Sustainable Neighborhoods and Housing Affordability in Canada:
Is housing affordable in neighborhood with more favorable active living environments?

by

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ABSTRACT

Sustainable neighborhoods are often praised as being model areas, as walking and other modes of active transportation found in them are more accessible. Active living environments are a dimension of sustainable neighborhoods, being areas which promote active living - i.e. a way of life that integrates physical activity into daily routines (Sallis et al., 2005, p.93). Little attention is given to whether affordable housing is found in sustainable neighborhoods. My research explores this question by first examining the variation in housing affordability by neighborhood active living potential in all of Canada, as well as in ten Canadian Census Metropolitan Areas (CMAs). I use statistical methods and data from the 2016 Canadian Census and the Canadian Active Living Environment database. I then turn to field observations in Montreal in order to better understand this relationship on the ground. Findings suggest that neighborhoods more favorable to active living have higher proportions of housing that are unaffordable, but that this relationship varies in different CMAs. Results from field observations suggest that there are micro-scaled, local specificities which may inform why certain environments favorable to active living are affordable and others are not. I end with a few suggestions to inform policy and indicate how to build on my research.

CHAPTER 1: INTRODUCTION

Most North American urban development plans, including those of Canadian metropolitan regions, are currently centered on smart growth and sustainability planning principles, encouraging intensification and walkability, while discouraging the use of private motorized vehicles (Filion & Kramer, 2012). Active living environments (ALEs) encompass some of the motivations behind current planning practices and do contribute to creating sustainable neighborhoods. Active living potential of environments is indeed a dimension of sustainable neighborhoods, as it may reduce carbon footprint by facilitating commute using active modes of transportation and therefore reducing the use of private motorized vehicles, as well as providing physical and mental health benefits for the population. However, sustainable neighborhoods are characterized by different dimensions of sustainability, and the development of sustainable neighborhoods should consider environmental, economic and social aspects of sustainability.

Neighborhoods with more favorable ALEs include features that regulate the likelihood of individuals integrating physical activity into their daily routines, whether during leisure-time or when engaging in physical activity for transportation and other purposes (Gauvin et al., 2005; Sallis et al., 2005). Such neighborhoods are naturally more walkable, but do consider that the environment could allow for a variety of other human-powered activities such as cycling (Gauvin et al., 2005). They may be planned from new or may, in many cases, already exist, as more urban centers often already have existing fabrics which make for denser and well connected and serviced areas which are naturally more walkable and therefore more favourable to active living (Herrmann et al., 2016). In the case of new neighborhoods favourable to active living, these are often developed with key planning principles in mind such as promoting higher densities, mixed land use, and walkability, in the hopes of improving efficiency and reducing carbon emission footprints (Gunder, 2006). In a context of increasing social polarization in cities, the impacts of creating sustainable neighborhoods characterized, for example, by a more favorable active living environment, requires attention. Indeed, the majority of published research on areas favourable to active living mostly disregarded the social problems related to developing sustainable urban environments, as it is more centered on assessing sustainable neighborhoods and the many benefits they represent (Cuthill et al., 2019).

My research questions whether sustainable neighborhoods, here defined as neighborhoods with more favorable active living environments, are inclusive – i.e. whether they offer housing options which are affordable to people. Housing is an important indicator of neighborhood sustainability as it is an essential component of the quality of life (Winston & Pareja, 2008; Smets & van Lindert, 2016).

Some Canadian regions are currently undergoing a housing crisis, most notably due to the lack of affordable housing. This is a nation-wide problem, affecting large cities and smaller communities (Armstrong, 2019). Housing unaffordability in Canada is described as households having to spend more than thirty percent of their income on housing-related costs (CMHC, 2015). Among all housing needs, unaffordability is the need most experienced by Canadian households (CMHC, 2017).

The geography of housing affordability is uneven across the country (Bunting et al., 2004), and may be patterned by characteristics of the built environment, such as the active living potential of neighborhoods. Furthermore, the peripheries of large urban areas which tend to be under-served and often isolated areas are becoming more impoverished, while well-served highly connected, and therefore more walkable, central urban areas tend to attract wealthier and less ethnically diverse residents (Kramer, 2018; Hess, 2018). I hope that my research will contribute to the scientific literature in terms of providing a nation-wide assessment of whether affordable housing is found in more sustainable neighborhoods in Canada, here described as neighborhoods with more favorable ALE. Indeed, the only research done examining dense, walkable environments in relation to housing affordability in Canada was conducted by Moos et al. (2018) and is specific to Toronto.

1.1 Purpose: Aim and research questions

This research examines the relationship between neighborhood-level active living environment and neighborhood-level housing affordability. My research is therefore guided by three questions:

1. Is the prevalence of housing unaffordability higher in neighborhood with more favorable ALEs in Canada?

a. Is this association confounded by neighborhood-level socioeconomic conditions?

2. Does the association between ALEs and housing unaffordability vary across selected Census Metropolitan Areas (CMAs)?
a. Is this association confounded by neighborhood-level socioeconomic conditions?

3. What characterizes neighborhoods with more favorable ALE and varying rates of housing unaffordability in the Montreal CMA?

My thesis first starts with a review of the literature on the topic of housing affordability in ALEs or walkable neighborhoods (Chapter 2). In the methodology section (Chapter 3) I explain the study design, data, the statistical methods used, and the field observations. The two results chapters present the outputs of my statistical analysis for Canada and for selected CMAs (Chapter 4), and the characterization of neighborhoods in the Montreal CMA using descriptive statistics and field observations (Chapter 5). Chapter 6, the discussion section, then analyzes the results found in the previous chapters in relation to the scientific literature, paying attention to the patterns and relationships observed. My research paper ends with Chapter 7, the conclusion section, which includes thoughts and suggestions based on my research findings.

CHAPTER 2: LITERATURE REVIEW

This chapter reviews the literature concerning sustainable neighborhoods as environments promoting active living and housing affordability, and how such environments and housing affordability relate to each other in the current western political-economic context. I first address active living environments (ALEs) and housing as determining aspects of sustainable residential/urban/neighborhood development and examine the privatization of both ALEs and housing in the current western society. I then review studies which examine the relationship between features of the built environment promoting active living and housing affordability. Other factors covered in the literature are socioeconomic features of areas, and how housing affordability varies spatially by socioeconomic features.

2.1 Sustainable neighborhoods and housing put in context

The pursuit of sustainability has been the main driver of recent planning initiatives (Cuthill et al., 2019). Planning for sustainability emerged as a practice to reverse the ills related to urban sprawl typical of car-centric post Second World War and suburban developments in Australasian and North America cities (Gunder, 2006; Mattingly & Morrissey, 2014). However, the concept of sustainability brings with it many conflicts, as sustainable developments must necessarily face certain trade-offs, and economic growth tends to come at the expense of social equity (Campbell, 1996). Housing and urban development are main contributors to processes that drive contemporary global capitalism (Madden & Marcuse, 2016, p.8), and given the current neoliberal context which favors the market, the conditions for justice in urban settings are unlikely to be prioritized (Fainstein, 2014). One of the most accurate ways of measuring social equity is through accessibility such as access to decent housing which encompasses affordability (Dempsey et al., 2011). Indeed, affordable housing may enable or prevent households from moving in and out of different neighborhoods (Dempsey et al., 2011). Housing is a basic component for both the built and the social environment, which is why assessing developments through a housing perspective would help determine whether they are striving towards being sustainable (Chui, 2004).

2.1.1 Sustainable neighborhoods in a neoliberal context

Activing Living Environments (ALEs), are areas with features of the built environment supportive of active living (including, but in addition to, walking). Such features include dwelling density, intersection density, as well as points of interests or key destinations found in the area (Herrmann, 2016). They generally refer to residential environments which have higher street connectivity, higher population density, more and diverse points of interest or potential walking destinations, and public transit stops (Hermann et al., 2016; Ross et al., 2016). By encouraging active commuting, ALEs promote physical health, mental health and well-being, reduce negative environmental impacts and offer alternative modes of transport which alleviate transportation costs and carbon footprint? (Rogers et al., 2011; Badland et al., 2014).

There are other definitions tied to active living potential used in the literature which encompass certain characteristics of ALEs. The notion of densification and/or proximity to key destinations is always present, as these are generally understood as promoting walkability, the idea whereby neighborhoods should support residents in walking and using transit so that they can accomplish daily tasks (Quastel et al., p.1056, 2012). For instance, mixed-use development aiming at increasing density and locating housing and key services or destinations within the same building or area (Moos et al., 2018), or transit oriented development (TOD) aiming to create "dense, mixed use, and walkable communities around transit nodes" (Renne et al., p.821, 2016), also promote walkability. Tools such as the Walk Score® are representative of the active living potential of areas. The Walk Score® is used to quantify and assess neighborhood walkability by measuring macro-scale features of the built environment, and is based on population density, block length, intersection density, and distance to common amenities (eg. shops, grocery stores, schools) (Bereitschaft, 2018). The Walk Score® tool is used in Australia, the United States and Canada. Finally, inner city areas are more favorable to active living as they are denser in nature and well-served, being in close proximity to key destinations, services or important transit hubs (Herrmann et al., 2016).

Gentrifying neighborhoods are most often found in inner city areas (Skaburskis, 2012), and may promote active living therefore making them ALEs. Gentrification should be addressed when discussing sustainable neighborhoods, given that densification (i.e. walkability, distance to transit corridors, and dwelling density) is associated with socioeconomic neighborhood conditions, lifestyle, and cultural characteristics of gentrification (Quastel et al., 2012). This

process is both a "spatial and social practice" which is characterized by "an influx of both capital (real estate investment) and higher-income or higher-educated residents" (Chapple & Zuk, 2016, p.112). Gentrification represents a "vast urban restructuring" (Newman & Wyly, 2006, p.52) which includes the displacement of local residents due to increased housing costs.

There are two complementary views of gentrification. The first is the consumption-side perspective whereby individual's preferences, notably for urban life, acts as a push for urban regeneration and investment (Ley, 1993; Padeiro et al., 2019). The second is the "rent gap" theory which explains that declining areas with cheap land but high location land value are prime spaces for capital investment which results in subsequent gentrification (Padeiro et al., 2019). Both views play a role in explaining the increasing housing costs in well-served or central areas. Higher income individuals with certain professions and lifestyle preferences find such areas appealing, and this contributes to increased social polarization due to an economic restructuring in urban landscapes (Sassen, 1991, p.9) which alters the "spatial distribution of households" by income and social class due to changes in housing costs (Moos at al., 2018). Furthermore, the potential profit gains well-served urban areas represent make them prime targets for gentrification. Walkable built environments are indeed good predictors of where gentrification may occur next in cities (Chapple & Zuk, 2016).

In the context of broad political forces, gentrification has become a state-driven process disguised under plans to improve quality of life and sustainability (Lees, 2000). Cities compete globally to develop attractive and mixed-use neighborhoods by encouraging private capital investment resulting in deliberate gentrification and ensuing socio-spatial inequalities (Padeiro et al., 2019). Sustainability or the promotion of high-density developments within this context are often used to market new communities and assure developers gain profit (Carr et al., 2015; Mapes and Wolch, 2011). Government policies for spatial sustainability which promotes concentration as density actually result in economies of scale and generate profit for the real estate community (Carr et al., 2015, p.117). Indeed, features of the built environment and land-use promoting walkability are valued by real estate markets (Sohn et al., 2012), and studies have shown that walkable neighborhoods have inherent economic value by promoting economic transactions and social exchanges (Litman, 2003) as well as increasing property values (Pivo & Fisher, 2011). The concern for social needs and benefits are therefore most often overlooked when it comes to the planning and management of neighborhoods favourable to active living.

2.1.2 Housing in a neoliberal context

Welfare state retrenchment and relating economic liberalization both contribute to the polarization of socioeconomic and class lines which is expressed spatially by the relocation of poverty in urban areas due to gentrification and the related displacement of lower income residents (Hochstenbah & Musterd, 2018). Such retrenchments include the reduction of social housing or protection of renters right, which the Canadian federal government did in the 1990s by dismantling the social housing supply program (Hulchanski, 2004).

The housing crisis Canada is facing stems from changes in the housing system done a few decades ago. Housing affordability, defined as households spending less than thirty percent of their before-tax income on household expenses (CMHC, 2015), is the main issue needing to be addressed, as it is the main contributor of core housing needs – i.e. households do not live in acceptable housing and do not have a sufficient before-tax income to access acceptable housing in their local area (CMHC, 2015). In metropolitan areas, housing unaffordability is much more common for Canadian households to experience than is living in unsuitable (i.e. housing does not have enough bedrooms for the size and composition of residents according to the National Occupancy Standard) or inadequate housing (i.e. housing is in need of major repairs), as it is three or more times more prevalent (Table 2.1).

Table 2.1. Dimensions of housing need by tenure in 2016

	All households		Renter		Owner	
	Number	Rate	Number	Rate	Number	Rate
Total — Need criteria	1,693,775		1,119,910		573,865	
Below one housing standard	1,435,815	84.8%	930,575	83.1%	505,245	88.0%
Affordability only	1,288,315	76.1%	836,770	74.7%	451,540	78.7%
Suitability only	72,100	4.3%	59,955	5.4%	12,140	2.1%
Adequacy only	75,405	4.5%	33,845	3.0%	41,560	7.2%
Below multiple housing standards	257,955	15.2%	189,335	16.9%	68,620	12.0%
Affordability and suitability	104,910	6.2%	83,530	7.5%	21,380	3.7%
Affordability and adequacy	129,125	7.6%	85,730	7.7%	43,395	7.6%
Suitability and adequacy	11,510	0.7%	9,490	0.8%	2,015	0.4%
Affordability, suitability, and adequacy	12,415	0.7%	10,585	0.9%	1,830	0.3%

(Source: Census 2016, https://www.cmhc-schl.gc.ca/en/housing-observer-online/2017-housing-observer/housing-need-stable-in-canada-1-point-7-million-canadian-households-affected)

Madden and Marcuse (2016) speak of housing crisis as stemming from "inequalities and antagonisms of class society" (p.4) and as being an indicator of the housing system working well given its unsustainable nature (Madden & Marcuse, 2016, p.11). Indeed, the Canadian housing system is currently out of balance, as it gives priority to its housing market and incentives for homeownership, while it neglects its housing system which considers renters, those in need of social housing (Hulchanski, 2004). For instance, the rise of condominiums in urban areas is a manifestation of the further privatization of housing whereby homeownership is meant to be more accessible to single or childless households, and especially to young people – those who are between 25 and 34 years old (Moos et al., 2018), living in amenity-rich areas because of convenience and preference despite high housing costs (Danielsen, 1999). However, condominiums found in such areas tend to be affordable only for workers in "well-paid service sector or creative class jobs" (Moos et al., 2018, p.9; Florida, 2012). The rental market is given little consideration regardless of the social need for housing, as many households do not have enough income to participate in the housing market which would generate market demand (Hulchanski, 2004). It is the financially privileged people who benefit from the home ownership system (Forrest & Hirayama, 2015), as the housing system serves the market first (Madden & Marcuse, 2016), which further differentiates social classes through their access to affordable housing.

