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Neighbourhood food environments revisited: When food deserts meet food swamps

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Key Messages

- We identify three types of vulnerable neighbourhoods: food deserts, food swamps, and those with overlaps of food swamps and food deserts.
- We adopt customized regression models to investigate associations between neighbourhood characteristics and different food store availability.
- We propose tailored strategies to effectively and efficiently improve food environments.

This study uses service area–based coverage and various count regression methods to assess neighbourhood-level healthy and unhealthy food environments, and food access associated with different socioeconomic groups in Edmonton, Canada. We identify three types of vulnerable neighbourhoods according to different food environments: food deserts (i.e., neighbourhoods lack sufficient access to healthy foods); food swamps (i.e., neighbourhoods have excess access to unhealthy foods); and those with overlaps of food swamps and food deserts. We also identify neighbourhoods with superior access to healthy foods (i.e., food oases). Additionally, our results from regression analyses indicate: (1) child population is negatively associated with both healthy and unhealthy food resources; (2) good access to public transportation is associated with good coverage of all healthy food outlets and convenience stores; and (3) deprived neighbourhoods with higher percentages of minority populations have better coverage of both healthy and unhealthy foods in general. The results from this study can help the City of Edmonton identify the key neighbourhoods with high potential for local business and the hotspot neighbourhoods that require particular support. Tailored strategies are proposed to effectively and efficiently improve food environments with limited resources.

Keywords: neighbourhood food environment, food desert, food swamp, food oasis, service area

Les environnements alimentaires de quartiers réexaminés : lorsque les déserts alimentaires rencontrent les marécages alimentaires

La présente étude utilise la couverture de l'aire de service et diverses méthodes statistiques afin d'évaluer les environnements alimentaires de quartiers et l'accès à la nourriture de différents groupes socioéconomiques, à Edmonton au Canada. Ainsi, nous identifions trois types de quartiers vulnérables en vertu de différents environnements alimentaires, c'est-à-dire les déserts alimentaires (les quartiers qui manquent d'un accès suffisant à

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une nourriture saine), les marécages alimentaires (les quartiers qui ont un accès excessif à une nourriture malsaine) et ceux qui chevauchent les marécages alimentaires et les déserts alimentaires. Notre typologie contient également des quartiers ayant un accès supérieur à une nourriture saine, soit des oasis alimentaires. De plus, les résultats des analyses de régression font ressortir les éléments qui suivent: (1) la population enfantine est négativement associée aux deux ressources de nourriture saine et malsaine ; (2) l'accès à la nourriture du transport public est associé à une bonne couverture des points de vente de nourriture saine et des dépanneurs, et (3) les quartiers défavorisés ayant un pourcentage plus élevé de populations minoritaires ont généralement une meilleure couverture de nourriture saine et malsaine. Les résultats de cette étude pourront aider la ville d'Edmonton et les entreprises locales à intervenir dans les quartiers qui nécessitent un soutien particulier. À cet égard, des stratégies ciblées sont proposées pour améliorer les environnements alimentaires ayant des ressources limitées.

Mots clés : environnement alimentaire de quartier, désert alimentaire, marécage alimentaire, oasis alimentaire, aire de service

Introduction

Healthy food intake is essential to overall health status and is reported to reduce the risk of nutrition-related chronic diseases such as obesity and type 2 diabetes (Camhi et al. 2015; Swan et al. 2015). There is growing evidence that physical access to different types of food outlets substantially influences dietary patterns and weight status at the population level (Morland et al. 2006; Moore et al. 2009; Morland and Evenson 2009). A report that systematically reviews 19 Canadian community food assessments found a positive relationship between geographic access to non-nutritious food sources and obesity rate, especially among children and youth (Health Canada 2013). Increasingly, the community food environment has become one of the most pressing public health concerns in Canada. Neighbourhood food environments are often studied through the lens of the accessibility to different types of food resources and there are mainly two streams of food outlets in literature. One refers to food retailers that can supply healthy and nutritious foods at relatively affordable prices, such as supermarkets and local grocery stores (see Walker, Keene, and Burke 2010 for a review). The other type is unhealthy food sources such as fast food restaurants and convenience stores that mainly sell fast food and nonperishable items (e.g., Fleischhacker et al. 2011; Black et al. 2014).

Another strand of research on food environments is the investigation of the associations between a neighbourhood's food availability and its socio-demographic characteristics (Sharkey et al. 2009; Lamichhane et al. 2013). In general, the availability of food retailers has been shown to vary according to the neighbourhood's socioeconomic status, depending on study areas. For example, fewer retail sources of healthy foods (e.g., supermarkets) and more sources of unhealthy foods (e.g., fast food restaurants and convenience stores) are found to be located in neighbourhoods with higher proportions of low-income and ethnic-minority residents relative to more affluent neighbourhoods or those with fewer minorities in the United States (US) (see Black et al. 2014 for a review). Comparatively, in Canada, more deprived neighbourhoods have greater access to both healthy and unhealthy food outlets, with some variations across study regions (Smoyer-Tomic et al. 2008; Black et al. 2011; Polsky et al. 2014). Therefore, an in-depth investigation of the association between subpopulations and their food availability is essential for government and interest groups to implement specific policies for communities in need.

This paper comprehensively assesses neighbourhood food environments and investigates associations between neighbourhood characteristics and different food stores availability. We make the following contributions to the food environment literature. First, most existing studies only focus on one aspect or one type of food environment such as investigating food deserts or food swamps in a specific place. This study conducts a comprehensive assessment of the food environment in Edmonton, Canada. We study both healthy and unhealthy food stores and identify four types of neighbourhoods based on different food environments: food deserts, food swamps, overlaps of food deserts and food swamps, and food oases. This is critical because different types of environments require different strategies to mitigate the

vulnerability or to improve the diet environment. For example, strategies for a food swamp with good access to affordable healthy food retailers would be quite different from strategies for a food swamp with no convenient access to healthy food nearby.

In addition to the food environment assessment, we also study the association between the socio-economic characteristics of the neighbourhoods and the food environment. The empirical techniques we have employed make two additional contributions to the literature. First, using the service area–based counts to represent the number of food outlets in regression analysis addresses the edge effects which are often criticized in the literature. Second, we have tested and adopted customized regression models for different food retailers. Models considered and adopted in the empirical analysis include Poisson regression, negative binomial regression, and zero-inflated Poisson regression. The results from the regression analyses therefore offer a more nuanced (less biased) understanding of the physical food environment in the study area and can provide better empirical support for future policy designs.

Literature review

Literature on food environment

Vivid descriptions of different food environments come from various ecological terms, such as "deserts," "oases," and "swamps" (Taylor and Ard 2015). Among them, the oldest and the most common term is the "food desert." The term was originated in the United Kingdom in the 1990s to describe areas with limited food store accessibility. Since then, a variety of studies have been developed and put forward the definition of food deserts. In early 2002, Cummins and Macintyre defined food deserts as areas where foods are relatively unavailable and expensive in their study. Guy and David (2004) suggested a food desert is an area where residents have no access to food outlets or only have access to low-quality food sources. Gregory et al. (2011, 160) defined it as "an area in which residents' access to healthy, affordable food is highly restricted, for example, because of the absence of food retailers in a low-income urban neighbourhood." Among the various definitions, the most influential definition of food desert is the one introduced by the United States Department of Agriculture (USDA). The department defined a food desert as: "An area with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower income neighbourhoods and communities" (USDA 2009). In addition, the USDA has taken into account the population parameter as a criterion to define food deserts in real business. For example, one measure of food deserts is defined as low-income census tracts where a significant number of people (at least 500) or share of the population (at least 33%) live greater than one mile from the nearest supermarket, supercentre, or large grocery store for an urban area or greater than 10 miles for a rural area (USDA 2015).

