CONTEXTUAL DETERMINANTS OF CHRONIC DISEASES

CONTEXTUAL DETERMINANTS OF CHRONIC DISEASES: CARDIOVASCULAR DISEASE AND CANCER

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Abstract

Background: In Canada, cardiovascular disease (CVD) and cancer are the leading causes of mortality and morbidity in adults. Research in health geography has established the importance of contextual factors (e.g., community nutrition, and physical activity environments) as significant contributors to CVD and cancer.

Objectives: The objectives of this project are to: 1) systematically review the Canadian literature on the effects of contextual exposures on chronic diseases (CVD and cancer); 2) develop a method of assessment of measuring key contextual factors; and 3) explore the variations in contextual characteristics of urban and rural areas using the pilot data collected by a Canada-wide cohort study (CVCD Alliance).

Methods: *Objective (1):* MEDLINE, EMBASE, and CINAHL databases, and reference list of articles were searched from inception through Jan 20, 2014. English language human studies, conducted in Canada, that relate to contextual factors/built environment and chronic diseases were eligible for inclusion. *Objective (2)*: EPOCH-1 was modified to correspond with definition of community used in CVCD. Mean agreement was calculated to measure the reliability of the modified EPOCH-1. *Objective (3):* Physical activity (walkscore) and nutrition (cost of food basket) environments of urban and rural areas were compared using t-test.

Results: *Objective (1):* Review of the literature indicated that fewer fast food outlets, increased density of destinations and higher socio-economic status were associated with positive health outcomes. *Objective (2):* Mean agreement between raters of modified EPOCH-1 was excellent (close to 0). *Objective (3):* Analysis of pilot data showed that as compared to urban areas, there was a trend towards higher food costs and lower walkability in rural areas. However, this trend was not statistically significant ($p>0.05$).

Conclusion: This project will add to the current understanding of the impact of contextual characteristics on health, and promote the development of new interventions that aim to change modifiable environmental exposures.

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List of Abbreviations

CVD	Cardiovascular Disease
WHO	World Health Organization
DM	Diabetes Mellitus
CADUMS	Canadian Alcohol and Drug Use Monitoring Survey
CAMH	Center of Addiction and Mental Health
SES	Socioeconomic Status
CVCD	Cardiac, Vascular, Cognitive Dysfunction
CCHS	Canadian Community Health Survey
OECD	Organization for Economic Cooperation and Development
BMI	Body Mass Index
OR	Odds Ratio
RR	Relative Risk
NOS	Newcastle-Ottawa Scale
GIS	Geographical Information System
ACS	Acute Coronary Syndrome
CIHI	Canadian Institute of Health Information
FSA	Forward Sortation Area
RFEI	Retail Food Environment Index
GPS	Global Positioning System
SE	Standard Error
NEMS-S	Nutrition Environment Measures Survey–Stores
HEI-C	Healthy Eating Index adapted for Canada
ONS	Ottawa Neighbourhood Study
ON	Ontario
QC	Quebec
AB	Alberta
BC	British Columbia
SK	Saskatchewan
MB	Manitoba
PEI	Prince Edward Island
CPTP	Canadian Partnership for Tomorrow Project
PURE	Prospective Urban Rural Evaluation
MHI	Montreal Heart Institute
IQR	Inter Quartile Range
PCCF	Postal Code Conversion File
RST	Rural and Small Town
CMA	Census Metropolitan Area
CA	Census Agglomeration
MIZ	Metropolitan Area and Census Agglomeration Influenced Zones
EPOCH	Environmental Profile of a Community's Health
ICC	Intraclass Correlation Coefficient

MD	Mean Difference
SD	Standard Deviation
NFB	Nutritious Food Basket

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Chapter 1 Introduction

Cardiovascular disease (CVD) and cancer are the leading causes of mortality and morbidity in adult men and women in Canada and worldwide.[1,2] While the management of CVD, and its risk factors has improved over the past four decades, the burden of CVD remains high[3,4], indicating a continued need for an emphasis on prevention.

In Canada, access to cancer screening programs is increasing and the treatment for many cancers is becoming more effective, however, the human and economic burden of cancer remains significant and is continually growing.[1,5,6] Since the mid-1990s, great progress has been made in understanding the cancer etiology. However, the causes of many cancers remain poorly understood, and likely involve a complex interplay of genetic and environmental factors.[5,6] Accumulating evidence supports that diet, physical activity, smoking and regular alcohol intake are important modifiable risk factors for several cancers.[5,6,7] Consequently, diet and lifestyle modifications are important primary prevention strategies for reducing cancer incidence in the population.[5,7,8,9]

The search for unrecognized risk factors remains an active field of chronic disease prevention research.[5] One such approach to identifying novel risk factors is health geography, which is the application of geographical information, and perspectives to the study of health.[9,10,11] Health geography has highlighted the importance of contextual factors, i.e., unique environmental variables, as significant contributors to risk factors for chronic diseases such as obesity, physical inactivity and diet.[3,5,6,10,11] There is an emerging

recognition that interventions targeting contextual factors can be promising strategies for reducing population rates of chronic diseases.[9,10,11] In Canada, the contextual determinants of chronic diseases and their risk factors are not well characterized. It is important to understand these "causes of the causes" in order to design effective population health interventions to prevent CVD and some cancers.

1.1 Burden of Chronic Diseases (CVD and Cancer)

The increasing global burden of chronic diseases, specifically CVD (coronary heart disease, stroke, congestive heart failure, peripheral artery disease and myocardial infarction) and cancer, is of great public health concern, with its associated negative impacts on the quality of life and fiscal structure.[7,12,13] According to the World Health Organization (WHO), 63% of the 57 million global deaths in 2008 were due to chronic diseases, mainly CVD, cancer, and diabetes mellitus (DM).[12,13] In Canada, cancer is the leading cause of death, followed by CVD. In 2011, cancer accounted for 29.9 % (72,380 deaths), and CVD for 25.2% (61,002).[14]

Additionally, both of these chronic diseases place a large burden on the Canadian healthcare system. Estimated direct (physician and hospital expenses) and indirect (lost productivity, or immature death) costs of CVD amount to $22 billion (2008) and are expected to increase over time.[2] Likewise, in 2008, cancer cost the Canadian health care system $17.4 billion in direct and indirect costs.[14] Furthermore, in low- and middle-

income countries experiencing swift economic growth, CVD and DM are estimated to reduce gross domestic product between 1 and 5%.[12]

Although there has been a decline in CVD event rates in the general population through an improvement in management of CVD and changes in prevalence of risk factors, the burden of CVD still remains high. Specifically, in Ontario, between 1994 and 2005, improvement in medical and surgical treatments accounted for a 43 % decrease in CVD mortality, and changes in risk factors through lifestyle changes were associated with 48% decrease in total CVD mortality. In particular, a reduction in total cholesterol accounted for 23% reduction in CVD deaths and systolic blood pressure for 20%.[15]

Prevention of chronic disease is a major Canadian public health focus. This includes: (a) primordial prevention, which seeks ways to avoid development of risk factors; (b) primary prevention, which refers to prevention of disease by treating risk factors once they develop, and (c) secondary prevention, which aims to prevent a recurrent event in those with the disease.[16] For a successful and cost-effective primordial preventive strategy, we require an understanding of the etiologic factors in the pathogenesis of risk factors for chronic diseases, known as the "causes of the causes" in the population. This includes an understanding of the environmental, social, and economic factors that shape health behaviours and contribute to an elevated risk of CVD and some cancers.

1.2 Risk Factors for CVD and Cancer

CVD and several cancers share some of the same risk factors. These include non-modifiable risk factors such as age, sex and family history; and modifiable risk factors such as tobacco use, obesity, diet quality, alcohol consumption, physical inactivity and psychosocial stress.[4,7] Each of these factors has been strongly associated with the incidence and prevalence of CVD and some cancers in observational studies[7] (see Table 1).

1.2.1 Contextual Factors: Definition and Significance

Contextual factors encompass socio-environmental determinants of health such as local community nutrition, physical activity, and tobacco environments, as well as socio-economic status (SES), transportation options and municipal policies regarding these community-level factors. These factors (e.g., neighbourhood infrastructure, established cultural norms, differential access to goods and services, inequalities in socioeconomic position, stress, and policy changes) have a substantial impact on individual behaviours and in turn on prevalence of chronic diseases.[7,10,11] An ecological framework for this relationship is presented in Figure 1.[4,10] This framework includes six elements: 1) *local actions*: furthest upstream in the framework are local actions that develop local capacity for leadership. Local capacity is the residents' ability to identify and respond to their needs effectively through community action (e.g., fundraising, networking); 2) *local context*: local action is determined by the local contextual elements including eating and activity options, smoking policies, and socioeconomic conditions of the community,

access and availability of health care, and support services; 3) *dietary intake, physical activity and stress*: local policies/options can inhibit or facilitate dietary intake (i.e., sodium, fat and fruit/vegetable intake) and physical activity, and may act as sources of psychosocial stress; 4) *risk factor prevalence*: any of the above-mentioned elements independently, or in combination with others, may strongly influence risk factor prevalence (i.e., obesity, hypertension, and high cholesterol); 5) *utilization of health services*: this includes uptake of services for behavioural change, social support, mental health and preventive health; and 6) *prevalence of chronic diseases*: the prevalence of risk factor is associated with health care costs attributable to risk factors as well as incidence and prevalence of chronic diseases.

1.2.1.1 Physical Activity Environment (i.e., built environment)

Physical inactivity has been linked to an increased risk of non-communicable diseases such as CVD, stroke, diabetes, some cancers, high blood pressure, and obesity and poor mental well being.[17-20] According to a recent Canadian Community Health Survey (CCHS), almost half of Canadians were not active enough (three 30-minute exercise sessions per week) to achieve or maintain health benefit, with over 18% of adults obese and 33% overweight.[21] Recent strategies aimed at improving physical activity levels in the population acknowledge the role of the built environment in promoting physical activity.[16,22,23,24] Health Canada defines built environment as the following[25]:

> The built environment includes our homes, schools, workplaces, parks/recreation areas, business areas and roads. It extends overhead in the form of electric

> transmission lines, underground in the form of waste disposal sites and subway trains, and across the country in the form of highways. The built environment encompasses all buildings, spaces and products that are created or modified by people. It impacts indoor and outdoor physical environments (e.g., climatic conditions and indoor/outdoor air quality), as well as social environments (e.g., civic participation, community capacity and investment) and subsequently our health and quality of life.

Studying the built environment in relation to physical activity involves examining mixed land use (i.e., integrated use of commercial, residential, and industrial land) and compactness (e.g., number of stores within walking distance of homes), residential density, street connectedness and trail networks (e.g., linking neighbourhoods, parks, and commercial areas), opportunities for active transport (e.g., walking, and use of public transit), air quality, and aesthetic features (e.g., natural areas, and gardens).[25,26]

1.2.1.2 Nutrition Environment

Dietary intake and obesity are two of the most frequently cited modifiable risk factors for cancer and CVD.[27,28,29] It is estimated that 2% of cancer deaths can be attributed to obesity, and 5% of cancer deaths can be attributed to low fruit and vegetable intake.[27,28] Research suggests that recommendations to increase intake of fruits, vegetables, and whole grains, and decrease intake of highly processed foods, likely reduce CVD and cancer rates.[27,28,29] Recent studies point to an important associations among the food environment, dietary intake, and other risk factors for chronic diseases.[27,28] Penchansky and Thomas[30,31] propose one method of conceptualizing nutrition environment using five key domains: 1) availability (e.g., density of restaurants around individuals' homes, and

number of places to buy fresh fruits and vegetables); 2) accessibility (e.g., travel time, and distance to the nearest supermarket); 3) affordability (e.g., prices of food items); 4) acceptability (e.g., perceived food environment); and 5) accommodation (e.g., store hours, and types of payments accepted). Food availability in neighborhood grocery stores, supermarket accessibility, and affordability of food items are linked with individual dietary intake and with obesity rates.[27,28,29]

1.2.1.3 Tobacco Environment

Use of tobacco is strongly linked with the development of chronic disease (i.e., CVD and some cancers). [7] In Canada, tobacco use in adults aged 12 years or older declined significantly in the past two decades, however, approximately one in five (22%) adults continue to smoke.[32,33,34] The tobacco environment includes government policies related to smoking bans/second-hand smoking bylaws, tobacco advertisements, and taxation on tobacco products. Increases in tobacco taxes/prices leads to a decline in overall tobacco use[7] and implementation of smoking bans is associated with a reduction in CVD incidence.[7,33]

1.2.1.4 Alcohol Environment

According to Canadian Alcohol and Drug Use Monitoring Survey (CADUMS) 2012, 78.4% of the population reported alcohol use in the past 12 months. Of these, 18.6%

drink more alcohol than what is recommended by the low-risk drinking guideline developed by Center of Addiction and Mental Health (CAMH) (i.e., more than two standard drinks on a given day, or more than 14 drinks per week for men, or nine drinks per week for women).[35] As with tobacco, pricing and taxation are possibly the strongest countermeasures to control alcohol-related problems including chronic diseases.[7] The alcohol environment includes studying the effects of pricing and taxation and physical availability (i.e., population density of outlets, hours of sale and off-premise monopoly sales system) of alcohol.[36,37,38] In Canada, policies regarding access and availability of alcoholic beverages are set and enforced by provincial liquor control boards. Currently, these liquor boards maintain some responsibility and control over the sales of alcohol in all provinces except Alberta.[36-40] For a detailed comparison of policies related to alcohol sales in Canadian provinces , please refer to Table 2.

1.2.1.5 Socioeconomic Status (SES)

Neighbourhood SES has been associated with availability and access to grocery stores[41], walkability of neighbourhood[42] and risk for developing CVD and cancer.[43,44] Neighbourhood SES is measured as neighbourhood income, ethnic composition, population density, average dwelling value, and unemployment rate.

1.3 Cardiac, Vascular, Cognitive Dysfunction (CVCD) Alliance Project

The CVCD Alliance[45] is a Canada-wide project (n≈ 9700) that aims to investigate the influence of societal, cultural, and environmental factors on the risk in the development of severe health conditions such as heart disease and stroke. In the contextual component of CVCD Alliance, data on physical activity, nutrition, tobacco and alcohol environments are collected in diverse Canadian communities through community audits using a semi - validated assessment tool and objective measures of the built environment available in public databases, such as streetsmart walkscore. The objective of this project is to describe the rationale, design, and methodological issues related to the assessment of contextual factors within the CVCD Alliance Project.

1.3.1 Variation in Contextual Factors in Urban and Rural Communities

Approximately, 19% of the Canadian population resides in rural areas, with the highest proportions living in Atlantic provinces and the territories (40% of the Canadian rural population).[45] Pong, 2009[46] used 1999 Canadian Census data to report that individuals living in rural settings (defined as areas outside metropolitan districts) are at 6-7% higher risk for CVD mortality as compared to their urban counterparts (Men OR: 1.07, 95% CI: 1.04, 1.09; Women OR: 1.06, 95% CI: 1.03, 1.09). However, when compared to men and women residing in urban areas, cancer mortality risks are similar for men (OR: 1.01, 95% CI: 0.98,1.04), but lower among women living in rural areas (OR: 0.96, 95% CI: 0.92, 0.99).[46] When the rural areas were disaggregated into finer categories based on urban-bound commuting patterns, considerable variation was noted in mortality rates within the

different categories of rural regions. Although those living in the most rural areas (i.e., areas with no commuting flow to urban areas) tended to have the worst health status, residents of less rural areas (i.e., areas with substantial commuting flow to urban areas), generally, experienced good health. [46]

Risk factors for chronic diseases, such as CVD and cancer, are more prevalent in individuals living in rural areas than those in urban areas. Using data from CCHS 2006, a report by Canadian initiative for health information concludes that higher proportions of rural Canadians smoke (32.4% vs. 24.9%) or are exposed to second-hand smoke (34.2% vs. 27.0%). Additionally, when compared to urban residents, a lower percentage of rural residents report eating the recommended daily servings of fruit and vegetables (31.1% vs. 38.2%).[47]

Some studies attribute these differences to variations in the contextual factors in urban and rural areas.[48-52] Literature from the US suggests that rural areas have lower walkability scores[53-55], and reduced access to, and availability of healthful foods.[56-57] In particular, individuals in rural areas are required to travel farther distances to access supermarkets, and the prices of fresh fruits and vegetables are higher in rural areas.[56-57] In Canada, rural communities typically cover a broad geographic area and have low population densities (3.3 persons/km^2).[52] Research on contextual factors in Canadian rural areas is sparse. Four studies have assessed the availability and access to nutritious foods in rural areas. Pouliot, 2009[58] found that distance to fresh fruit and vegetable stores in rural areas was considerably higher than for individuals living in urban areas. Travers,

1997[59], Jones, 2009[60] and Lawn, 1997[61] reported that the prices of fresh fruits and vegetables were higher in rural and remote northern communities than in central areas. Furthermore, according to the comprehensive review of food price comparisons in urban and rural areas by Human Resources Development Canada[62], the price of 'food basket' (consisting of daily food items, such as, apples, oranges, bananas, spinach, eggs and milk etc.) was cheaper in urban centers when compared to rural areas in Canada.

Two studies examined the physical activity environment in rural areas. In a study by Badland, 2006[63], individuals living in rural areas had to travel longer distances to reach destinations (e.g., recreational facilities). Specifically, individuals living in rural areas had to travel more than 20 km to reach their jobs than those living in urban areas, resulting in a higher reliance on automobile vehicles in these communities. Furthermore, in another study by Esbaugh, 2010[64], residents living in a rural community (Haldimand-Norfolk, ON) reported that they had poor access to and quality of sidewalks in the community, and this was cited as a significant barrier to physical activity.

To summarize, residents of rural areas have higher rates of CVD mortality, and prevalence of risk factors. Furthermore, there are unique challenges regarding land use, and built environment characteristics in rural areas. Rural areas have lower walkability, and limited access to nutritious food. In Canada, there is a dearth of research on contextual features of rural areas, creating a knowledge gap related to the unique physical activity and food environments in these regions.

1.4 Thesis Objectives

The overarching objective of this thesis is to enhance our understanding of the knowledge and to identify the gaps in knowledge regarding contextual factors on risk factors for CVD and cancer in communities across Canada (see Figure 2). The specific aims are: 1) to conduct a systematic review of the Canadian literature on the effects of contextual factor exposures on chronic disease (CVD and some cancers) risk factors; 2) to modify an existing assessment tool and to develop a method of assessment of measuring key contextual factors across urban and rural communities in Canada; and 3) to perform preliminary analysis of pilot data collected by CVCD contextual assessments to answer the following question: *What is the variation in physical activity and nutrition environments in urban and rural areas of Ontario?*

Chapter 2 Contextual Determinants of Chronic Diseases and Their Risk Factors: A Systematic Review

2.1. Introduction

Compared with other high-income countries, Canada has several unique characteristics, such as size, a large indigenous population, drastic climates in the Northern communities, and geographic and ethnic diversity. Furthermore, in a recent report by Organization for Economic Cooperation and Development (OECD), in the past decade, when compared to the average OECD rates, Canada had higher rates of income inequality.[65] There is limited data on the influence of contextual factors on health outcomes in Canada. However, in the past decade, there has been a steady increase in Canadian studies relating contextual factors to cardio-metabolic risk factors. In order to better understand the role of contextual factors in the development of chronic diseases (CVD and cancer) and chronic disease risk factors (i.e., obesity, dietary intake, physical activity, diabetes, tobacco and alcohol use), the Canadian literature was systematically reviewed. More specifically, the effect of the following contextual factors was examined in this review: community nutrition environment, community physical activity environments i.e., built environment, community tobacco environment, community alcohol environment and community SES. Information from this review will help identify current gaps and methodological limitations in the literature, and in policy formulation and will aid to promote the development of new interventions that aim to change modifiable contextual exposures.

2.2. Objectives

The objectives of this systematic review of Canadian research are to:

1. Catalogue and understand the contextual determinants of:
    a. Prevalence and incidence of CVD and cancer and;
    b. Risk factors for CVD and cancer (in particular, obesity, diet intake, tobacco and alcohol usage, physical activity, type 2 diabetes, dyslipidemia and blood pressure)
2. Understand the impact of area level SES on contextual factors in the area/community
3. Identify gaps and methodological strengths and limitations of the previous literature and propose recommendation for future research

2.3. Methods

2.3.1 Inclusion and Exclusion Criteria

Inclusion Criteria:

1. English language studies conducted in adult population residing in Canada
2. Examination of at least one of the following environmental variables:
    a. Physical activity environment (i.e., walkability, density of destinations, green space, and urban form)

   b. Nutrition environment (i.e., availability of fresh fruits and vegetables, access to fast food outlet or supermarkets, and cost of food items)
   c. Tobacco environment (i.e., tobacco prices and policies)
   d. Alcohol environment (i.e., alcohol prices and policies)
   e. SES (i.e., neighbourhood income, and material deprivation)
3. Investigation of an association between the aforementioned environmental variables and at least one outcome related to
   a. Prevalence, incidence, mortality, or survival after coronary heart disease or cancer **OR**
   b. Obesity, hypertension, cholesterol/triglyceride levels, insulin resistance, impaired fasting glucose or type 2 diabetes, physical activity levels and diet intake.
4. Investigation of the relationship between area-level SES and environmental factors (i.e., walkability, green space, density of recreations, availability, access and affordability of food items, alcohol and tobacco prices and policies)

Studies were included only if they met criteria 1-3 or criteria 1 and 4.

Exclusion Criteria:

1. Evaluation of geographical variations in the risk factors without examining any direct association between environment variables and outcomes
2. Only considered the specific environments in schools or workplaces

3. Primary focus on the social environment or social capital of an area
4. Works in progress or incomplete papers (e.g., conference abstracts, letters to the editors, etc.)

Studies were excluded if they met any of the exclusion criteria above, listed 1-4.