2.2 The spatial patterning of housing affordability in relation to sustainable neighborhoods

Considering the market-driven motivations behind sustainable neighborhoods and the lack of government support in the allocation and preservation of affordable housing, examining the extent of housing affordability in neighborhood favorable to active living is important, in order to determine whether sustainable neighborhoods are affordable or not. Residential moves of lower-income households are motivated by housing affordability; as a result, they often relocate into more deprived areas of a city with affordable housing options (Baker et al., 2016). Residential landscapes are characterized by increased spatial polarization between higher and lower-income neighborhoods especially in Montreal, Toronto, Ottawa-Gatineau, Calgary and Vancouver (Breau, 2018). Studies have attempted to determine whether such spatial polarization

may be explained by features of the built environment, by paying particular attention to housing affordability.

Research has shown that features of the built environment promoting active living do influence housing costs. Sohn et al. (2012) assessed the economic impact of aspects of the built environment supportive of active living with regards to property value in King County, WA. They found that developments of higher density with higher street and sidewalk coverage contribute to increasing surrounding property values as they were favored by retail service users. Indeed, pedestrian infrastructure and land use mix were shown to increase rental multi-family residential property values. However, this study did not account for other socioeconomic aspects of neighborhoods which may partially explain this relationship. Immergluck and Balan (2018) assumed that the new Atlanta Beltline[1] development was supportive of active living. They examined property values as a function of the proximity to the development. Housing costs within a half-mile of the Beltline increased by 18% to 27% from 2011 to 2015. This suggests increased difficulty for low- or moderate-income households to live in proximity to large-scale, sustainable urban development projects such as this one. However, measuring neighborhood walkability, rather than only considering proximity to environments more favorable to active living, would have made for a more rigorous analysis of the relationship between features of the built environment and housing costs.

Tools such as the Walk Score® have been used to examine how walkability plays a role in the spatial patterning of housing affordability. Findings suggest that access to housing in walkable areas is more expensive, as housing costs are positively correlated to neighborhood Walk Scores® (Gilderbloom, 2015; Knight et al., 2018). Socioeconomic conditions of neighborhoods showed to be associated with Walk Scores, and thus are potential confounders of the relationship between neighborhood walkability and increased housing costs. A study by Riggs (2016) conducted in San Francisco attempted to identify whether access to housing found in walkable neighborhoods was inclusive or not. Results showed that minorities were concentrated in areas with lower Walk Scores and faced many barriers to accessing walkable places which were most likely due to push and pull factors such as income, housing characteristics and social networks. Another study in Boston examined the spatial relationship

[1] This project will "connect 45 Atlanta neighborhoods via a 22-mile loop of trails, parks, and eventually a streetcar, all of which follow an abandoned railroad track." (Immergluck & Balan, 2018, p.546)

between Walk Scores® and socio-demographic conditions of neighborhoods, such as the percentage of minorities and of families below poverty level; they did not observe statistically significant association (Duncan et al., 2012). This may be due to the fact that neighborhoods in Boston are generally characterized by high Walk Scores® and that Walk Scores® do not account for the quality of the neighborhood amenities measured, therefore hiding spatial inequalities (Duncan et al., 2012). Also Walk Scores® may also not accurately measure walkability by overlooking the micro-scale features of areas (Bereitschaft, 2018). Furthermore, although some lower-income households live in more active living environments (Bereitschaft, 2017), they are at risk of being displaced given the attractive features of such areas. Indeed, many lower-income households find themselves living in pre-gentrification areas and face the potential of experiencing higher housing costs as areas redevelop and attract higher income residents (Knight et al., 2018).

Other studies have considered transit infrastructure in relation to housing costs and neighborhood composition. In a study conducted in large metropolitan areas in the United States and Canada, access to transit was associated with higher housing costs (Kramer, 2018). This, the author argued, prevented lower-income residents in need of access to transit from benefitting from it. There is indeed the potential for "geographies of poverty" (Kramer, 2018, p.9) whereby lower-income residents are forced to move into under-served areas, as wealthier residents move to better served areas; a manifestation of the process of gentrification. This may result into further exclusion and marginalization of such populations as they face increasing transportation costs due to their reliance on automobiles, and face limitations in movement (Kramer, 2018). A study by Hess (2018) showed that the presence of transit infrastructure forced the displacement of racialized and less socioeconomically advantaged groups to suburban peripheries, while more advantage white residents moved into these areas serviced by transit which could potentially become walkable neighborhoods in Seattle, Washington. Unlike Kramer's (2018), this study did not consider the role of housing value appreciation as a variable which may influence this spatial patterning.

Two studies focused on the location of subsidized housing and/or housing vouchers[2] that allow tenants to rent housing in the private market through rent subsidy to assess whether

[2] Housing vouchers are different from project-based subsidized housing which is primarily led by government, as they are private actors' adoption of the state's provision of low-income housing by which the housing market is

affordable housing is found in neighborhoods with more favorable ALEs. Findings from Talen and Koshinsky (2011) linked neighborhood-level features associated to sustainable neighborhoods (i.e. walkable, well-serviced, compact, and pedestrian-oriented) to project-based subsidized residential development and housing vouchers (as forms of subsidized housing). They showed that although there was project-based subsidized housing in sustainable neighborhoods, housing vouchers which are more market-based mechanism were not. This further supports the association between the decreasing accessibility of affordable housing among market-based housing found in sustainable neighborhoods (Talen & Koshinsky, 2011). A study by Kim and Woo (2016) came to a similar conclusion whereby Walk Scores® were lower in areas with properties granted Low Income Tax Credit (LITC), i.e., tax incentives for private developers to develop more affordable housing, but there was no significant association with subsidized housing. Kim and Woo showed that walkable areas were not made inclusive to households in need of financial support. As Madden & Marcuse explain (2016), LITC actually represent profit gains for investors. Both studies therefore showed that subsidized housing initiatives are not always found in areas which are more walkable and favorable to active living.

2.2.1 Canadian research on the spatial patterning of housing affordability

Research specific to Canada has spatially described housing affordability, but it does not go so far as to link such spatial patterning to active living features of the built environment.

Bunting et al. (2004) examined the unequal spatial distribution of affordable housing within Census Metropolitan Areas (CMAs) in Canada, and observed lower prevalence of housing affordability in areas further away from the central city. It is the only study assessing the spatial variation in housing affordability in Canadian CMAs, but uses data from the 1996 Canadian Census which is outdated. The authors argued that the higher prevalence of housing affordability in central city areas was due to "spatially-conditioned needs" (p.385) related to lifestyle and preferences which supports the idea that housing costs are not the only aspect considered when households choose a location. However, this study only accounts for tenant households as it assumed that owner households are less likely to experience housing

made more accessible to lower-income households; however, it primarily benefits private landlords (Madden & Marcuse, 2016).

affordability stress, yet first-time home-buyers are also likely to experience it (Moore and Skarburskis, 2004, p.401).

In another study, Moore and Skaburskis (2004) found that housing affordability problems among low-income households, who are not as mobile and in a position to adapt to changes in the urban landscapes, significantly manifested in the largest Canadian CMAs. They attributed this finding to the increase in the rent gap, the concentration of economic activities in cities, and the reduction of sprawl around central cities. Moore and Skaburskis' findings showed that geography or city and regional differences could be disregarded once all common factors in each city had been accounted for when considering socioeconomic aspects in relation to housing affordability. Household and employment incomes were most significant in explaining housing affordability while education had almost no effect (Moore and Skaburskis, 2004). However, this points to the importance of examining such relationships at smaller geographical scales, as geographies within cities are also important when it comes to explaining the prevalence of housing affordability.

A more recent study by Skarbuskis (2012) in Toronto did so by examining changes in household and family formation rates, rising income levels, and changing income distribution in census tracts in gentrified neighborhoods. Findings suggested that changes, notably low-income residents being displaced and the increased prevalence of higher income residents, are observed across the city but are more noticeable in gentrified areas (Skaburskis, 2012). In another study, Revington and Townsend focused on how rental housing location relative to rapid transit affects housing affordability in Vancouver and Montreal, taking into account household composition and median household? income (2016). They excluded owner-occupied housing on the basis that additional information about mortgage financing and long-term capital gains would be needed to assess the actual impact of housing affordability on households. They found that the spatial distribution of housing affordability varied in each metropolitan area, but that rental housing was mostly concentrated at the center for both. In the case of Montreal, housing affordability stress among renters was especially centralized in the city center, compared to rentals which are more dispersed in Vancouver. Non-family households in Montreal were also found to have more flexibility in the rental market when it came to housing options and location. These findings therefore suggest that housing affordability should be examined in different Canadian areas

given that its spatial distribution may take various forms according to certain characteristics of areas.

Finally, a study by Moos et al. (2018) examined who could afford to live in mixed-zones based on occupational categories. It considered mixed-used zoning specifically which is associated with improved walkability and increased transit use. Housing affordability was calculated at the enumeration and dissemination area-level[3] in order to identify social and spatial inequalities in Toronto. They found that housing for both owners and renters in zones where mixed use policies were applied was generally less affordable than in areas which were not subject to mixed-used zoning, but that housing affordability actually improved over time in mixed-use zones for people in management, business, technical and health occupations. These occupations are indeed linked to salaries able to cover higher housing costs, but individuals in other occupations found housing affordability to become increasingly difficult in mixed-use zones (Moos et al., 2018). Moos et al. explored the relationship between zones where mixed-used zoning was applied and housing affordability at a smaller geographical scale, and showed that mixed-use zones did indeed contribute to higher proportion of housing unaffordability overtime for people with lower earning occupations.

Although the study by Moos et al. (2018) considers the relationship between mixed land use and housing affordability at a smaller geographical level, it is specific to Toronto. Studies have pointed to an unevenness in the access to elements related to ALEs, such as mixed land use, when it comes to housing affordability. My research explores the relationship between housing affordability and active living environment for both homeowners and renters, while considering certain socioeconomic neighborhood conditions which may also contribute to the spatial patterning of housing affordability in ALEs.

[3] "Enumeration areas and dissemination areas are census data collection units that are normally equivalent to one or more adjacent blocks within a census tract." (Moos et al., 2018; p.17)

CHAPTER 3: METHODOLOGY

This section describes the methods used to fulfill the two components of this project which are: 1) the statistical analysis of data to examine the association between neighborhood-level housing affordability and active living potential; and 2) the audit of neighborhoods characterized by high active living potential and low or high rates of housing unaffordability. I describe the datasets, variables chosen, data manipulation and transformation, and statistical analyses used. I also explain the steps I took to create a map which pointed to the selection of neighborhoods to be audited, as well as the design of an audit tool that guided my field observations, and how these data were analyzed.

3.1 Examining the association between housing affordability and active living potential

3.1.1 Study design and unit of analysis

I conducted an ecological cross-sectional study, where the impact of group, rather than individual observations, is examined and at one point in time, i.e. in 2016.

Dissemination Areas (DAs) were selected as the main geographic unit of analysis in this study, given that I was interested in variation of proportions of housing unaffordability at the neighborhood scale. DAs are the smallest geographical areas for which Statistics Canada publicly disseminate information. A DA is defined as "a small area composed of one or more neighboring dissemination blocks, with a population of 400 to 700 persons" (Statistics Canada, 2018). Given that this research is focused on neighborhoods, DAs were the most appropriate geographical unit to use as they are more or less representative of neighborhood boundaries.

Census Metropolitan Areas (CMAs) were also used as units of analysis in order to compare how relationships between housing affordability and ALEs vary in selected Canadian cities. A CMA is an "area consisting of one or more neighboring municipalities situated around a core" and "must have a total population of at least 100,000 of which 50,000 or more live in the core" (Statistics Canada, 2018). DAs are fully included within the boundaries of CMAs.

In Canada, there are a total of 56,589 DAs. Ten CMAs were selected: Quebec City, Montreal, Ottawa-Gatineau, Toronto, Hamilton, Winnipeg, Calgary, Edmonton, Vancouver, and Victoria. These CMAs were selected because all five ALE classes were present in them.

3.1.2 Databases used and measures

I used three databases to undertake this project: i) the 2016 Canadian Census which included the dependent variable, housing unaffordability; ii) the Canadian Active Living Environment (Can-ALE) dataset included the Canadian ALE class variable, the principle independent variable under study; and iii) the Canadian Index of Multiple Deprivation, a multi-component measure of deprivation based on data from the 2016 Canadian Census, which provided information on relevant covariates (economic dependency, ethno-cultural composition, residential instability, and situational vulnerability). Table 3.1 presents a summary of the database and variables.

Table 3.1. Databases used and description of the variables

Database	**Variables**	**Definition**
2016 Canadian Census	Proportion of housing unaffordability	Percentage of households spending 30% or more of their income on shelter costs
Can-ALE dataset	Can-ALE class	Categorical measure of the active living environment based on a five-category, k-medians cluster of the connectivity, density, and destination measures
The four dimensions of the Canadian Index of Multiple Deprivation, based on data from the 2016 Canadian Census.	Residential instability: • Proportion of household owners • Proportion of movers in the past 5 years	Tendency of neighborhood inhabitants to fluctuate over time, taking into consideration both housing and familial characteristics
	Economic dependency: • Proportion of the population aged 65 years and older • Percentage of unemployment	Reliance on the workforce, or dependence on sources of income other than employment income
	Ethno-cultural composition: • Proportion of visible minorities • Proportion of recent immigrants	Community make-up of immigrant populations
	Situational vulnerability:	Variations in socio-demographic conditions in

	• Proportion of dwellings in need of major repairs • Proportion of the population without a certificate, diploma or degree	the areas of housing and education, while taking into account other demographic characteristics

3.1.2.1 Housing unaffordability: the dependent variable

The Canadian Census provides information for "governments, businesses, associations and community organizations and others" to be used so that key decisions be made for communities, provinces, territories and the whole of Canada (Statistics Canada, 2019). The 2016 Census is Canada's most recent census. It took place in May 2016, a period of the year when most Canadians are at home. Both short- and long-form questionnaires (referred to respectively as the 2A and 2A-L Forms) were distributed. The short form questionnaire is answered by all Canadians; it is the primary source of exhaustive demographic data in Canada. The long form questionnaire complements the data collected by the short form questionnaire and is designed to provide information about people in Canada based on their demographic, social and economic characteristics (Statistics Canada, 2019). The long form questionnaire is answered by 25 percent of Canadians.

Questions related to housing conditions, including housing affordability, were part of the long-form census. Housing affordability was measured using the shelter-cost-to-income ratio, defined as the "proportion of average total before-tax income of household which is spent on shelter costs". Housing would be deemed unaffordable if households spend 30 percent or more of their incomes on shelter costs. The shelter-cost-to-income ratio was calculated by dividing the average monthly shelter costs by the average monthly total household income and multiplying the result by 100. Shelter costs are the average monthly total of all shelter expenses paid by households that own or rent their dwelling. For owners, this included "mortgage payments, property taxes and condominium fees, along with the costs of electricity, heat, water and other municipal services", while for renter households this included "rent and costs of electricity, heat, water and other municipal services" (Statistics Canada, 2017). Private households were the statistical unit used to calculate this proportion and were described as "a person or group of persons who occupy the same dwelling and do not have a usual place of residence elsewhere in

Canada or abroad" (Statistics Canada, 2017). Only owner and renter households with household income greater than zero and in non-farm private dwellings were considered.

