Urban Geographic Food Retail Accessibility Indicator

Description

- **Density:** Population weighted mean number of food retail outlets of a given category within 1000m of dissemination block (DB) centroids per Dissemination Area (or other geographic unit of interest).
- **Relative Density:** Percentage of unhealthy food retail outlets (# unhealthy food retail outlets /# all food retail outlets)
- **Proximity:** Population weighted average distance between dissemination block (DB) centroids and nearest food retail outlet of a given category per Dissemination Area **(or geographic area of interest)**.

Specific Indicators & Method of Calculation

- Density of food outlets
- Relative density of less healthy food outlets (Modified Retail Food Environment Index, mRFEI)
- Proximity to food outlets

Method of Calculation

1. **Density: Population-weighted mean number of food outlets of a given category within an 1000m[1] (network distance) of dissemination block (DB) centroids per Dissemination Area (DA) (or geographic unit of interest).**

$$\text{Density of Food Outlets} = \frac{\sum_{\text{All DBs In a DA}} \textit{(DB Population) x (\# of food outlets of a given category within 1000m of DB centroid)}}{\textit{(Total Population of DA)}}$$

[1] [2]1000 meters is considered approximately a 15-minute walk for an adult in an urban setting(32)

2. Relative Density: Modified Retail Food Environment Index (mRFEI) per Dissemination Area (DA) (or geographic unit of interest).

$$\text{Modified Retail Food Environment Index} = \sum_{\text{All DBs In a DA}} \frac{\#\ \textit{less healthy food retailers within 1000m of DB centroid}}{\sum_{\text{All DBs in a DA}} \textit{f healthy + \# less healthy food retailers within 1000m of DB centroid}} \times 100$$

3. Proximity: Population weighted mean network distance (meters) between dissemination block (DB) centroids and nearest food outlets of a given category per Dissemination Area (DA) (or geographic unit of interest).

$$\text{Proximity to Food Outlets} = \frac{\sum_{\textit{All DBs in a DA}} \textit{(DB Population) x (Distance from DB centroid in meters to nearest food outlet of a given category)}}{\textit{(Total Population of DA)}}$$

Using North American Industry Classification NAICS codes to categorize food outlets from an inspection database

Food premise inspection is mandated by the Ontario Food Premises Regulation 562 under the Health Protection and Promotion Act. Typically every eating and drinking establishment is inspected one, two or three times per year depending on the level of "risk" to food safety. These data are entered into a data base at health units and can be used in the analysis of food outlets. In order to use these data that are collected for other uses they have to be recoded and categorized according to the NAICs code. It is important to ensure that misclassification of retailers is reduced by data cleaning.

Suggested Distinctions between Food Outlet Categories

Less Healthy Food Retailers	Healthy Food Retailers
Convenience Stores (NAICS 445120)	Supermarkets and other grocery stores (NAICS 445110)
Gasoline stations with convenience stores (NAICS 447110)	Fruit and Vegetable Markets (NAICS 445230)
Limited-service eating places (NAICS 722512)	

Ontario Public Health Standards (OPHS)(This section is under review pending finalization of the new Standards for Public Health Programs and Services.)

The Ontario Public Health Standards (OPHS) establish requirements for the fundamental public health programs and services carried out by boards of health, which include assessment and surveillance, health promotion and policy development, disease and injury prevention, and health protection. The OPHS consist of one Foundational Standard and 13 Program Standards that articulate broad societal goals that result from the activities undertaken by boards of health and many others, including community partners, non-governmental organizations, and governmental bodies. These results have been expressed in terms of two levels of outcomes: societal outcomes and board of health outcomes. Societal outcomes entail changes in health status, organizations, systems, norms, policies, environments, and practices and result from the work of many sectors of society, including boards of health, for the improvement of the overall health of the population. Board of health outcomes are the results of endeavours by boards of health and often focus on changes in awareness, knowledge, attitudes, skills, practices, environments, and policies. Boards of health are accountable for these outcomes. The standards also outline the requirements that boards of health must implement to achieve the stated results.

