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Identifying Food Swamps Based on Area-Level Socioeconomic Patterning of Retail Food Environments in Winnipeg, Canada

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Abstract
A gap in Canadian food environment research concerning Winnipeg's food swamps is addressed using geographical assessment of socio-demographic factors. Food swamp locations were identified using (1) a composite index of socioeconomic deprivation, (2) restaurant accessibility (Euclidean distance to nearest restaurant), and (3) restaurant clustering across 5740 Dissemination Blocks (DBs) in Winnipeg. Restaurants included fast food (FFR), sit-down (SDR) and coffee shop establishments combined (ALL). DBs with high deprivation levels, close restaurant access, and significant clustering of restaurants were identified as food swamps. Significant differences in restaurant access were observed between low and high socioeconomic deprivation levels, where the most socioeconomically deprived populations in Winnipeg had easier access to highly clustered restaurants. A total 3.74 km^2 of Winnipeg was designated as food swamps (ALL), impacting 10,053 (1.6%) people. We conclude that a breadth of policies is required to address food security in Winnipeg, as ~65% of the food swamps coincide with food deserts or food mirages observed by Wiebe et al. (2016).

Keywords: Food swamps, restaurants, retail food environment, Winnipeg, Canada

Résumé
Un écart dans les recherches sur les environnements alimentaires Canadiennes qui concerne les marais alimentaires de Winnipeg est abordé au moyen d'une évaluation géographique des facteurs socio-démographiques. L'identification des emplacements des marais alimentaires a été effectuée en utilisant (1) un indice composite de privation socioéconomique, (2) accès aux restaurants (distance euclidienne au restaurant le plus proche) et (3) les restaurants fortement regroupés sur 5740 blocs de dissémination (BD) à Winnipeg. Les restaurants analysés comprenaient les restaurants rapides (FFR), assis (SDR) et des cafés (ALL). Les BDs à haut niveau de privation, à haut accès aux restaurants et avec des restaurants fortement regroupés ont été identifiés comme marais alimentaires. Des différences significatives dans l'accès aux restaurants ont été observées entre les niveaux de privation faibles et hauts, où les plus démunies avaient l'accès plus facile aux restaurants fortement regroupés. Un total de 3,74 km^2 a été désigné comme marais alimentaires (ALL), affectant 10 053 (1,6%) individuels à Winnipeg. Nous concluons qu'une large gamme de politiques est nécessaire pour abordé le problème de la sécurité alimentaire à Winnipeg, car 65% des marais alimentaires coïncident avec les déserts alimentaires ou les mirages alimentaires observés par Wiebe et al. (2016).

Mots clés: Marais alimentaire, restaurants, environnement alimentaire, Winnipeg, Canada

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Introduction

On February 22, 2017, the Winnipeg city council voted unanimously to authorize the creation of a Winnipeg Food Council with public engagement via the Food Matters Manitoba portal (Food Matters Manitoba 2015; City of Winnipeg 2017). However, there is little research available about Winnipeg's retail food environment and associated demographic conditions. Retail food environment research in Canada is rapidly expanding, with most papers published between 2010 and 2015, and most conducted in larger Canadian cities such as Montreal, Vancouver and Toronto (Minaker 2016). This work focuses on the City of Winnipeg's socioeconomic patterning of food environments using Glanz's conceptual model (Glanz et al. 2005). To evaluate community-level nutrition environments, this model measures geographic food access in combination with the socio-demographic factors associated with eating patterns (Minaker et al. 2016).

To inform and develop effective public health policies, it is necessary to establish which neighbourhood characteristics are contributing to health inequalities. Socioeconomic disparities in health can often be attributed to an imbalance in the spatial distribution of retail food outlets. In an effort to target policy and planning decisions geared toward improving healthy food access, most studies have focused on the prevalence of "food deserts". These are commonly defined as areas where affordable, nutritious food is inaccessible to densely populated areas, particularly those where deprived or high-need populations are highly concentrated (Cummins and Macintyre 1999). In short, food deserts are "areas of relative exclusion where people experience physical and economic barriers to accessing healthy food" (Reisig and Hobbiss 2000). The most deprived neighbourhoods have been observed to be at greater distances from grocery stores and have fewer options in terms of surrounding food outlets than more affluent neighborhoods (Larsen and Gilliland 2008; Wiebe et al. 2016). While some socioeconomically disadvantaged neighborhoods may have reasonable geographic proximity to retail food outlets, the products may not be affordable to these populations, creating what have been termed "food mirages" (Breyer and Voss-Andreae 2013; Wiebe et al. 2016). According to Wiebe et al. (2016), food mirages are associated with economic barriers and gentrification, unlike food deserts which focus on the presence of food retailers.

