WALK AND THRIVE? THE IMPORTANCE OF LOW-INCOME HOUSEHOLD ACCESS TO MIXED-USE NEIGHBORHOODS IN THE METRO VANCOUVER REGION

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Planning)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

October 2021

The following individuals certify that they have read, and recommend to the Faculty of Graduate and Postdoctoral Studies for acceptance, the dissertation entitled:

WALK AND THRIVE? THE IMPORTANCE OF LOW-INCOME HOUSEHOLD ACCESS TO MIXED-USE NEIGHBORHOODS IN THE METRO VANCOUVER REGION

submitted by Lili Shulman in partial fulfillment of the requirements for

the degree of DOCTOR OF PHILOSOPHY

in Planning

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Abstract

The principal goal of this dissertation is to study whether mixed-use, pedestrian-oriented environments are universally accessible. Compact neighborhoods are viewed positively because they improve health and sustainable development, but access is limited to financially qualified populations (Riggs, 2016).

Housing (un)affordability becomes a problem when land prices and home values rise as demand for inner-city neighborhoods, often characterized by mixed-use, pedestrian-oriented design (MUPOD), increases (Leinberger & Alfonzo, 2012).

This dissertation explores the spatial distribution of MUPOD in the Metro Vancouver region (BC) and the health, housing, and demographic makeup of neighborhoods using a series of multiple linear regression models (2014/2015). This dissertation bridges planning research gaps on the impact of MUPOD on displacement, and the interactions between built form, health outcomes and housing prices. It is hypothesized that MUPOD is associated with gentrification and displacement.

I find a negative relationship between MUPOD and health and social well-being ($p>0.05$) which contradicts the understanding that residents of compact environments benefit from improved health. Different built environments contribute to uneven health outcomes for communities of different socioeconomic status. Consequently, negative health impacts associated with increased demand for inner-city neighborhoods need to be acknowledged.

The results exemplify gentrification processes in high MUPOD environments. A positive MUPOD/house value association is documented in Vancouver urban core whereas higher MUPOD scores predict reductions in house values in the Metro's suburban periphery. Moreover,

there is no statistically significant evidence to suggest household relocation from high MUPOD environments for affordability reasons. Unlike the study's expectations, increased MUPOD levels are shown to predict higher percentages of low-income households earning under $40k. Perhaps, it is not low-income households who are displaced? Maybe they cannot even afford to move? While these results cannot be used to explain causation, they encourage discussion about relevant correlational associations, namely accessibility, health, housing, social inequality, and displacement. Future studies need to ask - what are the costs of staying? Policies need to be designed using social and health equity lenses to benefit all. Ultimately, a qualitative approach to explore these research questions is necessary to improve understanding of displacement processes.

Lay Summary

The principal goal of this dissertation is to study whether mixed-use, pedestrian-oriented environments are accessible to all. Even though compact neighborhoods are generally viewed positively in research because they promote sustainable development and improve health, in the Metro Vancouver region (BC) context residents of mixed-use environments do not seem to benefit from improved health and social well-being. The results point to gentrification processes in mixed-use environments; however, they do not indicate displacement of low-income households from these neighborhoods. As it becomes clear that different built environments contribute to uneven health outcomes for communities of different socioeconomic status, the exacerbated negative health impacts resulting from increased demand for inner city neighborhoods need to be acknowledged. Policies need to be designed using social and health equity lenses in order to benefit all.

Preface

This dissertation is original, unpublished, independent work by the author, L. Shulman. The maps included in Chapter 3 and Chapter 4 were created by M. Michaux, University of British Columbia, for the purpose of this dissertation and with the author's direct guidance and supervision.

The following figures and tabular data are used with permission from applicable resources: Figure 3.4., Figure 3.7., Figure 3.8., Figure 6.2., Table 4.1., Appendix A, Appendix C and Appendix D.