2.3.2 Search Strategy and Data Extraction

In consultation with an information specialist, we developed search terms for MEDLINE, EMBASE, CINAHL and Cochrane Registry databases from inception through January 15, 2014. A full description of search terms and search strategy is included in Appendices 1 and 2. Briefly, key terms included a combination of environmental terms (e.g., environment design, residence characteristics, neighbourhood, or community) and risk factors (e.g., obesity, overweight, blood pressure, Body Mass Index (BMI), diabetes mellitus, dyslipidemia, or insulin resistance) and a combination of environmental terms and CVD/cancer prevalence and incidence terms (e.g., cardio, cardiovascular disease, coronary, cancer, neoplasm, sarcoma). The search was limited to English language, human studies published in Canada.

One investigator (AR) screened titles and abstracts of the studies identified by the electronic search to arrive at a list of articles for full text review. Two reviewers (AR and SK) assessed the eligibility of these full-text articles in duplicate and hand searched the

reference lists and citations of the selected articles. Disagreements were resolved by discussion and consensus (weighted kappa= 0.88).

The same two reviewers (AR and SK) extracted data from eligible articles in duplicate using a pre-determined, piloted data extraction form. The following information was extracted from each study: year of publication, location of the study, study design, study duration, sample size used for analysis, mean age of the sample, definition of community, geographic scale (e.g., census tracts, buffers or non-standard boundaries), definition of main environmental exposure (e.g., walkability score, availability or affordability of food items), duration of environmental exposure, outcomes, definition of outcomes, data sources, methods of exposure and outcome ascertainment, covariates, statistical analysis, whether the reported association was positive, inverse or not significant, measure of association (adjusted odds ratio (OR), relative Risk (RR) and prevalence statistics) and key findings. Associations were deemed significant when the p value reported in the study was less than 0.05.

2.3.3 Quality Assessment

Two reviewers (AR and SK) independently assessed the risk of bias of each of the included studies on a scale from 1 (high risk of bias; low quality) to 10 (low risk of bias; high quality). The Newcastle-Ottawa Scale (NOS) was adapted for this review based on recommendations from previous studies on contextual factors.[44,66,67] The modified scale

assessed: 1) study design; 2) representativeness of sample; 3) response rate; 4) sample size; 5) definition of community; 6) statistical analysis; 7) objectivity/reliability of outcome determination; 8) objectivity/reliability of exposure ascertainment; and 9) adjustment for confounders. In each of the first eight categories, a study can be given a maximum score of one. A maximum of two points can be given in the final ('adjustment of confounders') category. The total score for each study was compared between the two assessors and disagreements were resolved through discussion. Based on previous literature[67-69], a score of eight or higher was considered indicative of high quality, five to seven of moderate quality, and four or less of low quality.

2.4 Analysis: Qualitative Synthesis

There was significant variability in the design of the studies, and in methods and measures used in the included studies. Therefore, the results were qualitatively synthesized.

The key components of undertaking a narrative synthesis approach to systematic reviews were guided by Popay, 2006.[70] These key criteria include: 1) developing a theoretical model on how the intervention/exposure in question works; 2) developing a preliminary synthesis; 3) studying relationships in the data; and 4) evaluating the robustness of the final results obtained from narrative synthesis. Table 3 indicates how each of these components is addressed in this review.

2.5 Results

The search strategy identified 13,283 relevant articles. Of these, 13,178 were excluded after abstract review because they did not meet the eligibility criteria. The remaining 105 articles were retrieved for full-text review, and after this 63 articles were included in the systematic review (see Figure 3).

2.5.1 Study Characteristics

Characteristics of the studies (location of study, study design, outcomes, etc.) are shown in Table 4. There was significant variation across studies in use and definition of environmental factors and outcomes. The challenges and limitations of this are discussed in section 2.6.

The publication year of the included studies ranged from 1984-2013. Of the 63[59,71-132] included studies, 52 were cross-sectional (83%), six[86,114-116,120,125,132] were retrospective chart/database reviews (9%), three[33,124,126] were case-control studies (5%), and two[87,91] were longitudinal studies (3%).

For 11[59,79,91,96-102,106] articles, the methodological quality was rated as high, for 48[71-75,77-78,80,83-88,90,92-95,103-105,108-132] as moderate and for five as low[76,81-82,89,107](see Table 5).

2.5.2 Summary of Findings

2.5.2.1 Nutrition Environment

There were 13 [71-83] studies that directly examined the association between community nutrition environment and chronic diseases or their risk factors. To measure environmental factors and variables, ten studies used Geographical Information System (GIS) tools[72-77,79-80,82-83], two studies used administrative database[71,81], and one study used a validated audit tool.[78] For the definition of community, seven used administrative boundaries[71-73,75-76,78,81], four used buffer zones[74,77,79-80], and one study used non-standard definitions[82] (see Table 4 for specifics).

Availability: There were ten[71-80] cross-sectional studies (one of which was of high quality, eight were of moderate quality and one was of low quality) that examined the availability of food stores in relation to chronic disease risk factors.

CVD mortality: Alter, 2005[71] (Trans-Canada) analyzed hospitalization rates for Acute Coronary Syndrome (ACS), obtained from the Canadian Institute of Health Information (CIHI), in relation to density measure of common fast food chains in each of Ontario's Forward Sortation Areas (FSA). Higher rates of ACS hospitalization (Adjusted OR: 2.26, 95% CI: 1.42-3.59, $p<0.001$) were reported in areas with higher numbers of fast food outlets as compared to those with fewer outlets per 100,000 people. Similarly, Daniel,

2010[72] (Montreal, QC) compared the rates of CVD mortality, acquired from Quebec Ministry of Health and Social Services, across 845 census tracts. Accounting for covariates (i.e., age, gender, education and employment), a 10% increase in fast food restaurant density was linked to 36-39% increase in CVD mortality rates ($p<0.01$).

In summary, the two studies that examined CVD mortality in relation to the availability of food stores suggested that there is a positive association between a higher number of fast food outlets and CVD mortality.

CVD prevalence: Chum, 2013[73] (Toronto, ON) demonstrated that individuals living in census tracts with fewer food stores compared to those with more food stores were more likely to have CVD (OR: 1.12, 95 % CI: 1.05–1.18). Alternatively, having at least one fast food restaurant in the area was associated with increased odds of CVD (OR: 1.28, 95% CI: 1.07–1.78).

Obesity: Spence, 2009[74] (Edmonton, AB) reported that those living in buffer areas with lower Retail Food Environment Index (RFEI) (REFI is the ratio of fast food outlets and convenience stores to the number of grocery stores) were less likely to report a BMI of 30 or greater (OR: 0.74, 95%CI: 0.59, 0.94) as compared to those living in a higher REFI score. Similarly, Kestens, 2012[75] (Montreal & Quebec city, QC) monitored participant's mobility using a Global Positioning System (GPS) tracking device and noted that the exposure to fast food outlets had a positive association with being overweight (self-

reported BMI > 25 kg/m^2) in men (OR: 2.07, 95% CI: 1.25, 3.42). No statistically significant associations were reported for women. In another study by Hollands, 2013[76] (Trans-Canada), an additional fast food restaurant per 10,000 people in the community (defined as FSA) was linked to an increase of 0.02 kg/m^2 in BMI.

In summary, the three studies that reported on obesity and overweight in relation to the availability of food stores suggest that there is a positive relationship between the exposure to fast food outlets and a higher BMI and overweight.

Diet Intake and Quality: In a study of older individuals (65 and older) using buffer areas, Mercille, 2012[77] (QC) noted that a 'western' diet (composed of high caloric items) was related to a higher percentage of fast food outlets, but was not associated with the availability of healthful food stores ($p<0.01$). Minaker, 2013[78] (Waterloo, ON) noted that in men, perceived access (β (SE): 1.09 (0.46), $p<0.05$) and increased availability of fresh fruits and vegetables as measured by Nutrition Environment Measures Survey–Stores (NEMS-S) was linked to higher self-reported diet quality (higher score on Healthy Eating Index adapted for Canada (HEI-C)) (β (SE): 0.34 (0.12), $p<0.005$). The association was not significant for women.

Mediating factors: Paquet, 2009[79] (Montreal, QC) tested to see whether mastery (defined as beliefs about perception of control of one's environment) mediated the relationship between exposure to fast food restaurants (mapped using GIS), and directly measured overall metabolic risk (Adult Treatment Panel III). They found that higher mastery or

self-control was associated with lower metabolic risk (RR: 0.80, 95% CI: 0.76, 0.84) for those living in areas with a higher proportion of fast food outlets but not for those living in regions with lower numbers of fast food outlets. In a high quality study by Paquet, 2010[80](Montreal, QC), direct association between density of fast food restaurants and fast food consumption was not significant, however the interaction between fast food consumption and reward sensitivity (i.e., the ability to derive reward from food) was statistically significant. For participants with the highest self-reported reward sensitivity, the association between fast food restaurant exposure and consumption was positive (OR: 1.49, 95% CI: 1.20, 1.84, $p<0.001$). Minaker, 2013 (Waterloo, ON)[78] found no mediation effect of perceived access to healthful food items on the relationship between objective food environment measures (distance to supermarkets and density of supermarkets), and self-reported diet quality, BMI and waist circumference.

In summary, of the four studies that reported on diet intake and quality in relation to the availability of food stores, it was noted that high caloric diets were associated with buffer areas (i.e., 500 m circular buffer around the residence of participants) that contained a higher number of fast food outlets, increased availability of fresh fruits and vegetables was associated with higher self-reported diet quality, higher mastery was associated with lower metabolic risk in those living in areas with a high number of fast food outlets, and there was a positive relationship between those with the highest self-reported reward sensitivity and fast food restaurant exposure and consumption.

Affordability: There were one moderate[78] and two low quality[81-82] cross-sectional studies that examined the affordability of food in relation to chronic disease risk factors (BMI and diet intake).

Using data from the CCHS, 2001/2003, a low quality study by Willows, 2011[81] (Canada) studied the prevalence of perceived household food insecurity in the Aboriginal population and its relationship with self-reported fruit or vegetable intake and smoking. They reported that 29% of Aboriginal adults resided in food-insecure households. When adjusted for age, gender and education, there was no significant association between fruit/vegetable intake and household food insecurity or between smoking and household food insecurity.

In a moderate quality study by Minaker, 2013[78] (Waterloo, ON), reduced prices of healthful food items, as measured by NEMS-S, were associated with lower self-reported BMI and waist circumference in both men and women ($p<0.01$). Contrary to Minaker, 2013[78], a low quality study by Lear, 2013[82] (Vancouver, BC) reported a negative association between the price of food baskets (mixture of food items commonly consumed by residents e.g., milk, bananas, tomatoes, etc.) and BMI ($p=0.034$). In this study, after adjusting for SES, individuals who shopped at places with the lowest price of the food basket had 3.66-3.73 kg/m^2 higher BMI when compared to those who shopped at the supermarket with the highest price ($p<0.001$).

Overall, the results from the three studies that examined affordability and health outcomes are inconclusive. One study reported a positive association between

affordability and BMI, the second reported an inverse association between food prices and BMI and the third study reported no significant association between affordability and diet.

Accessibility: There were two moderate[78,83] and one low quality[82] studies that investigated the association between accessibility and chronic disease risk factors.

Kirkpatrick, 2010[83] (Toronto, ON) noted that distance to nearest discount supermarket had no significant association with self-reported household food insecurity in low-income families; however, food insecurity was associated with income or income sources. In a low quality study by Lear 2013[82] (Vancouver, BC), there was no significant association between the minimum distance to the supermarket and self-reported BMI. Minaker, 2013[78] (Montreal, QC) reported that in women, distance from home to the nearest convenience store was strongly associated with self-reported BMI (β (SE): 2.23(0.63), $p<0.001$) and waist circumference (β (SE): 6.41(1.42), $p<0.001$). For men, increased distance from home to the nearest supermarket (β (SE): 0.52(0.22), $p=0.020$) and restaurant intensity were associated with BMI (β (SE): 0.03 (0.01), $p=0.024$).

In summary, of the three studies that reported on access to food stores and health outcomes, one reported a significant association between distance to food stores and BMI and the other two noted no significant association between access and health outcomes (BMI and household food insecurity).

2.5.2.2. Physical Activity Environment

There were 12[84-95] studies that reported on the association between the physical environment and chronic disease risk factors. Of these, six studies[84,91-95] used GIS to measure the built environment, and six[85-90] used validated community audit tools. For the definition of community, four used administrative boundaries[84,86-87,90], two[89,95] studies used buffer zones and six[85,88,91-94] used non-standard definitions (see Table 4 for specifics)

Walkability: There were two cross-sectional studies[84-85], one database review[86] and one longitudinal study[87], all of moderate quality, that investigated the association between walkability and chronic disease risk factors.

Booth, 2012[86] (Greater Toronto Area, ON) conducted a retrospective database study comparing diabetes incidence (Ontario Diabetes Database) and walkability in neighbourhood census tracts. Measured using a validated walkability index, an inverse association between walkability and diabetes incidence was reported in both men and women. It was noted that recent immigrants living in areas with lower walkability score had 50% higher rates of diabetes than those living in census tracts with higher walkability (Men RR: 1.58, 95% CI: 1.42,1.75, Women RR: 1.67, 95% CI: 1.48-1.88). Additionally, these findings were less pronounced in long term immigrants (Men RR: 1.32, 95% CI: 1.26-1.38, Women RR: 1.24, 95% CI: 1.18-1.31). Pouliou, 2010[84] (Vancouver & Toronto) noted a trend towards lower BMIs in more walkable areas, as measured by a

validated index, of both Toronto and Vancouver, but the difference was only statistically significant for Vancouver (p=0.03). In a longitudinal study by Berry 2010[87] (Edmonton, AB), controlling for individual behaviours and choices, there was no significant association between walkability and self-reported physical activity levels. Similarly, using data from the Ottawa Neighbourhood Study (ONS), Riley, 2013[85] (Ottawa, ON) found no significant association between walkability, measured using a validated index, and self-reported physical activity levels.

In summary, of the four studies that investigated the association between walkability and health outcomes, one reported a statistically significant inverse association between neighbourhood walkability and diabetes incidence, one reported inverse association between BMI and walkability and the other two reported no significant association between BMI and walkability.

Other: There were six cross-sectional[88,90,92-95] of moderate quality, one cross-sectional study of low quality[89] and one longitudinal study of high quality[91] that examined the association between other measures of physical activity environment and cardio metabolic risk factors.

Walking/physical activity levels: A cross sectional study by Craig, 2002[88] (ON, QC & AB) defined neighbourhood using population density and noted that self-reported walking to work was significantly associated with an observer rated environment score (number of

destinations, variety of destinations, aesthetics, walking systems, transportation systems etc.) ($p<0.003$). A one-unit increase in score was related to a 25% increase in walking. In a low quality study by Taylor, 2008[89] (AB), there was no significant association between perceived built environment and likelihood of self-reported walking for recreation. However, living close to shops was significantly related to walking for transport (OR=1.92, 99% CI 1.11–3.32). A cross-sectional study by Gauvin, 2008[90] (Montreal, QC) showed that a higher density of destinations, as measured by a trained observer using an 18-item grid, was associated with a greater likelihood of self-reported walking (OR: 1.56, 95 % CI: 1.05, 2.32). These findings were consistent with the ones in a high quality, five year longitudinal study of senior participants by Gauvin, 2012[91] (Montreal, QC), where proximity to services (measured by GIS) was associated with greater likelihood of self-reported walking at all time points ($p<0.001$). Using non-standard definition for community, Schuurman, 2009[93] (Vancouver, BC) tested to see if obesity or moderate physical activity was clustered in specific neighbourhoods of varying SES and population densities. They found no significant evidence for global clustering. Oliver, 2011[92] (Vancouver, BC) noted that living in low land use mix areas, defined using 500-m buffers around residence, is associated with decreased likelihood of self-reported walking for leisure (OR: 1.36, 95% CI: 1.04, 1.78). Prince, 2011[94] (Ottawa), using data from ONS, reported that higher levels of self-reported physical activity were associated with an increased number of convenience stores/1000 people (OR: 2.09, 95% CI:1.46, 2.99) in men and a higher number of restaurants/1000 people in women (OR: 1.28, 95% CI: 1.04,1.56). Counter intuitively, area of green space (km^2) was associated with slightly

lower activity levels in men (OR: 0.93, 95% CI: 0.87, 0.99) yet lower rates of overweight in females (OR: 0.67, 95% CI: 0.54, 0.84).

In summary, of the eight studies that tested the association between physical activity environment and physical activity levels, six studies reported a positive association between density of destinations and physical activity levels. The other three reported no significant association between physical activity levels and the physical environment variable.

CVD mortality: Using vegetation index to measure green space, Villeneuve, 2012[95] (ON) reported lower rates of CVD mortality in postal codes with more green space (OR:0.94, 95% CI:0.92–0.96).

2.5.2.3 Socio-economic Status (SES)

In total, there were 33[59,87,96-126] studies (ten of which were of high quality[59,96-102,105-106], 22 were of moderate quality[87,103-104,108-126], and one was of low quality[107]) that evaluated area-level SES and cardio metabolic risk factors. Of the 33 studies, 32[59,87,96-106,108-126] used administrative database to measure SES and one study[107] studies used perceptions of individuals. All studies[59,87,96-126] used administrative boundaries to define community (see Table 4 for specifics).

Access to food stores: There were fourteen studies (eleven[59,71,96-102,105-106] of which were high quality, two[103,104] of moderate quality and one of low quality[107]) that examined the association of SES and access to food stores.

Travers, 1997 (NS)[59] reported no significant association between SES of census tracts and food availability. In Alter, 2005[71] (ON), there was no significant interaction between SES, per-capita rates of fast foods and prevalence of ACS ($p=0.52$). Smoyer-tomic, 2006[96] (Edmonton, AB) noted that access to supermarkets was better in high-need and inner city census tracts. Similarly, Apparcio, 2007[97] (Montreal, QC) examined the presence of food deserts (defined as areas that lack access to nutritious and affordable food), measured using the number of supermarkets, and SES, determined using census data. They found no significant association between SES and number of supermarkets. Latham, 2007[98] (Hamilton, ON) also found no significant association between SES as measured by census data, and objectively measured number of supermarket, food prices and availabilities. However, they reported that when compared to those with higher income, census tracts with lower income were more likely to have a greater number of convenience stores ($p<0.01$). Using 1996 and 2005 census data, Larsen, 2008[99] (London, ON) studied the presence of food deserts, using GIS, in relation to neighbourhood income and reported reduced access to supermarkets in materially deprived census tracts. Hemphill, 2008[100] also reported that higher rates of unemployment and renters were associated with high numbers of fast food outlets in a neighbourhood (census tract).

Daniel, 2009[101] (Montreal, QC) used marital status and education as a measure of SES and reported that fast food outlet density in census tracts was negatively associated with number of married and older adults and positively associated with full time students and densities of main roads. Additionally, fresh fruit and vegetable stores were also positively associated with communities that had increased numbers of single individuals, and university graduates ($p<001$). Smoyer-Tomic, 2008[102] (Edmonton, AB) reported a positive association between SES and density of fast food outlets. Those in census tracts with higher incomes were 74% less likely to have a fast food outlet than residents living in census tracts with lower incomes. Bertrand, 2008 (Montreal, QC)[103] found no significant association between income of dissemination area and availability of outlets selling fruits and vegetables. In Jones, 2009 (NS)[104], there was an inverse relationship between the number of restaurants and material deprivation in a neighbourhood. Similarly, Black, 2011[105] (BC) showed that higher-income areas were more likely to have fewer supermarkets within a one km distance when compared to other areas ($p<0.001$). In parallel, these areas were also significantly associated with a further distance to food markets ($p<0.01$). Gould, 2012[106] (Gatineau, QC) also reported an inverse association between material deprivation and the number of retail stores selling fruits and vegetables in a census tract ($p<0.0001$). Joseph, 2012[107] (Six Nations, ON) reported that in an Aboriginal community with a lower SES, perceived access to healthful foods was limited.

In summary, of the 14 studies that assessed the relationship between SES and access to food stores, five studies reported no significant association, four studies reported a

positive association, and five studies reported an inverse association between SES and access to food stores.

BMI: There were six cross-sectional[109-113,126] studies of moderate quality and one longitudinal study[87] of high quality that examined the association between SES and BMI. Using a deprivation index created using six Census Canada variables, Matheson, 2008[126] (Canada) noted that the association between SES and BMI had varying effect by gender. Women living in a deprived area had, on average, a BMI score of 1.8 points higher than women living in less disadvantaged areas. In contrast, men living in affluent neighborhoods had, on average, a BMI score of 1.0 point more than men living in deprived neighborhoods. In Finkelstein, 2008[109] (Hamilton, ON), mean self-reported BMI was about 0.2 units lower per $10,000 increase in neighbourhood (census tract) income ($p<0.001$). Naimi, 2009[110] (Montreal, QC) reported that directly measured BMI (OR: 2.11, 95% CI: 1.03, 3.19), total cardiometabolic risk (OR: 1.82, 95% CI: 1.35, 2.44), HDL-C levels (OR:4.19, 95% CI: 1.18, 14.84), TG (OR:4.51, 95% CI: 1.05, 19.24) and HbA1c (OR:7.45, 95%CI: 3.78, 14.68) were higher in neighbourhoods (census tract) with higher unemployment rates when compared to neighbourhoods (census tract) with lower unemployment rates. Lebel, 2009[111] (QC) showed no significant association between material deprivation and self-reported BMI. In Ross, 2009[112] (Canada), men and women in neighbourhoods with a high proportion of individuals of low educational attainment had incrementally higher self-reported BMI scores ($p< 0.01$). Likewise, Harrington, 2009[113] (ON) showed that females living in the in the most disadvantaged areas had larger

self-reported BMIs by 1.93 kg/m^2 than those living in the least disadvantaged areas ($p<0.001$). This relationship was not significant for men. In a longitudinal study, Berry, 2010[87] (Edmonton, AB) noted that participants in the lowest SES neighbourhoods were more likely to experience increases in BMI than participants in the highest SES neighbourhoods ($p=0.002$).

