01*
Recreational sport centre							
… in half-mile circular buffer[1]	74.8%	73.4%	72.7%	75.2%	76.1%	0.063	*0.36*
… in half-mile network buffer[1]	59.2%	54.8%	54.6%	61.5%	61.0%	0.103*	*0.09*
… in self-defined neighbourhood	76.5%	74.2%	70.8%	77.6%	79.2%	0.141*	*0.04*
Civic, social and fraternal organization							
… in half-mile circular buffer[1]	89.8%	94.4%	89.8%	90.4%	88.0%	-0.190*	*0.07*
… in half-mile network buffer[1]	81.7%	85.5%	79.2%	82.8%	81.1%	-0.038	*0.62*
… in self-defined neighbourhood	87.4%	87.1%	82.9%	87.5%	89.7%	0.158*	*0.07*
Bike path							
… in half-mile circular buffer[1]	96.2%	97.6%	97.7%	96.5%	95.0%	-0.321*	*0.07*
… in half-mile network buffer[1]	88.5%	89.5%	85.6%	91.2%	87.3%	-0.011	*0.90*
… in self-defined neighbourhood	89.9%	88.7%	87.5%	88.9%	92.3%	0.174*	*0.07*
Large park							
… in half-mile circular buffer[1]	92.7%	93.6%	90.3%	91.6%	94.7%	*0.148*	*0.18*
… in half-mile network buffer[1]	95.2%	92.7%	92.6%	95.9%	96.6%	*0.323**	*0.01*
… in self-defined neighbourhood	83.1%	79.0%	81.0%	83.4%	85.2%	*0.143**	*0.06*
Social service							
… in half-mile circular buffer[1]	76.7%	80.7%	73.6%	75.2%	78.5%	*0.021*	*0.76*
… in half-mile network buffer[1]	60.8%	57.3%	53.2%	60.3%	66.0%	*0.174**	*<0.01*
… in self-defined neighbourhood	74.6%	71.0%	70.8%	74.3%	77.8%	*0.139**	*0.07*
Library							
… in half-mile circular buffer[1]	26.0%	16.9%	22.7%	25.4%	30.9%	0.240*	*<0.01*
… in half-mile network buffer[1]	16.1%	11.3%	15.3%	15.7%	18.2%	0.152*	*<0.01*
… in self-defined neighbourhood	34.2%	25.8%	33.3%	28.9%	41.6%	0.218*	*<0.01*
Physician office or clinic							
… in half-mile circular buffer[1]	84.2%	79.8%	81.5%	84.3%	86.8%	0.179*	*0.02*
… in half-mile network buffer[1]	69.5%	64.5%	62.5%	67.9%	75.8%	0.222*	*<0.01*
… in self-defined neighbourhood	81.6%	77.4%	75.9%	80.5%	86.8%	0.255*	*<0.01*
Dental office or clinic							
… in half-mile circular buffer[1]	89.1%	91.9%	88.9%	88.3%	89.0%	-0.065	*0.50*
… in half-mile network buffer[1]	76.4%	78.2%	71.3%	78.1%	76.8%	0.035	*0.62*
… in self-defined neighbourhood	86.2%	79.8%	83.3%	86.6%	89.2%	0.248*	*<0.01*

Note. For circular and networks buffers, radius was similarly fixed at 805 metres (0.5 miles). It corresponds to a 203 ha. circular area, which is close to the median area of 1,101 self-defined neighbourhoods studied

[1] Coefficient for maternal education modelled as a continuous variable in a logistic regression comparing presence *versus* absence of given resource; Significance level: * $P < 0.10$

Four patterns emerged when comparing social gradients in spatial accessibility to health-related resources based on the three neighbourhoods definitions (Figure 3).

Figure 3. Comparison between social gradients in spatial accessibility to health-related resources based on the three neighbourhood definitions.