The metaphor of food deserts inverts the idea of food oases (Gregory et al. 2011). A few studies have introduced the concept of food oases to describe neighbourhoods that have good access to healthy food outlets, which are usually represented by supermarkets and grocery stores (Short et al. 2007; Walker, Butler, et al. 2010; Krizan et al. 2015). Washington State Department of Health (2019) provided an updated theoretical definition of a food oasis: "any place where people have the best possible access to healthy options and eating environments. Access includes financial and physical access to healthy foods and drinks that are high quality, affordable, culturally acceptable, and meet the nutritional needs of the people in the community." Of course, how to define the best possible financial and/or physical access to healthy eating environments in empirical investigations remains controversial.

To capture the idea that unhealthy food access is also important, Rose et al. (2009) came up with the term "food swamps" to describe low-income urban communities that have a plethora of fast food restaurants and convenience stores that sell unhealthy food. Rose et al. (2009) considered the food swamp to be an especially valuable concept to describe neighbourhood food environments since the excess amount of unhealthy food sources would "inundate" or "swamp out" the healthy food choices that residents have. Luan et al. (2015) and Hager et al. (2016) defined food swamps as areas where residents have access to

large amounts of energy-dense snack foods while having limited healthy food options in their study areas.

Some researchers also proposed the idea of "food mirage" to describe the phenomenon where residents have access to healthy food outlets, but they find them expensive and therefore travel long distances to shop in discount supermarkets (Short et al. 2007; Breyer and Voss-Andreae 2013). Breyer and Voss-Andreae (2013) proposed the definition of food mirage as an area that has abundant grocery stores but prices that are beyond the reach of low-income households and demonstrated the importance of identifying food mirages since the effect of a food mirage is the same as that of a food desert.

This study focuses on identifying three types of vulnerable food environments at the neighbourhood level: food deserts; food swamps; and most importantly, the overlaps of food deserts and food swamps as these neighbourhoods represent the most unfavourable food environment in terms of geographic access. In addition, we also identify the food oases using three different definitions to provide a complete view of the diet environment of the City.

Commonly used methods to identify food environment

Identification of food deserts, food oases, and food swamps often involves two basic criteria: (i) accessibility to food outlets and (ii) socio-economic status of neighbourhoods or census tracts (Apparicio et al. 2007; Jiao et al. 2012; Slater et al. 2017). Access has typically been measured as the physical distance between the centroids of spatial units of analysis and the nearest food outlets. Two common distance-based measurements that have been utilized are Euclidean distance and road network distance (Smoyer-Tomic et al. 2006; Larsen and Gilliland 2008; Wang et al. 2016). Euclidean distance is the most straightforward method to calculate the straight-line distance between two points in Euclidean space. Morton and Blanchard (2007) identified food deserts in US counties by calculating the Euclidean distance between residents' living areas and supermarkets and supercentres. Walker, Butler, et al. (2010) calculated the distance between the centroid residential zip codes and large chain supermarkets in Pittsburgh, Pennsylvania; they identified food deserts as geographic areas in which residents have no access to a large chain supermarket within 0.5 miles and food oases as areas in which residents have access to at least a large chain supermarket within 0.5 miles. With the improvement of network data availability, more researchers have adopted the road network analysis to calculate distance as it provides more accurate estimates by incorporating actual travel impedances such as directional turns, traffic volumes, and speed limits (McEntee and Agyeman 2010; McKenzie 2014; Wang et al. 2014; Wang et al. 2016). McEntee and Agyeman (2010) measured the distance between every residence and the closest food retailers and calculated the mean distance to food retailers within census tracts. The authors defined food deserts in rural Vermont as areas where residents live more than 10 miles from food retail and observed that around 4.5% of the state population lived in food deserts. Smoyer-Tomic et al. (2006) and Wang et al. (2014) used the shortest network distance measure to calculate actual distances between neighbourhoods' centroids and supermarkets and identified food deserts by combing neighbourhoods with high population need and low supermarket accessibility in Edmonton. Slater et al. (2017) calculated the shortest distance from the centroid of dissemination blocks to the nearest grocery stores. The authors defined food deserts in Winnipeg as areas where the lowest-income quintile population live greater than 500 m from a grocery store and found that a large proportion of the Winnipeg population lived in food deserts.

However, distance-based measurement sometimes cannot accurately depict residents' actual food availability when areas are clustered with food stores. For example, clusterings can occur in the case of food swamps, when there are areas where residents have access to abundant unhealthy food sources. Therefore, researchers have proposed the coverage method to more accurately capture neighbourhood food availability (Smoyer-Tomic et al. 2006; Wang et al. 2014; Lu and Qiu 2015; Luan et al. 2015). Lu and Qiu (2015), Smoyer-Tomic et al. (2006), and Wang et al. (2014) adopted the coverage method to measure neighbourhoods' food availability by creating road network buffers based on the centre of study areas and then counting the number of total food stores within a threshold distance (e.g., 1 km). Luan et al. (2015) created a 4-km road network (approximates a 5-minute driving distance) buffering distance

from dissemination area centroids and then calculated the relative healthy food access (the number of healthy food outlets divided by the sum of healthy and unhealthy food outlets) in each buffer area in the Region of Waterloo, Ontario. The authors assumed areas where the relative healthy food access is greater than 0% and less than 10% are food swamps, and areas where the relative healthy food access is equal to 0% are food deserts (Luan et al. 2015). Their results suggested that food swamps are more prevalent than food deserts in the Region of Waterloo (Luan et al. 2015).

Several studies (e.g., Larsen and Gilliland 2008; Russell and Heidkamp 2011; Jiao et al. 2012) came up with the service area method to measure food availability, which is the reverse idea of coverage method. Compared to the coverage method, the service area method focuses on creating buffer areas on the basis of food outlets instead of neighbourhood areas. A service area around each food outlet indicates that individuals living within it can be served by the food outlet (Larsen and Gilliland 2008). Larsen and Gilliland (2008) created a service area of 1 km based on each supermarket to assess the level of supermarket access in London, Ontario, and found the existence of food deserts. In a case study of New Haven, Connecticut, Russell and Heidkamp (2011) analyzed the severity of the food desert in this community by mapping ¼-mile, ½-mile, and 1-mile road network service areas around major supermarkets and grocery stores. Jiao et al. (2012) combined the physical and economic access to supermarket criteria and the income level of residents to estimate the food deserts in Seattle-King County, Washington. The physical access was measured by creating five service areas (1 mile from supermarket or 10-minute travel time to a supermarket by either walking, bicycling, riding transit, or driving) for each supermarket and the economic access was assessed by stratifying supermarkets into low-, medium-, and high-cost (Jiao et al. 2012).