Some argue that these socioeconomically vulnerable areas are served by smaller and often independently-owned convenience stores (Skerritt 2013); however, the negative consequences (e.g., higher obesity rates) of living in close proximity to a convenience store are well-documented (Morland et al. 2006; Powell et al. 2007; Liu et al. 2007; Wang et al. 2007). In a recent review of Canadian retail food impacts, *food swamps* or the marginalized neighbourhoods whose food environment are dominated by restaurants, are deemed more appropriate to describe socioeconomic-food relationships (Fielding and Simon 2011; Minaker 2016).

This study includes a geographic assessment of food swamps using (1) a Socioeconomic Deprivation Index (SDI) based on seven Census variables, (2) distance to restaurants, and (3) clustering of restaurants, to identify at-risk locations and populations. We hypothesize that restaurants are filling the void left by supermarket closures in Winnipeg. There is evidence that restaurants are more or equally accessible in socioeconomically deprived neighbourhoods and school regions compared to those neighbourhoods with little-to-no socioeconomic deprivation (Burns and Inglis 2007; Galvez et al. 2007; Pearce et al. 2007; Sharkey et al. 2009; Paez et al. 2010; Cushon et al. 2013). In this research, we identify food swamps using the SDI developed by Apparicio et al. (2007) and expanded upon by Wiebe et al. (2016). This approach will allow for a direct comparison between *a priori* Winnipeg food desert/mirage areas (Wiebe et al. 2016) and the areas of food swamps identified in this research. If an area is a food desert, then policy focus should be on accessibility and affordability. In comparison, if an area is a food swamp, the policy should be on deterrents to unhealthy food choices (Minaker 2016; Minaker et al. 2016). Raising awareness by providing information on policy focus for agencies such as the Winnipeg Food Council is the ultimate outcome (Botelho-Urbanski 2016).

Methods

The City of Winnipeg Urban Area (UA) has a population of approximately 660,000 over a 464 km^2 land area (Statistics Canada, 2012a) and 1301 restaurants (ALL) with n=531 Fast Food Restaurants (FFR), n=663 Sit-Down Restaurants (SDR), with the remaining n=107 designated as coffee shops based on Manitoba Health 2015 data (Figure 1, left). The restaurants were classified according to NAICS 2012 standards with FFR and coffee shops defined as "establishments primarily engaged in providing food services to patrons who order or select items at a counter, food bar or cafeteria line (or order by telephone) and pay before eating" (Statistics Canada 2012b). SDR are defined as "establishments primarily engaged in providing food services to patrons who order and are served while seated and pay after eating." (Statistics Canada 2012b). FFR, SDR and ALL restaurant datasets were included in this analysis as evidence suggests that eating at any restaurant, not just FFR, significantly increases fat, cholesterol and sodium intake per meal (An 2015). Restaurant meals are also more energy-dense and nutrient-poor compared to home-prepared meals, and eating away from home contributes to poor dietary patterns (Guthrie et al. 2002).

Within ArcGIS, Global Moran's I was used to test for spatial autocorrelation for ALL, FFR or SDR point data within Dissemination Blocks (DBs) to identify potential clustering of the datasets. The null hypothesis ($p > 0.05$) states that restaurants are randomly distributed across all DBs so that the distribution of the data is due to chance alone. Results showed clustering of restaurant locations for all datasets (ALL, FFR, SDR), justifying the use of spatial statistics.

