Demographic and Urban Form Correlates of Healthful and Unhealthful Food Availability in Montréal, Canada

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ABSTRACT

Objective: This study sought to extend previous analyses of food insecurity in Montréal by examining the relationship between neighbourhood socio-demographic and urban form variables and sources of food both unhealthful (fast-food outlets, FFO) and healthful (stores selling fruits and vegetables, FVS).

Methods: Densities of FFO and FVS were computed for 862 Census tract areas (CTA) (defined as census tract with a 1-km buffer around its limits) for the Montréal Census Metropolitan Area (CMA). Predictor variables included CTA socio-demographic characteristics reflecting income, household structure, language, and education, and urban form measures, specifically, densities of local roads, main roads, expressways and highways. Food source densities were regressed on CTA characteristics using stepwise regression.

Results: Socio-demographic and urban form measures explained 60% and 73% of the variance in densities of FFO and FVS, respectively. FFO were more prevalent in CTA with higher proportions of full-time students and households speaking neither French nor English; lower proportions of married individuals, children and older adults; and more high-traffic roads. FVS were more prevalent in CTA with higher proportions of single residents, university-educated residents and households speaking neither French nor English; lower proportion of French-speakers; and more local roads. Median household income was not related to the density of FFO or FVS.

Conclusion: The availability of healthful and unhealthful food varies across the Montréal CMA. Areas with lower education and more French-speaking households have a lesser availability of FVS. The association of FFO with high-traffic roadways and areas with high school attendance suggests a point for intervention via commercial zoning changes.

Key words: Residence characteristics; socioeconomic factors; food supply; obesity

Prevalence rates of obesity and overweight have risen in Canada[1] and will grow higher with an increasing prevalence of overweight/obesity among youth.[2,3] Societal shifts to increased dietary intake of energy-dense food and reduced energy expenditure underpin rising rates of overweight/obesity around the globe.[4,5] Canadians now obtain 30% of daily calories from nutrient-weak, energy-dense foods,[6] and more than 50% of Canadians fail to meet daily requirements of fruit and vegetable consumption,[7] widely promoted for protective effects on cardiovascular diseases[8-10] and cancer.[11,12]

These risk behaviours do not arise in a vacuum. A growing literature recognizes the role of environmental factors in predisposing, enabling and reinforcing risk behaviours related to overweight/obesity.[13-15] Neighbourhood disadvantage is one such factor which has been linked to unhealthful dietary behaviour[16,17] and risk of cardiometabolic diseases.[18-20] Associations between neighbourhood disadvantage and unhealthful diets have been partly explained by neighbourhood variations in sources of healthful and unhealthful food.[21] Availability of these food sources has recently been shown to be associated with overweight/obesity,[22-25] and greater mortality and rates of admission for acute coronary syndromes.[26] Availability of these same food sources has also been shown to vary with neighbourhood characteristics. For instance, studies in the United States demonstrate that economically disadvantaged neighbourhoods and those with high proportions of visible minorities have a lower availability of stores selling healthful foods[27-29] and a greater availability of fast-food outlets[30-32] relative to more advantaged neighbourhoods

or those with fewer minorities. Research in Canada,[33,34] the United Kingdom,[35,36] Australia,[37] and New Zealand[38] has similarly indicated that area-level socio-economic status (SES) is inversely related to the density of fast-food outlets. The inverse relation found in the US between area-level disadvantage and stores offering healthful foods has *not*, however, been observed by studies in the UK[39] or Australia.[40] Similarly, recent Canadian investigations have found disparities in access to fresh fruits and vegetables or supermarkets in Montreal,[41,42] London,[43] and Edmonton,[34] but such disparity has not been clearly explained by neighbourhood SES.

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There is a need to investigate factors beyond neighbourhood SES to better understand differentials in availability of food sources and help identify potential drivers of such disparities that could inform public health intervention. Socio-demographic indicators beyond SES, as well as urban form indicators, are especially relevant as these characteristics can inform public health actions to counter unhealthful or support healthful commercial presence in particular areas. Thus far, few published studies on food environments have investigated place-based correlates other than neighbourhood disadvantage operationalized using aggregated socio-economic data.