Some recent development in the food environment literature

Recently, Cooksey-Stowers et al. (2017) adopted alternative ways to identify food swamps and food deserts in the US. The authors also addressed the endogeneity problems associated with food environments since individuals may self-select into certain neighbourhoods. To solve this problem, the authors used a two-stage least squares regression to analyze the relationship between obesity and the presence of food swamps and food deserts, and utilized highway exits as the instrument for food outlets access. The regression results showed that the presence of a food swamp is a stronger predictor of obesity rates than the presence of a food desert among US adults. The results indicated that the typical ordinary least squares (OLS) regression analyses may have underestimated the effect of food swamps and food deserts on people's obesity rates. Su et al. (2017) obtained the daily travel time from each community to each healthy food store under four transport modes (walking, public transit, private car, and bicycle) in Shenzhen, China, and used this information to develop four travel time indicators to measure healthy food accessibility. The authors further defined food deserts as areas with lower healthy food accessibility and disadvantaged socio-economic characteristics, and mapped the food deserts with respect to this definition. The authors also examined the relationship between healthy food accessibility and socio-economic characteristics and found significant social inequalities in healthy food accessibility via walking and public transition in Shenzhen. Helbich et al. (2017) identified the food deserts and examined food inequalities in Amsterdam, the Netherlands. This research addressed the spatial autocorrelation in the clustering when locating food deserts, and tested the associations among supermarket accessibility, property prices, and the percentage of native Dutch people per area. The correlation test results showed accessibility differs by region; areas with high property prices and a larger percentage of native Dutch people had a higher supermarket density. However, the authors found no evidence that the healthy food supply in Amsterdam was insufficient in disadvantaged areas.

Study area

As a medium-sized North American city, Edmonton, Alberta provides an interesting case study because of its unique city structure and increasing policy focus on community food environment. The City of Edmonton has made substantial efforts to create a favourable food environment for Edmontonians. Established in 2012, the Edmonton Food Council

launched the City's food and agriculture strategy called "Fresh" (City of Edmonton 2012). One of the five goals in the strategy is to develop neighbourhoods into healthier and more food-secure communities. The City and the Province of Alberta have paid particular attention to children and adolescents partially because of the increasing childhood (including adolescent) obesity epidemic (Health Canada 2013). School-based health promotion programs have been established that aim to improve healthy living habits of students and to sustain capacity for healthy environments in school communities—and these have kept expanding across the city. For example, the Alberta "Project Promoting active Living and healthy Eating in Schools" (APPLE Schools) is a school-wide intervention that was launched in 2008. Fung et al. (2012) and Vander Ploeg et al. (2014) reported that APPLE Schools have increased students' vegetable and fruit intake by 10% and that students are 40% less likely to be overweight. In addition to educational campaigns and various nutrition programs, such as cooking clubs, the actual availability of fresh foods and unhealthy food in the neighbourhood is a key factor influencing household food consumption. The results from this study could provide useful information to further promote the program and develop tailored strategies.

Several prior studies on food access assessment have been done in Edmonton. Two of these focused on fresh food accessibility and the identification of food deserts. Smoyer-Tomic et al. (2006) looked at supermarket accessibility, and identified nine food desert neighbourhoods across the city based on low accessibility and high-need criteria. Wang et al. (2014) introduced community gardens and farmers' markets into the healthy food analysis, and their results indicated that community gardens and farmers' markets can help alleviate the food desert problem to some extent. Smoyer-Tomic et al. (2008) explored the association between neighbourhood socio-economic status and exposure to both supermarkets and fast food outlets. Their results showed that the odds of exposure to fast food outlets were greater in areas with deprived subpopulations.

However, previous studies in Edmonton ignored convenience stores as a common source of less healthy food in the literature (Smoyer-Tomic et al. 2008). Furthermore, all prior studies were based on nearest-distance calculation to describe neighbourhood food accessibility. The distance-based approach ignores the edge effect (Sadler et al. 2011); it also relies on the neighbourhood centroid to represent the whole neighbourhood food environment, which might be less realistic. The adoption of the service area method, which focuses on the areas that can be served by certain food stores, offers a solution to the edge effect problem and can even potentially explore the heterogeneous accesses within a community.

Data and methods

Data

There were four sets of food stores in this study that can be divided into two streams: healthy and unhealthy food outlets. Healthy food outlets included supermarkets and local grocery stores, and unhealthy food outlets included convenience stores and fast food restaurants. All of the food store data represented the situation in 2013 and were from DMTI Spatial Inc., which is a commercial company offering location-based data in Canada. Supermarkets were assumed to provide a full range of food products (e.g., fruit, vegetables, and meat and dairy products). These full-service supermarkets are mainly the outlets of chain stores such as Sobeys, Safeway, Superstore, and Walmart. Local grocery stores or specialty shops also sell fresh fruits and vegetables, meat, or fish and other seafood. Store information was further confirmed by verifying stores' official websites. Non-relevant shops, such as drugstores and liquor stores, were excluded from these two categories. Fast food restaurants were defined as quick-serving food outlets that offer relatively limited menus and food preparation options (e.g., burgers, sandwiches, pizzas), where patrons pay before receiving meals. In this study, they were primarily the outlets of franchised stores such as A&W, KFC, McDonald's, Subway, and Wendy's. Stores that do not provide food services on a regular basis or non-food restaurants, such as bars and inns, were excluded from the analysis. Convenience stores were considered outlets that sell a limited selection of daily living items and offer less healthy, sugar- and energy-intense food commodities. Based on the classification in the DMTI database, these stores were mainly some chain stores such as 7-Eleven and Mac's and gas station food stores. In the final dataset, we had 82 supermarkets, 40 local grocery stores, 783 fast food restaurants, and

199 convenience stores in Edmonton (see Figure 1 for geographic distribution of these stores).

We extracted the neighbourhood socio-demographics from the 2011 National Household Survey (Statistics Canada 2012). There were 392 defined neighbourhoods in the City of Edmonton. However, 145 were non-residential neighbourhoods (mainly industrial areas) that had no population data. We