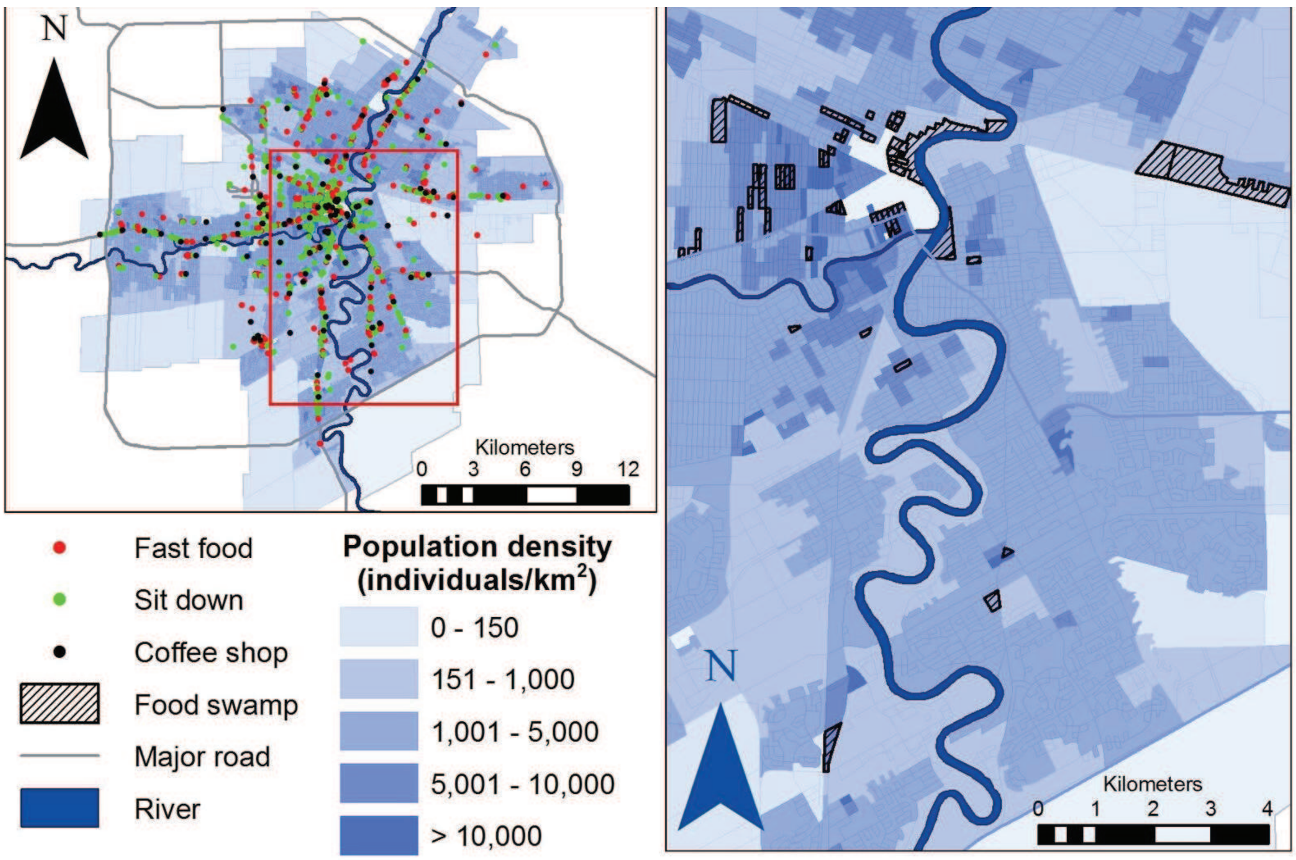

Figure 1. (left) City of Winnipeg Urban Area extent based on 2006 cartographic boundaries with population density from 2006 Statistics Canada Census. 2015 Restaurant point data for ALL, FFR and SDR was provided by Manitoba Health. (right) Food swamp locations based on ALL restaurants in Winnipeg.

The next step was to test for spatial autocorrelation of restaurant clusters within the 5740 DBs using Anselin Local Moran's I for ALL, FFR or SDR. DBs which result in positive Moran's I-values for restaurants indicate neighbouring DBs with *similarly* High or Low numbers of restaurants, whereas negative Moran's I-values indicate outlier DBs (neighbouring DBs have *dissimilar* numbers of restaurants). The resulting DBs that are identified as HH (High restaurant count surrounded by DBs also with High restaurant counts) and LH (Low restaurant count surrounded by DBs with High restaurant count) are then identified as high restaurant clusters (Figure 2).