This study aimed to determine urban area socio-demographic and urban form indicators associated with the Montréal food environment in terms of stores selling fruits and vegetables and fast-food outlets, these considered the primary modes by which environmental factors influence diet and obesity.[44]

METHODS

Population

The study region was the Montréal Census Metropolitan Area (CMA), having in 2001 a total population of 3.4 million persons residing in 862 census tracts (CT), 16 of which were excluded from analyses due to missing/incomplete data.

Measures

Outcomes were measures of stores offering healthful foods for home consumption (stores selling fruits and vegetables, FVS), and restaurants offering rapidly-prepared, mostly unhealthful foods, for home or out-of-home consumption (fast-food outlets, FFO). A commercial database,[45] containing a comprehensive inventory of businesses and services located within the Montréal CMA in 2003, was purchased. From this database, we extracted FVS as identified from Standard Industry Classification (SIC) codes for: fruit and vegetable stores; supermarkets and grocery retail stores; and farm markets. Restaurants were similarly extracted using the SIC code "eating places". Given the absence of a specific fast-food categorization, a geomatics specialist with extensive knowledge of the Montréal restaurant industry coded restaurants for chain-type FFO. Criteria for coding included the presence of at least five outlets in the CMA with a product line consisting primarily of high-calorie foods such as hamburgers, fries, hot dogs, and soft drinks. Non-chain restaurants were not targeted as they could not be straightforwardly validated as primarily offering fast food. A total of 371 FFO from eight major chains were so identified.

FFO and FVS were geocoded using 'GeoPinPoint' software and integrated within a Geographic Information System (GIS).[46] Eighty-two percent of businesses were geocoded at the address level and 18% at the six-digit postal code level (highly precise, being one side of one street section). FFO and FVS were expressed in terms of density (number of stores per square kilometre) within CTs with a one-kilometre buffer around the CT boundary to represent "census tract area" (CTA). This approach accounts for accessibility to stores located within an approximately 12-minute walk (1 km) of CT borders. Similar measures of absolute exposure have been used in previous studies.[30,33]

Predictor variables considered included standard socio-demographic variables from the 2001 Canada Census and road network structure. Socio-demographic variables considered included CT compositional measures of age structure, educational attain-

Table 1. Summary Statistics of Outcome and Explanatory Variables

Category	Variable	Average	SD
Business density	Fast-food chain density (n/km^2)	0.52	0.67
	Fruit and vegetable store density (n/km^2)	2.17	2.70
	Restaurant density (n/km^2)	10.86	19.87
Road network	Local road* density (km/km^2)	8.41	3.23
	Main road† density (km/km^2)	2.44	1.31
	Highway‡ density (km/km^2)	0.22	0.19
	Expressway§ density (km/km^2)	0.22	0.23
Household income	Median income ($)	22,723	6,687
Age structure	% population 65 and older	13.21	7.11
Language spoken at home	% French home language	74.69	27.09
	% English home language	15.55	21.03
	% no official home language	9.29	12.74
Marital status	% married	38.17	12.35
	% single	42.83	11.15
Household type	Average number of children/family	1.07	0.25
	% aged 15-24, full-time school	7.88	2.64
Educational attainment	% with university degree	16.64	9.65

* Defined as subdivision road[47]
† Defined as major or arterial road[47]
‡ Defined as controlled access road with maximum speed of at least 70 km/h[47]
§ Defined as controlled access road with maximum speed of at least 80 km/h[47]

ment, marital status, household type, language spoken at home, and household income. Road network structure measures included densities of different road types measured in kilometres of road per square kilometre for each CTA (Source: DMTI 2003[47]). Details of variables used for each category are provided in Table 1.

Data analysis

For each outcome variable (FFO and FVS density), two regression models were built, following a forward stepwise procedure with alpha of 0.10 and 0.05 as inclusion and exclusion criteria, respectively. Multicollinearity was evaluated by calculating Variance Inflation Factors (VIF). Analyses were conducted using SPSS version 12.0 (SPSS Inc., Chicago, IL). Statistical significance was set at the 0.01 level of probability.

RESULTS

Table 1 presents summary statistics for outcome variables and selected CTA measures. Results from regression analysis are presented in Table 2. Models explained 60% and 73% of the variance in FFO and FVS density, respectively. No VIF value was higher than 2.64, indicating nominal multicollinearity.