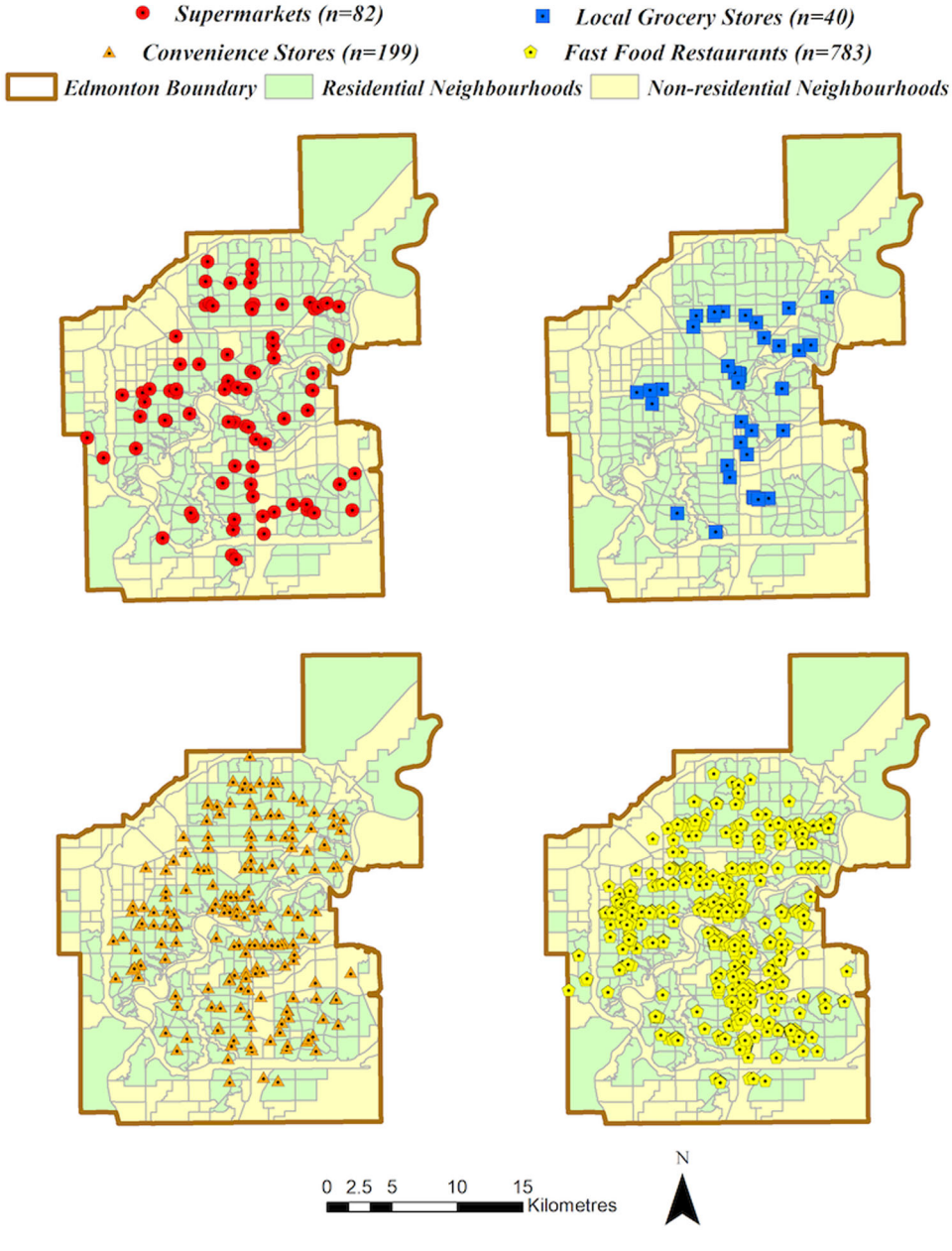

Figure 1
Distribution of food outlets in Edmonton.

thus excluded these non-residential neighbourhoods and only used 247 residential neighbourhoods for analysis. Road network data and the neighbourhood shapefile for Edmonton were obtained from CanMap RouteLogistics (v2012.3), which is managed by the University of British Columbia.

Measuring the availability using service areas

In this study, we first used the service area method to create buffer areas around each store. Following Larsen and Gilliland (2008) and many others, we chose 1 km as the threshold to conduct the service area analysis. The 1-km distance was defined as the real network/road distance around a specific store. A 1-km service area in our study was defined as a region that encompasses all accessible streets and roads within a 1-km network distance from that store. The intuition behind this is that a service area represents a collection of all the houses that this particular store can usually serve. Figure 2 shows the distribution of service areas in four different cases when different food outlets are selected. As suggested by recent literature (Wang et al. 2014; Lu and Qiu 2015), we also included food sources within a 10-km buffering area outside the city boundary so as to incorporate the fact that residents in periphery neighbourhoods can always cross the municipal boundary to purchase food. However, the inclusion of these food sources only affects the food availability of non-residential neighbourhoods in the periphery of the city, which are not within our analysis. Hence, we excluded these food stores for clarity and simplicity.

Regression models

The classic linear regression model using the OLS technique is a common practice in literature that examines the relationship between food accessibility and neighbourhood socio-demographics (Engler-Stringer et al. 2014; McKenzie 2014; Wang et al. 2014). Others have used Poisson regression models to investigate the number of stores in association with neighbourhood characteristics (Galvez et al. 2007; Lamichhane et al. 2015; Mundorf et al. 2015). This technique can mitigate the problem of clustering food stores in the study area, as a better representation of food availability than the distance-based method. However, most prior studies directly used the store counts within a neighbourhood, which ignores the case when residents commute to neighbouring communities to purchase food (the edge effect issue). To address this problem, we adopted the service area method and counted the overlapped service areas of stores in each neighbourhood. The specification of Poisson regression model is as follows,

$$\Pr(Y_i = y_i \mid \lambda_i) = \frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i!} \quad \text{where } \lambda_i = \exp(X_i\beta) \tag{1.1}$$

where Y_i is the count of service areas in neighbourhood i, λ_i is the expected count of service areas at the same neighbourhood, X_i is a vector of neighbourhood-level covariates (including an intercept term) of neighbourhood i, and β is a vector of coefficients to be estimated. Sometimes, the count number of service areas may display substantial extra Poisson variation or overdispersion. In order to solve this problem and to relax the assumption that the mean needs to be equal to the variance (Lawless 1987; Gardner et al. 1995), we adopt the negative binomial regression. The negative binomial regression model is written as:

$$\Pr(Y_i = y_i \mid \lambda_i, \alpha) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \lambda_i}\right)^{\alpha^{-1}}\left(\frac{\lambda_i}{\alpha^{-1} + \lambda_i}\right)^{y_i} \quad \text{where } \lambda_i = \exp(X_i\beta) \tag{1.2}$$

where α represents the over-dispersion parameter.

It is also possible that the dependent variable has an excess of zero counts. To solve this situation, it is necessary to use zero-inflated Poisson regression (Lambert 1992). The zero-inflated regression involves two processes: one logit model is used to predict excess zeros, and one Poisson model is used to predict the count data (including zeros). Suppose in the zero-inflated Poisson model, $Y_i \sim 0$ occurs with probability π_i, and $Y_i \sim Poisson(\lambda_i)$ with probability $1 - \pi_i$. Then, the mixed probability distribution of the count variable Y_i can be written as:

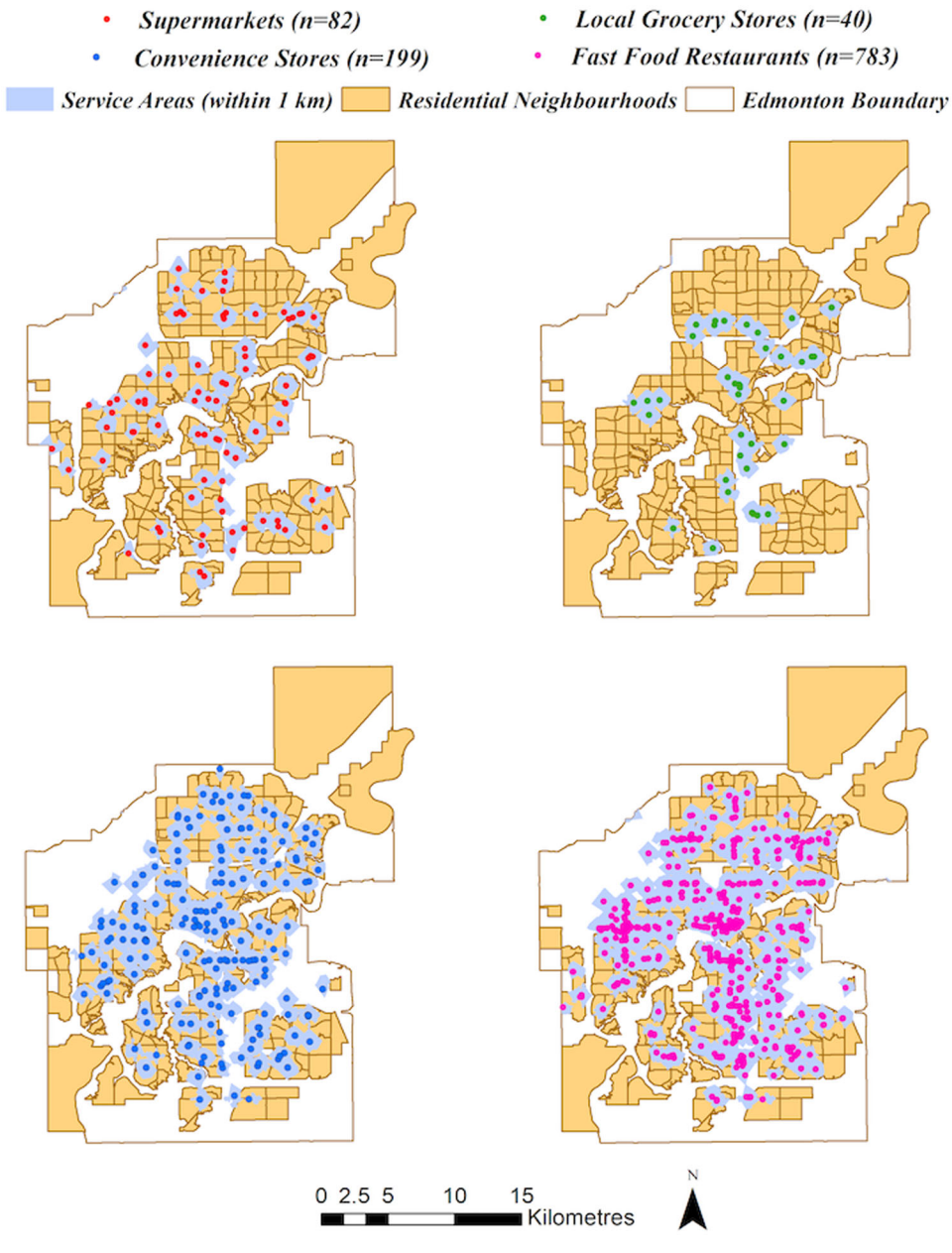

Figure 2
Service areas of food outlets in Edmonton.

$$\Pr(Y_i = j) = \begin{cases} \pi_i + (1 - \pi_i)\exp(-\lambda_i) & \text{if } j = 0 \\ (1 - \pi_i)\dfrac{\lambda_i^{y_i}\exp(-\lambda_i)}{y_i!} & \text{if } j > 0 \end{cases}$$
$$\text{where } \lambda_i = \exp(X_i\beta) \tag{1.3}$$

where the logistic link function π_i is determined by

$$\pi_i = \frac{\mu_i}{1 + \mu_i} \tag{1.4}$$
$$\text{where } \mu_i = \exp(Z_i\gamma).$$

Note that the z's in equation (1.4) and the x's in equation (1.3) may or may not include terms in common.

Following the previous studies, we chose eight socio-demographics as the key variables to observe the associations between food availability and neighbourhood socio-economic characteristics. We first included the percentage of the population aged under 19 (*Children*) and the percentage of the senior population aged 65 and over (*Senior*) as the control variables since these households are more vulnerable to unhealthy food sources (Larsen and Gilliland 2008; Wang et al. 2016; Su et al. 2017; Li and Ashuri 2018). Many studies have considered the effect of the education level on food accessibility (Larsen and Gilliland 2008; Laxy et al. 2015; Su et al. 2017; Li and Ashuri 2018). We chose the percentage of residents who have a higher education such as post-secondary certificate, diploma, or degree (*High Education*) as the education level indicator. The percentage of unemployed residents in a neighbourhood (*Unemployment*) and the percentage of minority group (*Minority*) were also variables that are widely used in other studies (Larsen and Gilliland 2008; Walker, Butler, et al. 2010; Black et al. 2014; Wang et al. 2016). Neighbourhood income level has also been identified as the key variable in food accessibility studies (Li and Ashuri 2018; Walker, Butler, et al. 2010; Wang et al. 2016). Following these studies, we chose the neighbourhood-level median income (*Median Income*) to define neighbourhood wealth. Another strand of variables often identified in studies are the means of travel modes since primary means of travel modes have been linked to food access (Smoyer-Tomic et al. 2008; Wang et al. 2016; Cooksey-Stowers et al. 2017). Thus, we included the percentage of private car access (*Private Car*), which refers to individuals who have access to a car, truck, or van as primary commuting transportation, and the percentage of residents using public transport as the primary travel option (*Public Transit*). Note that both *Private Car* and *Public Transit* are based on residents who are over 15 and employed. Table 1 summarizes the neighbourhood socio-demographics in Edmonton.

Results

Descriptive analysis

Statistics from Table 1 show that residential neighbourhoods in Edmonton in 2011 had an average of 2.31 service areas based on healthy food outlets. The supermarket availability is almost double that of local grocery stores. However, there were neighbourhoods with clustering local grocery stores that makes the maximum number of service areas even higher than that of supermarkets. For the unhealthy food sources, the average number of service areas was about 15, with 80% coming from fast food restaurants. Additionally, heterogeneity is evident among neighbourhoods with respect to the spatial pattern of service areas based on different food sources. Figure 2 demonstrates that neighbourhoods in the downtown area (located in the central part of the city) had good access to both healthy and unhealthy food stores. However, neighbourhoods in Riverbend in the southwest region of the city, specifically identified by Wang et al. (2014), had quite limited access to healthy food outlets, but there were several unhealthy food sources in that region. Another interesting finding is that the neighbourhoods in the northeast part of the city had very limited healthy food stores, but a rich clustering of convenience stores and quite a few fast food restaurants. In the southeast region, there were several supermarkets but almost no local grocery stores. At the same time, lots of fast food restaurants and convenience stores gathered in that region, which may crowd out the healthy food options.

When it comes to the neighbourhood socio-demographics, Table 1 further shows that slightly more than 40% of residents in the city relied on

Table 1
Summary of service area and neighbourhood characteristics in Edmonton in 2011 (N = 247).

Variable[a]	Median	Mean	10%	25%	75%	90%
Service Area (No.)						
Healthy Food Outlets	2.00	2.31	0.00	1.00	4.00	5.00
Supermarkets	1.00	1.52	0.00	0.00	2.00	3.00
Local Grocery Stores	0.00	0.79	0.00	0.00	1.00	3.00
Unhealthy Food Outlets	12.00	14.97	1.00	4.00	19.00	28.00
Fast Food Restaurants	9.00	12.08	1.00	3.00	16.00	23.00
Convenience Stores	3.00	2.89	0.00	1.00	4.00	6.00
Population Density (1,000 per km^2)	2.80	3.27	1.56	2.27	3.49	4.05
Children (%)	23.43	22.80	15.25	19.00	27.23	29.07
Senior (%)	10.91	12.36	4.69	7.38	16.00	21.22
High Education (%)	44.98	46.27	34.59	38.30	53.97	60.10
Unemployment (%)	2.13	2.24	0.76	1.25	2.95	3.84
Minority (%)	23.52	23.88	12.26	17.17	30.18	35.07
Median Income ($1,000)	35.91	37.60	27.53	31.24	43.89	50.06
Private Car (%)	42.00	41.71	33.19	37.04	46.51	50.20
Public Transport (%)	6.82	7.25	3.14	4.79	9.36	12.23

[a]We investigated the potential multicollinearity problem and found coefficients of correlation matrix are all relatively small.

private cars for daily commuting, and fewer than 8% chose public transport as their primary transit option. In terms of the socio-demographic status, almost half of residents earned a high education on average. The average median income among neighbourhoods across the city was around $38,000. However, the gap between the rich and poor was rather large, with the maximum income being more than 20 times the minimum. The rate of unemployment was relatively low in Edmonton, with an average of 2.24% across the city. The unemployment rate in some communities had even reached zero. There were neighbourhoods whose residents were predominantly white, while in some neighbourhoods more than half of their residents were in minority groups or were immigrants. In some neighbourhoods, the percentage of children and seniors was as high as 35.05% and 43.27%, respectively, and the minimum percentage was less than 5%.