The socioeconomic deprivation index (SDI) used in this analysis was developed by Apparicio et al. (2007) for Montreal (3 variables) and adapted by Wiebe et al. (2016) for Winnipeg (7 variables). The 7-variable composite SDI better represents the circumstances of socioeconomic deprivation compared to single metrics such as low-income population (Wiebe et al. 2016). Use of this SDI allowed for comparison of food swamp

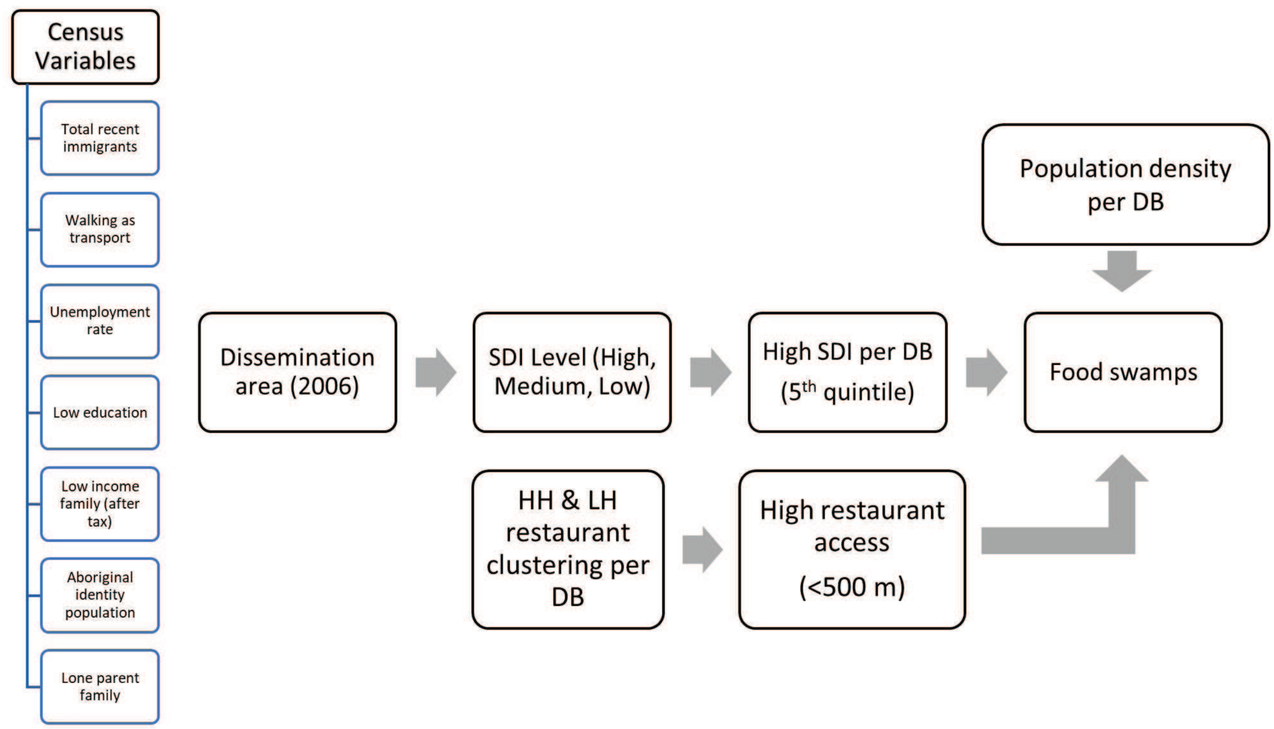

Figure 2. SDI levels were defined based on the seven census variables listed here[9, 29]. DBs with High SDI values combined with HH and LH Restaurant clusters and High restaurant access (<500 m) were used to define food swamp locations. Population density data was used to identify the population potentially impacted by food swamps in Winnipeg.

locations, obtained in this analysis, to food desert (lack of grocery stores) and food mirage (accessible but not affordable) locations obtained the Wiebe et al. (2016) study. While their study ascribed Census Tract-level variables from 2011 to DBs, this analysis opted to ascribe 2006 Dissemination Area-level variables to DBs. Dissemination Area data improved the accuracy of the socioeconomic values across the city, and 2006 data addressed gaps due to low reporting which were especially prevalent in low economic neighbourhoods that is well documented in the 2011 Census. The working hypothesis for our analysis is that *if* food deserts and mirages coincide with food swamps, a wider breadth of policies is required for these regions. If this hypothesis proves true, then policies regarding grocery store access, pricing and type of food at convenience stores, and taxing of unhealthy alternatives (Minaker 2016; Minaker et al. 2016) all need to be addressed by the Winnipeg Food Council.