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List of Abbreviations

BC: British Columbia

BE: Built Environment

BCAA: British Columbia Assessment Authority

BMI: Body Mass Index

BRT: Bus Rapid Transit

CBD: Central Business District

CMA: Census Metropolitan Area

CMHC: Canada Mortgage and Housing Corporation

COP: Community Official Plan

CPR: Canadian Pacific Railroad

CV: Coefficient Variation

CT: Census Tract

DA: Dissemination Area

FA: Floor Area

FH: Fraser Health

FTN: Frequent Transit Network

GIS: Geographic Information System

MHMC: My Health My Community

MUPOD: Mixed-Use, Pedestrian-Oriented Design

NHS: National Household Survey

PC: Principal Components

PCA: Principal Component Analysis

RMS: Rental Market Survey

SD: Standard Deviation

SOB: Sense of Belonging

SRO: Single Room Occupancy

TOC: Transit Oriented Communities

TOD: Transit Oriented Development

VCH: Vancouver Coastal Health

Acknowledgements

I will start by thanking my advisors: Penny Gurstein, Nathanael Lauster and Tsur Somerville. I thank you for trusting me with the process, letting me lead and supporting any route that I chose, demonstrating much flexibility. Thank you for being patient and encouraging when I needed to rethink my topic and make changes to my supervisory committee halfway in. You were kind with your time and showed your humanity in challenging times. Thank you for sharing your knowledge and expertise and for providing useful advice that kept me focused.

My supervisor in my master's degree, Danny Ben-Shahar, has had a tremendous impact on shaping my professional endeavors. His work ethic and attitude to research and academia have shaped mine. He has been my mentor and I thank him greatly for that.

During my PhD studies I gave birth to my son, Michael (מיכאל). This has been no less than transformative. He is my light and happiness; his presence gave me purpose. I thank my partner, Tal, who was supportive more than I could imagine. Thank you for being brave, adventurous, for making me laugh, for believing in me, and for understanding the highs and downs throughout the PhD process.

Special thanks are owed to my family. My mom completed her PhD before I was born and has always been an inspiration. Sadly, she was diagnosed with dementia and has been deteriorating rapidly while I was writing this dissertation. I am sorry that I cannot share this accomplishment with her. I thank my siblings, Adam and Alona, for being there for my mom when I couldn’t. I thank Mary, her dedicated caregiver, her presence put me at ease. Ilan, my mom’s partner, has provided me with endless support: starting with my PhD applications, through reviewing every paper submitted, including this dissertation, providing clarity, useful comments, and being the most up to date about this chapter in my life. I thank my dad for making the long trip to Vancouver and being there hours after I gave birth. It meant the world to me.

I'm grateful for having the best girlfriends one could ask for. Shiri, Shish, Yaeli, and Gali. It's been more than five years since they helped me pack and plan and encouraged me to follow my dream. Knowing that they will be there for me when I come back from my PhD adventure gave me strength.

The time I spent working in my office in the School of Community and Regional Planning earned me true friendships: Magdalena and Sara, I'm lucky to have had you in this process. You inspired me with your strong personalities, wisdom, and warmth. You made me feel welcome and made the journey feel much more possible and fun. For the latter half of the PhD: Sunya, Lauren, Becca, and Meryem, thanks for maintaining a strong community of scholars and for being supportive and thoughtful friends.

I thank Shimrit and Ido, my neighbors on the UBC campus, for being our family away from home and for keeping a constant supply of home-made baked goods. One could not ask for more!

I am grateful to Mielle Michaux for her help with visualizing my data. I could not have completed this work without her. Thank you for being available, for making me enthusiastic about R and the data analysis phase. Thank you for my points of contact in Vancouver Coastal Health and in Redfin Real Estate agency, Ellen Demlow and Aleisha Jacobson. Access to the data made it possible to examine my research questions and their attentiveness and willingness to address my many inquiries helped immensely.

Finally, the financial support received from the J. Armand Bombardier Foundation helped me to accomplish the project with more comfort and I am grateful for that.