Overall, all seven studies but one, reported an inverse association between SES and BMI. Therefore, there is a fairly consistent trend between lower BMI and higher SES.

CVD prevalence: Four cross-sectional studies examined the association between SES and CVD mortality. In Finkelstein, 2004[114] (Hamilton, ON), the prevalence of ischaemic heart disease, and diabetes was strongly associated with deprivation (defined as higher unemployment rate, lower household income and lower educational attainment) ($p<0.01$). Auger, 2009[115] (QC) noted no significant relationship between SES, defined using census Canada variables, and CVD mortality rates. Feldman, 2010[116] (ON) showed that when compared to other counties, the ones with lower education levels had higher hospitalization rates for angina ($p<0.001$). In Lemstra, 2006[117] (SK), hospital separations for CVD were higher in materially deprived areas (lower income, lower education, and higher unemployment rate) when compared to affluent areas (RR: 1.70, 95% CI: 1.14-2.53).

In summary, of the four studies that examined the relationship between SES and CVD mortality/hospitalization, three studies reported an inverse relationship and one study reported no significant association between the two.

Other: Southern, 2005[125] (AB), when compared to individuals living in high-income neighbourhoods (defined as enumeration area), those living in low-income neighbourhoods were more likely to report poor survival at 2.5 years after cardiac catheterization (HR: 2.61, 95% CI: 1.68, 5.54). In Matheson, 2010[108] (Canada), neighbourhood deprivation (defined using unemployment rate, census tract income, and the proportion of immigrants) was significantly associated with self-reported hypertension such that respondents were 12% more likely to report a diagnosis of hypertension with each unit increase in neighbourhood deprivation (OR: 1.12, 95% CI: 1.10,1.15). Menec, 2010[118] (Winnipeg, MB) reported that, in those aged 65-74 years, odds of reporting diabetes (OR: 1.47, $p<0.001$), hypertension (OR:1.19, $p<0.001$), congestive heart failure (OR: 1.53, $p<0.001$) and ischemic heart disease (OR: 1.37, $p<0.001$) were higher than those living in the poorest neighbourhoods when compared to high SES neighbourhoods. In White, 2013[119] (urban Canada), those living in materially deprived neighbourhoods were more likely to report higher prevalence of CVD (OR:1.07, 95% CI: 1.04, 1.10), diabetes (OR:1.14, 95% CI: 1.09, 1.20), obesity (OR:1.09, 95% CI: 1.06, 1.12), heavy drinking (OR:1.09, 95% CI: 1.04, 1.14) and heavy smoking (OR: 1.28, 95% CI: 1.25, 1.31).

Cancer: Mackillop, 1997[120] (ON), noted that the association between area-level (census tract) income and all types of cancer survival was statistically significant (p<0.001). Ng, 2004[121] (urban Canada) observed a strong income gradient in cervical cancer incidence in 1971 however, this diminished in the later years. In Haider, 2007[122] (Ontario), the rate per 10,000 increased from 7.6 melanoma cases in the lowest socioeconomic category (lowest census tract income) to 17.1 in the highest socioeconomic category (p<0.01). Borugian, 2011[123] reported that women living in the highest neighbourhood income (dissemination area income) quintile had the greatest likelihood of being diagnosed with breast cancer (p<0.01). Hystad, 2013[124] noted that lung cancer incidence was the highest in most deprived neighbourhoods (lowest census tract income) when compared to other neighbourhoods (OR:1.38, 95% CI: 1.01,1.88).

2.5.2.4 Tobacco Environment

There were two case-control[33,128] and one database review study[127], all of moderate quality, which examined the association between the implementation of tobacco ban and CVD hospitalization rates. Lemstra, 2009[127] (Saskatoon, SK) reported that the age standardized incidence rate ratio for acute myocardial infarction was 0.87 (95% CI 0.84-0.90) when comparing pre (July 1, 2000 to June 30, 2004) and post-smoking ban (July 1, 2004 to June 30,2005). They also noticed a significant relative reduction in smoking prevalence in Saskatoon when compared to the rest of Canada (p<0.01). In Naiman, 2010[33] (Toronto, ON), the largest declines were seen after the ban affecting restaurants came into effect,

and included a 17% decrease in the crude rate of acute myocardial infarction admission rates ($p<0.05$), a 39% (95% CI: 38, 40) decrease in crude rates of CVD admission rate ($p<0.001$). Gaudreau, 2013[128] (PEI) reported similar findings, suggesting that there was a 23.9% decrease in acute myocardial infarction admissions ($p=0.03$) and 41.8% decrease in angina admissions ($p<0.001$) in 2008 after 2003 smoking ban implementation.

In summary, all three studies reported an inverse association between the smoking ban and CVD hospitalization rates.

In one study by Joseph, 2012[107] (Six Nations, ON), 67 % of the participants reported that teenagers had easy access to tobacco on the Reserve.

2.5.2.5 Alcohol Environment

There were three[129-131] moderate quality studies that examined the association of alcohol prices and availabilities with consumption of alcohol. Rush, 1986 (ON)[129] reported that there was a strong positive association between retail availability of alcohol and per capita consumption of alcoholic beverages ($p<0.001$). In a longitudinal study, Stockwell, 2011[130] (BC) reported that a 10% increase in the minimum price of an alcoholic beverage reduced its consumption relative to other beverages by 16.1% ($p < 0.001$). In particular, the authors estimated that this price increase reduced consumption of wine by 8.9%, spirits by 6.8 %, and beer by 1.5 %. These findings were similar for Saskatchewan as

well[131], where a 10% increase in minimum price reduced consumption of wine by 5 %, spirits by 6 % and spirits by 6 %.

Overall, the three studies that assessed the relationship between alcohol policies and consumption of alcohol noted that there was a positive association between availability and consumption of alcohol, and an inverse association between price and consumption of alcoholic beverages.

2.6 Systematic Review: Implications and Recommendation for Future Research

2.6.1 Main Findings

In this systematic review of the Canadian literature on the effects of environmental factors on the prevalence of chronic disease and their risk factors, the collective evidence supports that, 1) people living in neighbourhoods with increased access to fast food outlets are more likely to report negative health outcomes (increased CVD prevalence, obesity and overweight) than people living in other neighbourhoods, 2) an increased density of destinations in a neighbourhood is associated with increased levels of physical activity, 3) individuals living in neighbourhoods with lower SES have higher BMIs and rates of obesity, and 4) there are very few food deserts within Canadian communities. The limited data does not support the association between affordability, accessibility of food stores and walkability and chronic disease risk factors.

2.6.2 Nutrition Environment

Increased density of fast food outlets in a community was strongly correlated with high rates of CVD and obesity.[71-80] Of the seven studies[71-72,74-77] that investigated the association between fast food outlets and cardiometabolic risk factors, six reported a positive relationship between the density of fast food outlets and negative health outcomes (CVD mortality and higher BMI). However, all seven cross-sectional studies were only of moderate quality, with almost 60% of studies using non-representative population samples (e.g., elderly residents), limiting generalizability. Nevertheless, the relationship between density of fast food outlets and obesity is consistent with trends observed in the US[62,132,133] and Australia.[134,135] Longitudinal studies in the US[132,133] suggest that increased exposure to fast food outlets is associated with higher BMIs in both adults and children. Similarly, Australian studies[134,135] report that, when compared to areas with fewer fast food outlets, areas with higher number of fast food outlets have higher rates of obesity.

Longitudinal data in the US[136-138] suggests that higher area-level prices of healthy food are associated with weight gain in both adults and children and are also linked to poor diet quality and lower intakes of fiber. There is limited Canadian data on the associations between affordability of food prices or accessibility of food stores and chronic disease risk factors. Due to the variations in outcomes and the tools used to measure contextual exposures, it was difficult to make comparisons across these studies. For example, of the

three studies that reported on the association between affordability and risk factors, two[78,81] studies used perceived affordability, and one[82] study used objective store audits to measure the exposure. Additionally, there were significant inconsistencies in the definitions of community used in these studies. For example, Willows, 2011[81] defined community using Aboriginal reserve boundaries whereas Minaker, 2013[78] defined it using FSAs. Furthermore, it was unclear if these studies controlled for area-level SES. For these reasons, the reported associations between affordability and health outcomes, and between accessibility and health outcomes are inconclusive.

Limited Canadian data exist relating acceptability (e.g., diet quality), accommodation (e.g., hours of food stores) and perceived food environment to chronic disease risk factors. For a holistic understanding of the relationship between nutrition environment and the development of chronic diseases, it is important to study these features. Moreover, current literature has not fully assessed the role of the cultural food environment. Future research should consider cultural relevance (e.g., through auditing ethnic specific stores), especially in areas with a significant immigrant population.[30]

2.6.3 Physical Activity Environment

Of the eight[88-95] studies that reported an association between physical activity environment and physical activity levels, six studies[88-91,92,94] (including one longitudinal study[91]) reported a positive association between density of destinations and physical activity

levels. These findings parallel results from US studies[139-141], where increased density of destinations is linked to higher physical activity levels and lower BMIs.

Similar to studies that assessed the nutrition environment, studies evaluating the physical activity environment used a variety of methods to evaluate the environment. For example, the different tools to measure physical activity environment included transportation options, density, diversity (arrangement of land use), design, street connectivity, spatial access to recreational facilities, and walkability. To date, there is no consensus on definition of the "physical activity environment", and no agreement on the optimal metric(s) to measure physical activity environment. [86]

Research from the US[142-144] and other systematic reviews[44,135] show a relationship between walkability and physical activity levels. However, Canadian literature is inconclusive with respect to the relationship between walkability and health outcomes. The reasons for this may be 1) inconsistencies in study designs, 2) variation in sampling methods used in the studies, or 3) use of different outcomes (e.g., diabetes, BMI and physical activity levels). For example, of the four studies that examined the association between walkability and risk factors for chronic diseases, two had a cross-sectional design and two were database reviews.

2.6.4 Socio economic Status (SES)

The most consistent associations reported were between socioeconomic characteristics of residential neighbourhoods and BMI, obesity[87,109-110,112-113,126] , and prevalence of CVD.[115-118] More unfavourable outcomes were observed in materially deprived neighbourhoods. Of the twelve studies that assessed the relationship between SES and chronic disease risk factors[87,109-118,126] ten reported a positive association between SES and the health outcomes; similar to studies conducted in the US[44,135], the UK[145,30] and New Zealand.[30]

There was considerable heterogeneity in methods used to measure SES. For example, some studies used an index of deprivation[108,111,119] (i.e., unemployment rate, income, percent immigrants) to study SES whereas others used simple area level income[115] or unemployment rate[110] as measures of SES. However, the associations between SES and chronic disease risk factors were consistent across studies, irrespective of the use of different definitions of SES.

Food Deserts: Previous literature suggests that countries outside the US, Australia and New Zealand do not show evidence for existence of food deserts.[62,30] Canadian literature from this review parallels these finding, with very little evidence supporting the presence of food deserts.

However, a few studies[98,100,102] reported an inverse association between SES and fast food outlets. This is referred to as 'food swamps', defined as low-income areas "with a plethora of fast food; convenience stores selling calorie-dense packaged foods, super-

sized sodas, and other sugar-loaded beverages; and other non-food retail venues selling junk food as a side activity".[62] A recent report by Health Canada[62] suggests that despite the lack of evidence for the presence of food deserts in academic literature, community food assessments (CFA), conducted by Health Canada, that aim to identify food deserts indicated the presence of at least a few food deserts in Toronto, Winnipeg and Saskatoon. This difference in findings between the scientific literature and CFA data can be attributed to variations in areas being studied and the definition of communities. For example, a large amount of research on contextual factors in the scientific literature is conducted in urban regions of Canada. There is a need for further Canada-wide research to clarify these findings regarding the access of food stores in high need and rural areas.

2.6.5 Tobacco Environment

Tobacco bans were strongly associated with lower rates of CVD hospitalization rates in Canada.[33,127-128] Furthermore, tobacco use was reported as a significant problem in an Aboriginal community, where children and young adults were perceived to have easy access to tobacco products.[107] These findings are consistent with those from the UK[95] and the US[96]; where increased taxation and smoking bans resulted in lower rates of CVD and self-reported smoking. Further research is required to study the impact of perceived environment (e.g., tobacco related advertisements and ease of access), and tobacco taxation on the development of chronic diseases.

2.6.6 Alcohol Environment

Retail availability and lower prices were associated with unhealthful consumption of alcoholic beverages. These findings are consistent with published 2010 report by CAMH, which found increased availability and lower prices of alcohol resulted in higher consumption of alcohol.[36-39] Using the data provided by Statistics Canada, CAMH also reported that privatization of alcohol sales in Alberta resulted in a significant increase in availability, access to and consumption of alcohol over pre-privatization levels. Specifically, post privatization, the density of alcohol outlets in Alberta increased by 72%.[37]

Canadian data are consistent with reports from the UK[146-147], the US[148], and New Zealand[149-150], which show that alcohol pricing and availability are linked to high-risk consumption of alcoholic beverages. Furthermore, increased prices and reduced availability of alcoholic beverages are associated with lower population rates of alcohol-related cancers (i.e., liver, mouth, and throat cancers).[36-39] However, more research is required to understand the impact of alcohol taxation and policies on the prevalence of chronic diseases and their risk factors in a Canadian context.

2.7 Strengths and Limitations

One major strength of this review is that it is the first to synthesize the diverse body of literature examining contextual risk factors for CVD and cancer in Canada. Most

findings are consistent with the U.K.[30,62] and the U.S.[68,135] reports, with some differences in findings with respect to the presence of food deserts and the associations between walkability and food affordability and health outcomes.

However, this review is not without limitations; 1) analysis of existing literature was difficult due to the limited number of studies, the diversity of study designs and sampling schema, and a lack of standardized measures for exposure and outcome ascertainment; 2) the small number of studies examining a specific environmental exposure and outcome prevented a quantitative meta-analysis; 4) the potential for publication bias to influence the results could not be assessed. In general, studies that show a positive relationship are more likely to be published than those that report non-significant associations. Existence of publication bias can lead to erroneous conclusions; 5) to limit the scope of the review, the grey literature, such as agency reports and government publications, an important source in this field, was not included in the review. Future research needs to consider evaluating research from reports published by the government and alcohol and tobacco industries; and 6) the inconsistency in definitions and methods of assessing each of the contextual factors limits the translation of these findings into public health recommendations.

2.8 Gaps in Literature and Recommendations for Future Studies

2.8.1 Study Design, and Outcome and Exposure Ascertainment

Study Design: Most of the studies utilized a cross-sectional design, which provides a snapshot of an association at a given point in time, but does not permit inference on the direction of the underlying causal effect(s). Future research should employ longitudinal designs to better understand the role of contextual factors and risk factors over time and to establish causation.

Exposure Ascertainment: In the studies included in this review, contextual characteristics of communities were measured using a variety of methods that can be broadly categorized into objective and subjective methods. Objective assessments included community assessments by a trained observer and GIS-derived measures. For example, community assessment for nutrition included checklists that may include items on availability, prices and quality of specific foods. GIS derived measures were used to measure access to food stores using distance or number of food stores in a community.[62,152-153] However, these measures may not accurately represent the access to food stores as they do not take into account the mode of transportation used to travel to these stores. Subjective methods relied on participants' perceptions of their neighbourhood environment. Although perceived environment measures are shown to be correlated with objective measures[30,62], they are generally criticized for being imprecise. Perhaps, the most effective method of measuring contextual factors is through the use of a standardized tool that incorporates both objective and subjective measures.[30,62]

Literature on contextual factors is stifled by methodological inconsistencies that make it difficult to compare studies. For example, there exist at least 500 different measures to assess the nutrition environment alone.[62] Limited research has compared methods of measuring contextual characteristics of a community[97], and it is necessary to compare these various methods to determine a gold standard (or standards) in the field. Because each community has its own unique layout, the creation of a uniform measure in the field poses a challenge. Collaboration among researchers studying contextual factors is essential for the development of mutually-agreed upon, consistent definitions (e.g., for community or exposures such as SES); and to establish a consistent language to facilitate comparability across studies.

Outcome Ascertainment: Approximately 90% of the included studies (55 of the total 61 studies) relied on self-reported outcomes, and only six of the 61 studies directly measured the outcomes.[86,88,108-109,118,128] Though simple and inexpensive to use, self-reported outcomes can be inaccurate due to recall bias, social desirability bias and errors in self-observation. Future methods work is needed to develop cost-effective, unbiased outcome measures, such as confirmation via medical records, and third-party adjudication. Research in contextual factors should consider directly measuring outcomes (e.g., anthropometry measure by clinical nurse) to increase the reliability of the results.

2.8.2 Community Definition

Measurement of environmental factors varied considerably with respect to the metrics used, the various contexts of the studies and the number of characteristics studied. Three different methods were used across studies to define geographic scale: administrative areas, buffer zone and activity spaces. A considerable number of studies (45 of the 61 included studies) defined contextual variables within administrative areas. These are boundaries drawn by the government, e.g., census tracts. Though administrative boundaries are convenient to use and objectively defined, strong evidence indicates that these boundaries do not reflect the neighbourhoods as experienced by residents.[62,151-152] A buffer region is a pre-determined area (usually circular) around residents' homes, schools or workplace. This method better accommodates individuals' perception of their environmental space (i.e., home and surrounding area). However, buffer zones suffer the limitation of not accounting for residents' mobility outside of their neighbourhoods.[152] A more recent way of defining neighbourhood is through activity spaces, which considers all the locations that an individual visits on a daily basis, by giving them a GPS device and creating a map for all the places they visit during the day.[152] The food/physical activity environment is then examined around the individual's activity space. This approach can help better understand how people interact with their environments without the restriction imposed by specific definitions of boundaries. More research is required to understand the advantages and disadvantages of this approach.[30,62,152]

2.8.3 Future areas of study

International studies[149-151] show that changes in alcohol prices are directly related to CVD prevalence and mortality, no studies investigating the effects of policies regarding taxation and prices of alcohol on CVD prevalence and mortality were found within the Canadian published literature. Further research is required on how policies and prices of alcohol affect purchasing and consumption behaviour, and how these relate with CVD risk factors and mortality within Canada. Additionally, no studies relating nutrition, physical and tobacco environment to cancer were located using the search strategy. However, literature investigating associations between cancer and these contextual factors is limited on a global scale. Therefore, there is a strong need for research investigating the association between contextual factors and cancer prevalence.

2.9 Conclusion

This review underscores the importance of research to more robustly assess the role of contextual factors in the development of chronic diseases. Lower number of fast food outlets, increased density of destinations and higher SES are associated with positive health outcomes. However, the strength of these conclusions is limited due to the methodological differences in measurement of contextual factors and the outcomes. Future research should be longitudinal in nature and use valid and reproducible measures of exposure ascertainment to strengthen the case for causality. A well-designed prospective trans Canadian study could address some of these deficiencies. Furthermore,

there is a need for a collaborative effort among contextual factors researchers to harmonize the definition for community, and establish gold standard(s) for measure contextual features and a reliable method of measuring the outcomes.

Chapter 3 Cardiac, Vascular, Cognitive Dysfunction (CVCD) Alliance Project

3.1 Introduction

Research on contextual factors is limited in Canada (see section 2.8). Several limitations exist in the current Canadian literature. These include: 1) use of a cross-sectional design, which limits inference of results; 2) lack of standardized definition of geographic scale/community; 3) inconsistency in metrics used to determine the exposure (i.e., contextual factors); 4) lack of research relating contextual factors to chronic disease development in high risk groups, such as South Asians, Chinese, African origin and Aboriginal people; and 5) paucity of research on contextual factors in rural communities, most research on the contextual factors and chronic disease risk factors has been conducted in urban areas, which may not be generalizable to rural communities. To fully understand the role of contextual factors in the development of chronic diseases, there is a need for a Canada-wide longitudinal study that uses objective methods of measuring exposures and outcomes. Using validated, objective and reliable measures, the CVCD Alliance study seeks to address the above listed gaps in the literature. The CVCD Alliance study explores pre-clinical risk factors for CVD, cancer and cognitive dysfunction. Additionally, this longitudinal study aims to investigate the impact of contextual factors, in both urban and rural areas of Canada, on chronic disease risk factors, subclinical disease and clinical CVD events at individual and population levels.

3.1.1 Study Objectives

The objectives of the CVCD[45] project are to:

1. Understand the roles of contextual factors (physical activity, nutrition, tobacco and alcohol environments, social capital and access to health services) in the development of CVD, cancer and cognitive dysfunction.
2. Understand the relationship between the contextual factors and migration experiences, and individual risk factors, health service utilization and clinical outcomes among high-risk ethnic groups including South Asians, Chinese, African origin, and reserve-based Aboriginal people from across Canada.
3. Use magnetic resonance imaging (MRI) technology to observe early signs of heart disease, stroke, and related brain disorders to investigate the relationship between these early changes in brain and heart function, and the contextual factors from objective (1).

3.2 Methods

3.2.1 Study Recruitment and Data Collection

CVCD will recruit and prospectively follow 9,700 participants aged 35-69 years representing diverse urban and rural communities of Canada, including 1000 participants

each of South Asian, Chinese and African origin. The participants will originate from cohorts recruited in previous studies. These include each of the five Canadian Partnership for Tomorrow Project (CPTP) cohorts, and two partner cohorts (the Prospective Urban Rural Evaluation (PURE) and the Montreal Heart Institute (MHI) BioBank). A new reserve-based Aboriginal cohort will also be assembled (n≈ 2000). CVCD Alliance will assess contextual factors (nutrition, physical activity, tobacco, and alcohol environments and social capital) using both an objective environmental audit (at the community level) and a subjective (perceived environment) measure of contextual factors (at the level of individual). Outcomes will be ascertained at the individual level using questionnaires (cardiac history, health services access, diet and physical activity, cognitive function, immigration, and acculturation experiences), and direct measurements (blood pressure, height, weight, waist and hip circumference and MRIs of the brain, heart and abdomen). Information on clinical events (such as myocardial infarction, stroke, hospitalization for angina, angioplasty, coronary artery bypass surgery, and cancers) will be collected prospectively using record linkage to health services database.