The seven census variables used to create the SDI were taken from Wiebe et al. (2016) and include low education (no certificate or diploma), low income families (less than median after taxes), walking as main transportation, unemployment rate, total recent immigrants, total lone parent families and Aboriginal-identified population (Figure 2). The values for these variables were converted to percentages of the total Census population within each DB, and the values for each census variable were normalized to a scale from 0 to 1 (Wiebe et al. 2016). The normalized variables values were summed to create the SDI, a composite socioeconomic view of people's ability to access food retail locations as well as afford retail products (Wiebe et al. 2016). The potential range of values that can be generated in the SDI go from 0 (no deprivation experienced) to 7 (significant challenges in accessing and ability to purchase food). However, the 2006 Winnipeg data resulted in SDI values that ranged from 0 to 2.86 across the 5740 DBs. The data was then organized into quintiles and binned into Low, Moderate and High SDI levels. The Low SDI category ranged from 0 to 1.13 (no significant statistical differences between the three lowest quintiles); these populations were considered to have low socioeconomic deprivation (high access and ability to afford food). The Moderate SDI category was defined by the second highest quintile with values ranging from 1.13 and 1.38. The High SDI category was defined by the highest quintile with values >1.38; these populations are considered to have high socioeconomic deprivation (least accessibility and least ability to afford food).

The next step was to calculate the mean distance (δ) from each (DB) centroid to the nearest restaurant for each SDI level (Low, Moderate, High). DBs were used as the spatial unit for distance measures as the DB is the smallest geographic area for which population and dwelling counts are disseminated. To determine restaurant accessibility, the proximity of the nearest restaurant location was calculated between the DB centroids to every restaurant location based on Euclidean distance using ArcGIS software. Researchers have demonstrated that Euclidean distance measures generate similar patterns to network distance measures and these different measures of food access can be compared without loss of generality (Sparks et al. 2010). Each DB was then assigned to a "level of restaurant access" category from High ($\delta \leq 500$ m), Moderate (500 m > $\delta \leq 1000$ m) or Low ($\delta > 1001$ m) accessibility previously defined in food environment studies (Apparicio et al. 2007). Since the δ values were not normally distributed, nor homoscedastic, but exhibited the same one-tailed shape, a non-parametric Kruskal-Wallis Rank Sum and Multiple Comparison tests were conducted using R software to determine if there are significant differences ($p < 0.05$) in the mean distances to nearest restaurant within each SDI level (Low, Moderate and High). Results from these tests report the H statistic, the degrees of freedom, p-value and the median δ value for each SDI level. If the H calculated value is less than the H critical value, the null hypothesis cannot be rejected and there is no difference between the SDI levels' median δ relationships.

DBs with High SDI values, which also had High accessibility ($\delta < 500$ m) and were located within high restaurant clusters (HH, LH) were identified as food swamp locations using ALL, FFR or SDR datasets. Dissemination Area 2006 population data was used to identify the population impacted by food swamps at the DB level. These food swamp DB locations were then compared to food desert and mirage locations (recognized by Wiebe et al. 2016) to identify the high priority areas which require a wider breadth of food policies.

Results

Table 1. Spatial clustering of restaurants with HH and LH clustering

Statistics	*Sit Down (SDR)*			*Fast Food (FFR)*			*All Restaurants (ALL)*		
Moran's I	0.045			0.008			0.027		
Z-score	34.5			6.63			21.0		
p-value	< 0.001			< 0.001			< 0.001		
Clustering type	*Restaurant clustering*								
	Sit Down (SDR)			*Fast Food (FFR)*			*All Restaurants (ALL)*		
	# DBs	*Area (km^2)*	*% pop.*	*# DBs*	*Area (km^2)*	*% pop.*	*# DBs*	*Area (km^2)*	*% pop.*
HH area	234	3.44	6.85	109	4.22	4.18	241	4.98	7.40
LH area	94	0.512	2.87	0	0	0	8	0.028	0.217
Total	328	3.96	9.72	109	4.22	4.18	249	5.01	7.62