3.1.2.2 CanALE: the main independent variable

The Canadian Active Living Environment (Can-ALE) is a pan-Canadian dataset including measures characterizing communities' active living environments, built using open data sources. It includes an index measure, as well as a measure of the index categorized in quintiles: the Can-ALE index and Can-ALE class. The Can-ALE index was derived from three measures: 1) the intersection density, that is the number of three-way intersections in a 1-km circular buffer around the centroid of DAs; 2) the dwelling density, the number of dwellings in a 1-km circular buffer area around the centroid of DAs; and 3) points of interests, that is the number of points of interest (eg. business, schools, hospitals) in a 1-km circular buffer around the centroid of DAs (Herrmann et al., 2016). Data to compute the intersection density and points of interest were derived from OpenStreetMap (OSM), while the weighted dwelling density measure was derived from Statistics Canada. The three measures were standardized using z-scores and summarized into the Can-ALE index. Using k-median clustering, the Can-ALE index variable was used to classify DAs in five groups according to their potential for active living. The five groups represent the Can-ALE class variable, which was the main independent variable in my research. All DAs across Canada are ranked on a scale from 1 to 5 based on their active living "potential", where class 5 indicates the most favorable ALE (Herrmann et al., 2017).

3.1.2.2 Covariates

The four dimensions of deprivation used to compute the Canadian Index of Multiple Deprivation (CIMD), residential instability, economic dependency, ethno-cultural composition, and situational vulnerability, were used as socioeconomic independent variables. Data from the 2016 Canadian Census was used to create the CIMD at the DA-level. Initially, 37 variables were considered to compute the CMID based on their known association with deprivation and marginalization. However, because some variables were conceptually similar and because of collinearity between variables, 17 variables were used to compute the CIMD (Statistics Canada, 2019) (Appendix A.1).

For each dimension, the CIMD is provided in two measures: factor scores and quintiles. Factor scores were constructed from the factor analysis process whereby lower scores corresponded to the least deprived areas and higher scores to the most deprived (Statistics Canada, 2019). Quintile rankings were determined by ordering factor scores from smallest to largest and then dividing them into five equally sized groups and categorizing them from 1 through 5, the lower rankings corresponding to the least deprived areas and higher rankings to the most deprived areas (Statistics Canada, 2019).

Scores and quintiles of all four dimensions of deprivation were considered in descriptive statistics. Furthermore, two variables were chosen from each dimension in order to provide more nuance in my analysis of my descriptive statistics. For the regression analyses, only the quintiles of economic dependency and ethno-cultural dimensions were considered; residential mobility and situational vulnerability were not included. Residential instability was strongly correlated with the proportion of housing unaffordability; this variable would therefore explain too much of the variation in the regression models, taking away from the ALE class which is the main independent variable under study. Situational vulnerability was also not considered, as this dimension only considered three variables, one of them being the proportion of population identifying as Indigenous, which varies considerably between CMAs, with higher concentration in a few CMA such as Winnipeg, Edmonton, Vancouver, and Toronto (Statistics Canada, 2017).

3.1.3 Statistical analyses

In order to run tests between the dependent and independent variables, the three databases were merged using the unique identifier of DAs into one large dataset. Preliminary analysis allowed me to become familiar with the data I was going to use and to "ensure the accuracy and representativeness of the information and the integrity of subsequent analyses" (Stanford Tomorrow's Professors, 2015). I assessed the normality of the distribution for all variables by generating histograms. I also generated correlation matrices in order to determine whether there was multicollinearity between certain independent variables. These steps were conducted for Canada as a whole, and for the 10 selected CMAs.

I correlated the proportion of housing unaffordability and the four measures of deprivation in order to determine whether there was multicollinearity between variables which would present a disturbance if high inter-correlations among the independent variables existed (Appendix A.2

and A.3. Research has shown that correlation coefficients above a value 0.7 present the potential for severe multicollinearity where model estimation may be greatly distorted (Dormann et al., 2013). However, I opted for a threshold of 0.6 in order to further ensure the accuracy of my regression outputs, as this value is deemed high enough to indicate potential problems for multicollinearity (Reddy et al. 2013). The residential instability score was strongly correlated with housing unaffordability for all CMAs (ranging from 0.6 to 0.83), which is why I decided to omit this variable from the regression models along with the situational vulnerability score which I decided to omit based on my research interests.

Then I calculated the mean values of all my variables according to each ALE class to get a sense of how housing unaffordability and the four deprivation dimensions (along with two variables for each deprivation measure) varied by the different ALE classes across Canada, and in the specific CMAs.

I then undertook multivariate regression analyses to examine how much of the variation in housing unaffordability (the dependent y variable) could be explained by Can-ALE classes (the main independent x variable), adjusting for socioeconomic covariates (the selected dimension of the index of deprivation).

Given that the dependent variable, housing unaffordability, was not normally distributed (Appendix A.4 & A.5), the variable was log-transformed by using a log-linear model which is able to automatically do so. This way the proportion of housing unaffordability would be more normally distributed which would allow the variable to be better suited when it came to testing linear associations with other variables in an Ordinary Least Square (OLS) regression. Although the independent variables were not all normally distributed, they do not necessarily need to be in linear regression models (Grace-Marten, 2009), which is why I did not transform them.

$\log Y_i = \alpha + \beta X_i + \varepsilon_i$, where

Y = the dependent variable, here the proportion of housing unaffordability

X = independent variable

i = variable in question

α = constant

β = coefficient of regression

ε = mean error

This means that each 1-unit increase in X multiplies the expected value of Y by e^{β}

I put the statistical significance level at $p<0.05$, as this has been the most conventional level used in social science since Fisher first established it in 1925, based on experimental results of probability values (Cowles & Davis, 1982). Indeed, the probability of obtaining a result by chance being less than 5% was an easier way to interpret and understand research results (Cowles & Davis, 1982). Therefore, coefficients with p values below 0.05 are able to reject the null hypothesis, indicating that they are statistically significant enough to explain varying proportions of housing unaffordability.

A total of four regression models were generated for Canada as a whole, and for each of the 10 CMAs. The first model only included the proportion of housing unaffordability as the dependent variable and ALE classes as the independent variable. The second model further adjusted for economic dependency quintiles, whereas the third model was adjusted for the ethno-cultural composition quintiles. The fourth and final model included all variables

Post estimation diagnostics helped determine whether the models were substantially significant by means of beta weights generated for each regression coefficient. Beta weights with values below 0.2 are considered to indicate that regression coefficients are weak in terms of being substantially significant, values between 0.2 and 0.5 are deemed moderate, and those above 0.5 indicate that the substantial significance of the coefficients is strong (Breau, 2019, slide 22).

3.2 Audit of neighborhoods in Montreal

In order to examine which neighborhood features might explain why some ALEs have affordable housing and others do not, I decided to undertake field observations in four areas in Montreal. The steps I took to do so are explained below.

3.2.1 Mapping

For Montreal, DAs were categorized in quintiles of the proportion of housing unaffordability. The two lowest and highest quintiles were associated with the two lowest and highest classes of active living environment in order to create four types of environments: 1) Low ALE class and Low proportion of housing unaffordability, LL; 2) Low ALE class and High proportion of housing unaffordability, LH; 3) High ALE class and Low proportion of housing unaffordability, HL; and 4) High ALE class and high proportion of housing unaffordability, HH.

In order to visualize the spatial relationship between housing unaffordability and more favorable ALE, I mapped the four types of environments using ArcMap. This map helped me identify clusters of DAs to visit in order to gain a better understanding of how housing unaffordability vary according to active living potential in residential neighborhoods in the city. I visited a total of four DA clusters, some of which included a mix of both HL and HH areas in order to compare and contrast them:

- Anjou district (HL and HH areas, visited in October 2019)
- Downtown area near Chinatown (HH area, visited in January 2020)
- The "Duff Court" and surrounding area in the Lachine borough (HL and HH area, visited in September 2019)
- Technopôle Angus and its surrounding area, in the Rosemont borough (HL and HH area, visited in August 2019)

3.2.2 Field observations

To determine features of the built and social environment of neighborhoods that I should pay particular attention to when undertaking field observations, I reviewed the scientific literature concerning neighborhood audit tools (based on a list compiled by Madeleine Steinmetz-Wood, Appendix A.6). I came up with a matrix to guide my observations of neighborhood environments with high active living potential but very low or high proportions of housing unaffordability (Appendix A.7). Included in the matrix were the accessibility, diversity, qualitative conditions, engagement or involvement, and safety dimensions of neighborhoods, and how these dimensions manifested themselves in neighborhoods by considering: the social environment (e.g. signs of segregation or crime), accessibility of public spaces (e.g. wheelchair ramps), the transportation environment (e.g. quality of paths or availability of public transportation), public services or amenities (e.g. variety in the types of stores or usage of recreational facilities), and of course built housing environments (types of building or signs of vacancy).

The question guiding my observations was the following: What can explain why certain high ALEs have affordable housing while others do not? I attempted to answer it by paying particular attention to features of the built and social environments. Taking pictures of relevant observations and recording voice memos on my phone allowed me to gather and save my field observations so that I could rely on them later for my analysis and include them in my findings

section. I then wrote short summaries of key findings for each cluster visited based on my audit matrix and selected pictures which I considered essential to conveying my observations. I also attempted to compare and contrast findings so that I may identify patterns to explain what may differentiate housing affordability in active living environments.

CHAPTER 4: RESULTS - Canada and select CMAs

4.1 All Canadian DAs considered

4.1.1 Descriptive statistics: mean distribution of all variables by Can-ALE classes

Means and standard errors for housing unaffordability and for the selected covariates by ALE classes are presented in Table 4.1.

Table 4.1. Means and standard errors (std. err) of all variables by Can-ALE class

Variables	**ALE classes**					
	1	**2**	**3**	**4**	**5**	**Total**
	Mean **Std. err**	**Mean** **Std. err**	**Mean** **Std. err**	**Mean** **Std. err**	**Mean** **Std. err**	**Mean** **Std. err**
% housing unaffordability	16.7 0.000	20.3 0.001	26.1 0.001	31.7 0.002	36.1 0.002	**22.2** **0.001**
Residential instability score	-0.444 0.004	-0.147 0.007	0.222 0.009	0.883 0.016	1.673 0.019	**0.001** **0.004**
% of household owners	80.5 0.001	75.4 0.002	66.1 0.002	48.2 0.004	34.2 0.005	**70.9** **0.001**
% movers in past 5 years	30.0 0.001	35.4 0.001	38.3 0.001	42.7 0.002	52.4 0.003	**35.5** **0.001**
Economic dependency score	0.154 0.007	-0.010 0.008	-0.053 0.008	0.0103 0.015	-0.463 0.018	**-0.005** **0.004**
% of pop. ≥ 65 years	19.4 0.001	17.7 0.001	17.1 0.001	16.8 0.002	13.7 0.002	**17.9** **0.000**
% unemployed	8.97 0.056	7.39 0.038	8.11 0.042	8.49 0.074	8.05 0.094	**8.24** **0.026**
Ethno-cultural composition score	-0.593 0.003	-0.093 0.007	0.559 0.010	0.995 0.018	0.667 0.020	**0.008** **0.004**
% visible minorities	3.8 0.001	16.5 0.002	31.3 0.002	38.7 0.004	31.5 0.004	**18.0** **0.001**
% recent immigrants	0.8 0.000	2.4 0.000	4.6 0.001	6.6 0.001	6.7 0.001	**2.9** **0.000**
Situational vulnerability score	0.222 0.009	-0.241 0.005	-0.107 0.005	-0.039 0.010	-0.257 0.012	**-0.028** **0.004**
% dwellings needing major repairs	9.0 0.001	5.4 0.000	6.3 0.001	7.9 0.001	8.7 0.001	**7.2** **0.000**
% pop. ≥ 25 ears without certificate, diploma or degree	15.7 0.001	10.2 0.001	11.8 0.001	12.1 0.002	7.6 0.002	**12.6** **0.000**

There was a gradual increase in the proportion of housing unaffordability across the ALE quintiles. Across Canada, the proportion of housing unaffordability was twice as high in ALE class 5 (most favorable ALE) at 36.1% compared to ALE class 1 (least favorable ALE) at 16.7%.

With regards to neighborhood socioeconomic conditions, we also see a general gradient across the ALE classes for dimensions of the multiple deprivation index, and selected sub-component variables. Residential instability scores increased by ALE quintiles. Within residential instability, the proportion of movers in the past 5 years increased by ALE quintiles, while the proportion of homeowners decreased. Economic dependency scores decreased between ALE class 1 and 5 but, but there was fluctuation across the ALE classes. The proportion of the population aged ≥65 years gradually decrease by ALE quintiles, but the percentage of unemployment showed no clear pattern in relation to ALE. While the ethno-cultural composition scores, and the proportion of recent immigrants, increased by ALE classes, the proportion of visible minorities increased overall but saw fluctuations between the ALE classes. Finally, situational vulnerability score, and the proportion of the population with lower education levels, decreased between ALE class 1 and 5. However, the proportion of dwellings in need of major repairs did not show a clear pattern across the ALE classes.

4.1.2 Association between neighborhood ALE and housing affordability

Results of associations between the ALE and housing affordability (model) adjusted for covariates (models 2 to 4) are in Table 4.2. All coefficients were significant at $p < 0.001$. In model 1, the ALE classes were the independent variables whose coefficients explained the variance in the proportions of housing unaffordability (y variable). One unit increase in the x independent variable would result in the y value increasing by e^{β}, where β equals the log value of the coefficient of regression, or by the percentage value of the coefficient, if the percentage value of the coefficient is considered.

Table 4. 2 Association between neighborhood ALE and housing unaffordability regression output for the four models, for Canada as a whole

Variables	Model 1			Model 2			Model 3			Model 4		
	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights
ALE Class												
2	0.171	18.64	0.14	0.191	21.00	0.16	0.088	9.22	0.07	0.095	9.96	0.08
3	0.425	52.94	0.33	0.441	55.46	0.34	0.255	29.09	0.20	0.250	28.45	0.20
4	0.658	93.15	0.34	0.670	95.45	0.34	0.439	55.14	0.22	0.425	52.89	0.22
5	0.802	122.91	0.30	0.848	133.49	0.32	0.618	85.48	0.24	0.641	89.82	0.24
Economic Dependency Quintiles												
2				0.061	6.26	0.04				0.057	5.83	0.04
3				0.092	9.66	0.07				0.094	9.81	0.07
4				0.121	12.87	0.09				0.130	13.86	0.09
5				0.226	25.31	0.16				0.269	30.88	0.19
Ethno-Cultural Quintiles												
2							0.084	8.81	0.06	0.101	10.57	0.07
3							0.115	12.21	0.08	0.155	16.77	0.11
4							0.171	18.69	0.13	0.229	25.75	0.17
5							0.406	50.03	0.30	0.454	57.47	0.33
Constant	-1.87			-1.98			-1.94			-2.08		
# obs.	51,220			51,124			51,124			51,124		
Adjusted R^2	0.193			0.210			0.235			0.259		

Note: All associations are statistically significant at $p < 0.001$

There was a statistically significant increase in the proportion of housing unaffordability by ALE classes 1. The coefficients for ALE quintile 3, 4 and 5 were all moderately substantially significant according to beta weight values, which means that they somewhat explained the variance in proportions of housing unaffordability. The percentage change of the coefficients also increased by ALE classes, which indicates that more favorable ALEs have a higher influence on housing unaffordability. The adjusted r-square value indicates that ALE class explains almost 20% of the variation in housing unaffordability, which can be considered quite a lot here, given that proportions of housing unaffordability are influenced by a variety of different factors other than the active living favourability of the area in which housing is found.