For my sister Alona (my Noni)

Chapter 1: Introduction

This chapter provides a summary of the dissertation and it is organized as follows: Section 1 poses the research problem and some theoretical background. Section 2 describes the research questions and lastly, Section 3 provides a guide to the structure of the dissertation document.

1.1 Problem and Background

To start the conversation on how to address the housing problem, we need to look at meeting housing needs more holistically than is being done in the current real estate market and understand more deeply what housing means as a social responsibility and right (Gurstein & Yan, 2019; 236).

The principal goal of this dissertation is to study whether mixed-use, pedestrian-oriented environments are accessible to all. Importantly, and as suggested by Gurstein and Yan (2019), to understand how housing is viewed broadly in its local context and in its relation to both health, environmental, economic, and social aspects. This will contribute to the understanding of how built environments (neighborhood design in particular) have significant, wide-range consequences.

Inspired by Mertens (2010) this dissertation incorporates the “transformative spirit” by surfacing social and economic inequality issues. It focuses on low-income, marginalized communities who often do not get full access to investments made for the public. My positionality and voice as a researcher (or the challenges I choose to voice) have evolved during my academic journey. This evolution was necessary. “*In order to support societal transformation, researchers also need to engage in personal transformation in their* *understandings of the origins of different versions of reality and consequences of accepting one version of reality over another*." (Mertens, 2018; 21). It helped to design my research questions and ultimately support my goal to inform changes in policy that challenge the current distribution of health, and economic resources.

The emergence of the planning profession in the Western world in the early 20th century intended to resolve not only the many physical challenges posed by urban areas but social aspects as well[1]. Overcrowding, lack of fresh air and sunlight, and run-down streets, all characterized the cities of that time. Howard, Wright, and Le Courbusier, the first and perhaps the most well recognized Western planners, envisioned cities as cancer, destroying the modern world and damaging health. It was clear to these planners that political and economic reform had to be weaved into the radical city reconstruction plans they proposed (Fishman, 2016).

These and subsequent plans directed investments in the urban periphery (excluding Le Courbusier's). Those who could afford to moved out of the city. This led to a massive suburbanization which in turn introduced new challenges. In recent decades there has been a decline in social capital due to suburbanization, long commutes, unhealthy lifestyle, and time and money constraints (Leyden, 2003). Moreover, urban sociology research predicted that characteristics of the urban environment such as population growth and density, mobility, and heterogeneity, will have a negative impact on life quality, society cohesiveness, social networks, sense of community, neighborliness, mental health, and social organization and engagement

[1] It is important to note that while the planning *profession* is a fairly recent endeavor, the planning *practice* is known to have a much longer history. Planning *practice* dates back to the first human settlement and in the American context it often mirrors the long history of its land disputes. Indigenous tribes have planned their communities (including space division to residential, commercial, open, and shared spaces) since time immemorial. European settler colonialists then used space appropriation mechanisms to force a western practice over native paths (Stein, 2019; Ugarte, 2014).

(Adams, 1992; Greenbaum & Greenbaum, 1985; Hunter, 1975; Sampson, 1988; Talen, 1999; Wirth, 1938).

Investments today are mostly directed into reconstruction of existing urban neighborhoods (Hwang & Lin, 2016). Here again, with some resemblance to the profession's emergence, different urban planning tools are used to address social and health threats. These investments, however, have been shown to have negative impacts including displacement. As demand for inner city neighborhoods, which are most often characterized by mixed-use, pedestrian-oriented design (hereafter: MUPOD) increases, land prices and home values rise and these neighborhoods are at risk of becoming unaffordable (Leinberger & Alfonzo, 2012). Low-income residents are then forced to move to more affordable places that have poorer access to transit, jobs, and services.

Compact neighborhoods are generally viewed positively in research because they promote sustainable development and improve health but access to these health-promoting environments is limited to those populations that can afford them (Riggs, 2016). Yet, the impact of mixed-use, pedestrian-oriented neighborhoods on displacement of low- and moderate-income households is understudied in planning literature.