3.2.2. Methodological Challenges in CVCD

The next sections will describe the design and methodological issues related to the objective assessment of contextual factors within the CVCD Alliance Project. These challenges include; 1) selecting an appropriate definition for community; 2) defining

urban and rural communities; and 3) modifying an existing tool, and adopting a suitable method for assessment of contextual factors in various communities across Canada.

3.2.2.1. Community Definition

Community area in CVCD was defined using the administrative boundaries of the Forward Sortation Area (FSA). FSA is the geographic area containing postal codes that start with the same three letters. FSAs are designed by Canada Post® to facilitate mail delivery.[153] There are approximately 1633 FSAs in Canada. Each FSA contains a median of about 20,000 households, with a mean population of approximately 6000-30000 people[153,154] (see Table 6).

FSAs were selected to represent the community in CVCD for a number of reasons. First, the representation of participants from partner cohorts in rural and eastern provinces was low in census tracts or dissemination areas (smallest census Canada units)[45]; therefore, the broader FSA was deemed as an optimal unit of analysis as it would better capture these communities. Second, FSAs are administrative boundaries that are convenient to use and objectively defined. FSAs are reported by Census respondents for their place of residence, and information on age, income, sex, marital status, mobility and migration, immigration and citizenship, and ethnic groups can be aggregated for each FSA.[154] Third, FSAs provide a reasonably large enough geographical area to capture built, nutrition, tobacco and alcohol environments. Because FSAs are designed for the purpose of mail delivery,

the sizes of FSAs vary as a function of population density. Hence, the size of FSA is the smallest in urban areas and largest in rural areas. When estimating access to amenities, this is a desirable quality as the time required to travel a certain distance is relative, depending on whether an area is urban, suburban or rural.[76] Fourth, several previous Canadian studies have used FSA boundaries to define community and found robust associations. For example, Alter, 2005[71] used FSAs to examine the effects of availability of fast food outlets and cardiovascular outcomes. Black, 2011[105] examined the distribution of food stores in British Columbia in relation to SES at the census tract level, however, their findings were robust to the use of FSAs as geographic areas to determine neighbourhood definition.

Despite many strengths and advantages of the use of FSA to define community, there are some limitations. First, postal codes are continually added or retired, and areas expand or contract, slightly changing the boundaries of FSAs.[153] To manage the fluidity of FSAs, all audits in CVCD will be conducted within four months of the start of the study (June 2014- September 2014). Second, areas covered by FSAs in some urban areas may be too large to well represent these communities. In CVCD, to capture the income variations that may exist within an FSA, additional audits will be conducted at the postal code level. Additional audits will be performed in the FSAs that meet the following criteria:

(Median Income of FSA – Inter Quartile Range (IQR) of income of dissemination areas in the FSA) × 100 % > 50 %

Within the FSAs that are above the 50% cut-off, two postal codes will be selected for the audit: one with the highest median income, and one with the lowest median income (see Table 7).

To maintain confidentiality of residents in postal codes, income information is not available at the postal code level. Income information was obtained for dissemination areas, which were matched to the postal codes in the FSA using the Postal Code Conversion File (PCCF, June 2013)[154] provided by Statistics Canada. Dissemination areas cover all of Canada, and are the smallest standard geographic area used by Statistics Canada (700-1000 households). Out of the series of geographical units used by Statistics Canada, dissemination areas are the most comparable in size to postal codes.

Reserve- based communities: There is a scarcity of research measuring and collecting data on contextual factors in reserve-based communities. There are unique challenges and issues associated with the built environment in reserve-based communities.[107] These include, 1) easy access to tobacco products and alcoholic beverages, 2) reduced walkability scores, and 3) reduced access to healthful foods.[107] Consequently, FSA boundaries will not be used to define reserve-based communities. Instead, the reserve in its entirety will be considered an individual community.

3.2.2.2 Defining Urban and Rural Communities

Statistics Canada suggests creating a degree of rurality that is customized to answer a specific research question. Alternatively, six different definitions are available to define rural areas for national level analysis.[155] These include the following: 1) census rural areas (individuals living in the countryside outside a metropolitan center); 2) Rural and Small Town (RST) (individuals in municipalities outside of the commuting zones of large urban centers); 3) OECD rural communities (individuals living in municipalities with a population density of less than 150 persons/km^2); 4) OECD predominantly rural region (individuals in areas with less than 50% of the population living in OECD rural communities); 5) Beale non-metropolitan regions (individuals living outside metropolitan regions); and 6) rural postal codes/FSAs (individuals with "0" as the second character in their postal code).

Since rural FSA definition (6) is based on delivery routes, it is variable and can misclassify rural areas. For example, for ease of mail delivery, as of 2008, Canada Post has removed all 35 rural postal codes for New Brunswick, resulting in no rural FSAs in New Brunswick.[154] Furthermore, a report by Statistics Canada[155] indicated that this definition might not be applicable or consistent for all provinces. As a result, to enhance comparability with other Canadian studies and Statistics Canada publications, the rural postal codes/FSA definition was not used in CVCD.

Rural and small town definition is based on smaller building blocks and is based on a functional criterion (the degree of integration within a large urban area). Accordingly, Statistics Canada recommends this definition as a benchmark to understand the rural

population of Canada.[155] According to this definition, residents of urban Canada are "those residing in the *Census Metropolitan Area* (CMA) or *Census Agglomeration* (CA)".[155] A CMA has a total population of ≥ 100,000, with 50,000 of more residing in the urban core. CAs have an urban core population between 10,000 and 99,999. CMAs and CAs include all adjacent municipalities where ≥ 50% of the employed labour force commutes into the core. Rural Canada is defined as RST regions that usually have a population of less than 10,000, of which less than 50% of individuals commute to a CMA or CA for employment. The RST areas can be further disaggregated into four groups using the Metropolitan Area and Census Agglomeration Influenced Zones (MIZ). The MIZ classification system uses commuting flow to measure the extent to which urban areas influence rural areas.[155]

For CVCD, the RST definition was adapted to categorize FSAs into urban and rural areas. FSAs were categorized based on the proportion of postal codes that fall within metropolitan regions (CMA/CA). A matrix of rurality was developed to understand the degree of rurality across these categories of FSAs. This included comparing the median population densities, and access to health care (indicators used by Statistics Canada to describe rural areas[155]) between three categories of FSAs; 1) FSAs where ≤ 20% of postal codes are located in a metropolitan area; 2) FSAs with 21-80% of postal codes located in a metropolitan area; and 3) FSAs with 81-100% of postal codes located in a metropolitan area. Access to health care was measured using distance (km) and the average time taken to travel (minutes) from the geographical center of each FSA to the nearest hospital. From this matrix (see Table 8), considerable variation was noted between the FSAs with ≤ 20%,

and those with 80-100% of postal codes in metropolitan areas, therefore, the following criteria were used to define the urban and rural areas:

- **Urban FSA:** An FSA where 21% or more postal codes fall within metropolitan regions (CMA/CA).
- **Rural FSA:** An FSA where ≤ 20% of postal codes fall within a metropolitan area (CMA/CA).

The rurality matrix will also be used as a continuous measure of rurality in future analyses.

3.2.2.3 Community Assessment

The community assessment will be conducted using a modified version of the Environmental Profile of a Community's Health (EPOCH 1 & 2) questionnaire. In addition to the questionnaire, publicly available databases, such as DMTI spatial and Streetsmart Walkscore, will provide supplemental information on the built environment of communities.

Databases: CVCD project will use two databases to obtain information on the built environment of the communities. These include Streetsmart Walkscore (www.walkscore.com) and DMTI spatial (www.DMTIspatial.com).

Streetsmart Walkscore is a well validated tool[156] that is used to estimate the walkability of a community and has been widely used in Canadian and international research related to contextual factors.[85-86] For example, in Canada, Booth, 2011[86] evaluated the association between walkability (measured as walkscore) and diabetes incidence. Another study by Riley, 2013[85] assessed the relationship between walkability and physical activity, where walkability was evaluated using Streetsmart Walkscore. Using publicly available data from Google, Education.com, Open Street Map and Localeze, the Walk Score algorithm assigns a walkability score (0-100) to a location based on the distance to and the variety of amenities available in the community, and road connectivity metrics.[156] Amenities are divided into five categories: 1) retail (e.g., grocery, convenience and drug stores); 2) educational (e.g., schools); 3) food (e.g., restaurants); 4) entertainment (e.g., movie theatres); and 5) recreational (e.g.; parks and gym). These data are available for all FSAs in Canada. The walkscore is interpreted as follows[157]:

Walkscore	Description
90-100	Walker's Paradise (No car required for daily errands)
70-89	Very Walkable (Most errands do not require a car)
50-69	Somewhat Walkable (Some errands can be completed on foot)
25-49	Car-Dependent (Most errands require a car)
0-24	Car-Dependent (A car is required for almost all errands)

DMTI spatial (www.DMTIspatial.com) (Markham, ON) will be used to obtain information for each community with regards to the density of supermarkets, groceries, and restaurant type.[158] DMTI spatial is a geodatabase that includes all the road networks and urban land uses in Canada and has been used in several Canadian studies. For example, Apparicio, 2007[97] used CanMap streetfiles from DMTI spatial to evaluate the accessibility to supermarkets in Montreal.

Assessment Tool: Modified EPOCH-1

EPOCH- 1 is a community audit tool that was developed and validated in the PURE study, a 17-country international study, to objectively measure environmental characteristics. Chow, 2010[159-160] created this instrument based on a comprehensive review of existing tools and measures of contextual factors that are related to cardiovascular risk factors in both urban and rural settings. EPOCH-1 consists of five domains, including: 1) community characteristics (a checklist of essential infrastructure and services); 2) community observation walk (observation of advertisements and side walks on a planned route); 3) assessment of a tobacco retail outlet (prices and availability of tobacco); 4) assessment of a grocery store (prices, availability and quality of fresh fruits and vegetables); and 5) assessment of a restaurant (availability of healthy menu options).[160]

The inter-rater reliability for EPOCH-1[160] was tested in 93 rural and urban communities in five countries (Canada, Colombia, Brazil, China, and India) amongst three observers. Reliability of EPOCH-1 was excellent (Intraclass Correlation Coefficient (ICC) ≥ 0.75) for 24 of 38 items and fair to good (ICC = 0.4-0.75) for the other 14 of 38 items. In Canada, 73% of the communities had excellent reliability between the 3 observers' audits.

EPOCH-1 was chosen for CVCD because: 1) it enables an objective assessment of the key contextual factors that may have a role in the development of chronic diseases; 2) it allows for a standardized assessment of urban and rural communities across Canada; and 3) it permits comparability of the results with other international studies (e.g., PURE).

EPOCH-1 was modified to accommodate the community definition used in CVCD (i.e., FSA). In particular, the following changes were made to EPOCH-1 for the purposes of CVCD: 1) due to the large sizes of FSAs, the 'community observation walk' (i.e., observation of sidewalks in a community) section was excluded, 2) since alcohol policy can potentially have a significant impact on the prevalence of risk factors for CVD and some cancers, a new section 'assessment of alcohol retail outlet' was added to the questionnaire; and 3) questions not applicable to Canadian communities were excluded, such as the availability of 'beedi'.

The modified EPOCH-1 consists of five domains: 1) community demographics/characteristics; 2) assessment of a grocery store; 3) assessment of a

tobacco retail outlet; 4) assessment of an alcohol retail outlet; and 5) assessment of a restaurant.

Assessment Method

A demographic profile (i.e., population size, number of postal codes, median income and walkability score) for each FSA is constructed using data from Statistics Canada and other publicly available databases (i.e., StreetSmart Walkscore and DMTI Spatial).

Because the geographical area of an FSA can be much larger than a few city blocks, the *community/commercial center* approach is used to evaluate the contextual features of an FSA. A pictorial representation of the audit process is presented in Figure 4. The "community center" is defined as the approximate commercial centre of the FSA. This is an area in the FSA that contains the highest number of grocery stores and restaurants. A community center is established through visual inspection of lists and maps, obtained using Google Maps, of grocery stores and restaurants located in an FSA. For CVCD, Google Maps is selected as the web-based map service provider because it is easily accessible, has a user-friendly interface, does not require advanced expertise in GIS technology, and has previously been used in research on contextual factors.[24]

Selection of a grocery store: A grocery store is defined as a store that sells fruits and vegetables and other daily food items (i.e., meat, eggs and dairy). Google Maps is used to

obtain a list of all grocery stores in the FSA. Using online flyers that provide price listings, the original prices of the food items listed in the modified EPOCH-1 (e.g., apples, pears, bananas, boneless skinless chicken thigh, eggs, and regular (2%) milk etc.) is compared for the chain grocery stores (grocery stores under the same ownership) located in the FSA. The chain grocery store located in the community center that offers the lowest prices for these food items is selected for the audit. For a list of all the chain grocery stores in Canada (obtained from the Canadian Business Database), please refer to Appendix 2.

In cases where chain grocery stores are unavailable in the FSA, the store most commonly used by the residents of the community to buy daily food items is designated as the representative grocery store for the community. At the grocery store, the auditor assesses for prices, quality and availability of fruits and vegetables.

Selection of a tobacco store: Any store or outlet that sells cigarettes in the community center is selected for the audit. At the tobacco store, the auditor records the prices of tobacco products, and the presence of warning labels on cigarette packs.

Selection of an alcohol retail outlet: Any store or outlet that sells alcohol in the FSA is selected for the audit. Those located in the community center are preferred. The alcohol store is assessed for prices and availability of beer and wine.

Selection of a family restaurant: A family restaurant is defined as a restaurant that offered sit-down service (full table service by wait staff), and a children's menu**.** For the audit, a restaurant that corresponds with the income of the FSA is deemed representative of the FSA. A list of all restaurants in the FSA is obtained using Google Maps. Price for an average meal for a specific FSA is calculated based on the FSA income (see below). In consultations with a registered dietitian, a "typical" meal rubric was developed, which consisted of an appetizer (salad or bread or soup), a main course (e.g., hamburger and fries or chicken burger and baked potato), a dessert (e.g., ice cream) and a non-alcoholic soft drink. The calculated price of an average Canadian meal was set at $30, using the menu from Kelsey's Bar and Grill, which was chosen as the reference restaurant.

To calculate the price for an average meal for a particular FSA, the following steps are used:

a. Percentage change in FSA income as compared to Canadian median income is calculated using the formula: [(Median FSA income- Median Canadian income)/ Median Canadian income]×100%.
b. This percentage change from 3a is added to the price of an average Canadian meal: [$30 +(30 × % change from step 3a/100)].

From the list of restaurants in the FSA, a restaurant that offers the price of a meal (appetizer, main course, dessert and a drink) closest to the calculated meal price for the FSA is selected for the audit. Below is an example of selecting a restaurant for FSA

'L5W'.

Example: According to Census Canada 2011, the median income for Canada is $ 76,511. The median income for FSA 'L5W' is $ 102,752. The percentage change in income of FSA is:

$$\frac{102752 - 76511}{76511} = 0.34 \times 100 = 34\ \%$$

Thus, the calculated price of an average meal for 'L5W' is the following:

$$30 + (30 \times (0.34) = \$\ 40$$

From the list of restaurants located in the community center of 'L5W', a restaurant that offers the closest meal price to that of the calculated price above ($40) is selected for the audit.

Reserve-based communities: For reserve-based communities, community center, tobacco store, grocery store and restaurant were selected based on consultations with local study contacts and other community members.

Chapter 4 CVCD: Analysis and Results

4.1 Introduction

The objectives of this section of the thesis project are to: 1) calculate the inter-rater agreement of the modified EPOCH- 1 tool using the data from the pilot audits that were conducted by the same observers in four communities; and 2) examine the variation in walkability score and cost of food items in urban and rural areas of Canada using the data collected from CVCD contextual to-date (May 2014).

4.2 Analysis

4.2.1 Inter-rater Agreement

It was not possible to calculate inter-rater reliability measures, such as ICC due to the small sample size (n=4 communities). Therefore, to measure inter-rater agreement of the modified EPOCH-1, average agreement was calculated using a two-step process:

First, for each community, an "agreement" score was calculated using the following formula:

$$\text{Agreement Score}_k = \text{Value}_{R1i} - \text{Value}_{R2i}, \quad (1)$$

where $Value_{R1}$ represents the score for the i^{th} question assigned by rater 1, and $Value_{R2}$ represents the score for the i^{th} question assigned by rater 2.

The agreement score for the i^{th} question is summed over k communities to yield an average agreement score for that question:

$$\text{Mean Difference (MD) in Agreement} = \sum_1^k \frac{Value_{R1i} - Value_{R2i}}{k} \quad (2)$$

An agreement score of zero indicates a perfect agreement, with absolute values closer to 0 representing higher agreement (i.e., if the two raters agreed and provided similar values for the prices and availability of food items, then the difference between their ratings will be zero). MD value is interpreted along with the variability measure (Standard Deviation (SD)). A mean agreement score closer to '0' with a small standard deviation is considered representative of good agreement. Negative values denote underestimation by rater 1, on average; and positive values denote overestimation by rater 1, on average.

Agreement was calculated using data from two urban, one rural and one reserve-based community (Six Nations) for the nutrition environment (prices and availability of food items) and from two urban communities for the alcohol environment (prices of beer and wine), where two trained observers independently assessed the communities. All communities were located in Ontario.

Agreement could not be calculated for restaurant and tobacco components of the questionnaire, as they were not completed independently by at least 2 auditors.

4.2.2 Variation in Urban and Rural Areas

By the time of writing this thesis, data were available for only a small number of communities (n=89), thus, a multi-level analysis was not possible. Mean variations in prices of the food basket, and walkability scores (www.walkscore.com) between urban and rural environments were compared using a student's t-test. The constructed food basket was based on the Public Health Ontario's Nutritious Food Basket (NFB).[161-162] An NFB is a survey tool that measures the cost of daily food items deemed to be a part of a balanced nutritious diet. NFB is designed to reflect the eating patterns that meet the Canada's Food Guide recommendations. It uses a list of food items from six departments in the grocery store. These departments include refrigerated foods, produce, meat, bakery, canned, packaged and dry foods, and frozen food departments. Items in the basket reflect the lowest prices available for each of the food items, irrespective of the brand.[161]

For the analysis in this project, the items in the food basket included: Apples (1 kg), Oranges (1 kg), Grapes (1 kg), Pears (1kg), Carrot (255 g), Tomato (1 kg), Lettuce, Spinach (455 g), 2 % Milk (4 L), White bread (675 g/1 loaf), White rice (900 g) Chicken (1 kg), and Eggs (1 carton). The cost of the food basket was the summed value of prices

of all the above items. Analyses were conducted using SPSS version 19.0. A p-value less than 0.05 was considered statistically significant.

4.3 Results

4.3.1 Interrater Agreement

As shown in table 9, agreement was high (i.e., value of MD was very close to zero with SD < 2) for summed prices of food items (MD (SD): $-0.05 (1.26)) [i.e., a $0.05 lower estimate overall by rater 1], and availability of fruits (MD (SD): 0.5 (1)) [i.e., rater 1 found 0.5 more items than rater 2] and vegetables (MD (SD): -0.25 (0.95)). The agreement for liquor prices, based on the data from two communities, was high as well (MD (SD): -$0.50 (0.71)) [i.e., a $0.50 lower estimate by rater #1]. On average, when compared to the data collected by rater 2 (DZ), rater 1 (AR) was more likely to report $0.05 lower for prices of food items, and $0.5 lower for prices of alcoholic beverages (wine and beer). The null hypothesis that the inter-rater difference was, on average, equal to 0 could not be formally tested due to the small sample size.

4.3.2 Urban vs. Rural Variation

There were 83 urban (56231 postal codes) and seven rural Ontario FSAs (2680 postal codes). Urban FSAs had higher population and median income when compared to rural

FSAs (Urban: $81981.5 vs. Rural: $71720). FSAs were from the following three regions: Waterloo/Kitchener, Hamilton/Burlington and surrounding areas, and Ottawa and surrounding areas. Please refer to figures 5-8 for maps of urban and rural FSAs in these regions.

4.3.2.1 Variation in Food Cost and Walkability Scores

Walkability Scores: The mean walkability score was higher in urban areas, but the trend was not statistically significant (Mean (SD) Urban: 45.2 (23.8) vs. Rural: 40.57 (38.9), p=0.64) (see Table 10 and Figures 9-12).

Food Cost: FSAs were excluded from the analysis if there was no grocery store in the FSA to audit, or data on cost of food items was missing. Seven urban FSAs had no grocery stores, and nine urban FSA had more than 40% of the data missing (due to unavailability of certain fruits/vegetables at the grocery stores). These 16 FSAs were excluded from the analysis, leaving data from 73 FSAs (66 urban and seven rural) for comparison. The mean price of the food basket was similar between urban and rural areas (Mean (SD) Urban: $72 (11) vs. Rural: $75 (11), p=0.55) (see Table 10).

4.4 Discussion

The aim of the CVCD Alliance project is to examine the impact of contextual characteristics on the development of chronic diseases and their respective risk factors. CVCD is a longitudinal study that will provide validated and objective data on contextual factors. Analysis of the pilot data reveals that there is high agreement amongst raters for most domains of modified EPOCH-1 and that the food prices and walkability scores are similar in urban and rural areas.

4.4.1 Strengths and Limitations of CVCD

The CVCD Alliance project has several strengths: 1) CVCD is the first Canada-wide longitudinal study that studies the role of contextual factors and chronic diseases; 2) CVCD seeks to recruit diverse populations (n=9700), including the groups at high-risk for CVD (i.e., South Asians and Aboriginals); 3) CVCD uses validated and reliable tools to assess contextual factors; 4) the use of FSA as the unit of analyses enhances comparability across other studies; and 5) a large sample size (n=9700) enables the linkage of contextual factors to biological markers.