ALL, FFR and SDR were found to be significantly clustered ($z > 1$) across DB cartographic boundaries (Table 1); however, SDR establishments exhibited the greatest degree of clustering ($z=34.5$) compared to ALL and FFR. Similar HH cluster patterns were observed throughout the city for ALL, FFR and SDR; i.e. all datasets resulted in clusters north of Portage Avenue, in the Regent area and near the St. Vital Centre. However, SDR locations exhibited a pattern of LH clusters in the city core, west of the Red River (e.g. east of Maryland St and north of Corydon), which was not present in the patterns for ALL or FFR. This core region, which includes the Forks and the Exchange District, as well as the already-established Osborne Village area, has been the focus of economic development in the City; the economic development appears to benefit SDR options more than FFR establishments. In addition to clusters in the city core, HH clusters were also present in the Regent, Polo Park, Linden Woods and Westwood Centre areas for ALL, FFR and SDR; these regions corresponded with aggregations of "big-box" retail centres (e.g. Walmart, Best Buy, Superstore).

Overall, there was a higher proportion of land area designated as restaurant clusters (HH or LH) for ALL (5 km^2; 1.1% of total) compared with FFR (4.2 km^2; 0.92%) and SDR (3.9 km^2; 0.87%). However, there was a higher number of DBs with restaurant clusters (HH or LH) based on SDR locations (n=328) compared to ALL (n=249) and FFR (n=109) locations. The number of DBs impacted by HH or LH clusters corresponded with a higher proportion of the population than the proportion of land area comprised in these clusters. For example, SDR resulted in a higher number of DBs with restaurant clusters associated with 9.72% of the population (62,000 people) while ALL resulted in a larger area with restaurant clusters but less population (7.62%).

Since there were no significant differences between the three lowest SDI quintiles, these were binned together as 'Low SDI' which accounts for 3/5th of all DBs and corresponds to 3/5th of the total population. Moderate and High SDI both contained 1/5th of the total DBs and total population. However, the land area that corresponded with Low or High SDI levels did not conform to the quintile proportions. The observed land area for Low SDI (65.3%) and High SDI (13.3%) varied from the expected land area of 60% and 20%, respectively. Because observed land area deviated from expected, this suggested that as socioeconomic deprivation increases, a corresponding increase in population density occurs in the city.

There was an inverse relationship observed between Winnipeg SDI levels and mean distance to nearest restaurant (δ); as SDI values increased, δ decreased (Table 2). For ALL establishments, people living in DBs with High or Moderate SDI values had significantly easier access to restaurants (δ ≤ 500 m) than people living in DBs with Low SDI values. There was no significant difference observed in the relationships between DBs with High or Moderate SDI and δ based on Kruskal-Wallis tests (H calculated values were less than the H critical values). Median δ differed between 3 m (Moderate SDI) to 40 m (High SDI). The median δ within Low SDI differed from Moderate (55 m) and High SDI (81 m).

Table 2: Relationships between SDI levels, δ and spatial clustering of restaurants

SDI levels	*# DBs (% of total)*	*Area (km²)*	*% Pop.*
Low SDI	3353 (58.4)	65.3	59.8
Mod SDI	1150 (20.0)	21.3	21.2
High SDI	1237 (21.6)	13.3	18.9

SDI levels	*Sit Down (SDR)*		*Fast Food (FFR)*		*All Restaurants (ALL)*	
	Mean δ	*% High access (δ ≤ 500m) pop[a]*	*Mean δ*	*% High access (δ ≤ 500m) pop[a]*	*Mean δ*	*% High access (δ ≤ 500m) pop[a]*
Low SDI	633	50.2	632	48.4	517	59.8
Mod SDI	530	58.4	563	54.8	415	70.1
High SDI	**485**	**60.5**	**497**	**57.5**	**388**	**70.2**

Kruskal-Wallis	*Sit Down (SDR)*	*Fast Food (FFR)*	*All Restaurants (ALL)*
H calculated	H(2)=100.48, p<0.001	H(2)=84.23, p<0.001	H(2)=117.35, p<0.001
Median δ-Low SDI	496 m	524 m	408 m
Median δ-Moderate SDI	415 m	469 m	330 m
Median δ-High SDI	394 m	429 m	323 m