Identification of four types of food environments

Following the common practice, we chose the combination of low healthy food availability, low income, and high population density to define food deserts (USDA 2009). Neighbourhoods with fewer than two service areas were considered to have low availability. We then selected the bottom quartile (25%) of median income and top quartile (25%) of population density as the other two criteria. This resulted in seven neighbourhoods that can be considered food deserts. Following Rose et al.'s (2009) definition of food swamps, we considered neighbourhoods with more than 20 services areas to have high availability of unhealthy food. Combined with the other two criteria, namely bottom quartile (25%) of median income and top quartile (25%) of population density, we identified 13 food swamp neighbourhoods for the city. As policymakers and other interest groups are particularly interested in identifying the most vulnerable neighbourhoods, we identified neighbourhoods with "overlaps of food deserts and food swamps" by overlapping the food deserts with the food swamps to characterize neighbourhoods with poor access to healthy food and excessive coverage of unhealthy food outlets. In particular, we found three overlapped neighbourhoods across the city. Figure 3 shows the three types of vulnerable neighbourhood with different food environments and Table 2 summarizes these neighbourhood characteristics.

Similar to the results in previous studies in Edmonton (Smoyer-Tomic et al. 2006; Wang et al. 2014), the food desert neighbourhoods were scattered across the city. Besides the relatively low availability of healthy food outlets in terms of service areas, they had lower private car access and a higher percentage of children and unemployed residents in comparison to the city mean. For the food swamp neighbourhoods, there was a clear

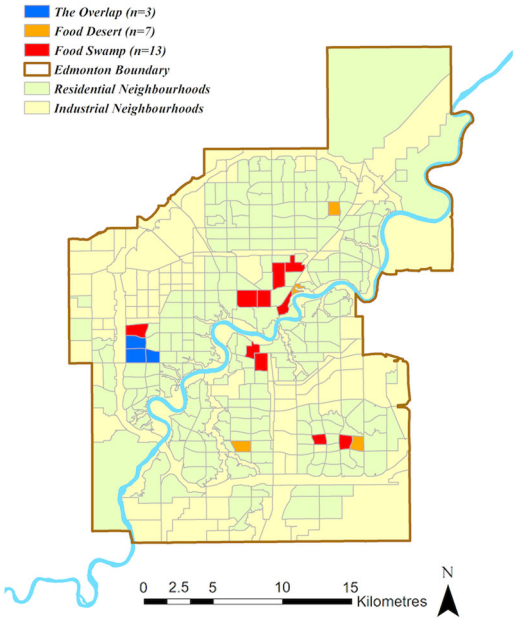

Figure 3
Identification of neighbourhoods with vulnerable food environments.

Table 2
Summary of neighbourhoods with vulnerable food environments.

Variable	Mean Value			
	Food Desert (N = 7)	Food Swamp (N = 13)	The Overlap (N = 3)	City (N = 247)
Service Area (No.)				
Healthy Food Outlets	1.00	4.85	1.00	2.31
Unhealthy Food Outlets	14.57	40.00	27.00	14.97
Population Density (1,000 per km^2)	4.15	4.72	3.73	3.27
Children (%)	24.10	19.77	25.42	22.80
Senior (%)	8.76	10.34	9.30	12.36
High Education (%)	44.27	44.68	43.99	46.27
Unemployment (%)	3.79	3.47	2.79	2.24
Minority (%)	24.06	26.67	28.89	23.88
Median Income ($1,000)	29.96	27.52	30.09	37.60
Private Car (%)	39.69	34.92	40.98	41.71
Public Transport (%)	10.54	10.64	10.02	7.25

pattern of three clusters in the city, including the city core, university area, and the western part of the city (Figure 3). In comparison to the city average, these neighbourhoods had a higher rate of unemployment and minority groups, had much lower private car access, and relied more on the public transportation systems. Additionally, the percentages of children and senior residents were lower in these regions.

For the three overlaps, on average, there was only one supermarket service area for each neighbourhood; however, each community had 27 unhealthy food retailers that could serve the residents. All three neighbourhoods (Aldergove, Belmead, and Thorncliff) are located in the western part of the city (see Figure 3). In 2011, these neighbourhoods had relatively high populations with disadvantaged socio-economic status (i.e., higher unemployment rate, less high educated populations, lower median income, and less access to private cars). Meanwhile, the three neighbourhoods had higher percentages of children and minority populations.

In addition to the above three types of vulnerable neighbourhoods, we also identified food oases (i.e., neighbourhoods with superior access to healthy food outlets). The identification of food oases is also important for a comprehensive assessment of the food environment and provides policymakers and other stakeholders with useful information. It is worth noting that there is currently no uniform standard definition for a food oasis in the literature. For example, Walker, Butler, et al. (2010) depicted and mapped food oases in Pittsburgh by defining a food oasis as a geographic area that contains a supermarket within 0.5 miles of the centre of the zip code. Relative to the specific definition of Walker, Butler et al. (2010), the Washington State Department of Health's (2019) definition of food oasis is rather vague. A neighbourhood, if its residents have the best financial and physical access to healthy food sources, could be considered as an oasis. In the empirical investigation, different researchers may have different interpretations regarding what constitutes the best financial and physical access.

Given the spatial nature of our study and the data limitation (e.g., we do not have access to data that reflect households' financial access), our identification of oases was based on physical access only. We, therefore, defined oases according to one or more of the following criteria: high availability of healthy food, low availability of

unhealthy food, and high population density at the neighbourhood level. Specifically, we used three definitions of oases.

Following Walker, Butler, et al. (2010), food oasis definition 1 considers only the high availability of healthy food. We chose a measure of more than two healthy service areas (above the city mean) as an indicator of high availability of healthy food. Based on this criterion, we identified 135 food oasis neighbourhoods in Edmonton. Food oasis definition 2 considers both high availability of healthy food and high population density. We first identified two groups of neighbourhoods: neighbourhoods with more than two healthy service areas and neighbourhoods with top quantile of population density. Then, we combined the two groups to identify 39 overlapping neighbourhoods as food oases. Based on defintion 2, food oasis definition 3 further narrowed down the number of oases by only including neighbourhoods with fewer than 15 unhealthy service areas (below the city mean). Based on these three criteria, we identified 15 oasis neighbourhoods in Edmonton. Figure 4 presents the oasis neighbourhoods with the three different definitions and Table 3 summarizes the corresponding neighbourhood characteristics.

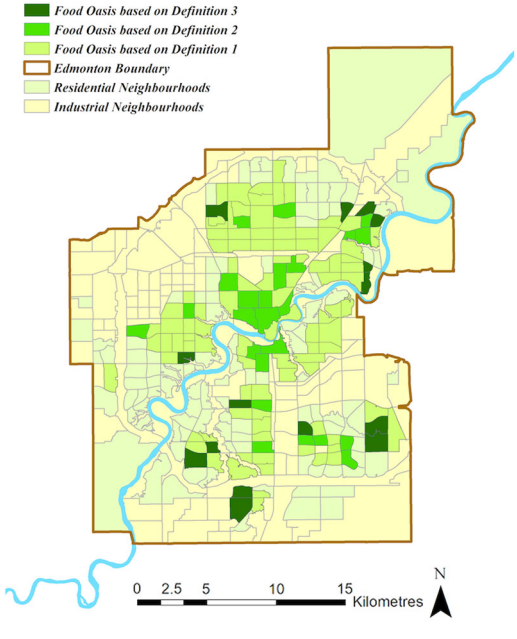

Figure 4
Identification of food oases based on different definitions.