When adjusting the model for economic dependency quintiles (model 2), there was still an increase in the proportion of housing unaffordability by the ALE quintiles. However, the ALE coefficients had larger values and were slightly more substantially significant, meaning that they held more weight in terms of explaining the variance in the dependent variable. While the quintiles of economic dependency increased by ALE quintiles, their effect was weaker in terms of substantial significance, and did not hold as much weight as the ALE classes. The adjusted r-square was also slightly higher than in the first model.

Adjusting the model for quintiles of ethno-cultural composition (model 3), ALE coefficients also increased in value by ALE classes. Most coefficients of the independent variables had weak beta weights, except for ALE classes 3, 4, 5 whose beta weights were moderate. The adjusted r-square was slightly higher than for model 2 with a value of 0.23, suggesting that ethno-cultural composition quintiles were slightly better at explaining the variation in proportions of housing unaffordability than economic dependency quintiles.

When all variables were considered (model 4), the ALE coefficients increased in value by ALE classes which still carried the most weight in terms of explaining the variance in proportions of housing unaffordability. Indeed, most coefficients were weak in terms of substantial significance expect for ALE classes 3, 4 and 5 and ethno-cultural composition quintile 5. Finally, the adjusted r-square was the highest of all the models at 0.26. This suggests that the ALE class coefficients are best suited to explain varying proportions of housing unaffordability, while ethno-cultural composition quintiles followed by economic dependency quintiles play a much smaller and secondary role as covariates.

4.2 Variation in housing unaffordability across Can-ALE classes in selected CMAs

4.2.1 Descriptive statistics: The mean distribution of all variables by Can-ALE classes in respective CMAs

The mean percentage of housing unaffordability by ALE classes for each CMA are shown in Table 4.3. Across all CMAs, there was a gradient in housing unaffordability such that housing unaffordability was generally lowest in ALE class 1 and highest in ALE class 5. Across all CMAs, not specific to ALE, the highest percentages of housing unaffordability were observed in Toronto at 29.2% and Vancouver at 30.1%; these larger CMAs also included the greatest number of DAs. Victoria, which is a much smaller CMA, followed with an average housing unaffordability of 27.3%. The lowest housing unaffordability percentages were observed in Quebec City (16.4%), followed by Winnipeg (18.7%), Calgary (20.7%) and Edmonton (20.8%).

Table 4.3. Means and standard errors (std. err) of percentage of housing unaffordability by ALE class in each CMA

CMAs	ALE classes					
	1	**2**	**3**	**4**	**5**	**All**
	Mean **Std. error**	**Mean** **Std. error**	**Mean** **Std. error**	**Mean** **Std. error**	**Mean** **Std. error**	**Mean** **Std. error**
Quebec City	11.5	11.1	18.7	27.3	29.1	**16.4**
	0.004	0.004	0.006	0.007	0.011	**0.003**
number of DAs	238	450	362	182	59	**1,291**
Montreal	16.2	15.2	21.3	28.7	33.6	**23.1**
	0.003	0.002	0.003	0.003	0.003	**0.002**
number of DAs	551	1,647	1,735	1,463	1,072	**6,468**
Ottawa-	16.1	17.2	21.2	34.3	35.3	**21.0**
Gatineau	0.005	0.005	0.005	0.010	0.011	**0.003**
number of DAs	258	417	579	153	48	**1,455**
Toronto	24.6	24.2	28.9	32.5	38.5	**29.2**
	0.005	0.003	0.002	0.003	0.004	**0.001**
number of DAs	463	1,769	3,071	1,433	788	**7,524**
Hamilton	18.1	19.2	23.0	35.9	42.5	**23.1**
	0.006	0.005	0.005	0.01	0.0181	**0.004**
number of DAs	156	374	507	131	31	**1,199**
Winnipeg	12.5	14.4	20.6	30.8	38.0	**18.7**
	0.006	0.004	0.005	0.011	0.025	**0.003**
number of DAs	146	412	555	102	14	**1,229**

Calgary	17.3	18.2	22.2	28.7	30.7	**20.7**
	0.008	0.004	0.003	0.012	0.009	**0.002**
number of DAs	130	718	800	61	49	**1,758**
Edmonton	15.8	17.4	24.0	37.0	35.7	**20.8**
	0.005	0.004	0.004	0.014	0.011	**0.003**
number of DAs	269	665	672	59	22	**1,687**
Vancouver	26.1	24.9	30.2	33.5	39.9	**30.1**
	0.006	0.004	0.003	0.004	0.005	**0.002**
number of DAs	284	887	1,235	711	333	**3,450**
Victoria	20.8	22.8	30.7	37.1	40.2	**27.3**
	0.008	0.006	0.008	0.009	0.040	**0.005**
number of DAs	128	189	155	95	6	**573**

Mean percentage of housing affordability in ALE class 1 were important to consider given that some CMAs were generally less affordable than others, regardless of whether areas were favorable to active living or not. The highest percentages of housing unaffordability in ALE class 1 were observed in Toronto (24.6%), Vancouver (26.1%) and Victoria (20.8%).

Means of housing unaffordability percentage in ALE class 5 were important to consider as well. The lowest percentages were observed in Quebec City (29.1%) and Calgary (30.7%). The highest values of housing unaffordability percentages in ALE class 5 were in Hamilton (42.5%), Victoria (40.2%) and Vancouver (39.9%).

Means of housing unaffordability percentage varied in the different CMAs. Although housing unaffordability gradually increased across ALE classes, Montreal, Toronto and Vancouver either showed similar value or even a slight decrease in housing unaffordability between ALE classes 1 and 2. On the other hand, Edmonton saw a decrease in the percentage of housing unaffordability between classes 4 and 5. The highest disparities observed between ALE classes 1 and 5 were in Hamilton, Winnipeg and Edmonton, and the lowest disparities were in Toronto, Calgary and Vancouver.

The mean statistics for the other socioeconomic variables by ALE classes are in Appendix B.1. These results are not reported here as they are not essential to answer my research questions and varied quite a lot from the Pan-Canadian mean statistics across the different CMAs.

4.2.2 OLS regression output for each selected CMA for models 1 and 4

The same regression models were generated for each CMA. Results are presented in Appendix B.2, B.3, and B.4. There were similar patterns of association to those observed for Canada as a whole. The main findings are highlighted below.

The general results among the selected CMAs include ALE class coefficients increasing in value by ALE class. Furthermore, the higher ALE classes had among the highest beta weight values when compared to the socioeconomic variables in model 4. Determining whether economic dependency or ethno-cultural dependency quintiles carried more weight in model 4 was difficult to do, as this would change for each CMA. However, coefficients for the two variables all saw an overall increase in most CMAs, with the highest quintiles characterized by higher values, and therefore by higher economic and socio-cultural deprivation.

Hamilton, Edmonton, Winnipeg, and Ottawa-Gatineau had regression results similar to those of Canada, with adjusted r-squared values ranging from 0.19 to 0.20 in Model 1 (Appendix B.2). In Model 1, coefficient values in Winnipeg, Hamilton and Edmonton were positive and increasing in classes 4 and 5, meaning that the proportion of housing unaffordability only increased in these two ALE classes. Economic dependency quintiles in model 4 showed to generally increase in value in all four CMAs, but only quintile 5 was statistically significant on all levels, and beta weight values were weak. Ethno-cultural composition quintiles also showed to generally increase in value, but did not seem to be strongly patterned with varying proportions of housing unaffordability, as most coefficients were not statistically significant on all levels, nor had they strong beta weight values. Proportions of housing unaffordability still showed to increase by ALE class coefficients.

Calgary, Toronto and Vancouver showed the weakest association between ALE coefficients and proportions of housing unaffordability. Models for these CMAs had the lowest adjusted r-squared values in model 1 (Appendix B.3). All three CMAs showed proportions of housing unaffordability as overall increasing by ALE class. In the fully adjusted model, coefficients of the quintiles for economic dependency and ethno-cultural composition quintiles were for the most part not statistically significant at level 0.05. Indeed, economic dependency quintiles were only statistically significant on all levels for quintile 5 in Toronto and Vancouver. None of the deprivation measure quintiles were statistically significant on all levels for Calgary.

The strongest association between ALE classes and housing unaffordability were observed in Montreal, Quebec City, and Victoria. The r-square value for the models and beta weights for the ALE coefficients had higher values than in the Pan-Canadian regression results (Appendix B.4). Models for these CMAs showed the highest adjusted r-square values and among the highest beta weights of coefficients for ALE classes 4 and 5 for Montreal and Quebec City, for ALE classes 3 and 4 for Victoria. Quebec City had especially high percentage change coefficients in ALE classes 4 and 5. Montreal's ALE class 5 coefficient's beta weight was even strongly substantially significant, being above the 0.5 value threshold, while it is Victoria's ALE class 4 which had the highest beta weight value. In model 4, economic dependency quintiles did not show to increase by ALE classes in Victoria, but did show a general increase for Montreal and Quebec City. Ethno-cultural composition quintiles were not patterned with varying proportions of housing unaffordability for Montreal and Quebec City, but did increase by quintile for Victoria. Model 4 therefore showed ALE coefficients and economic dependency quintiles as being best suited to explain the variance in the mean of housing unaffordability proportions for Montreal and Quebec City, while ethno-cultural composition quintiles were more clearly patterned to varying proportions of housing unaffordability in the case of Victoria.

CHAPTER 5: RESULTS–ALEs and proportions of housing unaffordability in Montreal

In order to examine which neighborhood features might explain why neighborhoods favorable to active living include affordable housing or not, I decided to undertake field observations in four areas in Montreal. The results are presented below.

5.1 Descriptive statistics of select DAs in Montreal

The description of housing unaffordability and selected socioeconomic indicators for DAs characterized by low ALE and low or high rates of housing unaffordability (LL or LH), and by high ALE and low or high rates of housing affordability (HL, HH) are presented in Table 5.1.

Table 5.1. Means and standard errors for all variables by ALE class in Montreal CMA

Variables	Low-Low	Low-High	High-Low	High-High	Average
	Mean Std. error	Mean Std. error	Mean Std. error	Mean Std. error	Mean Std. error
% Housing unaffordability	7.9 0.003	38.9 0.011	8.5 0.004	40.6 0.003	**28.4** **0.002**
Residential instability score	-0.953 0.024	1.401 0.158	-0.112 0.112	1.914 0.023	**1.068** **0.020**
% household owners	95.9 0.006	32.3 0.047	72.3 0.038	23.5 0.005	**43.2** **0.005**
% movers in the past 5 years	19.8 0.008	48.7 0.0308	26.3 0.013	52.5 0.004	**42.1** **0.003**
Economic dependency score	-0.221 0.065	0.395 0.271	0.129 0.099	0.052 0.030	**0.028** **0.016**
% pop aged ≥ 65 years	17.0 0.007	22.7 0.034	18.2 0.010	14.7 0.003	**16.1** **0.002**
% unemployment	4.79 0.351	7.82 0.572	7.94 0.994	11.31 0.171	**9.18** **0.092**
Ethno-cultural composition score	-0.050 0.044	0.478 0.204	0.314 0.099	1.065 0.034	**0.697** **0.017**
% visible minorities	16.5 0.011	29.0 0.045	27.0 0.028	37.3 0.007	**31.5** **0.004**
% recent immigrants	2.0 0.003	7.1 0.017	2.3 0.004	10.3 0.002	**6.8** **0.001**
Situational vulnerability score	-0.638 0.026	-0.279 0.115	-0.261 0.093	0.102 0.017	**-0.077** **0.010**
% dwellings needing major repairs	4.9 0.005	6.6 0.008	6.6 0.006	9.4 0.002	**8.0** **0.001**

% pop. ≥ 25 years without certificate, diploma or degree	3.2 0.004	8.2 0.017	9.1 0.012	12.3 0.003	**11.0** **0.002**

DAs with more favorable ALE and high housing unaffordability (HH) are areas characterized as having the highest residential instability, ethno-cultural composition and situational vulnerability scores. The highest economic dependency scores are found in DAs characterized by low ALE and high housing unaffordability (LH), perhaps because they also have the highest proportion of the population aged 65 years and older. In areas characterized by high ALE and low housing unaffordability (HL), there was 72.3% percent homeowners in contrast to only 24% in HH areas. Furthermore, there was a difference in terms of ethno-cultural composition characteristics in more favorable active living environments. Indeed, the proportion of visible minorities was 27 % in HL areas and up to 37% in HH areas, while the proportion of recent immigrants was 2% in HL areas and 10% in HH areas. HH areas also concentrated the highest proportion of inadequate housing (9.4%) and higher proportion of population without a certificate, diploma or degree at the secondary level and above (12.9%).

5.2 Montreal field observations results to inform varying proportions of housing unaffordability in high ALEs

Based on the mapping of the categories of environments (Figure 5.1), I selected four clusters of DAs to investigate using the audit matrix (Appendix A.5) in order to determine which attributes of neighborhood environments describe high active living environments where affordable housing is present or not. These clusters of DAs are located in: the Anjou borough; a part of the downtown area near Chinatown; the "Duff Court" and surrounding area in the Lachine borough; and Technopôle Angus and its surrounding area in the Rosemont borough. The main findings are presented below for each of these four areas.