- The most frequently observed pattern (Group A in Figure 3) was found for fruit and vegetable stores, eating and drinking places, dental offices and clinics, recreational sport centres, large parks and social services. For these six resources, there was no social gradient in spatial accessibility based on half-mile circular buffers and social gradient was found to be either no significant or positive with road-network buffers. However, a positive social gradient was systematically found for measures based on self-defined neighbourhoods. Taking into account individuals' perception of their neighbourhood boundaries thus revealed social inequalities in spatial accessibility to several types of resources that were not apparent with circular buffers and partially apparent with road-network buffers.
- A second pattern was found for bike paths and civic, social, and fraternal organizations (Group B in Figure 3). As the level of maternal education increased, the likelihood of living in a neighbourhood with these resources decreased when using circular buffers, but it increased when using self-defined neighbourhoods. No association was found, however, when using road-network buffers. There thus was a reversal in the direction of the social gradient in resource accessibility depending on the chosen neighbourhood definition.
- A third pattern emerged for physician offices and clinics and for libraries (Group C in Figure 3). There was a positive social gradient in spatial accessibility to these resources when using either circular buffers or road-network buffers or self-defined neighbourhoods. This suggests there is an unequal spatial distribution of physician offices and clinics and of libraries on the island of Montreal

even before taking into account the ways in which inhabitants experience their residential neighbourhood.

- Finally, a fourth pattern was observed for grocery stores and drugstores (Group D in Figure 3). These were the two only resources for which no difference in spatial accessibility to resources was observed according to materiel level of education when using self-defined neighbourhoods.

Inverse social gradients in spatial accessibility based on self-defined neighbourhoods were not observed for any of the resources, i. e., lower SES groups never experienced better accessibility to health-related resources than their higher SES counterparts. Referring to standard spatial units with a fixed geometry such as circular or road-network buffers rather than spatial units that take into account individuals' place experiences may therefore underestimate the magnitude of social inequalities in resource accessibility.

DISCUSSION

In this paper we assessed and compared the social gradients in spatial accessibility to health-related resources when spatial accessibility was uniformly defined for all participants in half-mile buffers around their place of residence using either circular or road-network buffers, and when it integrated individuals' unique place experiences via their self-defined neighbourhood.

Spatial accessibility to resources was, in most cases, lower for lower SES groups than for higher SES groups, regardless of neighbourhood definition. Most importantly, we did not find a case where the social gradient in spatial accessibility based on self-defined neighbourhoods was in favour of the lower SES groups. In fact, compared to their higher SES counterparts, lower SES groups had worse experience-based accessibility for 10 of the 12 health-related resources studied. This reflects, in part, the positive social gradient observed for the size of self-defined neighbourhoods, with higher SES participants reporting larger neighbourhoods than lower SES participants - as has also been observed in American (Coulton et al., 2013; Sastry et al., 2002) and European cities (Charreire et al., 2016) - and may also have to do with differences in neighbourhood shape (von Stülpnagel et al., 2019), an issue that was beyond the scope of this study.

In the health and place literature, road-network buffers are frequently considered to provide a more accurate representation of neighbourhoods than circular buffers since the spatial footprint of walking is influenced by the road network (Oliver et al., 2007; Shearer et al., 2015). In our own research, we found that road-network buffers tended, similarly to circular buffers, to underestimate social inequalities in spatial accessibility when compared to self-defined neighbourhoods. Even though it is almost impossible to say based on empirical findings alone which of these three neighbourhood definitions represents the 'true context' (Kwan, 2012), self-defined neighbourhoods, which integrate place experiences, may better represent what people actually have access to in their residential neighbourhood compared to uniform buffers. As such, they may be a relevant spatial unit when investigating neighbourhood effects involved in the creation or continuation of social inequalities in health.