Requirements for this indicator:

- The board of health shall work with municipalities to support healthy public policies and the creation or enhancement of supportive environments in recreational settings and the built environment.

Outcomes Related to this Indicator:

- Board of Health Outcome (Foundational Standard): Public health programs and services are planned and implemented to address local population health needs.

Assessment and/or Surveillance Requirements Related to this Indicator

- Board of Health Outcome (Foundational Standard): The board of health shall conduct surveillance, including the ongoing collection, collation, analysis, and periodic reporting of population health indicators, as required by the Health Protection and Promotion Act and in accordance with the Population Health Assessment and Surveillance Protocol, 2008 (or as current).

Protocol Requirements Related to this Indicator

- The board of health shall collect or access the following types of population health data and information: Physical environment factors (Population Health Assessment and Surveillance Protocol, 1b)

http://www.ontario.ca/publichealthstandards

Corresponding Health Indicator(s) from Statistics Canada and CIHI

None/Unknown

Corresponding Indicator(s) from Other Sources | Data Sources

None/Unknown

Data Sources

I. **Street Network Datasets**

Ontario Road Network (ORN)
Original Source: Ministry of Natural Resources
Distributed by: Ministry of Natural Resources and Land Information Ontario
Access/Download: http://www.ontario.ca/environment-and-energy/land-information-ontario
Suggested citation (see Data Citation Notes): See Existing Apheo Citation.
URL: http://www.apheo.ca/index.php?pid=303

Road Network File (RNF)
Original Source: Statistics Canada
Distributed by: Statistics Canada
Access/Download: http://www12.statcan.gc.ca/census-recensement/2011/geo/RNF-FRR/index-eng.cfm
Suggested citation (see Data Citation Notes): See Existing Apheo Citation.
URL: http://www.apheo.ca/index.php?pid=303

Local Street Network (SLRN)
Original Source: Local Agency, Government
Distributed by: Local Agency, Government

Access/Download: Contact local provider
Suggested citation (see Data Citation Notes): See Existing Apheo Citation.
URL: http://www.apheo.ca/index.php?pid=303

II. **Food Outlets**
III.

Local Food Inspection Database:
Original Source: Food inspection database used by your health unit
Distributed by: Local Public Health unit
Access/Download: Contact Public Health unit
Suggested citation: [Database name]. [Public Health unit]. [Years]. Extracted :[Date]

NAICS Codes:
North America Industry Classification System, Canada 2012
http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVDPage1&TVD=118464

IV. **Statistics Canada Census Geography**
V.

Dissemination Areas
Original Source: Statistics Canada
Distributed by: Statistics Canada
Access/Download: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-eng.cfm
Suggested citation: Statistics Canada. [Year]. Dissemination Areas,(cartographic boundary file, [filename]). http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2011-eng.cfm (accessed [Date]).

Dissemination Blocks
Original Source: Statistics Canada
Distributed by: Statistics Canada
Access/Download: http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-eng.cfm
Suggested citation: Statistics Canada. [Year]. Dissemination Blocks ,(cartographic boundary file, [filename]). http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2011-eng.cfm (accessed [Date]).

DA Population Weighted Representative Point (Population Centroid)
Original Source: Statistics Canada
Distributed by: Statistics Canada
Access/Download: http://www12.statcan.gc.ca/census-recensement/2011/geo/ref/att-eng.cfm

Analysis Checklist

1. **Software Requirements:** ArcGIS with Network Analyst Extension or applicable network routing functionality found in other software.
2. **Street Network:**

- Input Street Network file must conform to network connectivity standards. Refer to application (e.g. ESRI, Manifold) specific documentation regarding configuration specifications.
- Since most publicly available street network datasets exclude sidewalks, it is suggested that the user model the network with restrictions and/or barriers (e.g. 400 Series Highways, On-Ramps), as appropriate, to refine traversable street segments.
- It is assumed that the analyst performing the calculation for this indicator is familiar with the quality and availability of all spatial datasets that cover the intended study area. Based on the quality of the available data and the intended use of the indicator, the analyst should choose the appropriate spatial datasets for indicator calculations.