Despite the strengths of the study design, there are some limitations. First, the definition of 'community' is based on administrative boundaries (i.e., FSA), which may not represent residents' experience of neighbourhoods.[62] In addition, the method of assigning urban and rural FSAs has not been employed in previous research and thus, its validity has not been assessed. The validity of this definition will be assessed in future analyses. Finally, the criteria of selecting a representative grocery store and a restaurant are based

on assumptions that may not necessarily hold true for all participants in the study.

These strengths and limitation of the study methodology and the analysis of the pilot data are discussed in further detail in the next sections.

4.4.1.1 Community Definition:

There are several advantages to defining a community using administrative boundaries (i.e., FSA boundaries). FSAs are relatively stable geographic areas with relevant data easily available through Statistics Canada.[153] Additionally, use of FSAs is valuable for policy applications, as results from this study can be compared with other Canadian or international studies that use administrative boundaries to define the unit of sampling/analysis. Further, use of FSAs can help the government understand how the research connects to the area over which they have jurisdiction.

One serious limitation to this community definition exists, as it may not accurately represent the boundaries as experienced by the residents.[62] To address this limitation in CVCD, perceived environment measures will be collected and used for comparison.

4.4.1.2 Definition of Urban and Rural Areas

Defining rural areas is challenging in Canada. Based on Statistics Canada's definition of

RST, a rurality matrix and criteria were developed for the definition of rural and urban FSAs in CVCD. Generally, the trends observed across the rurality matrix in this study were consistent with that of Statistics Canada's report, where median population density and access to health care (indicators to differentiate between rural and urban areas) were higher in urban regions compared to rural regions.[153] However, the FSAs that had 21-80% of postal codes located in a metropolitan area generally did not follow this trend. A possible explanation for this may be that the number of FSAs within this specified range was very low (see Table 8). Further research using individual and community level data from the full CVCD sample can help establish the validity of this definition.

4.4.1.3 Modified EPOCH-1

EPOCH-1 is a validated tool that was developed to assess the built environment of communities in 17 countries. EPOCH-1 was adapted to correspond with the community definition used in CVCD (i.e., FSA). One of the objectives of this thesis project was to calculate inter-rater reliability for the modified EPOCH-1. ICC or Kappa coefficients could not be calculated due to small sample size. However, agreement between raters was estimated using mean agreement, where a value of mean agreement closer to 0 with small variability indicated a high agreement. Similar to EPOCH-1, the inter rater agreement of the modified EPOCH-1 was very high for prices of food items, availability of fruits and vegetables and prices of alcoholic beverages.

This analysis has some limitations. Agreement for some domains (i.e., community demographics, and restaurant and tobacco store assessments) could not be calculated, as the assessment for these categories was not conducted independently by at least two observers. Furthermore, the analysis used a convenience sample of a small number of communities.

Validity of modified EPOCH-1

The validity of modified EPOCH-1 can be assessed at three levels: 1) face validity (i.e., the extent to which a questionnaire measures what it is supposed to measure); 2) criterion validity (i.e., the degree to which the instrument behaves as expected when compared to the 'gold standard'); and 3) construct validity (i.e., the extent to which the instrument behaves as expected when compared to other instruments that measure the same constructs).[163]

In this project, face validity was assessed by examination of the various questions in modified EPOCH-1 by experts in the field of contextual factors research. The experts confirmed that the modified questionnaire measured the specified variables of interest (i.e., nutrition, physical activity, tobacco and alcohol environments of the community).

Due to feasibility constraints, and limited number of communities, criterion or construct validity of the modified EPOCH-1 could not be assessed in this thesis project. In future

analyses, using GIS assessments as the gold standard, criterion validity of modified EPOCH-1 will be evaluated by assessing the correlation between data obtained from contextual assessments using the modified EPOCH-1, and the data obtained by audits that used GIS-derived measures. The modified EPOCH-1 can be assessed for construct validity by evaluating the correlation between objective measures of EPOCH-1 and the perceived measures of EPOCH-2 (e.g., by testing the correlation between the quality of food items in a grocery store as measured by modified EPOCH-1, and the perceived quality of food items as measured by EPOCH-2).

4.4.1.4 Method of Assessment

Several assumptions were used when developing a method of selecting a representative grocery store and a representative restaurant for a particular FSA. When choosing a single, representative grocery store of an FSA, it was assumed that; 1) of all the grocery stores located in the FSA, residents were more likely to shop at the cheapest store; and 2) individuals preferred to shop at chain supermarkets. These assumptions were based on previous research that examined household shopping behaviours and preferences. In a study by Leszczyc, 2004[164], it was reported that when shopping for groceries and household items, consumers engage in single-stop, multi-purpose shopping. Furthermore, lower priced chain stores were more commonly used by consumers to buy groceries than the more expensive smaller convenience stores. In another study by Krukowski et al., 2012[167], participants were surveyed to examine the reasons for selecting a grocery store.

The results from the study indicated that 'low prices' was the most commonly reported reason for the choice of a grocery store.

However, recent research indicates that these models may not accurately reflect the choices made by shoppers. For example, some studies[166-167] suggest that a combination of several key factors guides the consumer's choice of a food store. These include proximity to home, quality of fruits and vegetables, variety of fruits and vegetables and cleanliness of the store. These factors were not taken into consideration when selecting a grocery store to represent a specific community in CVCD.

A method was developed to enable the selection of a restaurant that corresponds with the income of FSA. This method has not been previously used in research and has not been validated. Through comparisons of objective and perceived environment measures, future analyses from CVCD will be able to assess the precision of this criterion.

When conducting studies that analyze the relationship between contextual factors and chronic disease development, it is important to take into account the influence of individual-level characteristics. Relying on community-level data only may make the research prone to the ecological fallacy, i.e., making erroneous conclusions about individuals based on associations observed between factors on aggregate level.[48] Therefore, CVCD will use a multi-level model approach to partition effects due to community and individual level factors. In CVCD, objective community level

information obtained from the audits will be used together with self-reported perceptions of the community environment as well as behavior patterns, i.e., shopping, activity, and workplace. Overall, CVCD will provide a comprehensive evaluation of contextual risk factors for chronic diseases in Canadian communities.

4.4.2 Variation in Urban and Rural Areas

The results indicated a trend in higher prices for the food basket and lower walkability scores in rural areas, but the differences between urban and rural areas were not statistically significant. Although rural areas had lower walkability scores, both urban and rural areas were in the car-dependent zones (walkability scores: 25-49). More research is required to understand the clinical implications of these trends. Previous studies from Canada[49-50] and the US[52-57] parallel the trend observed in this study. These studies report that rural areas, typically, have lower walkability scores and higher prices for fruits and vegetables.

This analysis was limited due to data availability (n=89 audits), which precluded the use of a multi-level modeling approach. As a result, the variation between individual FSAs could not be examined, and the inherent nesting structure of the data was ignored. For the analysis of food cost, 16 FSAs with missing data were excluded. Multiple imputation analysis could not be performed due to a scarcity of data with which to inform the imputation. There were no grocery stores available for auditing in seven FSAs. These

were smaller urban FSAs where the grocery stores were generally located at a distance of 3-4 km outside the boundary of the FSA. Nine urban FSAs had more than 40% of the data missing. In these FSAs, the available grocery stores used were not full-service supermarkets, resulting in unavailability of 60 % of the items (fruits and vegetables) from the food basket.

Further research using multi level analysis with a larger number of communities is required to more completely understand the variations in contextual factors in urban and rural areas. In future analyses, it would be a benefit to explore and compare the cost of food baskets in urban and rural areas, relative to the average cost of a food basket in Canada. Furthermore, future research should compare the individual's willingness to pay for food baskets in urban and rural populations, and the impact of the relationship between the willingness to pay and the cost of a nutritious food basket on health outcomes.

4.4.3 Conclusion and Future Research

CVCD is a longitudinal study that will significantly enhance the current literature on contextual factors and chronic disease prevalence. Through its incorporation of both objective and subjective measures of contextual exposures, direct measurement of outcomes and an objective community definition, it will provide valid and reliable results that can be compared with other Canadian and international studies. Furthermore, it will

address the previously unanswered questions such as the impact of prices of alcohol on chronic disease risk factors.

Future research using the data from this study will help in understanding health variations across urban and rural areas of Canada. Future analyses will be multi-level in nature, accounting for individual characteristics and social capital of the community.

4.5 Conclusion to Thesis

There have been dramatic increases in the prevalence of chronic diseases and chronic disease risk factors in Canada. Within the Canadian public health sector, there is growing momentum to address these concerns by utilizing a community based population health intervention that complements individualized interventions. This intervention includes examining the contextual features of a community that may influence the development of chronic diseases. However, presently, in Canada, there is a lack of research relating contextual factors to chronic disease risk factors.

The objectives of this thesis project were to systematically review the current Canadian literature that related the role of contextual factors to chronic disease risk factors, to identify the current gaps in this literature, and to adapt an existing tool developed for a similar type of assessment to a study of contextual risk factors in Canada. Results from the systematic review indicated that fewer fast food outlets, increased density of

destinations and higher SES were associated with positive health outcomes. However, the inconsistencies across outcome and exposure measures prevented a statistical synthesis of these results using meta-analyses. The absence of a harmonized definition of community and standardized measures to determine exposures and outcomes pose a great challenge to this field. The CVCD Alliance project is conducted to address the current gaps and limitations in the literature on contextual factors (i.e., lack of data on the influence of provincial alcohol policies on chronic diseases, and the need for a longitudinal study that uses objective and reliable measures of exposure and outcome determination). Analyses of the pilot data suggest that when compared to urban areas in Canada, the rural areas tend to have lower walkability score and higher prices for nutritious food items. However, these differences were not statistically significant. To the researcher's knowledge, this is the first project to systematically review Canadian literature and analyze the pilot data from a large Canada-wide longitudinal study.

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Tables & Figures

Specific Diseases	Tobacco Use		Alcohol	Physical Inactivity	Unhealthy Eating			
	Current Smoker	Second hand Smoke	Alcohol Consumption	Physical Inactivity	Inadequate Vegetable and Fruit	Diets Low in Fibre	High Sodium	Trans fat
Cancer								
Breast	⇧		↑	⇧				
Lung	↑	↑		↑	⇧			
Colon and rectum	↑		↑			↑		
Leukemia	↑							
Bladder	↑							
Kidney	↑							
Oral cavity, pharynx	↑	⇧	↑		⇧			
CVD								
IHD	↑	↑	J	↑	↑	⇧	↑	↑
Stroke	↑	⇧	J		↑	⇧	↑	↑

Table 1. Links between selected risk factors and chronic diseases[8]
Table was assembled by Public Health Ontario using expert evaluations performed by WHO, International Agency for Research on Cancer, United Status Surgeon General and World Cancer Research Fund in 2011.
CVD: Cardiovascular Disease; IHD: Ischemic Heart Disease. ↑ = convincing increased risk; ⇧ = probable increased risk; J = convincing J-or U shaped risk.

Province	Alcohol Sales Structure	Legal Age for Purchase	Minimum Price	Other Important Policies	Driving Under Influence
ON	Mixed	19	▪ Minimum price set for all alcoholic beverages (on and off premise) ▪ Minimum price adjusted for inflation	*Locations of purchase*: Government regulated and privately run outlets. AGCO regulates the sale of alcohol in bars and restaurants. Limited sale of wine allowed in grocery stores. *Hours of Sale*: 11:00 am-2:00 am *Advertisements*: Must follow AGCO Guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: Immediate 24-hour licence suspension. If convicted, 30-day licence suspension and a fine of $60-$500. *Drivers under 21 years of age & novice drivers:* BAC: > 0 Penalty: Immediate 24-hour licence suspension. If convicted, a fine of $60-$500 and suspension period based on the Novice Driver Escalating Sanction (e.g., 30-day for the first occurrence, 90-day for the second occurrence of offence)
QC	Mixed	18	▪ Minimum price set for beer only ▪ Minimum price adjusted for inflation	*Locations of purchase*: Government regulated (SAQ) stores. Beer and wine allowed to be sold in grocery stores and convenience stores. *Hours of sale*: 8:00 am-11:00 pm *Advertisements*: Require preclearance from RACJ. Advertisements cannot be targeted to minors.	*Fully-licenced drivers* BAC: ≥ 0.08 Penalty: 1st offence: Immediate Licence suspension for 90 days. If convicted, minimum fine of $1000, driving prohibition of 1 year. Repeat offence: If convicted, incarceration, prohibition from registering, acquiring,

				Advertising cannot encourage non-drinkers to consume.	leasing or putting into operation a vehicle under one's name and ignition interlock device for life *Drivers under 21 years of age & novice drivers:* BAC: > 0 Penalty: Immediate licence suspension for 90 days, 4 demerit points and a fine from $300 to $600
BC	Mixed	19	▪ Minimum prices apply to government liquor stores only ▪ Minimum price adjusted for inflation ▪ Minimum price not adjusted for strength of the product	*Locations of purchase*: Government liquor stores and private outlets. Starting in 2015, alcoholic beverages will be sold in grocery stores *Hours of sale:* 9:00 am-4:00 am *Advertisements*: Must follow CRTC Guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st offence: Immediate Licence suspension for 3 days, $ 200 administrative penalty, vehicle impounded for 3 days. 2nd offence: Immediate Licence suspension for 7 days, $ 300 administrative penalty, vehicle impounded for 7 days. 3rd offence: Immediate Licence suspension for 30 days, $ 400 administrative penalty, vehicle impounded for 30 days. May be referred to Interlock Ignition Program. BAC: >0.08 Penalty: If convicted, minimum fine of $1000, driving prohibition of 1

					year. *Novice drivers* BAC: > 0 Penalty: Immediate licence suspension for 12 hours, reattempt testing.
AB	Private	18	No minimum price	*Locations of purchase:* Private retail outlets *Hours of sale:* 10:00 am-2:00 am *Advertisements*: Must follow AGLC guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st offence: Immediate 3-day licence suspension and 3-day vehicle seizure. 2nd offence: Immediate 15-day licence suspension, 7-day vehicle seizure, "Planning Ahead" course. 3rd offence: Immediate 30-day licence suspension, 7-day vehicle seizure, "Impact" course. BAC: >0.08 Penalty: On conviction, licence suspension, vehicle seizure and criminal charge. *Learner's Permit* BAC: >0 Penalty:30-day licence suspension and 7-day vehicle seizure
SK	Mixed	19	▪ Minimum price set for all alcoholic beverages (on and	*Location of purchase:* SLGA operated stores and private liquor stores.	*Fully-licenced drivers* BAC: ≥ 0.04 Penalty:

			off premise) ▪ Minimum price adjusted for inflation	*Hours of sale:* 9:30 am-2:00 am *Advertisements*: Must follow SLGA guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	1st offence: Immediate 3-day licence suspension and 3-day vehicle seizure. 2nd offence: Immediate 21-day licence suspension, 7-day vehicle seizure, alcohol and drug education program. 3rd offence: Immediate 90-day licence suspension, 14-day vehicle seizure, and alcohol and drug education program. BAC: >0.08 Penalty: On conviction, licence suspension, vehicle seizure and criminal charge. New drivers & those under 19 years of age: BAC: > 0 Penalty: 1st offence: Immediate 60-day licence suspension and 3-day vehicle seizure. 2nd offence: Immediate 120-day licence suspension, 7-day vehicle seizure, alcohol and drug education program. 3rd offence: Immediate 18-month licence suspension, 7-day vehicle seizure, and alcohol and drug education program.

MN	Mixed	18	▪ Minimum price adjusted for beer only ▪ Minimum price adjusted for inflation	*Locations of Purchase*: Government operated liquor store and some private wine stores. Limited Sales in grocery stores *Hours of sale:* 9:00 am-2:00 am *Advertisements*: Must follow MLCC guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st offence: Immediate 24-hour licence suspension 2nd offence: Immediate 15-day licence suspension. 3rd offence: Immediate 60-day licence suspension. BAC: >0.08 Penalty: On conviction, licence suspension, vehicle seizure and criminal charge. *New drivers (first five years)*: BAC: > 0 Penalty: Immediate 24-hour roadside licence suspension.
NS	Mixed	19	▪ Minimum price set for alcoholic beverages ▪ Minimum price adjusted for inflation	*Locations of Purchase*: Government operated liquor store and some private stores (rural areas). *Hours of sale*: 10:00 am-2:00 am *Advertisements*: Must follow Nova Scotia LGA guidelines. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.04 Penalty: Immediate 24-hour licence suspension BAC: >0.08 Penalty: On conviction, licence suspension, vehicle seizure and criminal charge. *New drivers*: BAC: > 0

					Penalty: Retake all tests
NL	Mixed	19	▪ Minimum price set for alcoholic beverages ▪ Minimum price adjusted for inflation	*Locations of purchase:* Government operated stores and private agency stores (rural areas). Limited sale of alcohol in convenience stores. *Hours of sale*: 9:00 am-2:00 am *Advertisements*: Must follow CRTC code. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st & 2nd offence: Immediate 24-hour licence suspension. 3rd offence: Immediate 2-month licence suspension. BAC: >0.08 Penalty: Immediate 24 hour licence suspension. On conviction, licence suspension, vehicle seizure and criminal charge. *New drivers (first five years)*: BAC: > 0 Penalty: 1st offence: Immediate 7-day licence suspension. 2nd offence: Immediate 4-month licence suspension. 3rd offence: Immediate 6-month licence suspension
NB	Government Monopoly	19	▪ Minimum price set for alcoholic beverages ▪ Minimum price adjusted for inflation	*Locations of purchase:* Government owned liquor stores *Hours of sale*: 9:00 am-2:00 am *Advertisements*: Must follow the NB Liquor Control Act guidelines. Advertisements cannot be	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st offence: Immediate 7-day licence suspension. BAC: >0.08 Penalty: Immediate 90-day licence suspension.

				targeted to minors. Advertising cannot encourage non-drinkers to consume.	On conviction, licence suspension, vehicle seizure and criminal charge. *Drivers under 21 years of age*: BAC: > 0 Penalty: Immediate 1-year license suspension, minimum $172 fine, retake all tests
PEI	Government Monopoly	19	▪ Minimum price set for alcoholic beverages ▪ Minimum price adjusted for inflation	*Locations of purchase:* Government owned liquor stores *Hours of sale*: 9:00 am-2:00 am *Advertisements*: Must follow PEI LCC code. Advertisements cannot be targeted to minors. Advertising cannot encourage non-drinkers to consume.	*Fully-licenced drivers* BAC: ≥ 0.05 Penalty: 1st offence: Immediate 24-hour licence suspension 2nd offence: Immediate 30-day licence suspension. 3rd offence: Immediate 90-day licence suspension BAC: >0.08 Penalty: On conviction, licence suspension, vehicle seizure and criminal charge. *New drivers (first three years) and those under 19 years of age*: BAC: > 0 Penalty: Immediate 24-hour licence suspension, 90-day driving prohibition.

Table 2. Alcohol policies in Canada by province[21-37].
ON: Ontario, QC: Quebec, AB: Alberta, SK: Saskatchewan, MN: Manitoba, NS: Nova Scotia, NB: New Brunswick, NL: Newfoundland and Labrador, PEI: Prince Edward Island.
AGCO: Alcohol and Gaming Commission of Ontario Liquor, BAC: Blood Alcohol Content (mg/100 ml of blood). RACJ: Régie des alcools, des courses et des jeux, SAQ: Societe d'Alcool du Quebec, CRTC: Canadian Radio-television and Telecommunications Commission, AGLC: Alberta Gaming and Liquor Commission, SLGA: Saskatchewan Liquor and Gaming Authority, MLCC: Manitoba Liquor Control Commission, LGA: Liquor and Gaming Authority, LCC: Liquor Control Commission.

Key Components	Explanation	Suggested strategies	Strategy used in this review
Theoretical Model	Develop a theoretical framework to form review question and assess the generalizability of findings		Theoretical framework (Figure 1) was used to inform the research question and focus of the review
Preliminary Synthesis	Describe patterns from findings in terms of direction and size of effect	1. Textual descriptions of studies 2. Groupings and clusters 3. Tabulation 4. Transforming data into a common rubric 5. Vote counting as a descriptive tool 6. Translating data; thematic analysis (N/A: for qualitative studies) 7. Translating data: content analysis (N/A: for qualitative studies)	1. Grouping (Studies were grouped based on macro environmental exposure) 2. Tabulation: Study characteristics and results were organized and tabulated. Findings were presented as positive, inverse or no association (Table 4) 3. Common rubric: Where possible, results were extracted as adjusted OR or RR for dichotomous outcomes and as mean differences for continuous outcomes (Table 4) 4. Vote Counting: Number of studies reporting positive and inverse association were compared (Table 4 & Results Section)
Relationships in data	Understand factors that may explain differences in directions and sizes in eligible studies	1. Moderator variables and sub-group analyses 2. Idea webbing and conceptual mapping 3. Translation: reciprocal and refutational (N/A) 4. Qualitative case descriptions 5.Investigator/methodological triangulation (N/A) 6. Conceptual triangulation (N/A) 7. Visual representation of results	1. Specific variables (such as geographical scale and population) that may result in difference in effectiveness of exposure were assessed across studies 2. Qualitative case descriptions: Key findings, populations and outcome from each study were qualitatively described (Table 4)
Assessing robustness	Generalize conclusions to various population groups	1. Use of validity assessment – e.g. the CDC approach or the EPPI approach 2. Best Evidence Synthesis 3. Reflecting critically on the synthesis process 4. Checking the synthesis with authors of primary studies	1. Use of validity assessment: quality of studies was assessed using modified Newcastle-Ottawa Scale (NOS) 2. Reflecting critically on synthesis process: Issues arising from synthesis are discussed in the strengths and limitations section of discussion

Table 3. Use of Popay et al., 2006's [37] recommendations for narrative synthesis.