Our findings lead us to re-examine social inequalities in resource accessibility when taking into account people's neighbourhood experiences as an additional source of inequality over and beyond inequality in the spatial distribution of resources (Vallée et al., 2015). In line with principles of equity and redistributive justice, we could have assumed that lower social groups would have a notably better accessibility to resources managed by institutional (federal, provincial, and municipal) actors: bike paths, large parks, social services, libraries, dental offices and clinics, and physician offices and clinics. However, we found that the highest SES groups always had better accessibility to these six resources when considering experienced-based neighbourhoods, compared to lower SES groups. Even when

considering road-network neighbourhoods, none of these six resources was found to be more accessible for lower SES groups. On the other hand, findings related to grocery store accessibility displayed radically different patterns. As previously described in Montreal (Apparicio et al., 2007), lower SES groups had better accessibility to grocery stores compared to higher SES groups when only considering the spatial distribution of resources. No significant social gradient in accessibility was observed, however, when accounting for people's neighbourhood experiences. Grocery stores as well as drugstores are actually the only resources for which no significant social gradient in accessibility was observed with self-defined neighbourhoods. These two resources could have both a positive and negative valence for health: these are places where people can buy the necessities of daily life as well as products that are detrimental to health (tobacco, alcohol and 'junk food' in particular).

In line with the relational approach to place and with multiscale spatial contexts behind neighbourhood effects (Petrović et al., 2019), our research argues in favour of recognizing that there are sociospatial variations in neighbourhood boundaries. By extending traditional notions of proximity and distance as defining the separation between people and places, this approach encourages us to consider places as relative to people, and place experiences as a constitutive dimension of socio-spatial processes (Cummins et al., 2007). Our research also argues in favour of shedding light on the variability in people's accessibility to resources. In this way, the capability approach's contribution to understanding spatial accessibility to neighbourhood resources is also noteworthy. When concerned with people's well-being or poverty, the capability approach emphasizes the importance of exploring agency and "*what a person is free to do and achieve in pursuit of whatever goals or values he or she regards as important*" (Sen, 1985, p. 203). The capability approach has also found echoes in transportation research to make explicit how opportunities for mobility are managed, shaped and directed by individuals (Nordbakke, 2013). It thus provides a useful lens to explore individuals' accessibility to resources within areas which they experience and perceive as possibly reachable, and to make visible social gradients in people's capacity to convert available resources into accessible resources. But is the capability approach meaningful to discuss the socially constructed inequalities in accessibility to health-related resources? Some authors have argued that the capability approach overlooks structural inequalities since it emphasises normative understandings of freedom or capability and leaves little room for the role of social structures in shaping the choices which individuals perceive as possible and ultimately make (Bowman, 2010). Dean (2009, p. 271) goes further and characterises the capability approach as "*in essence a restatement*" of the liberal ideal "*which assumes that citizens are constituted as formally free and equal and that participation in the public sphere is open upon the same terms to everybody*". Here, we drew from the capability approach to distinguish between resource 'availability' and 'accessibility', but we acknowledge that the capability approach needs to be extended if we are to gain a deeper understanding of the power relations and structural processes that contribute to social inequalities in health.

Study strengths and limitations

Our study is one of very few to have compared social gradients in spatial accessibility to resources between uniform and self-defined spatial units, and extends a previous one conducted in the Paris metropolitan area which had exclusively compared accessibility to health services (general practitioners, dentists and pharmacies) in circular buffers and in self-defined neighbourhoods (Vallée et al., 2015). A strength of the present study is the use of road-network buffers as a third way to define neighbourhoods. Moreover, considering a wider range of health-related resources involving various types of public or private operators and various rules of access is a strength since it allowed us to observe recurring and less common patterns.

We conceptualized self-defined neighbourhoods as shaping 'future' spatial accessibility to resources. However, they also reflect past and present neighbourhood experiences since they capture how residents differently know about and value surrounding resources (even if they do not use them).

According to the importance they give to some types of resources, residents may indeed be inclined to delineate their neighbourhoods in order to include (or exclude) places where these resources are located. A longitudinal analysis of variations in self-defined neighbourhoods would be helpful to better understanding long-term dynamics in neighbourhood experiences and in access to neighbourhood resources and their mutual influences.