Clustering type	*Sit Down (SDR) Population (%)[b]*			*Fast Food (FFR) Population (%)[b]*			*All Restaurants (ALL) Population (%)[b]*		
	Low	*Moderate*	*High*	*Low*	*Moderate*	*High*	*Low*	*Moderate*	*High*
HH area	5.6	8.91	8.49	3.97	5.25	3.61	6.64	8.92	8.11
LH area	2.54	3.61	3.1	0	0	0	0.276	0.098	0.166
Total	8.14	12.52	11.59	3.97	5.25	3.61	6.92	9.02	8.28

[a] Percent of all individuals in SDI level within less or equal to 500 m from the nearest restaurant (δ)

[b] Percent of all individuals in SDI level within a restaurant cluster type

DBs of High SDI values had a high proportion of the population with High access to restaurants (δ < 500 m) for all datasets; 70.5% (ALL), 57.5% (FFR) and 60.5% (SDR) of the population with High SDI and High access. DBs with Moderate SDI resulted in similar proportions for SDR (58.4%) and ALL (70.1%). In comparison, the proportion of people living in DBs with Low SDI values was approximately 10% lower within ALL , SDR or FFR databases (Table 2). Additionally, there were more DBs with High SDI values that also had High access to restaurants (δ < 500 m) compared to DBs with Moderate SDI values, although this trend was less pronounced when compared to the Low SDI DBs.

In addition to observing an inverse relationship between restaurant access and SDI values, results showed that there is a relationship between restaurant clusters and SDI values. There is a higher proportion of DBs with High or Moderate SDI values and restaurant clusters (HH, LH) compared to DBs with Low SDI values. However, this pattern was only observed for ALL and SDR establishments. When using the FFR data, a comparable percentage of DBs between Low SDI values with HH/LH clusters (3.97%) and High SDI values with HH/LH clusters (3.61%) was observed; DBs with Moderate SDI values had the highest percentage of HH/LH clusters at 5.25%.

Food swamp locations were then defined based on the DBs with High SDI values, High restaurant access (δ < 500 m) and HH/LH clustering of restaurants using ALL, SDR or FFR data. Figure 1 (right) shows the results of the ALL restaurant food swamp locations. SDR establishments resulted in the largest number of DBs identified as food swamp locations (n=88), followed by ALL (n=67) and FFR (n=25). SDR food swamps also had the highest proportion of land area (4.98 km^2; 1.09% of total) compared to ALL (3.74 km^2; 0.82%) and FFR (1.89 km^2; 0.41%). The SDR food swamp locations also encompassed more people compared to ALL and FFR; SDR n=14,074 people (2.19% of Winnipeg total); ALL n=10,053 people (1.57%); and FFR n=4,389 people (0.68%). Food swamp locations that are based on High SDI values using ALL, SDR or FFR data shared some similar patterns. The SDR results do emphasize that FFR are not the sole contributor to food swamp condition which supports An (2015). Food swamp locations were primarily located in the city core, along commuter roadways (Pembina Hwy; St. Mary's Rd) and big box retail centres such as Regent Park.

Table 3 shows the similarities between food swamp locations resulting from this research and food desert or mirage locations identified by Wiebe et al., (2016). Although there was a different number of DBs identified as food swamp with each restaurant dataset, they shared similar relationships with the food desert and mirage locations. For example, 65%-68% of food swamp DBs are also food deserts or mirages, regardless if ALL, SDR or FFR was used. Approximately half of the similar food swamp/desert/mirage locations were deemed high priority ('severe') food desert and mirages for all three datasets (ALL = 50%; FFR = 44%; SDR=45%). The remaining DBs with similar swamp/desert/mirage locations (ALL=19%; FFR=24%; SDR=21%) were identified as a secondary priority ('moderate') food desert or mirages.