FFO density was negatively associated with proportions of married individuals and older adults, as well as the average number of children per family. Positive associations were found between FFO density and proportions of individuals attending school full-time, households speaking neither French nor English, and densities of main roads and expressways.

The density of FVS was positively associated with proportions of single individuals, university graduates, and households speaking neither French nor English. Proportion of French-speaking households was negatively associated with FVS density. Local road density was positively associated with FVS density, whereas highway density was negatively associated with FVS density.

DISCUSSION

Our results provide evidence of a strong association between FFO density, FVS density, and socio-demographic and urban form measures within the Montréal CMA.

Table 2. Density of Fast-food Outlets and Stores Selling Fruits and Vegetables in Relation to Selected Census and Urban Form Indicators

Predictors	Fast-food Outlet Density					
	B	SE	Beta	t	Sig.	VIF
(Constant)	0.428	0.1		4.27	<0.001	
% population 65 and older	-0.006	0.002	-0.091	-3.19	0.001	1.73
% school full-time	0.049	0.005	0.241	10.00	<0.001	1.23
% married	-0.008	0.001	-0.199	-5.74	<0.001	2.57
Average number of children/family	-0.461	0.073	-0.221	-6.29	<0.001	2.64
% no official language	0.005	0.001	0.130	4.68	<0.001	1.64
Main road density	0.163	0.012	0.440	13.69	<0.001	2.20
Expressway density	0.204	0.028	0.170	7.22	<0.001	1.18

Predictors	Fruit and Vegetable Store Density					
	B	SE	Beta	t	Sig.	VIF
(Constant)	-5.465	0.254		-21.50	<0.001	
% university degree	0.051	0.005	0.216	11.24	<0.001	1.14
% single	0.127	0.004	0.618	29.41	<0.001	1.36
% French	-0.009	0.002	-0.105	-4.06	<0.001	2.08
% no official language	0.055	0.004	0.305	12.53	<0.001	1.83
Local road density	0.172	0.015	0.246	11.60	<0.001	1.39
Highway density	-0.227	0.092	-0.046	-2.48	0.013	1.07

Income

No relationship was found between income and FVS density for the CMA, consistent with findings on the distribution of such establishments on the Island of Montreal[41] and in other Canadian cities.[34,43] Similarly, no association was found between income and FFO density, contrasting with results obtained in Edmonton.[33,34] However, considering compositional measures beyond income, a number of relationships emerged.

Educational attainment

FVS density, but not FFO density, was strongly and positively associated with educational attainment. Although education and income were moderately correlated, our data indicate that primarily people with higher education are disproportionately exposed to a high density of FVS. These findings align with reports from the United States suggesting that the quality of dietary intake is more strongly related to education than income status[48] and with Canadian data indicating that BMI is higher for residents of neighbourhoods with low proportions of educated individuals.[49]

Household structure

The density of FFO was strongly associated with measures of household structure. Proportionately fewer FFO were located in areas where households are composed of married persons, where the number of children per family is high, and areas with high proportions of older adults. These findings suggest that children in such areas have lesser local exposure to fast food. We observed a strong positive association, however, between the proportion of young adults attending school full time and FFO density. This result could be explained by specific targeting of this young clientele by the food industry or self-selection of fast-food outlets into areas in proximity to higher education institutions, which in Montreal tend to cluster in urban rather than suburban areas. Finally, FVS were primarily found in CT areas with high proportions of single individuals. It remains to be determined whether this result is specific to FVS or applies to retailing businesses in general, as single individuals might be more likely to live in more urban settings, where retail density is high.

Language

In the Montréal context, race is perhaps a less pertinent indicator of ethnic differentiation than language spoken at home. The latter can be used to distinguish predominantly Francophone and Anglophone areas, and areas with immigrants or secular traditions. We found that the proportion of residents speaking neither official language was related to FFO, suggesting that immigrants have greater availability of fast food in Montréal. The new types of foods and large portion sizes that immigrants encounter may lead to high calorie consumption, considering that immigrants often adapt their eating patterns to new environments upon immigrating.[50] CT area proportions of households speaking neither official language were also positively related to FVS density, indicating a more-or-less balanced exposure to FFO and FVS. One explanation could be that ethnic neighbourhoods populated with immigrants may be characterized by a higher diversity of local specialty stores, including FVS, as already suggested by others.[41] Areas with French-speaking households were clearly underprovided with FVS, but no association of French or English language with FFO was observed.