Moreover, different features of the mixed-use, pedestrian-oriented neighborhood might be in conflict. For instance, a neighborhood can be mixed-use but have a high crime rate, or pedestrian-oriented but not diverse. These contrasts are especially likely in less affluent areas, thus critiques of the walkable neighborhood usually target issues of gentrification and displacement (McDowell, 1997; Talen & Koschinsky, 2013). When advocating for increased mixed-use design of built environments for the sake of the positive environmental, social, and health impacts for its residents, these problematic contrasts need to be addressed. If the meaning of increased transit investment at one locale contributes only to the already well-off by not considering affordable housing measures for middle- and low-income households, these policies might result in displacement and exacerbate existing inequalities (Edelson et al., 2019).

Clearly, pedestrian infrastructure investment has an impact on access to public goods. Who gets to benefit from these infrastructure improvements is my concern. The purpose of this research is to help illuminate whether mixed-use, pedestrian-oriented development is associated with gentrification and displacement that potentially reduces access to these features for low-income households. I explore the relationships between built environment design (MUPOD, in particular) and: (1) health and social well-being outcomes; (2) housing cost; (3) need to move for affordability; and (4) share of households earning under $40,000[2].

Research so far has mostly focused on interactions between built form, and either health outcomes, or housing prices. The proposed contribution of this research lays in bridging these areas of research together. By linking data from different sources, this dissertation tells a broader, more holistic story. While results cannot be used to explain causation, they encourage conversation on relevant correlational associations of closely connected factors namely accessibility, health, housing, social inequality, and displacement.

Literature in transportation, urban political ecology, housing preferences, behavioral economics, the rational choice model, transit-oriented gentrification, and public health, informs this dissertation.

[2] This number refers to 2016 Canada Census definition of low-income measures threshold for a private 2 persons household (Statistics Canada, 2016).

1.2 Research Questions

A growing interest in built environments that encourage physical activity is partly a result of efforts to address health challenges of the 21st century such as obesity (Braun et al., 2016; Catlin, Simoes, & Brownson, 2003; Ewing, Brownson, & Berrigan, 2006; Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Sööt et al., 2006).

However, socioeconomic, demographic and social-equity related aspects that often mask the ability of the individual to choose where to live have not received enough attention in research. This is particularly important to low-income and minority households who have been historically discriminated against by lending institutions thus preventing them from moving to neighborhoods which benefited from public investment. This then becomes a public health problem since higher MUPOD levels are generally shown to support improved health and well-being for residents (Riggs, 2011).

Ultimately, this research will contribute to the understanding of increased MUPOD and potential displacement of low-income households. I conjecture that mixed-use, pedestrian-oriented development and displacement are related. That is, investment in mechanisms to promote active travel modes exacerbates housing (un)affordability which leads not only to displacement but to additional negative health outcomes which existing policies do not address. It needs to be noted, however, that this research's intent is not to prove causation rather relational associations between variables. Since the utilized data are cross-sectional and because of endogeneity (that is, the challenge in isolating specific characteristics of the built environment and learn their impact) - causality cannot be proven. Insights could potentially help explain these processes, and what can be done by decision makers to build more inclusive environments.

The study examines the following research questions:

1. Controlling for relevant personal characteristics, is there a significant association between the degree of neighborhood MUPOD and health and social well-being outcomes?

2. Controlling for relevant neighborhood characteristics, is there a significant association between the degree of neighborhood MUPOD and housing costs?

3. Does housing affordability play a significant factor in household decisions to move to neighborhoods characterized by lower levels of MUPOD?

4. Controlling for relevant personal characteristics, is there a significant association between the degree of neighborhood MUPOD and the share of households earning $40,000 or less?