NUITRITION ENVIRONMENT													
Availability													
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association***
Alter	2005	5/10	Ontario	Cross-sectional	Fast food chains and CVD mortality	380		Density of fast food outlets/100,000 people	Database: Canada 411 and Canada Post	Region specific hospitalization rates ACS	Registered person database	FSA	+
Paquet	2009	8/10	Montreal	Cross-sectional	Fast food exposure and fast food consumption	6	374	Fast food Exposure	Number of fast food restaurants located within 500 m. Commercial database. (GIS)	Mastery and metabolic risk	Mastery self reported (Pearlin's mastery scale)	500 m buffer	+
Spence	2009	5/10	Edmonton	Cross-sectional	Fast food and obesity		2900	Availability of food stores (RFEI)	Health inspection data (ArcGIS)	BMI	Self-reported	Buffer 800 m and 1600 m around the place of residence	+
Daniel	2010	6/10	Montreal	Cross-sectional	Fast food stores and CVD mortality	845	30,388 CVD deaths	Availability of fast food stores	Commercial business database (GIS)	CVD mortality	Ministry of Health data (ICD coding)	CT	+
Paquet	2010	7/10	Montreal	Cross-sectional	Fast food exposure and fast food consumption	6	404	Fast food Exposure	Number of fast food restaurants located within 500 m. Commercial database (GIS)	Reward sensitivity	Self-reported (Montreal survey of lifestyle and health)	500 m buffer	+
Kestens	2012	6/10	Montreal	Cross-sectional	Food exposure and overweight	65	78020 (travel survey), 5568 (CCHS)	Residential and non-residential food exposure	Mobility data (GIS)	BMI	Self-reported (CCHS)	PHU (Montreal), neighbourhood (QC)	+
Mercille	2012	5/10	Montreal	Cross-sectional	Availability of food stores and dietary patterns		751	Availability of food sources (proportion of stores selling healthful foods and fast food outlets)	GIS	Dietary patterns	FFQ	500 m buffer	+
Hollands	2013	4/10	Canada	Cross-sectional	Fast food and BMI	1269		Fast food density	Number of restaurants/100000 population (GIS)	BMI	Self-reported (CCHS)	FSA	+
Access													
Author		**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**		**Outcome**		

	Year									Outcome	Ascertainment	Community Definition	Association
Kirkpatrick	2010	5/10	Toronto	Cross-sectional	Access to discount supermarket and self-reported household food insecurity	12	484	Access (distance) to discount supermarket	ArcGIS	household food insecurity	Household Food Security Survey Module	CT	NS
Chum	2013	6/10	Toronto	Cross-sectional	Built environment and CVD outcomes	302	1626	Distance to supermarket	CanMap Route, Food inspection reports, Census Canada (GIS)	CVD incidence	Self-reported	CT	+

Affordability

Author	Year	Score	Location	Design	Relationship Studied	N (communities)	N (individuals)	Contextual factor	Contextual factor measurement	Outcome	Outcome Ascertainment	Community Definition	Association
Willows	2011	4/10	Canada	Cross-sectional	Household food insecurity and Aboriginal health		837 Aboriginal	Food insecurity	CCHS (self-reported)	Smoking, fruit/vegetable intake	self-reported CCHS	Reserve boundaries	NS
Lear	2013	4/10	Vancouver	Cross-sectional	Food basket and BMI	5 supermarkets	423	Cost of food basket and access	GIS Audit Definition of food basket: 2 percent fat milk (4L), bananas (per lb), tomatoes (per lb), eggs (medium size, dozen), white rice (900 grams), white flour (2.5 kg), white sugar (1 kg) and white bread (loaf).	BMI	Self-reported (survey)	5 supermarkets from various income regions	-
Minaker	2013	5/10	Waterloo	Cross-sectional	If diet related perception mediates the relationship between		4902	Food affordability	Nutrition Environment Measures Survey–Stores (NEMS-S)	Diet patterns	Self-reported	FSA	NS

					food cost/affordability and diet								
PHYSICAL ACTIVITY													
								Walkability					
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association**
Pouliou	2010	5/10	Toronto and Vancouver	Cross-sectional	Built Environment and BMI		5418218	Land-use mix index (Street connectivity, residential density, density of opportunities, walkability index)	CanMap RouteLogistics Frank and Engelke (GIS)	BMI	self-reported (CCHS)	CMA (1km buffer)	NS
Berry	2010	7/10	Edmonton	Longitudinal	SES, Walkability and BMI		500	SES	Census (DA)	BMI	Self-reported (survey)	DA	SES: - Walkability: NS
Booth	2013	7/10	Toronto	Retrospective cohort	Walkability and diabetes	10535	1239262	Walkability	Walkscore	Incidence of diabetes	Ontario diabetes database	Dissemination blocks	+
Riley	2013	6/10	Ottawa	Cross-sectional	Walkability and physical activity		292	Walkability	Walkscore	Physical activity	IPAQ-self-reported	Neighbourhood (Non-standard)	NS
								Other					
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association**
Craig	2002	6/10	Ontario, Quebec, Alberta	Cross-sectional	Physical environment and physical activity	27	10983	Environment	Objective scale (community audit)	Walking to work	1996 Canadian census	Non-standard definition (Median CTs: 3)	+
Gauvin	2008	6/10	Montreal	Cross-sectional	Active living potential and walking	270	2614	Active potential	18-item observation grid	Walking	IPAQ (self-reported)	CT	+
Taylor	2008	4/10	Alberta	Cross-sectional	Perceived physical environm		717	Physical environment	NEWS	Walking	Self-reported-IPAQ	10-15 mins from home	

					ent and walking								
Schuurman	2009	5/10	Vancouver	Cross-sectional	Clustering of physical activity and obesity in neighbourhood	8	1863	Built environment	Greater Vancouver Land Use Data (GIS)	Physical activity	Self-reported	Non-standard definition based on population density (3-4 CTs)	NS
Gauvin	2011	8/10	Montreal	Longitudinal	Proximity to amenities and walking	521		Proximity	MEGAPHONE GIS	Walking	Physical activity scale for seniors (PASE)	Non-standard	+
Oliver	2011	5/10	Vancouver	Cross-sectional	Built environment and physical activity	8	1602	Built environment:land use	Greater Vancouver Land Use Data	Physical activity	Self-reported telephone survey	Non-standard definition based on population density (3-4 CTs)	+
Prince	2011	6/10	Ottawa	Cross-sectional	Built environment and physical activity	85	3514	Built environment	Ottawa Neighbourhood Study	Physical activity	IPAQ (self-reported)	Non-standard	+
Villeneuve	2012	7/10	10 urban areas in Ontario	Cross-sectional	Green space and CVD mortality		186,990	Green space	Vegetation index	CVD Mortality	Canadian mortality database	500 m buffer	-
SOCIO ECONOMIC STATUS													
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association**
Mackillop	1997	7/10	Ontario	Database	SES and cancer survival	357,530		SES	Census 1991 (DA)	Cancer Survival	Ontario Cancer Registry	DA	+
Travers	1997	4/5	Nova Scotia	Cross-sectional	Cost of implementing nutritious food	8		SES	Statistics Canada	Food basket price	Survey	County	NS
Finkelstein	2004	6/10	Hamilton	Database review	SES and CVD mortality		5228	SES (Deprivation index)	Census 2001 (DA)	Mortality	Register at a clinic	EA	-
Ng	2004	7/10	CMAs Canada	Cross-sectional	SES and prevalence of			SES	Census 2001 (CT)	Cervical cancer	Death registration	CMA	NS

					cervical cancer								
Southern	2005	7/10	Alberta	Cross-sectional	SES and cardiac outcomes		4367	SES	Census 1996 (EA)	Cardiac outcomes:2.5 year survival and QOL	APPROACH Database	DA	+
Lemstra	2006	5/10	Saskatoon	Cross-sectional	SES and CHD			SES	Statistics Canada low income neighbourhoods	CHD	Hospital discharge data	Statistics Canada	+
Smoyer-tomic	2006	4/5	Edmonton	Cross-sectional	Accessibility in high-need areas	212 urban and residential	N/A	Need	Inner-city vs. rest of city	Supermarket accessibility	Minimum distance and coverage methods (Arcview 3.2 GIS)	Neighbourhood (Need defined using 1999 Edmonton Civic census)	NS
Ross	2007	7/10	All CMAS	Cross-sectional	SES and BMI	M:2615, W: 2660	32964	SES	Proportion recent immigrants, low education, income, dwelling density/walkability	BMI	Self-reported-CCHS	CT	+
Haider	2007	7/10	Ontario	Cross-sectional	SES and prevalence of melanoma	14623		SES	Census 2001 (DA)	Prevalence of melanoma	Ontario Cancer Registry	DA	-
Apparicio	2007	4/5	Montreal	Cross-sectional	SES and food deserts	846		SES	Census 2001	Number of supermarkets within walking distance, distance to closest market, mean distance to supermarkets belonging to different companies	Yellow pages	CT	-
Latham	2007	4/5	Hamilton	Cross-sectional	SES and food access/availability			SES	Census 2001	Food cost and access	Food outlet mapping, food-price surveys, produce availability surveys, and semi-structured interviews with food outlet owner/managers and public health professionals.	CT	NS
Matheson	2008	7/10	Canada	Cross-sectional	SES and BMI	3522	64,277	SES	CCHS- factorial research (education,	BMI	Self-reported	CT	+

									marital status, employment, income cut-off, home repair)				
Finkelstein	2008	6/10	Hamilton and Toronto	Cross-sectional	SES and BMI	7634		SES	Census 2001 (DA)	BMI	Clinic Register		+
Larsen	2008	4/5	London	Cross-sectional	SES and food deserts	CTs in London		SES	Census 2001	Access to supermarkets	Network based approach: GIS	CT	-
Smoyer-Tomic	2008	4/5	Edmonton	Cross-sectional	SES and food access	215		SES	Census 2001	Food access	Capital Health Region, Health Inspection Division	census block	+
Hemphill	2008	4/5	Edmonton	Cross-sectional	SES and access to fast food outlets	204	3128/neighbourhood	SES	Low income individuals, recent immigrants, individuals w/o a high school diploma, renters, unemployment	Fast food outlets	Health Inspection Division Database	Equivalent to CT	+
Bertrand	2008	3/5	Montreal	Cross-sectional	SES and distribution of food stores	3158		SES	Census 2001	Food stores (buffer zone)	Source: ministère de l'Agriculture, des Pêcheries et de l'Alimentation and GIS mapping	DA	NS
Auger	2009	6/10	Quebec	retrosepctive database	SES and CVD, alcohol and tobacco related mortality	143	271,068	SES	Census (DA income)	CVD Mortality	Death database	Non-standard (Local community service center)	+
Naimi	2009	6/10	Montreal	Cross-sectional	SES and BMI	7	342	SES	Census (area level unemployment)	BMI	Measured directly	DA	+
Harrington	2009	7/10	Canada	Cross-sectional	Contribution of area level factors to development of obesity	163	2538	SES	1991 Canadian Census	Obesity (BMI)	Measured directly (OHS)	FSA	+
Label	2009	5/10	Quebec	Cross-sectional	SES and overweight	51	20449	SES (Deprivation index)	Census 2001 (DA income)	Overweight	Self-reported-CCHS		NS

Jones	2009	3/5	Nova Scotia	Cross-sectional	SES and fast food restaurants	306		Material deprivation	Age standardized score	Count of total number of restaurants per community	GIS	Admin-Nova Scotia community counts	-
Daniel	2009	4/5	Montreal	Cross-sectional	SES and access to stores selling fresh foods and veggies	846		SES	Census 2001 composite index	Density of stores	Commercial business database	CT	NS
Feldman	2010	6/10	Ontario	Database review	SES and CVD morbidity and risk factors	49		SES	Census 1996	CVD morbidity	Hospitalization rated (ICES). Risk factors (OHS)	County	+
Matheson	2010	7/10	Canada	Cross-sectional	SES and hypertension	3663	116277	SES (Deprivation index)	Census 2001	Hypertension	Self-reported		+
Menec	2010	5/10	Winnipeg	Cross-sectional	SES and hypertension, CHD, IHD, MI		77,930	SES (Deprivation index)	Census 2006 (DA income)	Outcomes	Administrative data files	CMA	+
Borugian	2011	7/10	Canada	Cross-sectional	SES and prevalence of breast cancer	226,169		SES	Census (DA) 1991,2001,2006	Breast Cancer	Cancer registry	EA	-
Black	2011	4/5	British Columbia	Cross-setional	SES and access to food stores	630 CTs		SES	Neighbourhood socioeconomic status (Median household income, ethnic composition)	Access to food stores	Proximity (median distance to closest store), Availability (median number of stores available within 1 km of random selections of households in CT)	CT	NS
Joseph	2012	4/10	Six Nations	Cross-sectional	Built environment at Six nations	1	63	Built Environment and perceived food environment	NEWS and EPOCH-2			Reserve boundaries	
Gould	2012	4/5	Gatineau	Cross-sectional	SES and access to stores selling fresh	17		SES	Census 2001: composite index	Access: distance, number, size		DA	-

					foods and veggies								
White	2013	7/10	Urban Canada	Cross-sectional	Material deprivation and health		110,031	SES (Deprivation index)	Census 2001 (CT)	Health: CVD, diabetes, obese, smoking, drinking	CCHS-self-reported	CT	+
Hystad	2013	7/10	Newfoundland, Nova Scotia, Prince Edward Island, Ontario, Manitoba, SaskatchewanAlberta and British Columbia	Case-control	SES and incidence of lung cancer	3026		SES	Census 2001 (CT)	Incidence of lung cancer	National Enhanced Cancer Surveillance System	CT	+
TOBACCO ENVIRONMENT													
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association**
Lemstra	2009	7/10	Saskatoon	Retrospective database	Smoking ban and incidence rate of CVD		2545	Smoking ban (July 1, 2004)		Hospitalization rates	Strategic Health Information Planning Services (SHIPS)	City	+
Naiman	2010	7/10	Toronto	Case control. Toronto (Case), ThunderBay and Durham (Control)	Smoking ban and hospitalization rates		Toronto: 2 503 281 Thunder Bay: 109 140 Durham: 561 256 Canada: 36 612 897	Smoking ban: 1999 (public and workplaces), June 2001 (restaurants, diners, theatres), June 2004 (all bars, casinos, racetracks, bingo halls)		Hospitalization rates	DAD	Municipalities	+
Gaudreau	2013	7/10	Prince Edward Island	Case control Prince Edward Island(Case), New Brunswick (Control)	Smoking ban and hospitalization rate			Smoking ban (2003 with amendments in 2006)		Hospitalization rates	DAD	Province	+

ALCOHOL ENVIRONMENT													
Author	**Year**	**Score**	**Location**	**Design**	**Relationship Studied**	**N (communities)**	**N (individuals)**	**Contextual factor**	**Contextual factor measurement**	**Outcome**	**Outcome Ascertainment**	**Community Definition**	**Association**
Rush	1984	6/10	Ontario	Cross-sectional	Alcohol availability, consumption and alcohol related damage	49 counties		Alcohol Availability	49 counties	Density of alcohol outlets/1000 adults	Alcohol Consumption		+
Stockwell	2011	6/10	British Columbia	Time-series	Alcohol price and consumption	British Columbia		Minimum price	Price increase policy	Liquor board data	Alcohol consumption		+
Stockwell	2011	6/10	Saskatchewan	Time-series	Alcohol outlet density and consumption	Saskatchewan		Minimum Price	Price increase policy	Liquor board data	Alcohol consumption		+

Table 4. Characteristics of included studies.
*Association positive (+), inverse (-) or not significant (-)
CVD: Cardiovascular Disease, ACS: Acute Coronary Syndrome, CHD: Coronary Heart Disease, IHD: Ischemic Heart Disease, MI: Myocardial Infarction.
FSA: Forward Sortation Area, CT: Census Tract, PHU: Public Health Unit, CCHS: Canada Community Health Survey, CMA: Census Metropolitan Area, DA: Dissemination Area
GIS: Geographic Information System, RFEI: Retail Food Environment Index,
IPAQ: International Physical Activity Questionnaire, QOL: Qulaity of Life, APPROACH: *Alberta* Provincial Project for Outcome Assessment in Coronary Heart Disease, NEWS: Neighbourhood Environment Walkability Scale, EPOCH: Environmental Profile of Community Health, OHS: Ontario Health Study, DAD: Discharge Abstract Database.

Nutrition Environment										
Author, Year	**Study Design**	**Sample Representativeness**	**Sample Size**	**Non-Respondents**	**Ascertainment of Exposure**	**Community Definition**	**Outcome Ascertainment**	**Analysis**	**Comparability***	**Total**
Paquet, 2009	0	1	0	1	1	1	1	1	2	8
Paquet, 2010	0	1	0	1	1	1	0	1	2	7
Daniel, 2010	0	1	0	0	1	1	0	1	2	6
Kestens, 2012	0	1	0	0	1	1	0	1	2	6
Chum, 2013	0	1	0	0	1	1	0	1	2	6
Alter, 2005	0	1	0	0	0	1	0	1	2	5
Mercille, 2012	0	0	0	0	1	1	0	1	2	5
Minaker, 2013	0	0	0	0	1	1	0	1	2	5
Spence, 2009	0	0	0	0	1	1	0	1	2	5
Kirkpatrick, 2010	0	0	0	0	1	1	0	1	2	5
Lear, 2013	0	0	0	0	1	0	0	1	2	4
Willows, 2011	0	0	0	0	1	0	0	1	2	4
Hollands, 2013	0	0	0	0	1	1	0	1	1	4
Physical Activity Environment										
Author, Year	**Study Design**	**Sample Representativeness**	**Sample Size**	**Non-Respondents**	**Ascertainment of Exposure**	**Community Definition**	**Outcome Ascertainment**	**Analysis**	**Comparability***	**Total**
Gauvin,2011	1	1	0	0	1	1	1	1	2	8
Booth,2013	1	1	0	0	1	1	0	1	2	7
Villeneuve,2012	0	1	0	1	1	1	0	1	2	7
Craig,2002	0	1	0	0	1	1	0	1	2	6
Gauvin, 2008	0	1	0	0	1	1	0	1	2	6
Prince,2011	0	1	0	0	1	1	0	1	2	6
Riley,2013	0	1	0	0	1	1	0	1	2	6
Oliver,2011	0	0	0	0	1	1	0	1	2	5
Schuurman, 2009	0	0	0	0	1	1	0	1	2	5
Poulioi,2010	0	1	0	0	1	0	0	1	2	5
Taylor,2009	0	0	0	0	1	0	0	1	2	4
Socio Economic Status										
Author, Year	**Study Design**	**Sample Representativeness**	**Sample Size**	**Non-Respondents**	**Ascertainment of Exposure**	**Community Definition**	**Outcome Ascertainment**	**Analysis**	**Comparability***	**Total**
**Apparicio, 2007	0				1	1	1	1		4/5
**Black, 2011	0				1	1	1	1		4/5
**Daniel,	0				1	1	1	1		4/5

2009										
**Gould, 2012	0				1	1	1	1		4/5
**Jones,2009	0				1	1	0	1		3/5
**Larsen,2010	0				1	1	1	1		4/5
**Latham,2007	0				1	1	1	1		4/5
**Bertrand, 2008	0				0	1	1	1		3/5
Matheson, 2008	0	1	0	1	1	1	0	1	2	7
Matheson, 2010	0	1	0	1	1	1	0	1	2	7
Ng, 2004	1	1	0	0	1	1	0	1	2	7
Borugian, 2011	1	1	0	0	1	1	0	1	2	7
Ross,2007	0	1	0	1	1	1	0	1	2	7
Ross,2007	0	1	0	1	1	1	0	1	2	7
Mackillop, 2007	1	1	0	0	1	1	0	1	2	6
Naimi, 2009	0	0	0	0	1	1	1	1	2	6
Menec, 2010	0	0	0	0	1	1	0	1	2	5
Lemstra, 2006	0	0	0	0	1	1	0	1	2	5
Tobacco Environment										
Author, Year	**Study Design**	**Sample Representativeness**	**Sample Size**	**Non-Respondents**	**Ascertainment of Exposure**	**Community Definition**	**Outcome Ascertainment**	**Analysis**	**Comparability***	**Total**
Lemstra,2008	1	1	0	0	1	1	0	1	2	7
Naiman,2010	1	1	0	0	1	1	0	1	2	7
Gaudreau,2013	1	1	0	0	1	1	0	1	2	7
Alcohol Environment										
Author, Year	**Study Design**	**Sample Representativeness**	**Sample Size**	**Non-Respondents**	**Ascertainment of Exposure**	**Community Definition**	**Outcome Ascertainment**	**Analysis**	**Comparability***	**Total**
Rush,1984	0	0	0	0	1	0	1	1	2	5
Stockwell,2011	1	0	0	0	1	0	0	1	2	5
Stockwell,2011	1	0	0	0	1	0	0	1	2	5

Table 5. Methodological quality of the included studies.

*A maximum of 2 scores can be given in the comparability section.

**Studies that examined the association between SES and access to food store were scored out of a total of 5 points. The questions on sample size were not applicable to these studies.

Province	Number of FSAs	Total Number of Postal Codes	Population	Median Income ($)*
ON	526 (Urban: 465, Rural: 61)	282123	12651785	81041
QC	419 (Urban: 351, Rural: 68)	215565	7732500	68699
BC	190 (Urban: 167, Rural: 23)	116462	4324405	76685
AB	153 (Urban: 125, Rural: 28)	82962	3567800	91510
SK	49 (Urban: 37, Rural: 12)	22214	1008895	80609
MN	66 (Urban: 49, Rural: 17)	24934	1174350	74205
NS	77 (Urban: 57, Rural: 20)	28171	906160	68543
NB	111 (Urban: 50, Rural: 61)	59530	735850	60767
NL	35 (Urban: 18, Rural: 17)	11133	507270	66788
PEI	7 (Urban: 5, Rural: 2)	3995	137375	67990
Total	1633			

Table 6. Population and Median Income for Canadian FSAs by province. Data obtained from Census Canada 2011 and PCCF 2013[18]. ON: Ontario, QC: Quebec, AB: Alberta, SK: Saskatchewan, MN: Manitoba, NS: Nova Scotia, NB: New Brunswick, NL: Newfoundland and Labrador, PEI: Prince Edward Island.
*Median income of economic families: economic family is defined as a group of two or more persons who are related to each other by marriage, common-law or adoption and live in the same dwelling.