By relating spatial accessibility to resources with neighbourhood experiences and agency, the present research is connected with literature centred on transport disadvantage and capabilities for mobility (Delbosc, 2012; Nordbakke, 2013; Preston and Rajé, 2007) although it does not explicitly account for everyday travel needs and practices. The main objective of this paper was indeed to assess and compare inequalities in resource accessibility between social groups according to neighbourhood boundaries rather than to explore individual or household level factors (such as physical limitations or access to transportation) related with self-defined neighbourhood size or with social variations therein.

Our findings should be interpreted in light of the specificity of the study population and site. Young adults may have unique ways of experiencing space and appropriating health-related resources compared to other age groups (Morency et al., 2011; Skelton, 2013). Since there are – to the best of our knowledge – no studies exploring social variations in neighbourhood experiences according to age, it is difficult to know if an older sample would have led us to observe a stronger or weaker social gradient in resources accessibility. Our sample also had a relatively high SES composition with 69% of participants categorized as being of intermediate SES or higher. ISIS respondents at baseline (2011) tended to be more educated compared to those of a representative sample of Montréal residents aged 18 to 24. At wave 2 (2014) non-respondents were also more likely to be in lower educational categories (Frohlich et al., 2015). The relatively high SES of the sample may have slightly impacted social gradient estimate in self-defined neighbourhood size and resource accessibility.

Our findings are also closely tied to the socio-spatial morphology of Montreal, where, as in other North American cities typical of the 'new' post-war cities, socially disadvantaged populations often live in the more densely serviced city centres, unlike the European 'old' pre-war cities, in which higher densities, public spaces, and public transportation impact differently urban social mix and physical proximity to urban services (Charmes and Keil, 2015; Walks, 2007). Finally, by dichotomizing the presence of health-related resources as present/absent instead of analyzing the number of each type of resources in each neighbourhood definition, we lost some of the variability in accessibility measures. In the absence of clear cutpoints to define accessibility to a given resource, we adopted a conservative approach and assumed that minimum accessibility should be based on the presence of at least one resource.

Implications for future research

A future research avenue would be to extend the assessment of place experiences to the scale of the city. Although place of residence is an essential anchor point for daily life activities, the residential scale is indeed – at least for mobile populations – only one piece of the puzzle when exploring relationships between spatial accessibility to resources and effective use of health-related services (Vallée, 2010; Vallée and Chauvin, 2012) or health behaviours (Shareck et al., 2015). This could be done by considering individuals' experience of the multiple residential and non-residential areas that make up their activity space, i.e., the combination of places with which they come into contact as a result of their day-to-day activities (Golledge and Stimson, 1997), and assessed empirically by delineating self-defined neighbourhoods around these activity locations (i.e., a 'self-defined activity space').

CONCLUSION

Our study addresses social inequalities in spatial accessibility to neighbourhood health-related resources from a new angle by encouraging researchers to consider that health may be produced not only with (or without) the structural constraints and opportunities offered at the local level, but also through individuals' place experiences which permit them to identify and to access resources to their health advantage. In light of our findings, we encourage researchers to consider place experiences as a way to prevent mis-estimating resource accessibility and under-estimating social inequalities therein. In a related vein, we invite political actors tasked with developing equity-focused area-based interventions to stop considering spatial accessibility via uniform neighbourhood definitions in order for initiatives which target places to not miss the mark.

Author contribution

Julie Vallée: Conceptualization, Methodology, Data curation, Formal analysis, Writing original draft, Review and Editing. **Martine Shareck**: Conceptualization, Data curation, Writing original draft, Review and Editing. **Guillaume Le Roux**: Data curation, Review and Editing. **Yan Kestens**: Review and Editing. **Katherine L Frohlich**: Conceptualization, Contribution in writing original draft, Review and Editing.

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