Research has shown that infrastructure to promote active transit mode improves accessibility and thus the desirability of these residential environments and in turn leads to housing price appreciation (Bartholomew & Ewing, 2011; Leinberger, 2008; Leinberger & Alfonzo, 2012; Stokenberga, 2014; Wang & Immergluck, 2015; Zuk, Bierbaum, Chapple, Gorska, & Loukaitou-Sideris, 2018). Moreover, increased MUPOD is associated with improved health and social well-being outcomes which I suspect is also associated with increased housing values[3]. According to the classic filtering model, low-income residents are expected to be displaced by higher income households who are willing to pay for accessibility (McKinnish et

[3] The health/housing value relationship, however, is outside the scope of this research and will not be examined here.

al., 2010). I hypothesized that increases in housing costs produce neighborhood change and displacement of low- and moderate-income households to more car-oriented, affordable environments. It is therefore expected that affordability is a significant factor in household moving decisions to neighborhoods characterized by low MUPOD, and that fewer low-income households (earning under $40,000 annually) reside in neighborhoods characterized by a higher degree of MUPOD.

A quantitative approach is chosen to address the research questions in order to leverage existing large data sets for the Metro Vancouver region. The different data sources are typically studied separately so that relationships between these datasets are often overlooked. The integrated analysis performed here is one of the major contributions of this dissertation. While a mixed-methods approach, including a qualitative aspect (e.g., surveying households who had moved for affordability reasons), would have contributed to the analysis, this was beyond the scope of the study. A qualitative angle is an important topic for future research to explore.

1.3 Organization of the Dissertation

The dissertation essay is organized as follows: **Chapter 2**: provides a review of relevant literature on public investment as a redevelopment strategy, housing preferences and choice, gentrification, and displacement. This chapter provides the theoretical background needed to explore the relevant research questions on the relationships between MUPOD and: (1) health and social well-being outcomes; (2) housing cost; (3) need to move for affordability; and (4) low-income households. The gap in existing research that the dissertation aims to address is described in Section 4. **Chapter 3**: describes the research methods and research design of the dissertation. The research's purpose and questions are in Section 3.1. Section 3.2 outlines the analysis approach. An overview of the research location and the Metro Vancouver historical context is introduced in Section 3.3. Data sources for this dissertation are presented in Section 3.4. Geography conversion approach and implementation are offered in Section 3.5. The independent, dependent and control variables used in the estimation models are described in Sections 3.6, 3.7, and 3.8, respectively. The statistical tests used to estimate the research questions are discussed in Section 3.9 and 3. 10. Finally, the process of joining the five data sets and cleaning the data is introduced in Section 3.11. Descriptive statistics and maps are used in **Chapter 4**: to portray the sample, its representativeness and to describe the characteristics of the independent, dependent, and control variables. **Chapter 5**: discusses the estimation model results, where a section is dedicated to each of the research questions. **Chapter 6**: discusses the results in relation to existing literature and to the dissertation's conceptual model, and future research opportunities (6.1), reviews limitations of the study beginning with linking data from five sources using different geographies and ending with challenges in measuring displacement (6.2), portrays policy implications (6.3), and concludes with a short discussion of MUPOD in light of COVID-19 (6.4). The last chapter, **Chapter 7**: summarizes the conclusions and offers final remarks.

Chapter 2: Review of Relevant Literature

In this chapter, the research problem is introduced, and some theoretical background is provided to build an argument in support of pursuing this dissertation. The chapter is organized into four sections. The first section discusses redevelopment strategies including public investment in mixed-use, pedestrian-oriented neighborhoods and the associated health and well-being benefits to residents. The following Section reviews approaches to measuring housing preferences and choices and their compatibility to the dissertation's goals. The existing academic literature in the areas that support the focus of this dissertation, namely gentrification and displacement, and in particular transit-induced and green gentrification is debated in Section 3. Section 4 points to the research gaps this dissertation aims to fill. Figure 2.1 illustrates the literature covered here and the connections between the different fields of investigation.