Province	**Number of Postal Codes to be Audited in CVCD**
ON	208
QC	108
BC	50
AB	46
SK	8
MN	12
NS	26
NB	30
NL	14
PEI	2

Table 7. Number of postal codes assessed in CVCD by province. ON: Ontario, QC: Quebec, AB: Alberta, SK: Saskatchewan, MN: Manitoba, NS: Nova Scotia, NB: New Brunswick, NL: Newfoundland and Labrador, PEI: Prince Edward Island.

ON					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	61	24.4	8.0, 72.9	40.67	38.36
21-80	16	26.6	13.4, 43.1	30.4	30.72
81-100	454	1121.6	316.6, 2439.9	7.59	11.31
QC					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	69	24.8	10.6, 83.7	20.04	24.53
21-80	16	14.7	6, 24.3	68.52	84.2
81-100	233	1137.7	409.2, 4517.6	7.31	11.43
BC					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	20	19.6	1.3, 236.6	70.04	68.9
21-40	8	89.1	32.5, 342.4	90.125	98.625
81-100	164	1034	355.4, 2463.5	9.886	15.363
AB					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	28	403.19	171, 547.4	38.425	29.72727
21-80	6	2.6	1.3, 3.6	112.32	82.8
81-100	118	1186.8	685.3, 1329	12.5904	14.38333
SK					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	13	1.26	0.73, 74.1		
21-80	N/A	N/A	N/A	N/A	N/A
81-100	36	1060.3	602.7, 1327.6		
MN					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	16	61.6	1.8, 415.7	43.783	46.533
21-80	3	3.1	3, 7.15	38.733	40.333
81-100	45	1430	746.9, 1429.9	6.843	10.953
NS					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km²**	**IQR (Population Density)**	**Access to Health Care**	

				Distance (km)	Travel time (mins)
0-20	19	4.6	3.1, 214.5	38.31	44.9
21-80	6	13.3	12.4, 17	37.517	31.6
81-100	52	1186.8	685.3, 1329	18.345	21.137
NB					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km^2**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	62	10.1	5.5, 40.9	46.862	43.1
21-80	12	6.9	4.1, 49.5	38.75	47
81-100	37	199.2	20.7, 313.5	21.889	24.487
NL					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km^2**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	17	34.5	7.9, 106	40.41	40.3
21-80	2	30	28.7, 31.3	55.2	117.5
81-100	16	238	238, 293.1	22.569	21.0625
PEI					
% Urban Postal Codes in the FSA	**Total # FSAs in the province**	**Median Population Density/km^2**	**IQR (Population Density)**	**Access to Health Care**	
				Distance (km)	Travel time (mins)
0-20	2	11	10.9, 11.2	23.8	22.5
21-80		N/A	N/A	N/A	N/A
81-100	5	779.7	520.1, 779.7	6.82	8.6

Table 8. Matrix of Rurality. ON: Ontario, QC: Quebec, AB: Alberta, SK: Saskatchewan, MN: Manitoba, NS: Nova Scotia, NB: New Brunswick, NL: Newfoundland and Labrador, PEI: Prince Edward Island.
Rural FSA: ≤20% postal codes fall within a metropolitan area. Urban FSA: > 20% postal codes fall within a metropolitan area.
Distance measured in km from the geographical center of each FSA to the nearest hospital. Time taken to travel (in mins) from the geographical center of each FSA to the nearest hospital

Cost of Food Basket ($)				
Community	Rater 1	Rater 2	Agreement	Mean Agreement (SD)
L0N (Rural)	103.93	105.58	-1.65	-0.05(1.26)
L8E (Urban)	83.53	83.34	0.20	
L7S (Urban)	73.74	73.74	0	
Six Nations Reserve	87.86	86.46	1.40	
Total Number of Available Fruits				
Community	Rater 1	Rater 2	Agreement	Mean Agreement (SD)
L0N (Rural)	28	27	1	0.5 (1)
L8E (Urban)	26	27	-1	
L7S (Urban)	26	25	1	
Six Nations Reserve	6	5	1	
Total Number of Available Vegetables				
Community	Rater 1	Rater 2	Agreement	Mean Agreement (SD)
L0N (Rural)	32	33	-1	
L8E (Urban)	33	32	1	-0.25(0.96)
L7S (Urban)	5	5	0	
Six Nations Reserve	32	33	-1	
Price of a Case of 24 Cans of Beer (12 Oz. Each)				
	Rater 1	Rater 2	Agreement	Mean Agreement (SD)
L8S (Urban)	10.95	10.95	0	-0.5 (0.71)
L8K (Urban)	9.95	8.95	-1	
Price of a Bottle of White Wine (750 ml)				
	Rater 1	Rater 2	Agreement	Mean Agreement (SD)
L8S (Urban)	34.95	34.95	0	
L8K (Urban)	38.95	37.95	-1	-0.5 (0.71)

Table 9. Inter-rater agreement for the prices and availability of food items and prices of alcoholic beverages.

	Urban	**Rural**	**p-value**
Number of FSAs	83	7	
Total Number of Postal Codes within the FSAs	56231	2860	
Median Income ($)	81981.5	71720	
Mean Walkscore (SD)	45.20 (23.8)	40.57 (38.9)	0.64
Food Cost			
Number of FSAs Analysed	66	7	
Mean Cost for Food Basket ($)(SD)	72.73 (10.8)	75.35 (11.2)	0.55

Table 10. Variation in food basket cost and mean walk score in urban and rural areas. Mean costs and walkscores were compared using student's t-test.

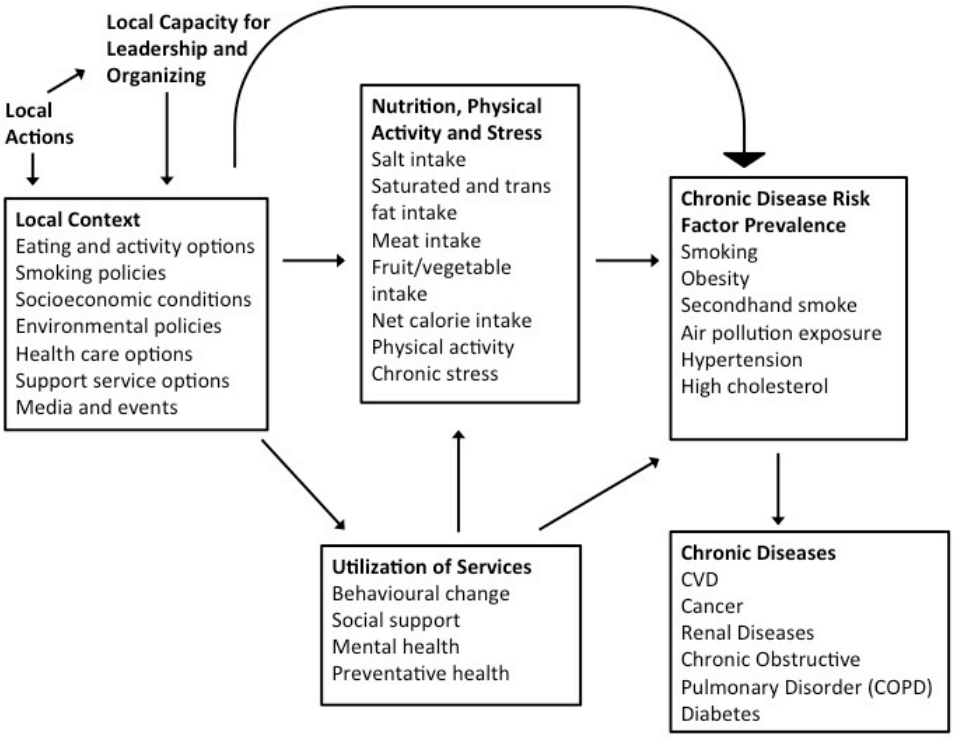

Figure 1. A framework for the influence of contextual factors on the prevalence of risk factors for chronic diseases[3,5]

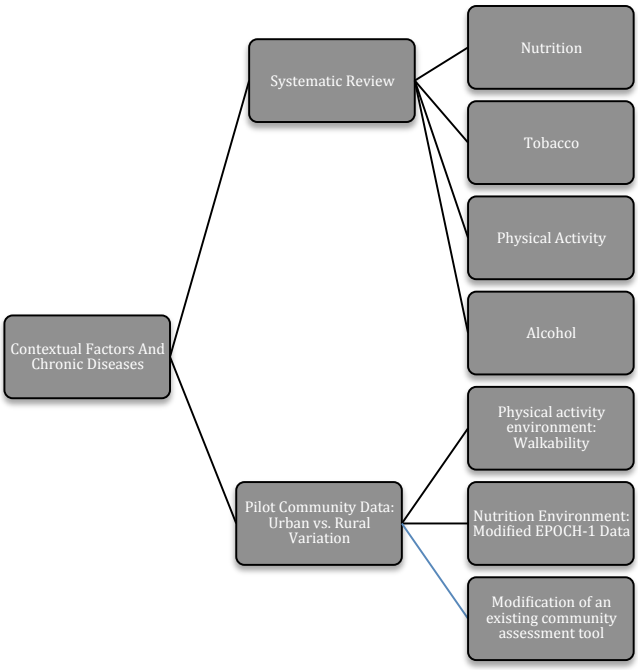

Figure 2. A pictorial depiction of thesis objectives.

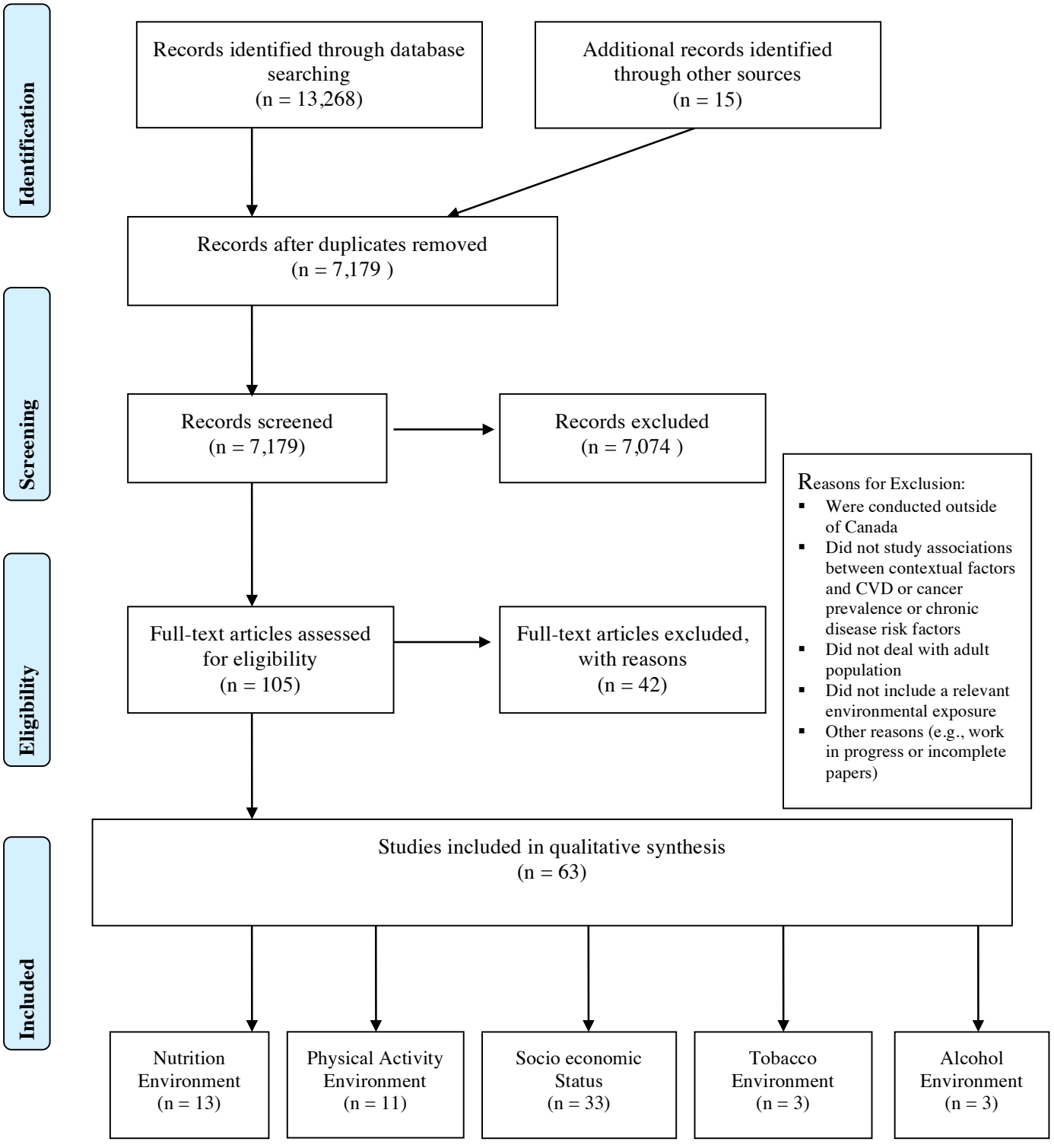

Figure 3. CONSORT diagram of flow of studies through selection process.

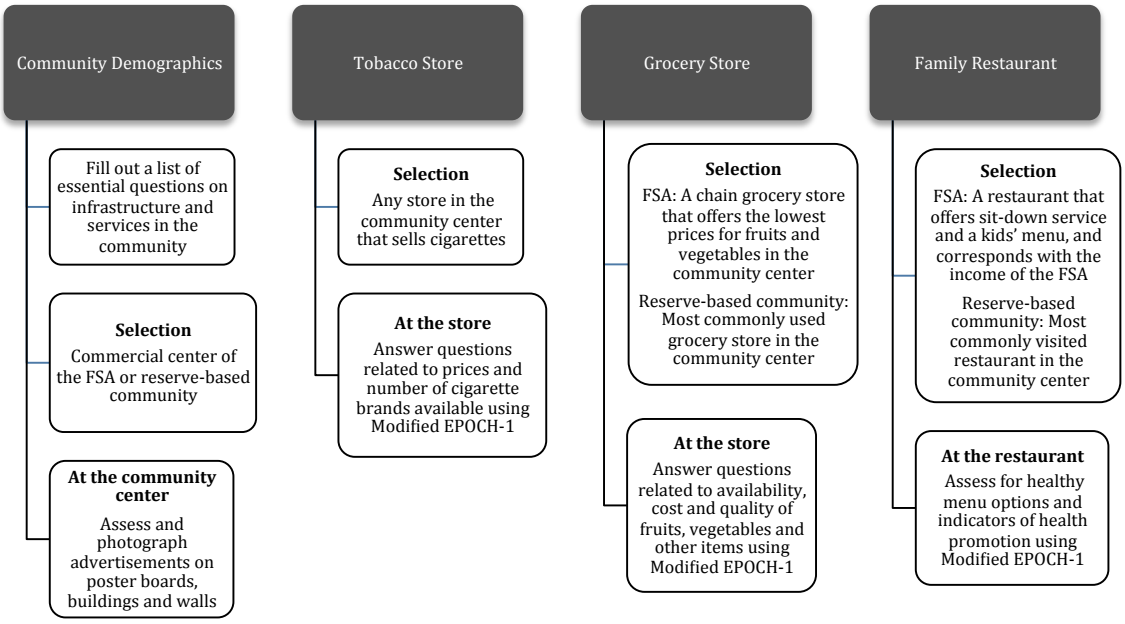

Figure 4. A pictorial representation of the CVCD audit process using modified EPOCH-1 questionnaire.

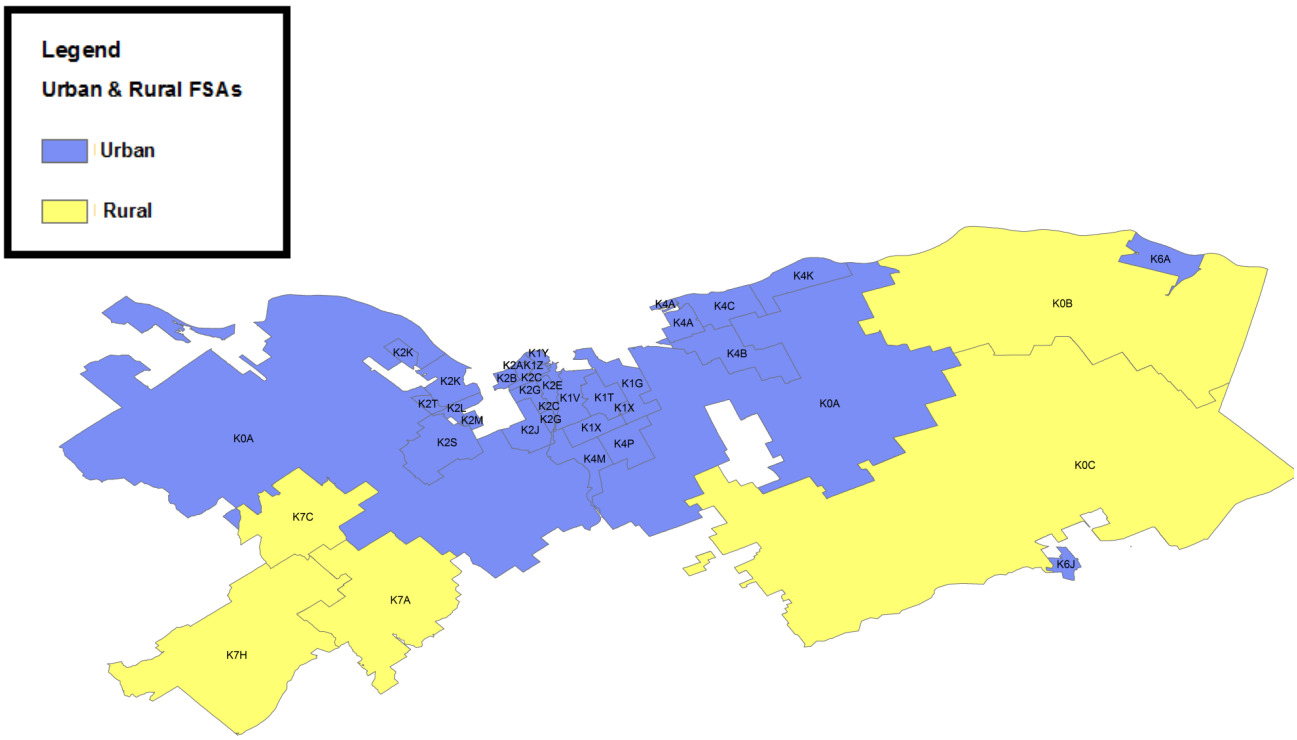

Figure 5. Urban and rural FSAs in Ottawa and surrounding areas.

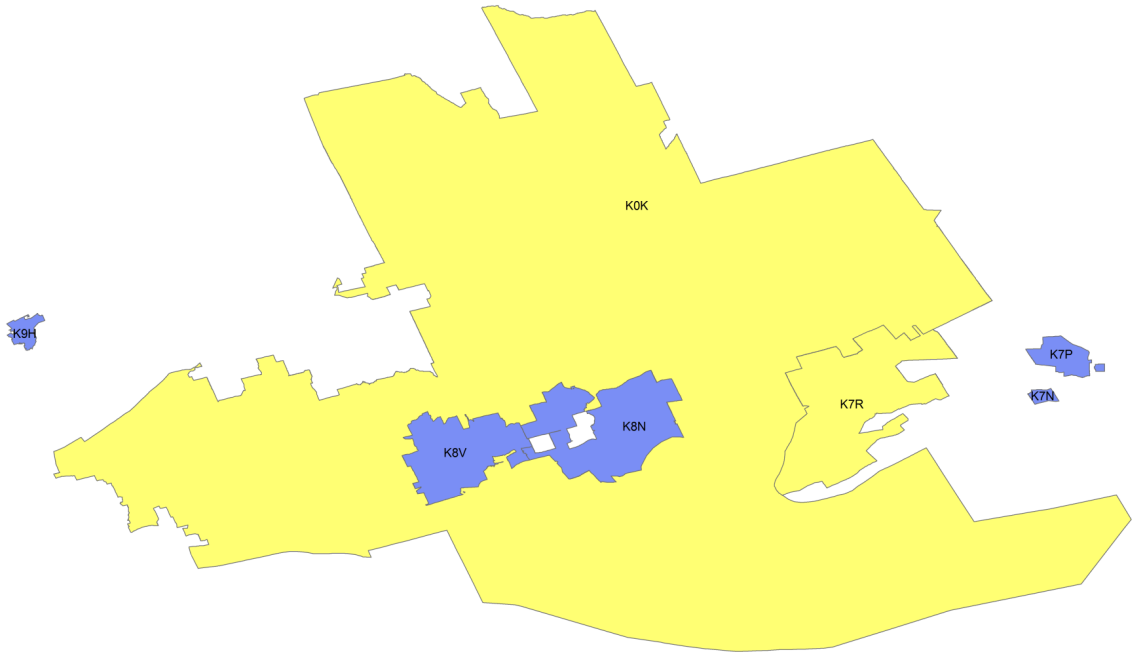

Figure 6. Urban and rural FSAs in Ottawa and surrounding areas.