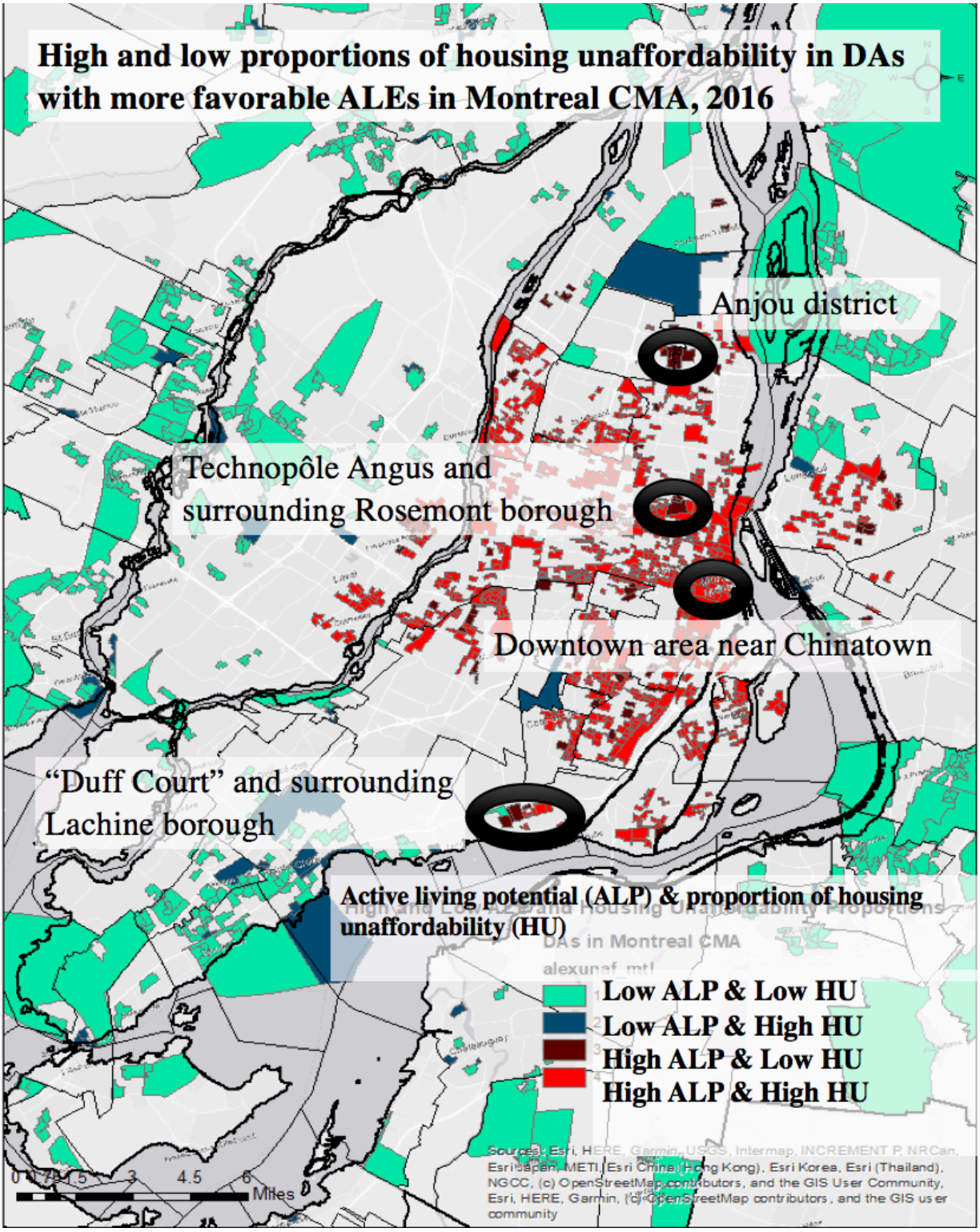

Figure 5.1 Map of high and low proportions of housing unaffordability in DAs with more favorable ALEs in Montreal CMA, 2016

Note: The map would have been more refined, but I no longer had access to the ArcMap Software due to COVID 19 confinement.

5.2.1 Anjou sector

The sector I visited in Anjou (Figure 5.2) included mainly HL areas, but also a small HH area. The Anjou sector is indeed favorable to active living by its high street connectivity and key destinations such as metro and bus stops, which made it easy to get around by active modes of transportation. The streets were not too busy with car traffic, which also made it a pleasant area to walk or cycle in. However, the Anjou area I visited did not have the high dwelling density one would expect in a high ALE. My observations (Figure 5.3) did indeed explain the high percentage of homeowners found in HL areas from the descriptive statistics (Table 5.1), as there were a lot of private housing types, mainly single-detached dwellings (Pictures 1 & 2). There were also some row-houses, and semi-detached housing, but these were less common (Picture 3). There was little sign of social disorder and the surrounding environment was overall clean. Most dwellings seemed to be well maintained as they had nice exteriors or were undergoing renovation (Picture 4). I encountered a large community garden and walked through a large field which showed that the residents of this area had good access to green space (Pictures 5 & 6). The majority of the people I encountered walking on the street or keeping busy by their home fronts were white, perhaps middle-class people. When I made my way into the small HH sector, I noticed this was the only area where there were apartments and duplex housing types (Picture 7). It was also located next to a commercial area, unlike the HL areas which seemed to be mostly residential.

Figure 5.2 Anjou sector study area, HH (bright red) and HL (burgundy)

Figure 5.3. Anjou district pictures, Fall 2019

5.2.2 Duff Court, in Lachine borough

I visited two different HL areas, and one HH area in the Lachine borough (Figure 5.4). This sector in Lachine is favorable to active living by its high dwelling density, high street connectivity, and points of interest as there is public transit available in the area. Pictures from my field observations are in Figure 5.5. One area characterize by HL was the Duff Court area, one of the largest social housing estates on the Island of Montreal. This area appeared to be a high-density development, as it mainly included multiplex buildings (Picture 1). There was also a park which seemed to be used by the residents living nearby (Picture 2), and an outdoor pool which suggested there was somewhat of a community aspect that was made possible through the presence of these amenities. The people I encountered were primarily visible minorities. The area was highly walkable, as there was little vehicular traffic and the sidewalks were decently maintained. The HH cluster next to it was also highly walkable, but the housing there appeared to be more planned. Most were semi-detached or row-houses with a few duplexes and single detached dwellings (Pictures 3 & 4).

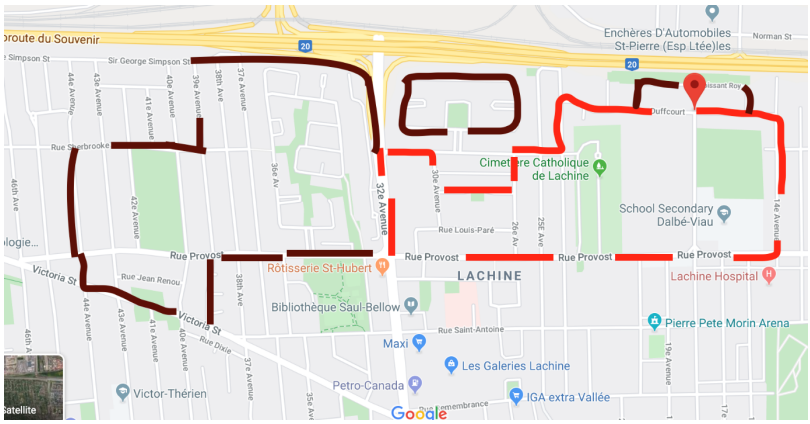

Figure 5.4. Duff Court/ Lachine study area, HH (bright red) and HL (burgundy)

I also visited another HL area which was different from Duff Court as it had more single detached or semi-detached dwellings rather than apartments (Picture 5). This area also had a nicer landscape with well-maintained pathways, parks and more green space overall (Picture 6). I encountered a few families engaging in the open spaces. This HL area seemed to be a nice and quiet residential area where predominantly white middle class families may reside.

Figure 5.5. Duff Court/ Lachine pictures, Fall 2019

5.2.3 Downtown area

The HH area I visited downtown was favorable to active living by its high dwelling density, street connectivity, and points of interest, being located in a central area of the city (Figure 5.6). The pictures taken to recorded my observations are found in Figure 5.7. The area included a mix of residential and commercial land use. There was also the presence of both newer condo buildings (Picture 1) and older row houses (Pictures 2 and 3), but all housing type was rather dense in nature. I also noticed some construction which was taking place, but could not tell what type of building was being built (Picture 4). There were signs of social disorder as the streets and sidewalks were not as calm and clean as ones that I had observed in more residential areas, which was expected. I encountered a variety of people who appeared to be from various socio-cultural backgrounds which is not surprising to find in a highly urban area such as this one.

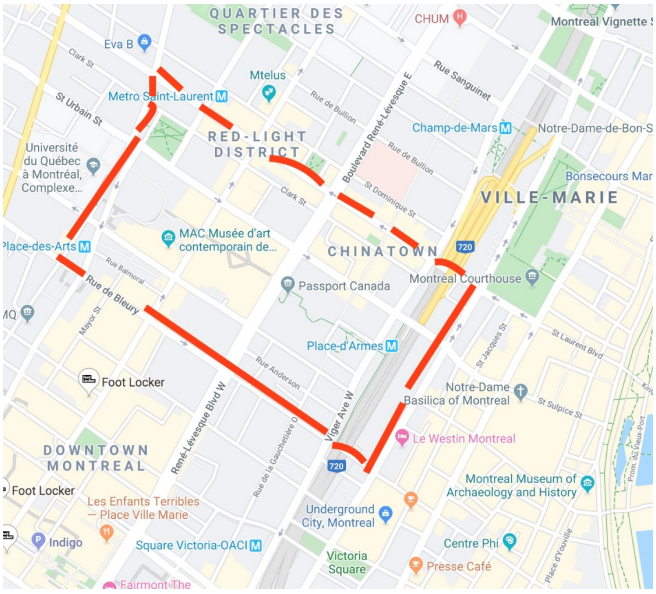

Figure 5.6. Downtown study area, HH (bright red)

Figure 5.7. Downton area pictures, Winter 2020

5.2.4 Technopôle Angus, in Rosemont borough

In the borough of Rosemont, I visited the HL area of Technopôle Angus and a small HH area next to it (Figure 5.8). Much like the two previous sectors, Technopôle Angus and the HH area next to it was favorable to active living by the three main components which characterizes high ALEs. Pictures taken for my field observations are in Figure 5.9.

Technopôle Angus appeared to be a fairly recent and organized development as the houses were in good condition and looked similar in design and structure. This contrasted greatly with the HH area right next to it, which included all sorts of housing from run-down (Picture 1) to better kept dwellings and also poorly maintained streets (Picture 2). Angus was indeed an environment favorable to active living as the streets were easy to walk on and there was little car traffic which also made it safe for cyclists (Picture 3). There were pathways, parks and open spaces for residents to use which were all well-maintained and quite attractive in design (Picture 4). I even saw road signs which indicated how far away key destinations were by estimated walking times (Picture 5), which would prove useful and encourage residents to walk. A few buses did pass by during my walk, indicating that the area was well-served in terms of public transport. The area was also well-serviced as there was a small commercial area with a Provigo and few other services, which were easy to access by means of active transportation. The housing was dense in nature, including mixed housing types such as apartment complexes, row houses as well as semi-detached dwellings (Pictures 6 & 7). I was impressed by the amount of vegetation found along the streets, and I was able to tell that the residents took specific care of their homes, as most front lawns were well-gardened with healthy grass and colorful flowers (Picture 6). However, I did not see any people from visible minority groups during my time there, as most of the residents appeared to be white middle-class. I also noticed that the majority were older people, but this may be explained by the time of day during which I undertook my observations which was a Friday morning.

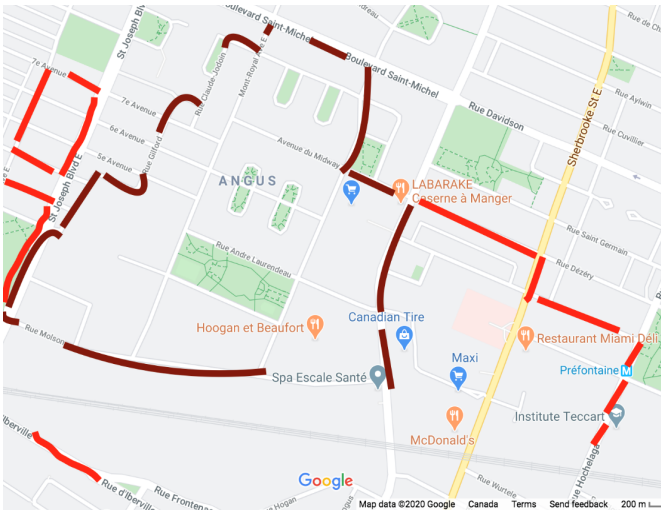

Figure 5. 8 Technopôle Angus and Rosemont study area, HH (bright red) and HL (burgundy)

Figure 5. 9 Technopôle Angus and Rosemont pictures, Summer 2019

CHAPTER 6: DISCUSSION

This final section will summarize the results from the previous section and relate them to the scientific literature (see Chapter 2). The motivation behind this research was to determine whether sustainable neighborhoods, here described as ALEs, had affordable housing options. My research aim was therefore to examine the relationship between the active living potential of sustainable neighborhoods and housing affordability. My three main research questions were: 1) Is the prevalence of housing unaffordability higher in more favorable ALEs in Canada? And is this association confounded by neighborhood-level socioeconomic and cultural conditions? 2) Does the association between ALEs and housing unaffordability vary across selected CMAs? And is this association confounded by neighborhood-level socioeconomic and cultural conditions? 3) What characterizes urban neighborhoods with more favorable ALEs and low and high rates of housing unaffordability in Montreal? My research findings suggest that housing is less likely to be affordable in more active living neighborhoods, but that this relationship varies in different CMAs. There are also micro-scaled and local specifies of neighborhoods which are likely to influence whether a high active living area has affordable housing or not.

6.1 Answering questions 1 and 2: Patterns and relationships between ALEs and housing unaffordability in Canada as a whole and select CMAs

Results showed that the ALE coefficients were best suited when it came to explaining the variance of housing unaffordability proportions, but that ethno-cultural composition quintiles also played a lesser role, followed by economic dependency quintiles. My findings therefore generally support those of other studies, whereby walkable, well-served areas supportive of active living are characterized by higher proportion of housing unaffordability (Sohn et al., 2012; Immergluck & Balan, 2018; Moos et al., 2018).

According to the OLS regression for Canada, the more an area is favorable to active living, the higher the proportion of housing unaffordability. However, it is important to consider that central urban areas inherently include features which would describe them as higher ALEs (Herrmann et al., 2016), and at the same time tend to have higher land values and concentrate a larger portion of poor households. These areas therefore tend to be more expensive to live in and attract households which enjoy more favorable financial situation (Sohn et al., 2012; Immergluck

& Balan, 2018), potentially forcing lower-income households to live in less or underserved areas, creating "geographies of poverty" in the city (Kramer, 2018). Nonetheless, lower-income households still reside in well-served central areas which tend to rank in high ALE classes despite the high costs of living there. This may be explained by these lower income households having been living in these areas at a time when they were affordable due to housing being less valued by real estate markets. However, the process of gentrification would most likely increase housing costs, as formerly impoverished inner-city areas are now seen as walkable and attractive residential environments; qualities that are greatly valued by the real estate market (Sohn et al., 2012). This trend is indeed prevalent in most Canadian CMAs, as neighborhoods are becoming increasingly polarized between higher and lower income households (Breau, 2018).

Although the ALE class was the predominant variable, socioeconomic conditions of neighborhoods also explained some of the variation in the proportions of housing unaffordability. Unlike previous research conducted in the United States (Hess, 2018; Riggs, 2016), the presence of racialized groups did not decrease in higher ALEs, but rather increased. Ethno-cultural composition seemed to explain more of the variation in housing affordability than economic dependency, but still less than the ALE classes. Indeed, Canadian urban centers tend to include more visible minorities or recent immigrants who may be low-waged households in need of shelter (Bunting, 2004). Ethnic and immigration composition of neighborhoods may also explain the level of income inequality found in certain areas, as there are larger shares of visible minorities and recent immigrants in those areas, which also proved to be true according to the mean statistics for the ethno-cultural composition scores. This not only happens in gateway cities, but also in smaller ones such as Winnipeg and Edmonton where there are large populations of Indigenous Peoples who are earning much less than the majority Canadian-born groups (Breau, 2018).