3. **Geographic Units:**

- Results generated from the indicator measures are subject to inherent statistical variability in the measurement and analysis of geographic data, namely, edge effects and the modifiable areal unit problem (MAUP).We suggest evaluating and/or expanding relevant geographic datasets using adjacent regions outside of the area under measurement to assess and mitigate and edge effects (e.g. what effect do food retail outlets outside, but very near the study area have?). Recognizing the MAUP has both the scale (size) and zone (shape) effect, it is impractical to suggest one specific mitigation strategy. The analyst should familiarise themselves with the MAUP and ensure that end users/decision makers are aware that results differ depending on how data are aggregated.
- Minimum Geographic Units: The Dissemination Block is required to undertake this analysis. As the population gets sparser, it is recommended that the geographic unit at which the indicators are reported be scaled up from Dissemination Area to Census Tract and/or to Census Subdivision.

Basic Categories

Applicable geographic units: Statistics Canada Census geography; Dissemination Areas, Census Tracts, Census Subdivisions or Custom "Neighbourhood" geographies built from Statistics Canada census geography.

Age Groups: Total Population by Geographic Unit

Food Outlets NAICS codes: Limited-service eating places (722512), Supermarkets and Grocery Stores (445110), Convenience Stores (445120), Fruit and Vegetable Markets (445230), and Gasoline stations with convenience stores (NAICS 447110).

Links to the NAICS code definitions:

North America Industry Classification System, Canada 2012
http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVDPage1&TVD=118464

Indicator Comments

Caution: Indicators Represent Only One Aspect of the Food Environment

- The manner in which the built environment impacts health outcomes is complex and varied, since human behaviour is influenced by multiple factors. The value of an individual indicator is strengthened when considered in combination with other built environment indicators.
- The indicators recommended in this document assess the relationship between geographic access to food retail outlets within a specific area of interest to give a broad picture of the geographic nature of the retail food environment (i.e., the "community nutrition environment").
- While geographic measures have been the predominant food environment measures examined in previous studies on the food environment since the 1990's (Lytle, 2017) (potentially due to the ease of obtaining data on locations of retail food outlets and the growing availability of GIS-based tools), users should take caution when using accessibility indicators of community nutrition environment.
- The relative ease of measuring geographic accessibility presents a risk of over-reliance on geographical indicators (e.g., proximity and number of food retail outlets) as being the primary influence on eating behaviour. While the location and number of food retail outlets within communities may help to shape food choices, eating behaviour is determined by multiple environmental

factors (e.g., food prices, media and advertising), as well as their complex interaction with individual factors (e.g. food preferences, nutritional literacy, cooking skills) (Glanz,2005).

- Geographic indicators provide public health units with a way to characterize their local retail food landscape in terms of geographic accessibility; ***however, the indicators described in this document should not be used in isolation but rather as part of a comprehensive food environment assessment,*** which may include consumer nutrition environment data (i.e. in-store assessments), socio-demographic, and/or health-related data (Health Canada in press, 2015; Caspi, 2012). These additional data can be layered on food accessibility maps to further enhance the understanding of how community design impacts on the health and well-being of populations.
- Consumer nutrition environment indicators require more labour-intensive efforts to assess the types of foods offered within food outlets, placement of foods, pricing, etc (Farley 2009)

Urban vs Rural Areas

- The indicators described in this document are recommended for urban areas. Measuring geographical access to food retail in rural areas and small towns requires caution as research has identified a higher margin of error in these settings (Healy & Gilliland, 2012). When measuring geographical food retail access in regions comprised of both urban and rural areas , Health Units may want to consider:
    - The use of larger geographical units (see scalability under geographical units / analysis checklist above).
    - Looking at additional literature and resources around food environment measurement in the rural context. Appendix B of the draft Health Canada Food Environment Assessment Manual provides a comprehensive list of resources and materials that may apply in urban and rural contexts.
    - There are many ways of distinguishing urban and rural/remote areas (including Statistics Canada's CMA/MIZ Statistical Area Classification [SAC] code-based as described at APHEO.ca), however these indicators work best using Statistics Canada's definition of Population Centres (POPCTR) formerly Urban Areas (UA(-- see "Definitions" section at the end of this document.