Regression results

Regression results are presented in Tables 4 and 5. With regard to socio-demographic inequity, many US studies found that deprived populations—such as seniors, immigrants, and unemployed residents—have comparatively limited access to fresh foods (see Larson et al. 2009; Walker, Keene, and Burke 2010). However, in Edmonton these disadvantaged groups were found to have relatively better fresh food availability, based on results shown in Table 4. Specifically, the unemployment rate was significantly positively correlated with an increase in the log of expected counts of service areas, and minority groups were also found to be living in neighbourhoods that were well served by healthy food outlets in general. Such evidence can also be found in other Canadian studies. For example, a study in Montreal, Quebec showed a positive relationship between social deprivation index (which includes unemployment rate and recent immigrants) and the number of supermarkets within 1 km (Apparicio et al. 2007). Similar results were also found in Gatineau, Quebec: deprivation was overall positively correlated with better accessibility to fresh fruits and vegetables (Gould et al. 2012). Black et al. (2011) also indicated a positive association between visible minority resident rate and the number of large supermarkets and fresh food stores within 1 km of residential addresses in British Columbia. One noteworthy outcome from our regression analysis was the significantly negative association between neighbourhood's children as a percentage of the neighbourhood population and the number of healthy food service areas. Similar results in Saskatoon showed that neighbourhoods with a higher percentage of children aged 5–14 had longer distances to travel to the nearest healthy food stores (Engler-Stringer et al. 2014). Considering the increasing obesity rate among children and youth in Alberta (Health Canada 2013), this finding should raise local authorities' awareness of the food environment, especially for adolescents. The unfavourable access to healthy food could potentially contribute to children's unhealthy food intake.

Although we found that, overall, disadvantaged groups had relatively adequate access to healthy

Table 3
Summary statistics for food oases.

Variable	Mean Value			
	Food Oases based on Definition 1 (N = 135)	Food Oases based on Definition 2 (N = 39)	Food Oases based on Definition 3 (N = 15)	City (N = 247)
Service Area (No.)				
Healthy Food Outlets	3.84	4.23	2.87	2.31
Unhealthy Food Outlets	21.62	25.00	9.20	14.97
Population Density (1,000 per km^2)	3.11	4.54	4.01	3.27
Children (%)	21.53	23.07	28.03	22.80
Senior (%)	13.44	9.64	7.85	12.36
High Education (%)	44.55	44.90	44.81	46.27
Unemployment (%)	2.58	3.16	2.81	2.24
Minority (%)	24.84	27.87	29.96	23.88
Median Income ($1,000)	34.35	32.74	37.38	37.60
Private Car (%)	39.36	37.11	40.18	41.71
Public Transport (%)	8.11	9.40	8.12	7.25

food stores, we also revealed that for these swamps, deserts, and overlaps of the two, the percentages of of the population that could be considered deprived were higher than the city average. However, the high percentage of deprived population in those 20 neighbourhoods was not significant enough to influence the regression results, which represent the average situation of the 247 neighbourhoods. Our seemingly contradictory results from the food environment assessment for specific vulnerable neighbourhoods and a general association analysis are both important and essential to better understand the issue and design appropriate policies and programs to improve the food environment in the city. Meanwhile, overly exaggerating the food environment issue and the unfavourable inequality between different socio-economic groups should be avoided.

In terms of unhealthy food availability, many studies in the US have tended to find that unemployed and immigrant groups are more vulnerable and have easier access to less favourable food outlets such as fast food restaurants and convenience stores (see Pearce et al. 2007; Powell et al. 2007; Laxy et al. 2015). Our results from Table 5 are generally consistent with their outcomes. For instance, neighbourhoods with higher rates of minority groups had more service areas of unhealthy food sources. Adolescents, however, were less likely to get access to these unhealthy foods compared to other age groups. Similar results were found in another Canadian prairie city (Saskatoon) (Engler-Stringer et al. 2014). Our results also indicated that wealthy residents tended to live where there are fewer services of unhealthy food outlets, but such results did not exist when it comes to healthy food availability such as supermarkets.

In the combination of results from both healthy and unhealthy food outlets (Tables 4 and 5), we can see that public transit displayed a significantly positive association with healthy food availability and convenience stores. This positive relationship can be explained through the principles of supply and demand theory. Residents largely relying on public transit tended to live near public transit centres in the city, where a fairly large number of food outlets, both healthy and unhealthy ones, are located. Despite quite a few available healthy food outlets, there were pervasive unhealthy food sources, which could inundate residents' healthy food options. As a result, it is not surprising that a group of food swamp neighbourhoods were clustered in the downtown area where there was the most convenient public transit system across the city, as shown in Figure 3. While establishing a more complete public transit network can improve healthy food access by attracting more fresh food businesses, our results further imply that advocating educational campaigns for a healthy diet may be of higher need to ameliorate the overall

Table 4
Regression results for healthy food outlets (N = 247).

	Service Area (No.)		
Variables	**Supermarkets (Poisson regression)**	**Local Grocery Stores (Zero-inflated Poisson regression)**	**Healthy Food Outlets (Negative binomial regression)**
Constant	1.979***	1.999*	2.507***
	(0.597)	(1.126)	(0.651)
Children	-0.039***	-0.095***	-0.052***
	(0.013)	(0.018)	(0.013)
Senior	0.007	0.002	0.006
	(0.009)	(0.017)	(0.009)
High Education	-0.011	-0.034**	-0.016**
	(0.007)	(0.014)	(0.007)
Unemployment	-0.025	0.268***	0.098*
	(0.052)	(0.082)	(0.054)
Minority	0.017***	-0.008	0.012**
	(0.006)	(0.011)	(0.006)
Median Income	-0.015	0.068***	-0.003
	(0.010)	(0.023)	(0.010)
Private Car	-0.012	-0.046***	-0.018**
	(0.009)	(0.017)	(0.009)
Public Transport	0.049**	0.067**	0.048**
	(0.020)	(0.031)	(0.020)
Inflate			
Constant		-5.202***	
		(1.531)	
Population Density		0.298*	
		(0.171)	
Median Income		0.096***	
		(0.031)	
Log-likelihood	-361.900	-251.832	-443.338
Pseudo R^2	0.103	0.180	0.106
AIC	741.796	527.663	906.676
LR test of alpha			12.920***
Vuong test		2.490***	
VIF (Maximum)	2.980		

***, **, and * indicate the coefficient is significant at 1%, 5%, and 10% level, respectively. Standard errors are in parentheses.

food environment in these neighbourhoods. Another finding of note from the comparison was the negative relationship between the children group and the number of service areas with both healthy and unhealthy food sources. Through childhood, children begin to make their own food choices and the dietary habits formed during these years can have a long-lasting impact on their food intake throughout the lifespan (Kelder et al. 1994), so policymakers and other interest groups in the city may want to pay special attention to the food environment of this group.

Our findings can thus provide some clues for future policy designs. Although we found that children tended to have fewer service areas of unhealthy food, the healthy food availability was quite limited as well in a general sense. Specific programs, such as the involvement in community gardens and participation in APPLE Schools, can be effectively implemented in neighbourhoods with higher concentrations of children.

Discussion

The results from food environment assessment can help the City identify the key neighbourhoods with high potential for local business and the hotspot neighbourhoods that require particular support. In terms of strategy, improving the neighbourhoods'

Table 5
Regression results for unhealthy food outlets (N = 247).