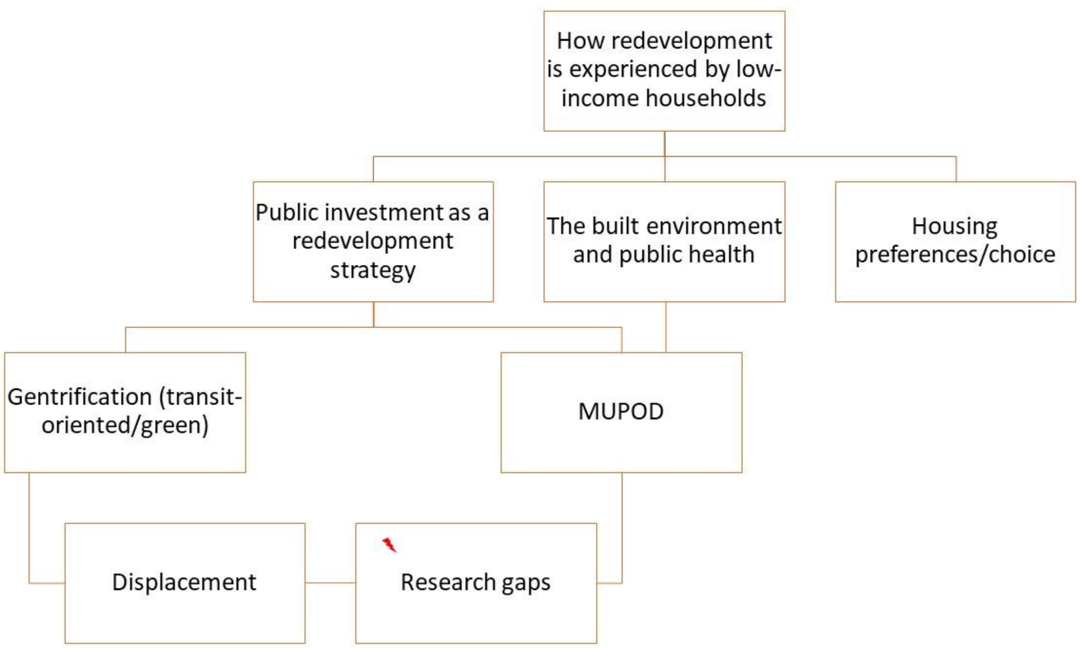

Figure 2.1 Literature review map

2.1 Public Investment as a Redevelopment Strategy

Government intervention in the ordering of the urban built environment – that is, urban planning – can be seen as a response to the social character of land, to the fact that land is not only a commodity but also a collective good, a social resource as well as a private right. Indeed, as the Marxist urban literature has sought to demonstrate, the treatment of land as a commodity fails to satisfy the social needs of either capital or labor. ... Thus, if urban planning is necessary for the reproduction of the capitalist system on the one hand, it threatens and is restrained by the capitalist system on the other; and it is in terms of this Janus-faced reality that the development of urban planning is to be understood (Foglesong, 2016; 112).

Repurposing and redevelopment of existing infrastructure including highways, rail lines and streets encompass a large portion of urban development processes over the past two decades. These efforts often include densification and development of new transit systems which are argued to contribute to growing inequality as they result in housing value increase followed by social exclusion from these newly created economies (Immergluck & Balan, 2018).

The public sector as well as the private are important players in neighborhood improvement efforts but the literature often only refers to the latter. By choosing to invest in specific projects the government affects the socioeconomic and demographic character of the neighborhood (Nilsson & Delmnelle, 2018). While some local government policymakers genuinely believe that promoting development for the wealthier will increase tax revenues which will result in improvements to the public good, or that increasing housing supply will result in reduced housing prices; others understand planning's emphasis on real estate and that outcomes will not benefit all populations (Stein, 2019).

In theory, housing construction reacts to positive demand spikes which, in turn, impact housing prices. Housing supply elasticity, or the way it responds to demand, depends on the availability of land, thus making this product different from others in the sense that land is limited (or inelastically supplied). Therefore, in reality, an increase in demand might not result in construction in inner city locations, where population growth and demand occur, but by new construction in the periphery of cities (Mayer & Somerville, 2000).