Food Retail Outlets

- Your Health Unit's food premise database may already have a system for categorizing food outlets into supermarkets, restaurants, specialty food stores,

etc. To create maps and reports that are comparable across municipalities, it is highly advisable to spend some time ensuring that all food premises are appropriately categorized into the relevant NAICS category, and review previously categorized NAICS codes to make sure they are properly classified (For example it in not uncommon to have convenience stores misclassified as grocery stores, leading to a falsely elevated number of healthy outlet types).

- We recommend calculating Density and Proximity indicators for at least the following four food outlet types: Supermarkets and Grocery Stores (NAICS code 445110), Fruit and Vegetable Markets (445230), Convenience Stores (445120), and Limited-service eating places (722512).
- Density and Proximity indicators may be calculated for individual outlet types (e.g., supermarket) or for categories of food outlets (e.g. healthy or less healthy outlets), depending on the local issues of concern identified in your Health Unit. For example, if inadequate fruit and vegetable consumption is of interest, then it would be appropriate to map locations of all outlets where fruits and vegetables are available (e.g., supermarkets and grocery stores and fruit & vegetable shops combined). Framing your issue around intakes of high-calorie, nutrient-poor food choices may direct focus to less healthy food retail types (e.g. limited-service restaurants, convenience stores, etc.)

Centroids

- To better account for the distribution of the population within neighbourhoods, we recommend using population centroids instead of geographic centroids, if possible.
- It is usually impractical to measure the distance to a food outlet from individuals' homes (i.e. street address). Often, a single proxy location is used to represent a small collection of homes. The centre (a.k.a. centroid) of a Statistics Canada standard geographical unit (e.g., Dissemination Block [DB], Dissemination Area [DA], Census Tract [CT], etc.) is commonly used as a proxy for such a location. The methodology to calculate the above described indicators use the centroid of the DB as a proxy for a small cluster of homes.
- A DB is Statistic Canada's smallest census areal unit, see Definitions section
- Of course, distances measured from a proxy point will differ from the average (mean or median) distances from all individuals' home locations (i.e. some distance error will be present). When commonly used proxies such as the CT, DA, population-weighted DA or DB centroids (even individual postal codes) are used instead of exact street addresses, distance errors can be significantly large. The degree of error increases with the size of the geographic unit.
- Research suggests that DA centroids and population-weighted DA centroids (a.k.a. Representative Points – see Definitions section) should only be used as residential address proxies in urban areas where threshold distances are

set at greater than 1000 m, and in suburban areas or small towns when threshold distances are set at greater than 1600 m (Healey & Gilliland, 2012). The same research presents DB centroids as having lower facility mis-classifications and distance errors

- The analysis should check their metadata or file reference guides to determine what type of centroids they are working with. The type of centroid (weighted or not –see definitions Centroid and DA Population Weighted Representative Point below) can also be determined by comparing mapped features and their respective centroids.

Alternate analysis

- Street network files do not typically include cyclist or pedestrian pathways. Where more detailed pathway networks exist that include trails and sidewalks the analysis may replicate the above analysis by adding these to the road network resulting in a more accurate indicator of urban food retail accessibility. The indicators presented in this document use distance as "cost" in the network analysis. However, the "cost" of travelling along a network can be measured in many ways including time. Distance is often used as a proxy for time travelled (e.g. 800 meter =10 minute walk;1000 metres = 15 minute walk) because length is easily computed in a GIS environment. Time needs to be computed using distance and speed, but the latter is not typically included in street network files. Where speed is available, an analysis could be undertaken using time thresholds (e.g. 10 minute walk, 15 minute bike ride, 5 minute drive) to assess urban food retail accessibility. For the full list of attributes (e.g. Addressing, Posted Speed Limit) associated with the Ontario Road Network ensure the inclusion of related tables are selected when downloading from Land Information Ontario (LIO).