However, these general patterns of housing unaffordability and socioeconomic conditions did vary across different CMAs. Housing unaffordability did not manifest itself the same way in different Canadian regions and CMAs, which is why geographic differences must be considered (Moore & Skaburskis, 2004). The varying results may be due to geographic differences found in CMAs such as the different housing costs, spatial patterning of low-income households and whether these households are found in more central or urban areas.

Ottawa-Gatineau, Hamilton, Winnipeg and Edmonton showed similar patterns to the Canada-wide results, where areas favorable to active living were similar in terms of explaining variation in the proportions of housing unaffordability, which gradually increased as areas became more favorable to active living. However, economic dependency and ethno-cultural composition did not explain variation in rates of housing unaffordability in these CMAs. According to the mean statistics, the highest disparities found between low and high ALEs in terms of proportion of housing unaffordability were in Hamilton, Winnipeg and Edmonton. Housing affordability stress in Hamilton and Winnipeg is concentrated in central urban areas (Bunting et al., 2004), which are naturally more favorable toward active living. For Winnipeg and Edmonton, there is a significant difference between low proportions of housing affordability in the inner city and the rest of the metropolitan region, as the inner-city experiences higher proportions of housing unaffordability (Bunting et al., 2014), which may also account for ALEs relationship to housing unaffordability. There are areas in Ottawa's inner city which have undergone gentrification and have developed luxury condominiums which is directly related to the growth of white-collar employment in its central business district (Bunting et al., 2014). These four CMAs therefore show a pattern whereby housing unaffordability is experienced in more central urban areas, most likely due to the concentration of lower income households and/or higher real estate valuations, given that these areas undergoing gentrification.

Calgary, Toronto and Vancouver had similar results; ALE coefficients did not show to explain much of the variation in proportions of housing unaffordability, even if they seemed to increase in value as ALE classes became higher. This is not surprising as the mean statistics showed the smallest disparities in proportions of housing unaffordability between ALE class 1 and 5 in those three CMAs; housing unaffordability proportions were high in all ALE class. Ethno-cultural composition nor economic dependency did not play a significant role in explaining the variation in the proportions of housing unaffordability.

It is important to consider that Vancouver, Calgary and Toronto have experienced the greatest 'leaps' in income inequality (Breau, 2014), which naturally impacts housing unaffordability, as household incomes are part of the equation. Vancouver and Toronto have especially suffered from the housing affordability crisis; housing costs are generally the highest in these CMAs (Rozworski, 2019). This may explain why Toronto and Vancouver did not demonstrate a strong linear association between ALE classes and proportions of housing

unaffordability, as housing costs in ALE class 1 were already high to start off with, and were the highest out of all CMAs. Vancouver suburbs for instance have been found to be expensive areas to live in (Bunting et al., 2004).

Although Calgary showed similar results to Toronto and Vancouver, the same explanation would not be appropriate in this case. Calgary has experienced the largest economic segregation of neighborhoods in recent years, whereby wealthier neighborhoods are flourishing and the poorer neighborhoods are stagnating. Calgary was said to be the most unequal city in Canada in 2006 (Breau, 2014). However, almost all the urbanized territory of Calgary's metropolitan region is included within the city, which means there are very few suburban low-density areas (Fillion & Kramer, 2012). Most housing affordability stress for renters is concentrated in the inner suburbs (Bunting et al., 2004), therefore also explaining the weak statistical inference output. This may explain why levels of active living environments of neighborhoods did not seem to explain much of the different proportions of housing affordability, as most areas in Calgary's CMA are higher in density. Furthermore, the spatial patterning of neighborhood incomes which are increasingly polarized has shown to be less apparent in Calgary (Breau, 2018), therefore making it more difficult to pin point where housing unaffordability is found in relation to ALEs.

Out of all three CMAs, ethno-cultural composition explained the least for Toronto. This is most likely due to the many "ethno-burbs" characterizing Toronto and which concentrate high proportion of minorities in suburban, less walkable areas (Bunting et al., 2004), and visible minorities therefore not found in disproportionate numbers in inner city areas as is commonly the case in most CMAs. Although housing affordability stress tends to be more generally concentrated in the inner cities, this general trend varies due to the urban poor not being spatially located the same way in each CMA (Bunting et al., 2004). For instance, there is inner suburban poverty in Toronto's "ethno-burbs" (Bunting et al., 2004), and housing affordability stress may therefore not concentrate itself in inner city areas more catered to neighborhood walkability. Similarly, renters tend to be more spread out in Vancouver as there are much larger charges of rental housing in the outer suburbs (Revington & Townsend, 2016), which makes it so that low-income households are also not only concentrated in urban centers. This naturally results in varying outcomes in terms of how much the active living favourability of neighborhoods can explain the varying proportions of housing unaffordability.

High ALEs in Montreal, Quebec City, and Victoria explained the most in terms of having higher proportions of housing unaffordability. As Montreal's rental housing is centralized in the urban zones (Revington & Townsend, 2016), a large proportion of low income households find themselves in these high-density central areas. Economic dependency also explains differences in proportions of housing unaffordability, as poorer and less financially stable households tend to concentrate inner-city areas (Bunting et al., 2004). Montreal showed evidence of a rich-poor income gradient whereby neighborhoods that have low or high incomes are spatially patterned (Breau, 2018). Furthermore, inner cities have often been described as areas where impoverished immigrants and people enlisted in the low-income service sector concentrate (Bunting et al. 2014; Sassen, 1991; Van Kempen, 1994), which also explains why economic dependency contributes to explaining the variation in proportions of housing unaffordability. Quebec City had the lowest average proportion of housing unaffordability among all ten CMAs, which may explain why proportions of housing unaffordability are much higher in more central areas. Furthermore, renters have been found to concentrate in the least affordable sectors of the Quebec CMA (CMHC, 2020) which may also be contributing to housing unaffordability in these areas. Recent trends have shown housing in Victoria to be especially unaffordable (Spalteholz, 2019), and given that it is a very small CMA with very few DAs in ALE class 5, it is not surprising that housing unaffordability would be much higher in these more exclusive areas.

6.2 Answering question 3: Profile of Montreal's ALEs and field observation findings

According to quantitative results of the mean statistics of the four types of areas in Montreal (LL, LH, HL, HH), areas with more favorable ALE which are unaffordable (HH) were characterized by higher residential instability, ethnic and cultural diversity, and situational vulnerability (socio-demographic conditions related to housing and education). They indeed concentrate a large proportion of poorly educated populations and inadequate housing. The largest proportions of movers, visible minorities and recent immigrants were also found in HH areas. These characteristics are different from favorable active living environments which are affordable (HL), as these concentrate significantly smaller proportions of visible minorities and recent immigrants, a more educated population, and a much larger proportion of homeowners. It appears that HH areas are characterized more by social deprivation than are HL areas. These findings were supplemented by my field observations.

During my field observations of the four selected areas in Montreal, I observed systematic differences between more favorable ALEs which were affordable and those that were not. First, areas characterized by high ALE and higher affordability (HL) were less culturally and ethnically diverse or showed almost no diversity, and had a lot of single-detached or semi-detached dwelling types. They were also primarily residential areas which were well-maintained and had pleasant atmospheres. The reason why these areas did not experience high proportions of housing unaffordability may be due to the types of residents living there who can afford to live in them (Moos et al., 2018). Inversely, lower income residents may be prevented from living in such places, as little subsidized housing tends to be found there (Kim and Woo, 2016), and are rather found in less desirable areas (Kramer, 2018).

There were however two exceptions to this: Technopôle Angus and the Duff Court area in Lachine which are two developments providing affordable housing to households in well-served areas. These two areas are, however, very different in terms of social deprivation. The Duff Court includes 2,800 affordable housing units, half of which are owned by the Office Municipal d'Habitation de Montreal (OMHM) and the other half by private owners (Greenaway, 2018). Yet, many tenants residing there have been complaining in recent years about the conditions of the housing buildings and fear for their safety (Carpenter, 2018). Therefore, although well-served, walkable and affordable, the built and social conditions of the environment is not necessarily the best. Furthermore, the Duff Court has also been deemed one of the most violent districts in Lachine (Leduc, 2014), and I did notice a few people loitering about. This is why the socioeconomic features of ALEs are also important to consider, as indicators of sustainable form may not represent the same things in less advantaged areas (Talen & Kochinsky, 2011).

Technôpole Angus was a planned strategic project which was successful and deemed a good example of a sustainable development in 2016 by the UN (Klein et al., 2017). The success was due to local governance's active role as a mediator to regulate social and economic goals or interests which tend to be very divergent (Fontan et al., 2001). The interests of local residents were therefore taken into consideration when coming up with a development plan which included the desire for affordable housing (Klein et al., 2017). Based on my observations, the Technôpole Angus development was indeed successful in terms of serving local social needs despite neoliberal motivations which usually take away from any kind of social beneficial endeavors in new development. The district therefore confirmed that new developments can be both

economically viable in a neoliberal context and answer to local social needs if they are well managed by local governance (Fontan et al., 2001).

The main explanation I could give to describe why some areas with more favorable active living potential have affordable housing or not, is that those that are affordable seem to have planned for housing to be found there, as they are primarily residential in nature, while those who do not include sporadic housing in and around commercial areas. Indeed, the HH areas visited were not purely residential and included commercial areas around. They were also much more ethnically and culturally diverse. I did not observe any single-detached housing, but I did notice quite a few signs of social deprivation and poor maintenance including cracked sidewalks, a lot of littering and few homeless people.

Generally speaking, it is certain that those better off, notably from high-earning occupations, would be able to live in more expensive areas favorable to active living, while those who are of lower income levels would likely experience housing unaffordability in the long run (Moos et al., 2018). It is perhaps for this reason that the highly walkable and affordable areas which I visited appeared to be composed of households which were financially better off and of at least middle-class status based on the cars, quality of the housing, and built environment of such areas.

6.4 Research limitations

Although I attempted to conduct my research in the most systematic and unbiased way possible, there are inevitably important limitations to consider.

First of all, the ALE class measure is quantitative and does not consider the qualitative aspects of neighborhoods. Indeed, high ALEs do not necessarily mean that these places are supportive of active living, as the qualitative aspects which have been shown to affect walking behavior (Duncan et al., 2012) are not considered. Aspects such as safety, deprivation and social cohesion should also be considered in relation to housing in future research.

Secondly, neighborhoods are difficult to delimit and do not necessarily equate to DA boundaries. The modifiable area unit problem is therefore an important problem to consider, as it is easy to fall into the trap of prescribing onto neighborhoods characteristics found in one point-

based area which actually vary a lot on the ground, as different communities may be included under one DA.

Thirdly, defining housing unaffordability is in and of itself very tricky to do. The standard definition in Canada includes two aspects: household income and shelter-related costs (CMHC, 2015). However, whether housing unaffordability is primarily due to low incomes of households or high housing costs remains uncertain and is a difficult distinction to make (Bunting, 2004), and shelter-related costs may not be representative of all costs households are responsible for. There are also necessarily other costs linked to where housing is found which would likely impact housing unaffordability, such as the presence of amenities, public transportation and services in and around the idea. These features would especially influence transportation costs, as households far removed from them would necessarily have to rely on car travel which represents high vehicle and fuel costs.

The data used was from 2016, and most neighborhoods are currently undergoing change at very rapid rates. Income polarization is becoming more pronounced in CMAs neighborhoods (Breau, 2018). Analyses should therefore be replicated using data from the 2021 census.

Lastly, my field observations were only taken on specific days and times, and only through my own perception. The pictures taken and aspects I noticed the most were naturally subject to my own biased opinions, as well as to when my field observations were undertaken.

Future research should take special consideration to looking beyond the general built environment features, in order to observe how certain ALE classes may manifest themselves differently depending on the environment. The qualitative elements of the built environment such as the quality of the infrastructure and cleanliness of the area are important factors to consider, which most likely have implications for housing affordability. There has recently been a new housing affordability metric developed to assess households' ability to afford basic goods, including non-housing expenses such as food and transportation called the Housing Hardship Measure (CMHC, 2020) which, if used, would make for a more accurate assessment of whether households are truly experiencing housing unaffordability or not.

CHAPTER 7: CONCLUSION

To conclude, the findings of my research showed that neighborhood environments more conducive to active living are also those where the prevalence of housing unaffordability is higher. This was observed in Canada as a whole, as well as in specific CMAs. While socioeconomic deprivation measures further explained some of the variation in housing unaffordability, their effect was generally not as large as those for active living environment quintiles. However, the relationship between ALE and housing unaffordability varied. I identified three main categories in relation to the Pan-Canadian results in order to organize my findings. Four CMAs had similar results to the Pan-Canadian ones, as all these CMAs seem to be experiencing housing unaffordability stress and/or gentrification in their most central areas. More favorable ALEs in Toronto, Vancouver and Calgary did not seem to explain the variation in proportions of housing unaffordability as well as in other CMAs. Finally, Montreal, Quebec and Victoria showed ALE classes to explain the most variation in housing unaffordability.

Field observations allowed me to understand why certain areas more favorable to active living are affordable while others are not. Findings suggest that there are important qualitative aspects of the social and built environment of these areas that should be considered, such as the condition and maintenance of streets, sidewalks and parks, the types of housing, whether the area is safe or not, as these vary between affordable and unaffordable neighborhoods characterized by high ALEs.

It is possible that low-income households experiencing unaffordable housing costs in high ALEs are displaced due to higher housing costs in these types of areas (Knight et al., 2018). Therefore, it is important to plan neighborhoods considering their needs in order to prevent "geographies of poverty" where poor households are forced to live in under-serviced areas outside the city (Kramer, 2018, p.9). It is for this reason that regulations to include affordable housing at the early stages of development plans is a common strategy to attempt to prevent such an outcome from happening (Immergluck & Balan, 2018). However, many studies have shown that defining housing affordability simply through housing costs is limited, and may actually go against their intended purpose.

Indeed, researchers have attempted to include transportation and amenity costs among other indicators in defining housing affordability measures (Bieri & Dawkins, 2019; Fisher et al.,

2009; Acevedo-Garcia, 2016). For instance, in terms of transportation costs, the "drive until you qualify (to afford housing)" concept does not always make housing more affordable if other costs related to gas and vehicle maintenance are considered. This challenges commonly cited affordability studies which advocate for urban fringe development as a means to offer more affordable housing (Hamidi & Ewing, 2015; Mattingly & Morrissey, 2014). Furthermore, long commuting distances and high automobile dependency are also factors which offset the lower cost of housing in the urban fringe (Mattingly & Morrissey, 2014). However, this is not to discourage new developments to promote active living, as these can be successful and provide affordable housing if they are well planned. The Technôpole Angus area for instance is an exemplary case whereby housing remained affordable for residents living there, despite also planning for successful economic development in a neoliberal context. Furthermore, high ALEs have been shown to alleviate transportation costs for low-income households, given that these households do not require private motorized vehicles to get around, saving them car maintenance and fuel costs.