Moreover, in the short term, supply is slow to respond to changes in demand since development takes time and often entails delays resulting from lengthy construction times and planning processes (Mayer & Somerville, 2000; Rappaport, 2013). Slow housing supply responsiveness requires developers to predict demand well before actual completion time. Over the long term, however, supply will typically accommodate demand (Mayer & Somerville, 2000; Rappaport, 2013).

Besides new construction, housing supply in the market in a given period comprises of management and maintenance of existing stock (e.g., conversion from different uses or tenure, and/or a release of stock as a result of death or household dissolution) (Bramley, 1993, 1996). Housing supply is determined in a complex decision-making process made by builders and owners of existing stock and there is little transparency in these processes. Homeowners, in particular, have a critical role in the market through their decisions regarding rehabilitating, investments, and maintenance of their units: they can act to increase (e.g., split an existing home into two units) or decrease housing services. In the case of renovation of existing housing stock, there are surveys documenting homeowner decisions but less is known about rental properties (Dipasquale, 1999). Indeed, one of the most significant challenges for research seems to be a lack of available, accurate data on existing housing supply, including type, size, and price.

Adding new housing units to a neighborhood often causes objection resulting from fear of gentrification. That is, it is expected that improvements to the built environment (such as infrastructure improvement but also new housing construction) result in increased real estate values that benefit property owners but deprive those households who lack the financial means to live there (Stein, 2019). This assumption is based on the expectation that new housing values will be higher and will attract higher-earning households who will, in turn, facilitate amenity investment and increase pressure on low-income households to move out of these neighborhoods for unaffordability (known as the “amenity or demand effect”) (Bergmann, 2019; Shane et al., 2021).

Analysis of Canadian data as well as a review of several relevant studies on market-rate development and neighborhood rents dispute the demand effect argument by revealing that increased housing supply in fact reduces pressure from existing stock (known as the “supply effect”) and results in more low-income households. This conclusion does not imply that displacement does not occur but that in the overall population, increasing housing supply is *correlated* with an increase in the number of low-income households. Or that gentrification is not expected where housing supply is increased even at the neighborhood scale (Bergmann, 2019; Shane et al., 2021). Moreover, it is shown that an influx in market-rate housing results in more affordable rents in nearby projects at the neighborhood level (Shane et al., 2021). Yet, project and neighborhood contexts matter. New housing construction is preferred in wealthier communities where risk of displacement and other threats are lower. In reality, this rarely happens because of existing planning restrictions such as zoning. Rent protection and public investment in housing need to be prioritized to protect low-income households. Both private and public market have important roles in creating and maintaining affordable housing (ibid).

2.1.1 Mixed-use, Pedestrian-Oriented Development as a Redevelopment Strategy

By the end of the 20th century, low-density suburban features were integral to development politics, and the overall planning discourse. Yet, suburbanization introduces new challenges including a decline in social capital, long commutes, unhealthy lifestyle, and time and financial constraints (Leyden, 2003). The Transit-Oriented-Development (TOD) strategy, partly aimed at addressing these challenges, included a “transit village”, where a group of neighboring buildings were sited near a rail transit system with a pedestrian-focused design (Rayle, 2014). The TOD idea was first conceptualized in the 1980s but wide-range implementation arrived in the early 2000’s with an overall increase in rail transit infrastructure investment in the United States (Nilsson & Delmnelle, 2018).