	Service Area (No.)		
Variables	**Fast Food Restaurants (Negative binomial regression)**	**Convenience Stores (Poisson regression)**	**Unhealthy Food Outlets (Negative binomial regression)**
Constant	5.182***	1.902***	5.090***
	(0.835)	(0.488)	(0.755)
Children	−0.081***	-0.030***	-0.073***
	(0.016)	(0.010)	(0.014)
Senior	-0.004	0.005	-0.003
	(0.011)	(0.007)	(0.010)
High Education	0.006	-0.007	0.003
	(0.009)	(0.006)	(0.008)
Unemployment	0.085	-0.015	0.070
	(0.066)	(0.039)	(0.060)
Minority	0.014*	0.011**	0.014**
	(0.007)	(0.005)	(0.006)
Median Income	-0.029**	-0.027***	-0.028***
	(0.011)	(0.008)	(0.010)
Private Car	-0.020**	0.012*	-0.014
	(0.010)	(0.007)	(0.009)
Public Transport	0.010	0.042***	0.017
	(0.024)	(0.015)	(0.021)
Log-likelihood	-804.755	-464.290	-855.893
Pseudo R^2	0.077	0.096	0.073
AIC	1629.510	946.589	1731.786
LR test of alpha	889.09***		888.870***
VIF (Maximum)	2.980		

***, **, and * indicate the coefficient is significant at 1%, 5%, and 10% level, respectively. Standard errors are in parentheses.

diet environments requires careful consideration and tailored plans for different food environments. For those food swamps with adequate access to healthy foods, policy and public efforts may focus on educational campaigns and community-supported programs to promote healthy diet habits. For those food deserts (the overlaps of food deserts and food swamps excluded), because these neighbourhoods are spread across the city, one big supermarket will not solve the problem for all simultaneously. Policy interventions that encourage new supermarket businesses through tax credits and other forms of benefits may not work effectively as these big businesses usually require large amounts of input (e.g., infrastructure, labour, parking space), and the purchasing power is relatively low in these areas. A more realistic plan is to support other small businesses (e.g., local grocery stores and specialty stores) through tools such as zoning and tax benefits. In addition, the City can encourage the establishment of alternative fresh food suppliers such as community gardens and farmers' markets via official community plans and programs such as Fresh (City of Edmonton 2012). Fresh was developed in consultation with citizens, interested groups, businesses, and organizations. It proactively provides strategic directions for developing local food infrastructure capacity, expanding urban agriculture and growing local food supply and demand. The strategy also introduces the concept of urban agriculture such as building community gardens and further using existing community assets as anchors for neighbourhood level learning programs such as food production, processing, and preservation. One particular recommendation for the Fresh strategy is to create small-scale neighbourhood food hubs based on the needs and resources of specific neighbourhoods. A food hub is a collective of farmers who pool their resources to deliver their product directly to market in much greater quantities than a single farmer could do on his own. Food hubs may take the form of farmers' markets, home delivery services, and on-farm stores, among which farmers' markets stand out as most prevalent. As a supplier of local food, farmers' markets could potentially mitigate the food desert problems as suggested by Wang et al. (2014). But in the case of Edmonton, the benefits have not yet manifested and boosting the farmers' markets could be a fit strategy from the policy perspective. Other forms of food hubs, such as mobile markets, can also be located in or near food deserts and pedestrian traffic areas such as LRT stations and community centres to promote convenient pedestrian access to healthy food sources.

The three overlaps of food swamps and food deserts were the most vulnerable communities, with no easy access to healthy foods but heavily surrounded by abundant unhealthy food outlets. The cost of accessing fast foods was lower while the cost for healthy foods was higher than other neighbourhoods in the city. This left disadvantaged subpopulations within these areas—such as children, low-income families, and households without access to private cars—the most vulnerable groups. These groups deserve more public attention and policy effort. The strategies outlined above that improve healthy food access, such as supporting

local grocery stores and alternative fresh food suppliers, could help relieve these issues. At the same time, because all three neighbourhoods are located at the same area, a new large supermarket offering a wide variety of healthy food such as meat, fresh produce, and dairy and baked goods might substantially improve the food environment for the whole area and thus warrants consideration for municipal and community interventions.

Conclusions

Summary of this study

This study adopted a service area–based method to assess neighbourhood food environments and investigated the associations between food availability and neighbourhood socio-economic status using Poisson regression models. The first key finding was that deprived communities with high rates of unemployed and minority groups had better access to both healthy and unhealthy foods in general. However, for the three types of vulnerable neighbourhoods (food swamps, food deserts, overlaps), we found that they had relatively high percentages of disadvantaged populations. The second key finding was that children faced poor coverage of both healthy and unhealthy food stores in nearby areas. Our third key finding was that public transport was positively associated with the availability of all healthy food retailers and convenience stores. Implications for improving vulnerable neighbourhoods' food environments using different strategies and promoting local grocery stores and urban agriculture are discussed to provide useful information for future policy designs and project improvement.

From an empirical perspective, the identification of food swamps, food deserts, and overlaps of the two provides policymakers and the general public with an in-depth understanding of neighbourhood food environments and contributes to the design of more effective strategies given different types of neighbourhoods. Results also assist in identifying the most vulnerable communities that require immediate and substantial support and thus attribute to a better allocation of the limited municipal resources (e.g., financial and staff supports). Meanwhile, the service area-based method considers spatial heterogeneity within a neighbourhood/community and solves the edge effects at the same time. Therefore, it might be a useful expansion of the traditional distance-, coverage-, and density-based assessments and OLS/Poisson regression methods. Future studies might also find it useful when investigating other related food environment issues.

Limitations and future work

There are a number of study limitations that need noting. First, we only included regular commercial food retailers in our empirical analysis. However, alternative food outlets such as community gardens and food hubs can have an impact on the healthy/unhealthy food accessibility (Wang et al. 2014). Future work will find it helpful to include these alternative food suppliers and investigate how to utilize them to improve the overall food environment. Second, this study only investigates spatial/physical food accessibility. However, actual household food assumption is also highly related to food affordability (which depends on food prices, household income, time constraints, etc.) and food quality (e.g., see discussion in the food mirage literature). Future work will find it helpful to investigate these aspects to design effective strategies to improve actual healthy food accessibility. Third, our study focuses on residential neighbourhoods and excludes non-residential ones (mainly industrial zones). Future work may find it helpful to examine how including workplace food environments could affect the results of the food environment identification.

Finally, a very important point we want to emphasize is that the majority of studies that use the GIS approach to assess food environment, including this research, are comprised of aggregate assessments that reveal information about study areas at the neighbourhood or community level. Census tracts (Duran et al. 2013) or dissemination areas have also been used to define communities (Gould et al. 2012). However, results from these studies do not always reflect the experiences of individuals and households. Due to personal factors such as financial and time constraints as well as limited access to private vehicles, large gaps may exist between the GIS-identified vulnerable communities and individual households that have difficulty accessing healthy foods and avoiding unhealthy foods in real life. For instance, the

amount of time available for grocery shopping can influence the real accessibility of individuals (Widener et al. 2013) to supermarkets. This information may be revealed in a survey approach; however, it would be neglected in the GIS analysis.

For future work, combining the use of GIS with a method that analyzes personal information would be especially useful. A well-designed survey with household characteristics (e.g., household income, parental status, access to public transport and private cars, average travel time from home to grocery stores, personal constraints) and residents' perception of their communities' food environment (e.g., whether they consider their neighbourhoods to be vulnerable) will be very helpful for identifying vulnerable individual households in all types of food environments, including food oasis neighbourhoods that are identified by the GIS. It would also be useful and interesting to ask for individual opinions on how to define a food desert/swamp/oasis and how a city government can participate in improving its eating environment. Comparing the opinions and feedback of residents living in food deserts and food swamps with those of residents living in food oases can provide necessary input to support tailored policy interventions.

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