Suggestions may be presented to inform policy. Most studies emphasize the importance of considering public transportation when planning new developments especially when it comes to housing affordability (Saberi et al., 2017). For instance, Greenlee and Wilson (2017) refer to Blackman and Krupnick's (2001) location-efficient mortgages as an effective tool in terms of making housing more affordable in metropolitan areas that are well-served by public transit, as transportation costs are considered in housing costs, allowing households to afford to purchase expensive homes in well-served areas at a cheaper cost (2017). Furthermore, Mattingly and Morrissey explain that policy-makers should establish a balance between densification and the actual land available while simultaneously considering the relationship between housing and transportation costs (2014).

My research only scratches the surface of what could be done in terms of exploring the relationship between housing and sustainable neighborhoods. My results showed that sustainable neighborhoods are generally not very inclusive of affordable housing options, which indicates that more attention should be given to social features of sustainable neighborhoods. Further research is therefore needed when it comes to housing in sustainable neighborhoods which takes a social critical perspective, in order to draw a full picture of what sustainable neighborhoods really entail.

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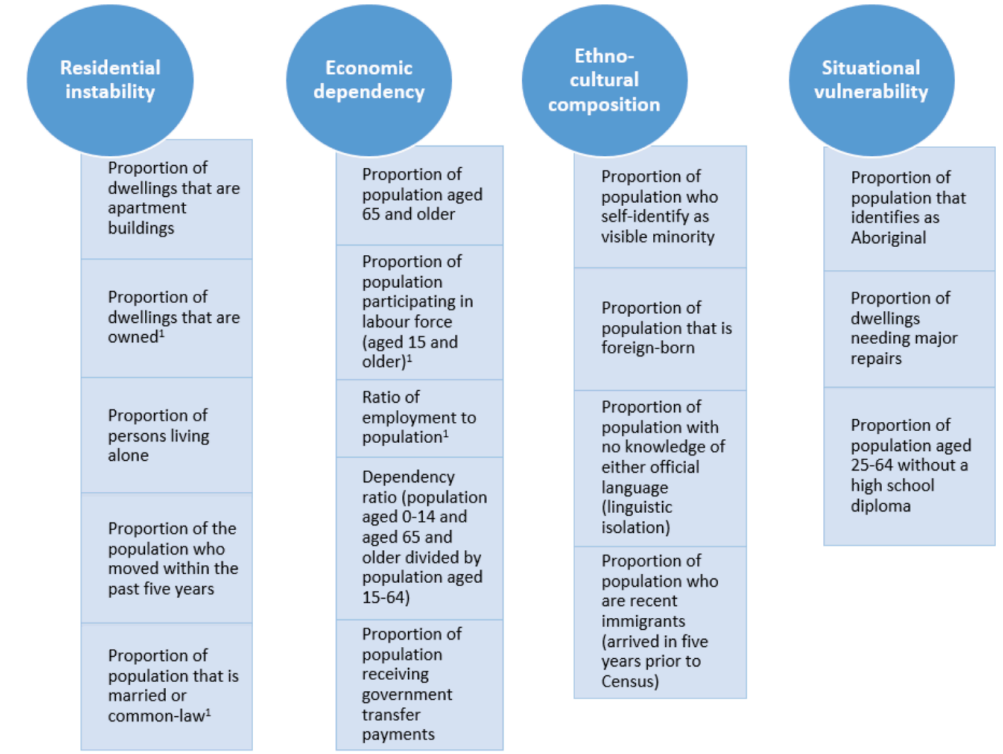
APPENDIX A: Methods

A.1 The four dimensions of multiple deprivation and their corresponding indicators, Canada, 2016



[1] This indicator was reverse-coded, meaning it was coded opposite of the measure. For example, proportion of population that is married or common-law becomes proportion of population that is single, divorced, separated or widowed.
Note: The dimensions are ordered such that the dimension on the left explains the highest percentage of the variance of the data and the dimension on the right explains the lowest percentage. Excludes the territories.

(Source: Census Canada 2016)

A.2 Correlation matrix between proportion of housing unaffordability and socioeconomic variables

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.6810*	1.0000			
Econ. dep.	0.1259*	0.1295*	1.0000		
Ethn.-cul. comp.	0.4381*	0.1947*	-0.1080*	1.0000	
Sit. vulnerability	0.2015*	0.1892*	0.1980*	-0.0351*	1.0000

A.3 Correlation matrix of proportion of housing unaffordability and all social deprivation measures in all CMAs

Quebec City

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.8165*	1.0000			
Econ. dep.	0.3229*	0.2614*	1.0000		
Ethn.-cul. comp.	0.3088*	0.4152*	0.0033	1.0000	
Sit. vulnerability	0.3967*	0.4622*	0.1146*	0.3816*	1.0000

Winnipeg

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.8328*	1.0000			
Econ. dep.	0.2697*	0.2226*	1.0000		
Ethn.-cul. comp.	0.3528*	0.3824*	-0.0073	1.0000	
Sit. vulnerability	0.4657*	0.4434*	0.1737*	0.2465*	1.0000

Montreal

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.7852*	1.0000			
Econ. dep.	0.2660*	0.1812*	1.0000		
Ethn.-cul. comp.	0.4558*	0.3971*	0.1413*	1.0000	
Sit. vulnerability	0.4059*	0.4280*	0.2068*	0.3615*	1.0000

Calgary

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.7098*	1.0000			
Econ. dep.	-0.0797*	-0.1534*	1.0000		
Ethn.-cul. comp.	0.3459*	0.1694*	-0.0575*	1.0000	
Sit. vulnerability	0.2901*	0.1568*	-0.0280*	0.3228*	1.0000

Ottawa-Gatineau

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.8296*	1.0000			
Econ. dep.	0.1117*	0.0938*	1.0000		
Ethn.-cul. comp.	0.3980*	0.3388*	0.0399*	1.0000	
Sit. vulnerability	0.4649*	0.4223*	0.1692*	0.4372*	1.0000

Edmonton

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.7996*	1.0000			
Econ. dep.	0.0658*	-0.0380*	1.0000		
Ethn.-cul. comp.	0.3952*	0.4166*	-0.0962*	1.0000	
Sit. vulnerability	0.3518*	0.2749*	0.1652*	0.1574*	1.0000

Toronto

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.6775*	1.0000			
Econ. dep.	0.1301*	0.0351*	1.0000		
Ethn.-cul. comp.	0.4129*	0.1054*	0.2141*	1.0000	
Sit. vulnerability	0.2519*	0.2442*	0.1994*	0.4156*	1.0000

Vancouver

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.5993*	1.0000			
Econ. dep.	0.0906*	-0.0504*	1.0000		
Ethn.-cul. comp.	0.3285*	-0.0304*	0.2005*	1.0000	
Sit. vulnerability	0.1860*	0.0429*	0.1255*	0.3587*	1.0000

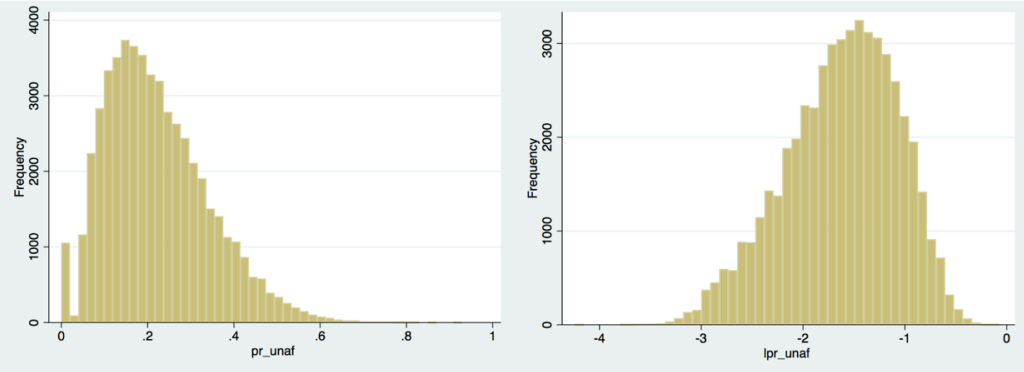
Hamilton

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.8258*	1.0000			
Econ. dep.	0.2444*	0.2598*	1.0000		
Ethn.-cul. comp.	0.3519*	0.3475*	0.0222*	1.0000	
Sit. vulnerability	0.4575*	0.4766*	0.0371*	0.3809*	1.0000

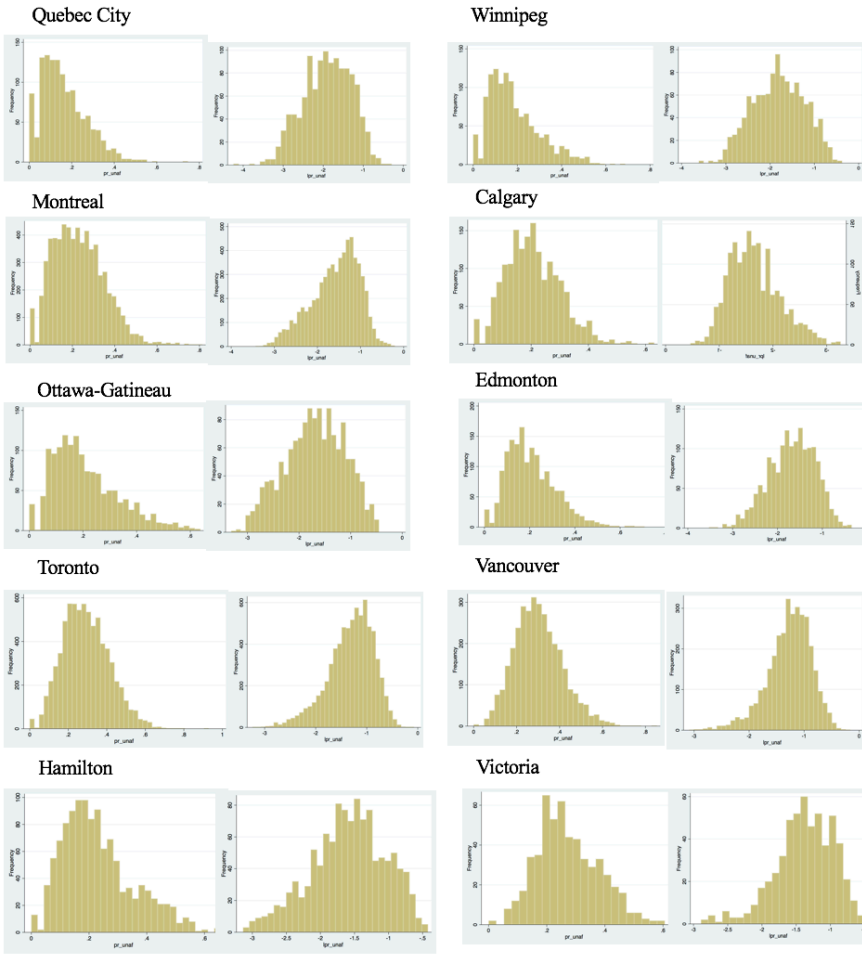
Victoria

	H.unaf.	Res.insta.	Econ.dep.	Eth.-c.	Sit.v.
Housing unaf.	1.0000				
Res. instability	0.7607*	1.0000			
Econ. dep.	-0.1562*	-0.1081*	1.0000		
Ethn.-cul. comp.	0.2127*	0.1061*	-0.1210*	1.0000	
Sit. vulnerability	0.3888*	0.1465*	-0.2203*	0.0003	1.0000

A.4 Histogram of proportion of housing unaffordability variable (left) and log-transformed variable (right)



A.5 Histogram of proportion of housing unaffordability in each CMA in its original form (left) and log-transformed (right)



*statistically significant at 0.5 level

A.2 Glossary of names, acronyms and related publications for virtual auditing tools reviewed prior to the development of the Virtual;-STEPS tool

Tool acronym	Name of tool	Reference
ANC	Active Neighborhood Checklist	Hoehner et al., 2007
CANVAS	Computer Assisted Neighborhood Visual Assessment System	Bader et al., 2015
CAT	Community Audit Tool	Brownson et al., 2004
CAT-AV	Community Audit Tool - Analytic Version	Hoehner et al., 2005
EAPRS	Environmental Assessment of Public Recreation Spaces	Saelens et al., 2006
FASTVIEW	Forty Area Study Street View	Griew et al., 2013
IMI	Irvine Minnesota Inventory	Boarnet et al., 2011
MAPS	Microscale Audit of Pedestrian Streetscapes	Millstein et al., 2013
MAPS-Mini	Microscale Audit of Pedestrian Streetscapes - Mini	Sallis et al., 2015
MIUDQ	Maryland Inventory of Urban Design Qualities	Ewing et al., 2006
NASH	Neighborhoods and Senior Health Study	King, 2008
NBOT	Neighborhood Brief Observation Tool	Caughy et al., 2001
NeDeCC	Neighbourhood Design Characteristics Checklist	Burton et al., 2011
NZ-SPACES	Systematic Pedestrian and Cycling Environmental Scan	Badland et al., 2010
PEDS	Pedestrian Environmental Data Scan	Clifton et al., 2007
PIN3	Pregnancy, Infection, and Nutrition Study	Evenson et al., 2009
REAT2.0	The revised Residential Environment Assessment Tool	Rodgers et al., 2018
SPACES	Systematic Pedestrian and Cycling Environmental Scan Instrument	Pikora et al., 2002
S-VAT	SPOTLIGHT Virtual Audit Tool	Bethlehem et al., 2014
SWAT	Scottish Walkability Assessment Tool	Millington et al., 2009
SWEAT	Senior Walking Environmental Audit Tool	Cunningham et al., 2005
WSAF	Walking Suitability Assessment Form	Emery et al., 2003

(Source: Madeleine Steinmetz-Wood)