The following maps provide examples of how one might illustrate the indicators in this document.

Figure 1: Density

Example from Kingston, Frontenac, Lennox and Addington (KFL&A) Public Health showing mean number of supermarkets within 1000 metres of the dissemination block (DB) centroid, aggregated to the dissemination area (DA).

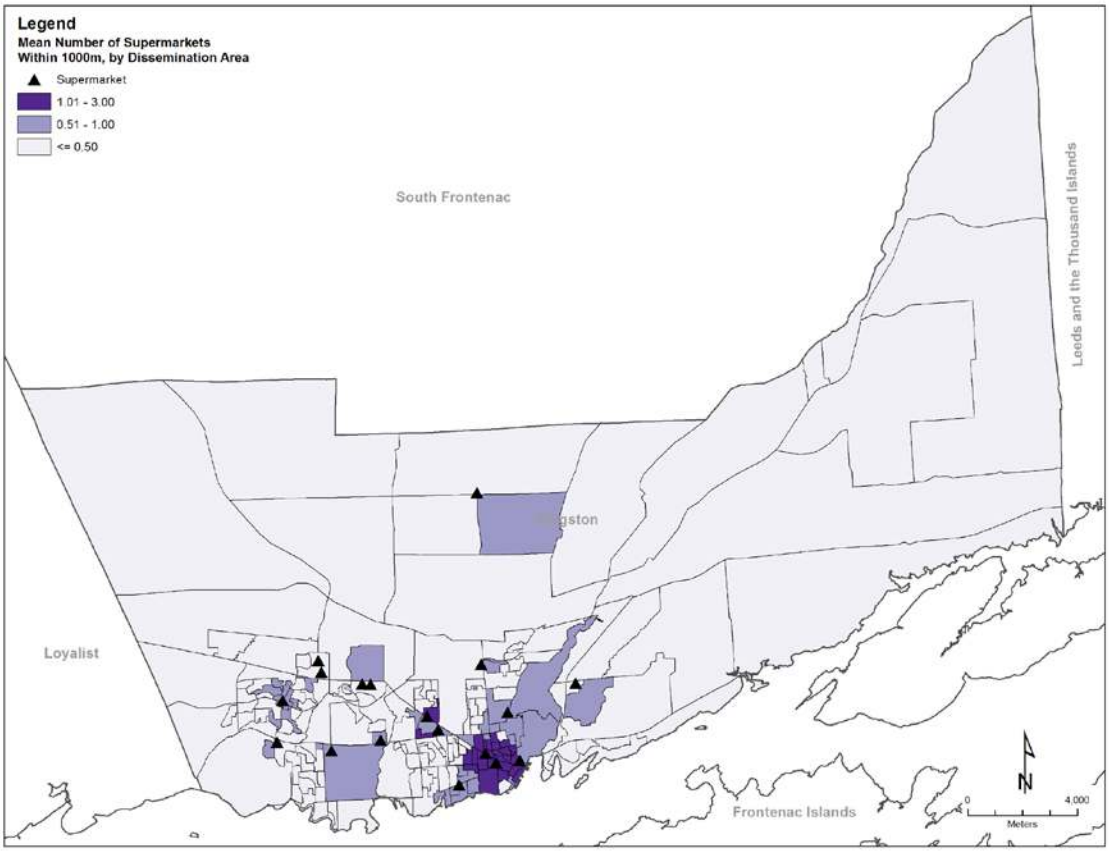


Figure 2: Relative Density (Modified Retail Food Environment Index, mRFEI)

Toronto map showing the percentage of *healthy* food retail relative to total food retail in an area (e.g. darker red colour = lower percentage of healthy food retail, i.e. worse food environment). Relative density can also be calculated as the percentage of *less healthy* food retail relative to all food retail.