Table 3: Comparison of Food Swamp with Food Desert and Mirage locations within Winnipeg

Food Swamp DBs	*From Wiebe et al. (2016)*				
	Total Food Desert/Mirages	*'Severe' Mirages*	*'Severe' Deserts*	*Moderate Mirages*	*Moderate Desert*
ALL n=67	n=45 (67%)	n=24 (36%)	n=8 (12%)	n=9 (13%)	n=4 (6%)
FFR n=25	n=17 (68%)	n=9 (36%)	n=2 (8%)	n=2 (8%)	n=4 (16%)
SDR n=88	n=57 (65%)	n=26 (30%)	n=13 (15%)	n=13 (15%)	n=5 (6%)

Discussion

There is little research on Winnipeg's retail food environment to inform policy decisions by the newly formed Winnipeg Food Council. Exploration of food swamps and their relationships with food deserts or mirages in the City is a good starting point to aid this Council. The results of this research showed that restaurants are indeed clustered in certain areas of the city (e.g., city core, big box locations, commuter roads). Over 122,000 people (18.9% of total) in Winnipeg are categorized as socioeconomically deprived (High SDI values) and these populations have closer access to restaurants (δ < 500 m) which are more likely to be clustered compared to Low SDI populations. When comparing the food swamp locations to food desert/mirage locations identified *a priori*, these same socioeconomically deprived populations have little or no grocery stores (food deserts) or affordable product options (food mirages).

These findings provide guidance on the wide breadth of policies needed to address food deserts, mirages and swamps rather than mimicking policies developed for larger cities that do not have food deserts or mirages. For example, policies need to address zoning restrictions on restaurants, establish tax incentives to grocery stores, provide grants and loans to service high-risk populations, offer alternative strategies to curb poor dietary consumption patterns or further refine initiatives to support retail food projects in underserved areas (Centers for Disease Control and Prevention 2011; Minaker 2016; Minaker et al. 2016; Wiebe et al. 2016). By incorporating food mirages into policy intervention, inner-city neighbourhoods at risk of health problems associated with the inability to purchase healthy food can be targeted (Wiebe et al. 2016).

This strong correlation between food swamps and food desert/mirage locations emphasize the underlying economic conditions of the neighbourhoods coupled with the legacy retail structure. The food swamp results were obtained using different Census data compared to the food desert/mirage analysis (2006 for food swamps; 2011 for food deserts and mirages). This shows that these High socioeconomically deprived neighbourhoods have long experienced these conditions, at least over the time period. The legacy of retail structures means that development of existing buildings and infrastructure are hard to change (e.g., the city core, the historic Exchange District), so large-store retailers (e.g., grocery stores) tend to develop in suburbs for ease. Restaurants have a relatively easier time converting older buildings to accommodate their business compared to grocery stores and can exist in neighbourhoods where population density is only high during business hours.

A question that comes out of food retail research is why do certain Canadian cities have food swamps, deserts and mirages while others have only food swamps? The results obtained in Winnipeg coincide with studies in cities that show the most socioeconomically deprived populations have the highest access to restaurants in cities within Australia, New Zealand, along the Texas-Mexico border, Quebec, Saskatchewan, Ontario, British Columbia (Burns and Inglis 2007; Pearce et al. 2007; Sharkey et al. 2009; Paez et al. 2010; Cushon et al. 2013; Minaker 2016; Minaker et al. 2016). Those low-income and/or ethnic minority populations predominantly reside in areas with significant overlap of high restaurant access and low supermarket access (Burns and Inglis 2007; Pearce et al. 2007; Sharkey et al. 2009; Paez et al. 2010; Cushon et al. 2013; Minaker 2016; Minaker et al. 2016). However, Canadian cities demonstrate a different retail food pattern compared to the US cities when it comes to existences of food deserts and mirages. Larger Canadian cities tend not to show food desert/mirages but do have food swamps (Minaker 2016; Minaker et al. 2016) while other Canadian cities do exhibit all three food environments. We hypothesize that the city population density may impact whether food deserts and mirages exist within Canadian cities which still needs to be assessed. Additionally, a more nuanced view of food environments in Winnipeg could be achieved by considering the temporal element of access patterns to account for seasonal differences (Center for Disease Control and Prevention 2011).

The findings of this research provide a reference to identify at-risk food environments and the people affected in Winnipeg. Building on this work and the work of Wiebe et al. (2016), there is a strong need for food policy action to improve access to nutritious food for socioeconomically deprived populations, especially in the city core. Future implementation of policy initiatives would benefit from additional food environment studies and evaluations of the success of strategies that have been proposed or implemented in other cities to curb food insecurity. By prioritizing disadvantaged populations which cannot access or afford to purchase nutritious foods, future food policy initiatives will be more effective in improving access to healthy food.

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