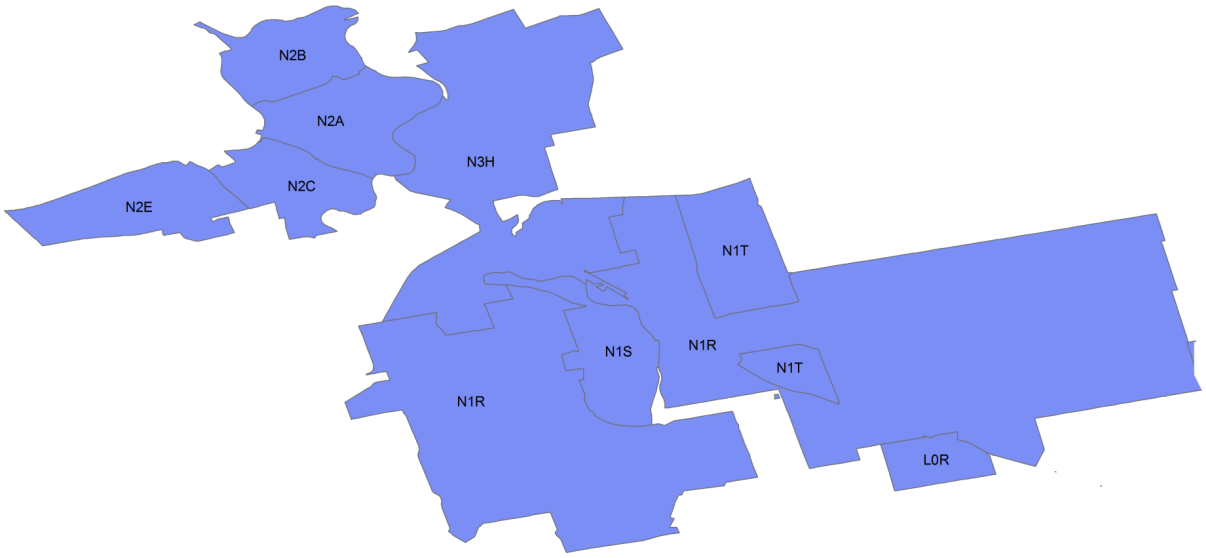

Figure 7. Urban and rural FSAs in region of Kitchener/Waterloo.

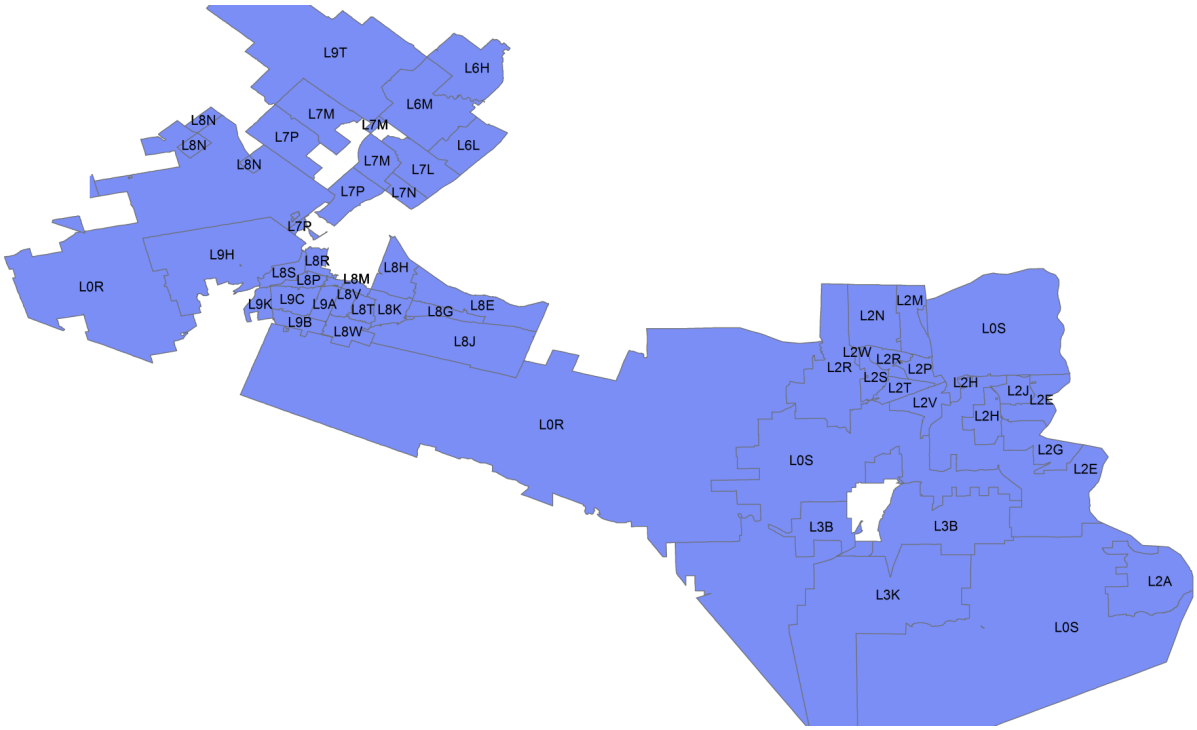

Figure 8. Urban and rural FSAs in Hamilton, Burlington and surrounding areas.

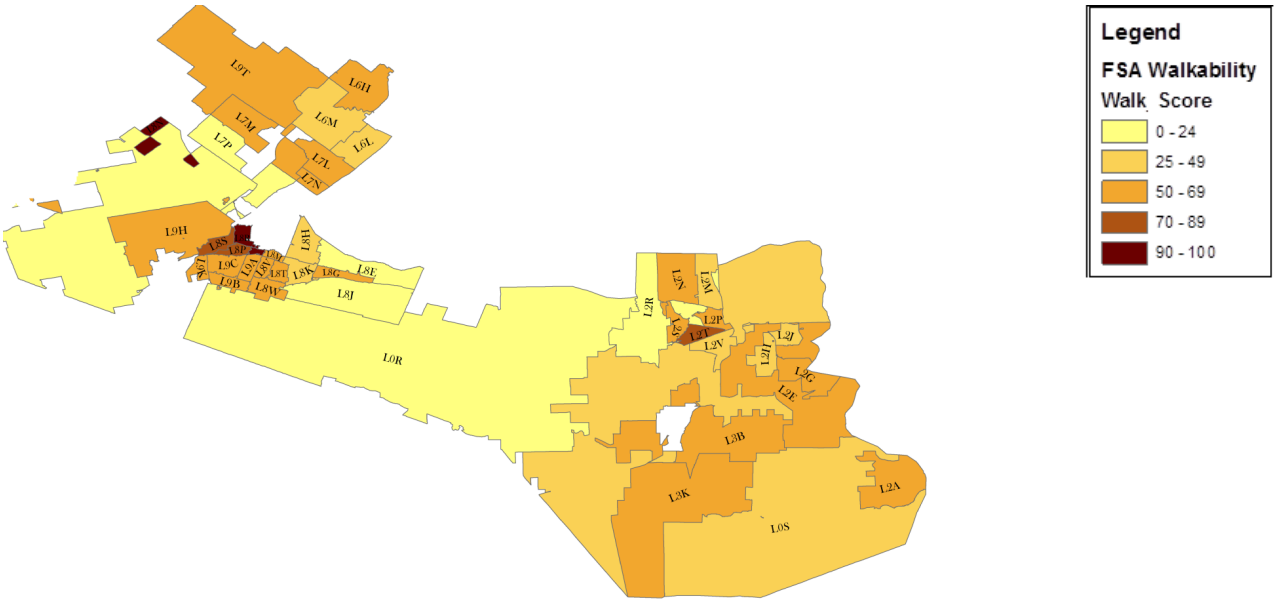

Figure 9. Walkability map for Hamilton, Burlington and surrounding areas.

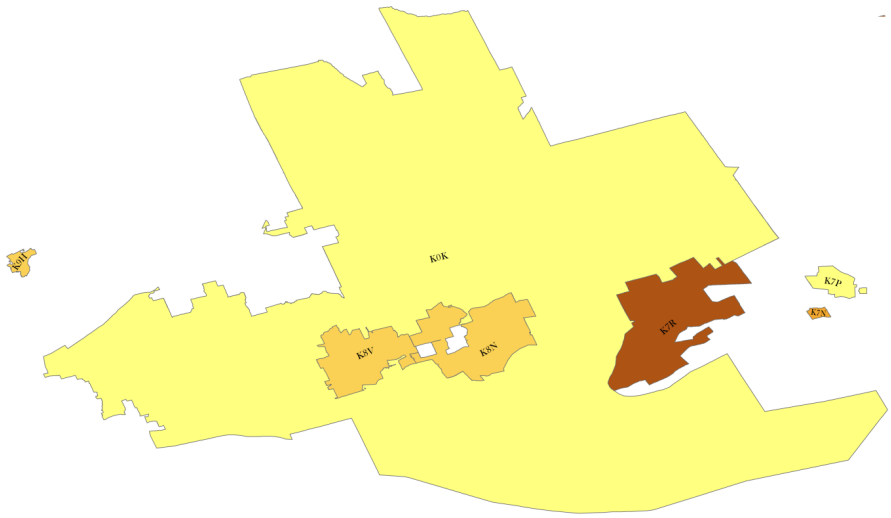

Figure 10. Walkability map for Ottawa and surrounding areas.

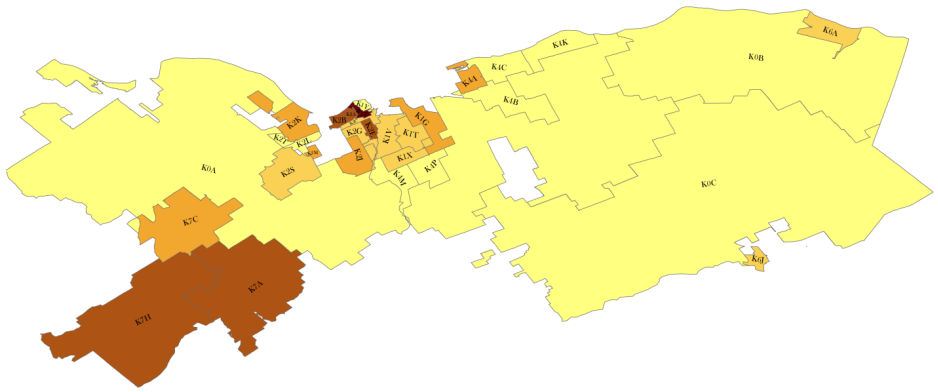

Figure 11. Walkability map for Ottawa and surrounding areas.

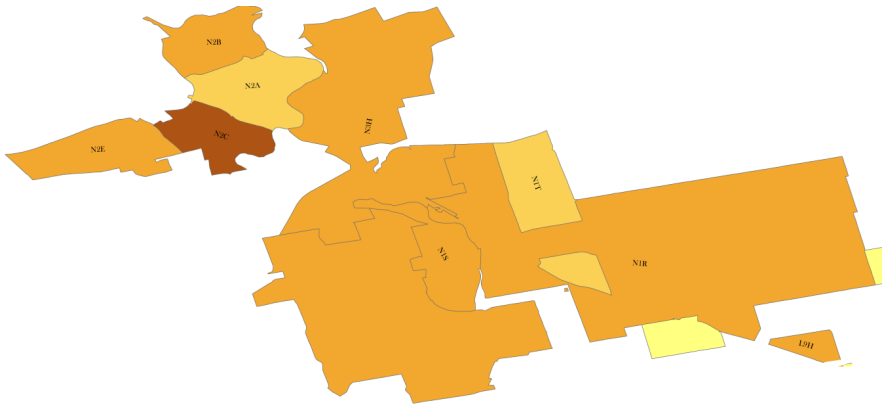

Figure 12. Walkability map for Waterloo/Kitchener region.

Appendix 1

Search Strategy: Medline, Inception-January 15, 2014.

1	exp cardiovascular disease/	2997531
2	cardio*.mp.	1080024
3	coronary*.mp.	520138
4	angina*.mp.	93698
5	ischemi*.mp.	484336
6	arrhythmi*.mp.	156140
7	myocard*.mp.	411501
8	1 or 2 or 3 or 4 or 5 or 6 or 7	3444356
9	exp environment/	4510251
10	park*.mp.	163258
11	exp demography/	140353
12	exp environmental planning/	6490
13	neighbourhood*.mp.	5052
14	neighborhood*.mp.	14587
15	grocer*.mp.	1556
16	fast food/	2605
17	exp smoking/	187174
18	smok*.mp.	320659
19	exp Tobacco Industry/ or tobacco.mp. or exp Tobacco/	100539
20	exp Alcohol Drinking/ or alcohol*.mp.	481553
21	drink*.mp. or exp Alcoholism/	229354
22	canad*.mp.	197702
23	exp Canada/	128675
24	Ontario/ or ontario*.mp.	137055
25	Alberta/ or alberta*.mp.	130859
26	Quebec/ or quebec*.mp.	123094
27	"Newfoundland and Labrador"/ or newfoundland*.mp.	129250
28	Manitoba/ or manitoba*.mp.	129630
29	Saskatchewan.mp. or Saskatchewan/	129491
30	Prince Edward Island/ or prince*.mp.	134869
31	Nova Scotia/ or nova*.mp.	172984

32	British Columbia/	128675
33	yukon.mp. or Yukon Territory/	128953
34	northwest*.mp. or Northwest Territories/	142311
35	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21	5232420
36	22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34	271321
37	8 and 35 and 36	12961
38	limit 37 to (english language and humans)	11147
39	exp Cholesterol/ or cholesterol*.mp.	308523
40	lipid*.mp.	558530
41	exp Lipids/	1143718
42	exp Hypercholesterolemia/ or exp Hyperlipidemias/	109624
43	exp Blood Pressure/	397205
44	exp Hypertension/	486655
45	exp Body Weight/	403748
46	exp Body Mass Index/	177800
47	exp Hyperglycemia/	59078
48	39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47	2505294
49	35 and 36 and 48	10161
50	limit 49 to (english language and humans)	7600
51	50 not 38	3205
52	cancer*.mp.	2182570
53	Cell Line, Tumor/ or Adrenal Rest Tumor/ or Adenomatoid Tumor/ or Wilms Tumor/ or tumor*.mp. or Granular Cell Tumor/ or Carcinoid Tumor/	2156530
54	Neoplasms/ or tumour*.mp.	522786
55	Carcinoma/ or carcinoma*.mp.	852878
56	sarcoma*.mp.	123455
57	Teratoma/ or teratoma*.mp.	27883
58	52 or 53 or 54 or 55 or 56 or 57	3541495
59	environment/ or atmosphere/ or air/ or weather/ or air movements/ or rain/ or sunlight/ or temperature/ or cities/ or exp climate/ or noise/	384455
60	park*.mp.	163258
61	demography/ or age distribution/ or censuses/ or family characteristics/ or health status/ or population dynamics/ or sex distribution/	424007
62	exp Population/ or exp Environmental Exposure/ or commute.mp. or exp Residence Characteristics/	399830
63	walkability.mp. or Environment Design/	6772

64	neighbourhood.mp.	4231
65	neighborhood*.mp.	14587
66	Food/ or food*.mp.	570146
67	grocer*.mp.	1556
68	Fast Foods/ or Diet/ or Restaurants/ or restaurant*.mp.	165955
69	exp Smoking/ or smok*.mp.	320659
70	exp Tobacco Industry/ or exp Tobacco/ or tobacco*.mp.	100613
71	alcohol*.mp.	472946
72	Alcoholism/ or drink*.mp. or exp Alcohol Drinking/ or Drinking Behavior/	229354
73	canad*.mp.	197702
74	exp Canada/	128675
75	ontario*.mp.	21222
76	alberta*.mp.	6537
77	quebec*.mp.	11143
78	newfoundland*.mp.	1453
79	manitoba*.mp.	3012
80	Saskatchewan.mp. or Saskatchewan/	129491
81	73 or 74 or 75 or 76 or 77 or 78 or 79 or 80	208750
82	59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 71 or 72	2559190
83	58 and 81 and 82	4159
84	limit 83 to (english language and humans)	3439
85	84 not 51	3252
86	85 not 38	2821

Appendix 2

Search Strategy: CINAHL, Inception-January 15, 2014

Search Terms	Search Options	Actions
S44 AND S45 AND S46	Search modes Boolean/Phrase	- (558)
S43 AND S45 AND S46	Search modes Boolean/Phrase	- (587)
S8 AND S45 AND S46	Search modes Boolean/Phrase	- (642)
S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20	Search modes Boolean/Phrase	- (325,451)
S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33	Search modes Boolean/Phrase	- (56,060)
S34 OR S35 OR S36 OR S37 OR S38 OR S39	Search modes Boolean/Phrase	- (127,125)
S40 OR S41 OR S42	Search modes Boolean/Phrase	- (139,917)
(MH "Teratoma+")	Search modes Boolean/Phrase	- (264)
(MH "Carcinoma+")	Search modes Boolean/Phrase	- (17,878)
(MH "Neoplasms, Germ Cell and Embryonal+") OR "cancer"	Search modes Boolean/Phrase	- (130,632)
(MH "Hyperglycemia+") OR "hyperglycemia"	Search modes Boolean/Phrase	- (6,341)
(MH "Body Mass Index")	Search modes Boolean/Phrase	- (30,022)
(MH "Hypertension+") OR "hypertension"	Search modes Boolean/Phrase	- (40,145)
(MH "Blood Pressure+") OR "blood pressure"	Search modes Boolean/Phrase	- (32,405)

(MH "Lipids+") OR "lipids"	Search modes Boolean/Phrase	-	(41,982)
(MH "Cholesterol+") OR "cholesterol"	Search modes Boolean/Phrase	-	(18,311)
(MH "Northwest Territories")	Search modes Boolean/Phrase	-	(53)
(MH "Yukon Territory")	Search modes Boolean/Phrase	-	(33)
(MH "British Columbia")	Search modes Boolean/Phrase	-	(3,263)
(MH "Nova Scotia")	Search modes Boolean/Phrase	-	(1,016)
(MH "Prince Edward Island")	Search modes Boolean/Phrase	-	(92)
(MH "Saskatchewan") OR "saskatchewan"	Search modes Boolean/Phrase	-	(1,772)
(MH "Manitoba") OR "manitoba"	Search modes Boolean/Phrase	-	(1,413)
(MH "Newfoundland")	Search modes Boolean/Phrase	-	(327)
"newfoundland"	Search modes Boolean/Phrase	-	(471)
(MH "Quebec") OR "quebec"	Search modes Boolean/Phrase	-	(4,702)
(MH "Alberta") OR "alberta"	Search modes Boolean/Phrase	-	(3,741)
(MH "Ontario") OR "ontario"	Search modes Boolean/Phrase	-	(12,068)
(MH "Canada+")	Search modes Boolean/Phrase	-	(52,558)
"alcohol" OR (MH "Alcoholism")	Search modes Boolean/Phrase	-	(35,867)
(MH "Tobacco") OR "tobacco"	Search modes Boolean/Phrase	-	(11,953)

"smok*"	Search modes Boolean/Phrase	-	(46,719)
(MH "Smoking+") OR "smoking"	Search modes Boolean/Phrase	-	(43,198)
"fast food"	Search modes Boolean/Phrase	-	(601)
"grocer*"	Search modes Boolean/Phrase	-	(465)
"neighbourhood"	Search modes Boolean/Phrase	-	(890)
"environment design"	Search modes Boolean/Phrase	-	(83)
"park*"	Search modes Boolean/Phrase	-	(11,268)
(MH "Demography+") OR "demography"	Search modes Boolean/Phrase	-	(202,865)
"park*"	Search modes Boolean/Phrase	-	(11,268)
(MH "Environment+")	Search modes Boolean/Phrase	-	(56,174)
S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7	Search modes Boolean/Phrase	-	(162,619)
"cardiovascular"	Search modes Boolean/Phrase	-	(61,503)
"myocard*"	Search modes Boolean/Phrase	-	(39,518)
"arrhythmi*"	Search modes Boolean/Phrase	-	(10,037)
"ischemi*"	Search modes Boolean/Phrase	-	(22,758)
"angina*"	Search modes Boolean/Phrase	-	(5,645)

"coronary*"	Search modes - Boolean/Phrase	(45,958)
"cardio*"	Search modes - Boolean/Phrase	

Appendix 3

List of chain grocery stores in Canada

1. Loblaw Companies Limited
    a. Ontario
        i. Zehrs
        ii. Independent
        iii. T&T Supermarket
        iv. Valu-mart
        v. Fortinos
        vi. Superstore
        vii. No-frills
        viii. Wholesale Club
    b. West
        i. Extra Foods
        ii. Nofrills
        iii. Superstore
        iv. T&T supermarket
        v. Wholesale club
    c. Quebec
        i. Provigo
        ii. Maxi Maxi
        iii. Club entrepot
    d. Atlantic
        i. SaveEasy
        ii. Atlantic superstore
        iii. Nofrills
        iv. Wholesale club

2. Sobeys
    a. Ontario
        i. Sobeys (99)
        ii. Freshco (76)
        iii. Pricechopper (6)
        iv. Foodland (148)
    b. Quebec
        i. IGA extra (112)
        ii. IGA (161)
        iii. Racehlle-bery (19)
        iv. Bonichoix (87)
        v. Tradition (28)
    c. Atlantic
        i. Sobeys (85)

        ii. Foodland (60)
        iii. Needs convenience (124)
        iv. TRA Atlantic Cash and Carry (6)
    d. West
        i. Sobeys (127)
        ii. Thrifty Foods (29)
        iii. IGA (46)
        iv. Price Chopper (1)

3. Metro Inc.
    a. Metro
    b. Super C (Quebec only)
    c. Les 5 saison (Quebec only)
    d. Food Basics
    e. Marché Richelieu (Quebec only)
    f. AMI (Quebec)
4. Safeway Inc (western Canada only)
5. Jim Pattison Group (Alberta and British Columbia)
    a. Buy-low foods
    b. Nesters markets
    c. Save on foods
    d. Price smart foods
    e. Cooper's foods
    f. AG foods
6. North West Company
    a. Giant Tiger
    b. North Mart (Manitoba, Saskatchewan, Nunavut, North-western Territories)
    c. Northern (Manitoba, Saskatchewan, Nunavut, North-western Territories)
7. Co-op Atlantic
    a. Valufoods
    b. Country store
    c. Co-op
    d. Country Garden
8. Costco
9. Walmart

Regional

1. Farmboy (Eastern Ontario)
2. Shop easy (western Canada)
3. Supervalue (east Vancouver)
4. Calgary co-op
5. Faiway Markets (B.C)