"Healthfulness" of Food Retail

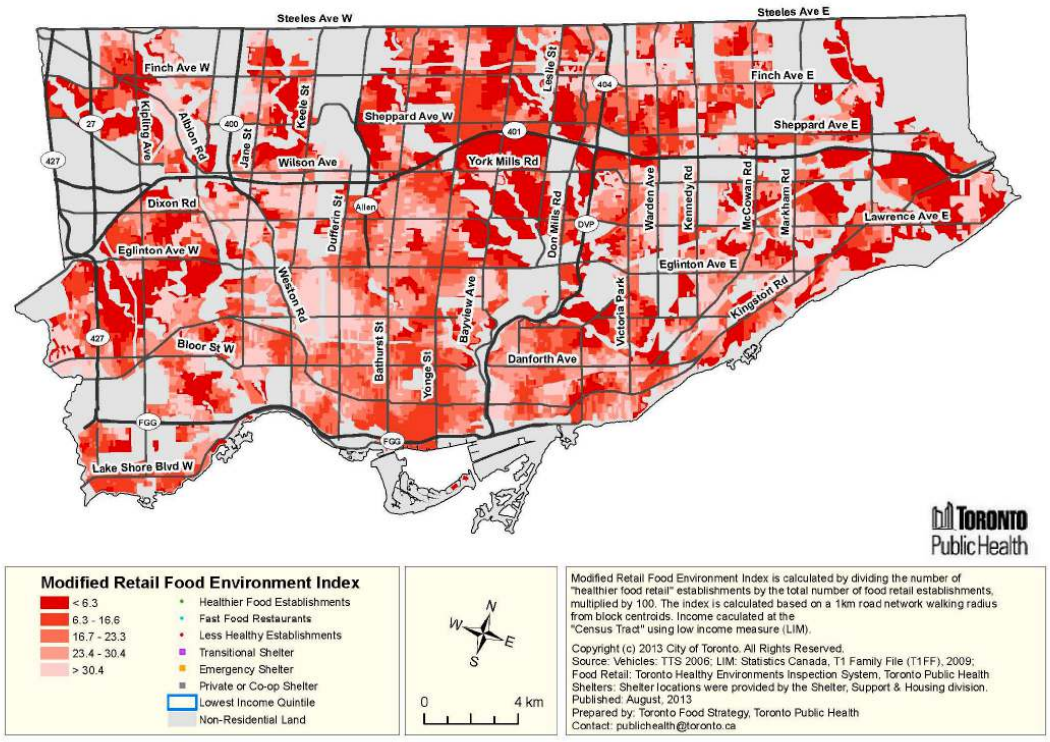
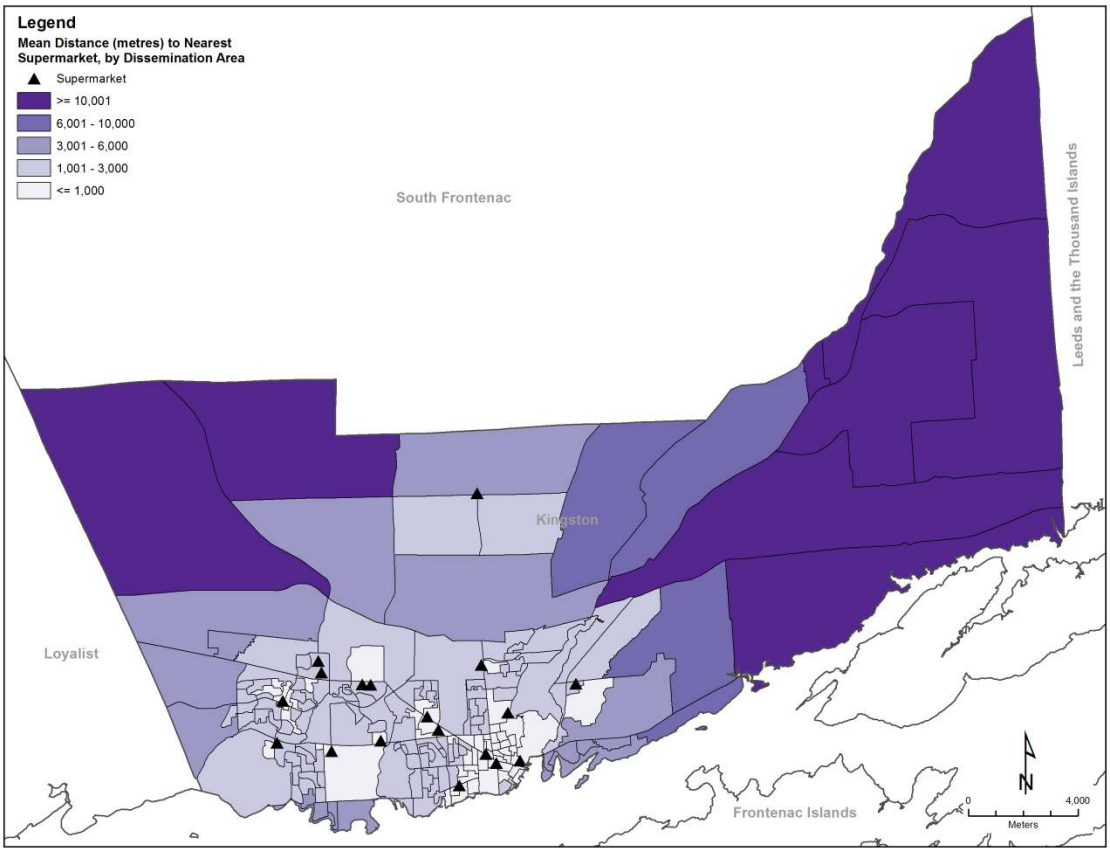