A.3 Audit matrix with five categories and four dimensions

	Social environment	**Public spaces: *parks & gathering spaces***	**Transportation environment: *paths, transport, traffic***	**Public services/ Amenities: *institutions, shops, recreational facilities…***	**Housing**
Accessibility	Signs of segregation: • Gated communities • Barriers/fences/gates	Signs: • Wheelchair ramps • Benches/seating areas	Paths: • Hilliness/steepness • Obstruction (construction, pot holes) • Dropped kerbs • Way finding and legibility (street name and pedestrian signage) • Shade • Enclosure Transport: • Different options present • Bicycle/pedestrian friendly signs • Bus stops/metro signs • Biking storage/racks • Parking spots	Location: • Centrally located • Accessible by transport Inclusivity: • Accessible to people from different ethnicities or religious backgrounds	Affordability: • Modest to more upscale designs
Diversity	Mix of ethnicities and classes: • Different ethnic shops/restaurants • Flags	Signs: • Various parks • Various gathering spaces	Options: • Different transportation options • Different road options	Can serve people from different backgrounds: • Variety in types of institutions, shops and recreational facilities	Mix of housing types: • Single homes/condos/apartments • Modest to more upscale designs
Status/Condition/Aesthetic	Signs of socio-economic status • Education: nice schools • Income: low or higher scale homes/shops/infrastructure • Private car ownership (cars in driveways)	Maintenance: • Mowed lawns • Garbage/littering • Graffiti/ vandalism • Design/ layout • Trees/plants/flowers	Sidewalk/ Road condition: • Uneven/cracked pavement • Visible painted signs on roads • Attractiveness vs. difficulty for walking Public transport condition: • Buses/trains on time • Buses/trains well maintained Traffic: • Fluid vs. Jammed • Number of lanes • Private cars vs. trucks/buses	Order and maintenance: • Shops are clean, stocked and organized • Institutions are clean, organized, cared for	Condition of homes: • Major repairs needed • Newly built vs. renovated vs. old • Housing under construction • Nice design: layout and appearance • Garden/green space
Engagement/ Involvement	Community activities and gatherings: • Signs of upcoming community events/ clubs Media: • Local newspaper or other media outlets Behavior: • People sitting/standing/walking/running	Usage: • Garbage/littering • Traces of people having used the space • Children playing in playground	Usage: • People on roads/paths • People on buses/trains	Usage: • Public services are not empty • Shops are not empty • Recreational facilities are not empty and are cared for	Vacancy: • For sale signs • Abandoned homes Care for home: • Decorations • Housing under renovations
Safety	Signs of protection: • Police • Neighborhood watch Signs of crime • Gang activity • Drug usage and dealing	Signs of protection: • Public lighting	• Proper signs/ traffic lights • Speed limit • Sidewalk buffer • Public lighting • Pavement markings/crosswalk • Yield to pedestrian • Honking • Aggressive driving or biking	Signs of defensiveness: • Cops patrolling • Fences/barbed wire	Signs of defensiveness: • Guard dogs • Large fences • Surveillance cameras • No trespassing signs

APPENDIX B: Results

B.1 Mean statistics of socioeconomic variables by ALE class for each CMA

Variables	ALE class	Canada	Quebec City	Montreal	Ottawa-Gatineau	Toronto	Hamilton	Winnipeg	Calgary	Edmonton	Vancouver	Victoria
		Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error	Mean s. error
Residential instability score	**1**	-0.444 0.004	-0.511 0.033	-0.435 0.026	-0.768 0.027	-0.616 0.022	-0.705 0.035	-0.777 0.049	-0.656 0.055	-0.666 0.040	-0.513 0.027	-0.469 0.042
	2	-0.147 0.007	-0.24 0.044	-0.315 0.021	-0.410 0.038	-0.576 0.015	-0.488 0.035	-0.336 0.039	-0.407 0.029	-0.323 0.029	-0.440 0.021	-0.277 0.040
	3	0.222 0.009	0.636 0.063	0.294 0.027	-0.017 0.044	-0.254 0.015	-0.052 0.041	0.333 0.044	-0.017 0.029	0.283 0.039	-0.048 0.022	0.656 0.072
	4	0.883 0.016	1.852 0.06	1.101 0.023	1.420 0.079	0.306 0.024	0.905 0.081	1.637 0.115	1.660 0.128	2.457 0.065	0.594 0.035	1.617 0.092
	5	1.673 0.019	2.226 0.07	1.829 0.023	2.293 0.109	1.199 0.037	2.463 0.142	2.868 0.117	2.282 0.063	2.389 0.067	1.826 0.045	2.523 0.157
Economic dependency score	**1**	0.154 0.007	-0.396 0.047	-0.352 0.030	-0.468 0.041	-0.333 0.037	-0.282 0.058	-0.548 0.054	-0.650 0.192	-0.699 0.042	-0.073 0.056	0.213 0.082
	2	-0.010 0.008	-0.183 0.041	-0.266 0.020	-0.216 0.044	-0.260 0.019	-0.081 0.073	-0.382 0.035	-0.708 0.027	-0.592 0.033	-0.274 0.026	0.194 0.084
	3	-0.053 0.008	0.262 0.052	0.189 0.022	-0.233 0.038	-0.105 0.014	0.164 0.043	-0.239 0.038	-0.806 0.027	-0.626 0.031	-0.109 0.023	-0.109 0.076
	4	0.0103 0.0148	0.410 0.084	0.298 0.021	-0.257 0.084	-0.081 0.030	0.047 0.064	-0.421 0.090	-1.340 0.166	-1.109 0.130	-0.168 0.038	-0.237 0.100
	5	-0.463 0.018	0.034 0.142	-0.322 0.025	-0.799 0.127	-0.510 0.031	0.031 0.20	-0.036 0.243	-1.598 0.114	-1.068 0.157	-0.705 0.052	-0.117 0.187
Ethno-cultural composition score	**1**	-0.593 0.003	-0.776 0.009	-0.546 0.016	-0.480 0.025	0.085 0.039	-0.342 0.024	-0.452 0.045	-0.089 0.064	-0.508 0.027	0.363 0.054	-0.392 0.025
	2	-0.093 0.007	-0.703 0.009	-0.358 0.012	0.034 0.029	0.838 0.024	-0.107 0.025	0.189 0.042	0.271 0.032	0.023 0.028	0.783 0.0356	-0.168 0.032
	3	0.559 0.010	-0.549 0.025	0.207 0.020	0.237 0.031	1.432 0.020	0.114 0.026	0.362 0.043	0.758 0.033	0.678 0.032	1.538 0.032	-0.047 0.035
	4	0.995 0.018	-0.290 0.043	0.890 0.025	0.098 0.058	1.285 0.031	0.169 0.074	0.944 0.115	0.291 0.128	0.714 0.143	1.704 0.047	-0.211 0.036
	5	0.667 0.020	-0.491 0.055	0.593 0.029	-0.036 0.083	0.890 0.035	0.523 0.166	0.238 0.175	0.596 0.114	0.192 0.094	0.774 0.060	-0.204 0.187
Situational vulnerability score	**1**	0.222 0.009	-0.467 0.023	-0.266 0.019	-0.484 0.022	-0.431 0.020	-0.464 0.043	-0.203 0.051	-0.566 0.078	-0.156 0.064	-0.348 0.046	-0.297 0.097
	2	-0.241 0.005	-0.558 0.015	-0.364 0.010	-0.511 0.022	-0.469 0.010	-0.536 0.026	-0.134 0.034	-0.540 0.017	-0.377 0.021	-0.425 0.015	-0.463 0.035
	3	-0.107 0.005	-0.370 0.023	-0.137 0.012	-0.361 0.024	-0.243 0.010	-0.112 0.029	0.235 0.035	-0.324 0.019	-0.063 0.022	-0.239 0.013	-0.368 0.033
	4	-0.039 0.010	-0.130 0.038	0.062 0.015	-0.097 0.061	-0.140 0.017	0.604 0.065	0.880 0.092	-0.682 0.049	-0.320 0.087	-0.171 0.021	-0.322 0.048
	5	-0.257 0.012	-0.222 0.0687	-0.059 0.015	-0.478 0.068	-0.334 0.024	0.073 0.112	0.368 0.229	-0.880 0.043	-0.623 0.080	-0.623 0.027	-0.568 0.159

B.2 OLS regression output of models 1 and 4 for Hamilton, Edmonton, Winnipeg, and Ottawa-Gatineau CMAs

Variables	Hamilton			Edmonton			Winnipeg			Ottawa-Gatineau		
	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights
Model 1												
ALE Class												
2	0.033†	3.31†	0.03	0.075*	7.78*	0.07	0.130*	13.84*	0.1	0.012†	1.24†	0.01
3	0.217	-39.16	0.19	0.403	-3.63	0.38	0.434	-1.39	0.37	0.226	25.41	0.19
4	0.713	24.17	0.41	0.884	49.58	0.32	0.910	54.37	0.43	0.768	115.57	0.41
5	0.911	103.95	0.26	0.879	141.96	0.2	1.147	148.42	0.21	0.832	129.82	0.26
Constant	-1.797			-1.917			-2.145			-1.899		
# obs.	1,158			1,587			1,163			1,390		
Adjusted R^2	0.185			0.187			0.194			0.195		
Model 4												
ALE Class												
2	-0.043†	-4.22†	-0.04	-0.041†	-4.01†	-0.04	0.012†	1.23†	0.01	-0.075†	-7.22†	-0.06
3	0.067†	6.95†	0.06	0.178	19.44	0.17	0.260	29.64	0.22	0.094*	9.87*	0.08
4	0.591	80.6	0.34	0.681	97.52	0.25	0.676	96.64	0.32	0.675	96.38	0.36
5	0.713	104.08	0.21	0.722	105.9	0.16	0.897	145.23	0.17	0.813	125.37	0.26
Economic Dependency Quintiles												
2	0.016†	1.65†	0.01	-0.006†	-0.61†	-0.01	0.054†	5.58†	0.04	0.086*	8.95*	0.06
3	0.076†	7.9†	0.06	0.029†	2.96†	0.02	-0.080†	-7.61†	-0.05	0.103**	10.86**	0.07
4	0.062†	6.43†	0.05	-0.033†	-3.280†	-0.02	0.061†	6.33†	0.04	0.094*	9.82*	0.06
5	0.283	32.65	0.19	0.313	36.8	0.12	0.509	66.36	0.25	0.212	23.62	0.11
Ethno-Cultural Quintiles												
2	-0.330*	-28.13*	-0.19	-0.141*	-13.16*	-0.1	-0.042†	-4.16†	-0.03	-0.050†	-4.92†	-0.03
3	-0.308*	-26.54*	-0.27	-0.001†	-0.12†	0.00	-0.064†	-6.23†	-0.05	-0.142*	-13.19*	-0.11
4	-0.148†	-13.77†	-0.13	0.102†	10.77†	0.09	0.177*	19.4*	0.14	0.082†	8.56†	0.07
5	0.090†	9.41†	0.06	0.288	33.41	0.25	0.310	36.32	0.24	0.435	54.48	0.27
Constant	-1.579			-1.877			-2.175			-1.941		
# obs.	1,158			1,587			1,163			1,390		
Adjusted R^2	0.267			0.252			0.314			0.297		

All associations are statistically significant at $p < 0.001$ except where identified †: ≥ 0.05; *≤ 0.05; **≤ 0.01

B.3 OLS regression output of models 1 and 4 for Toronto, Calgary, and Vancouver CMAs

Variables	Toronto			Calgary			Vancouver		
	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights
Model 1									
ALE Class									
2	-0.20†	-1.94†	-0.02	0.007†	0.74†	0.01	-0.070**	-6.67**	-0.07
3	0.159	-32.23	0.17	0.209	23.22	0.22	0.156	16.86	0.19
4	0.277	17.19	0.24	0.500	64.9	0.2	0.277	31.85	0.28
5	0.468	31.94	0.32	0.592	80.77	0.21	0.461	58.63	0.34
Constant	-1.478			-1.794			-1.414		
# obs.	7,247			1,670			3,364		
Adjusted R^2	0.107			0.092			0.162		
Model 4									
ALE Class									
2	-0.153	-14.22	-0.14	-0.042†	-4.1†	-0.04	-0.109	-10.33	-0.12
3	-0.058**	-5.62**	-0.06	-0.109**	-10.34**	0.09	0.036†	3.71†	0.04
4	0.089	9.27	0.08	0.441	55.49	0.17	0.156	16.92	0.16
5	0.327	38.71	0.22	0.465	59.16	0.17	0.436	54.6	0.32
Economic Dependency Quintiles									
2	0.009†	0.89†	0.01	-0.042†	-4.1†	-0.04	0.013†	1.27†	0.01
3	0.017†	1.69†	0.02	-0.109**	-10.34**	-0.07	0.015†	1.52†	0.02
4	-0.010†	-0.98†	-0.01	-0.112**	-10.62**	-0.06	0.008†	0.79†	0.01
5	0.082	8.5	0.06	0.061†	6.32†	0.02!	0.121	12.9	0.09
Ethno-Cultural Quintiles									
2	-0.288**	-25.02**	-0.09	0.026†	2.65†	0.01	-0.022†	-2.22†	-0.01
3	-0.353**	-29.78**	-0.24	0.027†	2.76†	0.02	0.116†	12.34†	0.09
4	-0.221*	-19.81*	-0.22	0.131†	13.95†	0.13	0.227†	25.42†	0.25
5	0.076†	7.91†	0.08	0.346**	41.30**	0.35	0.431*	53.93*	0.52
Constant	-1.266			-1.863			-1.688		
# obs.	7,247			1,670			3,364		
Adjusted R^2	0.235			0.165			0.249		

All associations are statistically significant at $p < 0.001$ except where identified †: ≥ 0.05; *≤ 0.05; **≤ 0.01

B.4 OLS regression output of models 1 and 4 for Montreal, Quebec, and Victoria CMAs

Variables	Montreal			Quebec			Victoria		
	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights	Log coeff.	% change	Beta weights
Model 1									
ALE Class									
2	-0.054*	-5.25*	-0.04	-0.008†	-0.78†	-0.01	0.070†	7.23†	0.08
3	0.240	27.13	0.19	0.403	49.61	0.31	0.379	46.06	0.40
4	0.583	79.14	0.45	0.828	128.77	0.49	0.597	81.59	0.53
5	0.752	112.17	0.51	0.913	149.15	0.33	0.685	98.29	0.17
Constant	-1.897			-2.189			-1.619		
# obs.	6,222			1,187			547		
Adjusted R^2	0.305			0.307			0.28		
Model 4									
ALE Class									
2	-0.073**	-7.06**	-0.06	-0.048†	-4.65†	-0.04	0.019	1.59	0.02
3	0.105	11.03	0.08	0.278	32.1	0.21	0.306	35.74	0.33
4	0.370	44.73	0.28	0.633	88.36	0.38	0.531	70.14	0.48
5	0.661	93.77	0.45	0.807	124	0.29	0.638	89.33	0.16
Econ. Dep. Quintiles									
2	0.126	13.43	0.09	0.165	17.93	0.11	-0.002	-0.16	0.00
3	0.206	22.9	0.16	0.225	25.2	0.15	-0.098	-9.31	-0.09
4	0.224	25.1	0.17	0.218	24.34	0.14	-0.097	-9.24	-0.09
5	0.345	41.16	0.23	0.292	33.97	0.2	-0.104	-9.88	-0.10
Ethno-Cul. Quintiles									
2	-0.031†	-3.02†	-0.02	-0.007†	-0.66†	0	-0.209	-18.89	-0.18
3	0.052*	-18.37*	-0.04	0.141**	15.09**	0.09	-0.153	-14.19	-0.18
4	0.335†	-5.09†	0.03	0.282	32.61	0.13	0.134	-8.01	-0.09
5	0.202	3.4	0.16	0.241*	27.29*	0.06	-1.390	14.28	0.07
Constant	-2.021			-2.334			-1.390		
# obs.	6,222			1,187			547		
Adjusted R^2	0.369			0.3470			0.31		

All associations are statistically significant at $p < 0.001$ except where identified †: ≥ 0.05; *≤ 0.05; **≤ 0.01