Road network

Road network indicators including the density of main roads and expressways were positively correlated with FFO density. Such results corroborate location marketing strategies that aim to facilitate FFO accessibility and visibility for car drivers.[51] In contrast, FVS were more likely to be found in CT areas characterized by higher densities of local roads and lower densities of highways. Such results are not unexpected, as Montreal is characterized by a high number of FVS in medium-to-high density central areas that primarily target a local pedestrian clientele. It is also possible that FVS, generating lower revenues than FFO, cannot afford high traffic locations. These results are consistent with the reported positive association between BMI and levels of metropolitan sprawl.[49]

Limitations of the study

Our results should be interpreted in light of methodological limitations. First, fast foods and fruit and vegetables are just two examples of food types within the diverse composition of typically urban western dietary opportunity, and thus are not exhaustively representative of unhealthful/healthful food. Second, this study offers only a partial representation of opportunities to access fast foods and fruits and vegetables. For instance, non-chain fast-food outlets were not included in our analysis as they could not be identified from the database. Furthermore, fast-food and soft-drink distribu-

tion in educational institutions was not accounted for, although these are of concern given sophisticated marketing campaigns by food distributors targeting youth.[52,53] Last, although Montréal has similarities to other major North American cities, it is atypical in terms of language composition and density of FVS serving local community needs. Similar studies of socio-demographic composition and road network measures in other North American cities may replicate some but not all of our findings. Our results are nevertheless relevant to health promotion and public health intervention, and could support the implementation of novel urban planning strategies in Montreal, such as municipal zoning regulations to limit numbers of FFO in areas with high proportions of school-age youth and high-traffic roads, and efforts to promote or support the sale of fruit and vegetables in low education and French-speaking areas.

In summary, our results indicate that unequal access to healthy food in Montreal is associated with factors beyond area-level income. Such factors are likely driven by market conditions and opportunities tied to urban structure and locations of target clientele, and by individuals' choice of, and options for, residence based on existing neighbourhood resources. Recognizing such constraints might serve policies aimed at providing equal access to healthful food, an important issue in an era of increasing social inequalities and upward trends in obesity.

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RÉSUMÉ

Objectif : Contribuer à l'étude de l'insécurité alimentaire à Montréal en analysant la relation entre caractéristiques socio-démographiques, forme urbaine et sources alimentaires malsaine (restauration rapide, RR) et saine (commerces de fruits et légumes, CFL).

Méthode : Les densités de RR et de CFL ont été calculées pour 862 aires de secteurs de recensement (ASR) (secteur de recensement et 1 km au-delà) pour la Région Métropolitaine de Recensement (RMR) de Montréal. Ces densités sont modélisées à partir de caractéristiques socio-démographiques concernant le revenu, la structure des ménages, la langue et l'éducation, ainsi que des mesures liées à la forme urbaine soit les densités de routes locales, principales, express, et autoroutes. Les associations entre ces variables environnementales et les densités de RR et CFL ont été établies à l'aide de régressions multiples séquentielles.

Résultats : Les mesures socio-démographiques et de forme urbaine expliquent respectivement 60 % et 73 % de la variance des densités de RR et de CFL. La densité de RR était positivement associée à la proportion d'étudiants à temps plein et de ménages ne parlant ni français, ni anglais, et à la densité de routes à haute circulation, et négativement associée à la proportion de personnes mariées, d'enfants et de personnes âgées. La densité de CFL était positivement associée à la proportion de personnes célibataires, de résidents avec diplôme universitaire et de ménages ne parlant ni anglais, ni français, et à la densité de routes locales, et négativement associée à la proportion de francophones. Le revenu médian n'était pas associé aux densités de RR et de CFL.

Conclusions : La disponibilité de nourriture saine et malsaine varie dans la RMR de Montréal. La disponibilité de CFL est moindre dans les zones avec de faibles taux d'éducation et une plus grande proportion de francophones. Les liens entre la RR, les routes à haute circulation, et les zones à forte concentration d'étudiants suggèrent de possibles interventions via le zonage.

Mots clés : facteurs sociodémographiques; obésité; paysage alimentaire; forme urbaine