Figure 3: Proximity

Example from Kingston, Frontenac, Lennox and Addington (KFL&A) Public Health showing mean distance to supermarkets within 1000 metres of the dissemination block (DB) centroid, aggregated to the dissemination area (DA).



Definitions

Census Tract: Census tracts (CTs) are small, relatively stable geographic areas that usually have a population between 2,500 and 8,000 persons. They are located in census metropolitan areas and in census agglomerations that had a core population of 50,000 or more in the previous census (Statistics Canada, 2014).

Centroid: A centroid is a point used to represent the approximate centre of a feature, usually a polygon. Centroid coordinates (its position on a map) are usually calculated from the coordinates that represent the geometric centre of its respective features but are sometimes adjusted (moved) for different reasons.

1. Sometimes, the geometric centre of an object can be found on the outside of the object it represent, as in the case of a crescent or a feature made of multiple parts (E.g. large unorganized municipalities sometimes have smaller municipalities that interrupt to contiguity – in GIS these are known as "multi-part features"). In the case of a crescent-like feature the centroid is "forced" into the feature and for multi-part features the centroid is moved into one of the feature's parts.
2. In some cases centroids are weighted by population, i.e. the centroid coordinates are moved from the geometric centre to a position that more realistically represents where a population lives. For example a large census Dissemination Area may have most of its population living in one corner of it, so the centroid is moved towards that corner.
   Centroid weighting and adjustments are resource intensive. They are usually done manually using other data sources (air photo or satellite imagery) but can be done with GIS using other data such as road or house density.
   Weighted centroids are sometimes known as Representative Points (see **DA Population-Weighted Representative Point below**).

Convenience Stores: Establishments primarily engaged in retailing a limited line of convenience items that generally includes milk, bread, soft drinks, snacks, tobacco products, newspapers, and magazines. These establishments may retail a limited line of canned goods, dairy products, household paper and cleaning products, as well as alcoholic beverages, and provide related services, such as lottery ticket sales and video rental. (StatsCan NAICS 2012 - 445120)

Dissemination Area: A dissemination area (DA) is a small, relatively stable geographic unit composed of one or more adjacent dissemination blocks. It is the smallest standard geographic area for which all census data are disseminated. DAs cover all the territory of Canada (Statistics Canada, 2015).

Dissemination Block: A dissemination block (DB) is an area bounded on all sides by roads and/or boundaries of standard geographic areas. The dissemination block is the smallest geographic area for which population and dwelling counts are disseminated. Dissemination blocks cover all the territory of Canada (Statistics Canada, 2015).

DA Population-Weighted Representative Point (Population Centroid)
A Weighted Representative Point (RP), i.e., mean centre weighted by population, for a Dissemination Area is calculated by multiplying each of its component Dissemination Block (DB) geometric centroid coordinates (both x and y) by its DB-respective population, summing the products and dividing by the total DA population (sum of all component DB population). Statistics Canada generates Weighted Representative Points for Dissemination Areas which are available in their Geographic Attribute file available at http://www12.statcan.gc.ca/census-recensement/2011/geo/ref/att-eng.cfm
Additional steps are taken by Statistics Canada to adjust a RP so it falls within it geographic area (an issue when a DB or DA is crescent shaped) and does not appear in a water body. Detailed methodology on how Representative Points for populated and unpopulated DAs are generated can be found at: https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo040-eng.cfm#formula2
Weighted Representative Points are only available for Dissemination Areas but can be calculated using the same procedure outlined above for all larger geographic units.

Fruit and Vegetable Markets: Establishments primarily engaged in retailing fresh fruits and vegetables (StatsCan NAICS 2012 - 445230)

Gasoline Stations with Convenience Stores: Establishments primarily engaged in retailing automotive fuels combined with the retail sale of a limited line of merchandise, such as milk, bread, soft drinks and snacks in a convenience store setting. Establishments that operate such establishments on behalf of their owners are also included. (StatsCan NAICS 2012 - 447110)

LIO: Land Information Ontario

Limited-service eating places: Establishments primarily engaged in providing food services to patrons who order or select items at a counter, food bar, or cafeteria line, or who order by telephone, and pay before eating. Food and drink are picked up to consume on the premises, packed up for take-out, or delivered to the customer. These establishments may offer a variety of food items or they may offer specialty snacks or non-alcoholic beverages. (StatsCan NAICS 2012 - 722510)

ORN: Ontario Road Network

Population Centre: Area with a population of at least 1,000 and no fewer than 400 persons per square kilometre. The term “population centre” (POPCTR) replaces the term “urban area” (UA). Population centres are classified into three groups, depending on the size of their population:

- small population centres, with a population between 1,000 and 29,999
- medium population centres, with a population between 30,000 and 99,999
- large urban population centres, with a population of 100,000 or more.

https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo049a-eng.cfm

RNF: Road Network File

SLRN: Single Line Road Network

Supermarkets and Grocery Stores: Establishments primarily engaged in retailing a general line of food, such as canned, dry and frozen foods; fresh fruits and vegetables; fresh and prepared meats; fish, poultry, dairy products, baked products, and snack foods. These establishments also typically retail a range of non-food household products, such paper products, toiletries, and non-prescription drugs. (StatsCan NAICS 2012 - 445110)

Urban: See population centre definition.

Cross-References to Other Indicators

- Population Density (Section 2C: Built Environment and Health)
- Job Density: (Section 2C: Built Environment and Health)
- Commuting population (Section 2A: Social Environment and Health)
- Proximity to Community Focal point (Section 2C: Built Environment and Health)

References

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Statistics C. Dissemination block (DB). 2015-11-27; Available at: https://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo014-eng.cfm. Accessed October/27, 2016.

Changes Made

(Comments: Insert)

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