Essentially, TOD proposals include transit investment, land use plans, and zoning and design guidelines to promote mixed-use environments with increased density where transit stops are within walking distance (Dong, 2017). Mixed land-use[4] (possible at both parcel- and neighborhood and city levels) was endorsed in Jacobs (1961) as a tool to promote lively neighborhoods. Mixed-use environments are typically located in city center locations where they have been argued to produce environmental benefits such as shorter trips and lower vehicular use, health benefits resulting from active transport mode, and economic profits from increased

[4] Mixed use is often subscribed as a percentage of the overall development and includes a mix of retail, residential, and office uses (Loukaitou-Sideris & Banerjee, 2000; Moos, Vinodrai, Revington, & Seasons, 2018).

land values (Moos, Vinodrai, Revington, & Seasons, 2018). As such, mixed-use environments have gained popularity in the North American context over the past two decades[5] (Dong, 2017).

While elements of TOD can be viewed as part of the new urbanism and smart growth visions including compactness and mixed-use design, transit infrastructure investment (or investment around existing transit infrastructure[6]) distinguishes TOD from other urban redevelopment strategies. Rail transit infrastructure is characterized by being geographically fixed, providing access to a spatially concentrated crowd, and for its association with low-income users. It is partly due to this that TOD is supported by diverse groups, including low-income households who are public transport's main users, and it is often favored when allocating public funds (Rayle, 2014). High-frequent bus service often delivers similar benefits (e.g., environmental, economic, and health) to mass transit infrastructure (Luckey et al., 2018).

A theoretical view of mixed-use, pedestrian-oriented environments is offered in Ferdman (2018). The suggested framework is perfectionism, it is situated in ethics, and it defines the good life as enabling the exercise of a range of human capacities to their fullest. What is then an environment most conducive to the perfectionist view? According to the liberal approach, for example, it is most important that individuals have opportunities to choose their living environments without being oppressed or dominated – be it homogeneous single-use or mixed-use. A society can be viewed as just even if it is not optimal in terms of human thriving. The liberal approach is therefore not quite helpful in comparing urban forms (i.e., compact vs. sprawl). The perfectionist approach, on the other hand, provides a more practical framework for

[5] Even so, segregated land uses continue to dominate both U.S. and Canadian cities landscapes.
[6] Also referred to as Transit Oriented Communities (TOC).

analyzing thriving as it exposes the things that provide intrinsic value. This analysis framework is not used by planners but it provides a sophisticated view on issues of rights, justice, and equality (Ferdman, 2018).

Theoreticians include different aspects in the bucket list contributing to human thriving, including food, shelter, health, education, friendship and love, public participation, sports, access to nature, culture, and opportunities for intellectual engagement (this is developed based on Martha Nussbaum's capability approach). Others emphasize physical capacities, and theoretical and practical rationality (this is an Aristotelian approach). Human capacities need to be exercised by all individuals and not just by a limited, privileged few (ibid).

According to this view of basic human needs, mixed-use designs are the most conducive to perfectionism compared to single-use environments because they enable us to develop human capacities in multiple ways. Face-to-face encounters that are made possible in pedestrian-oriented environments, for instance, are important for exercising emotional, affection, trust, and social capacities. These random, often unexpected, social encounters and experiences are hypothesized to support determination, imagination, compassion, and creative capacities. Compared to single-use environments which often entail long commutes with only limited exposure to the outside environment, diversity in mixed-use environments is permitted due to the mix of people and ideas, as well as the tolerance level that creates culturally rich spaces that support intellectual exchanges. Complexity in a single-use environment then becomes a foreign concept for people who are prevented from interaction with peers who hold a different set of values. Moreover, commute time is increasingly viewed at the expense of other flourishing activities, especially if done by private car (ibid).

Mixed land use is closely related to walking as it shortens the distance between one's residence and amenities (Su et al., 2017). Walkability indicates proximity and diversity of different everyday services (stores, schools, parks, and workplaces), and grid street design (Thielman et al., 2015). Several definitions appear in the literature, including a neighborhood's conduciveness to walking for different purposes (e.g., leisure, workout, amenities, and work). Some refer to neighborhood compatibility with pedestrians (Su et al., 2017). Generally, walkability implies that the built environment design encourages walking and lingering (Su et al., 2017; Thielman et al., 2015).

A range of methodologies is used in research to measure walkability at different scales (e.g., address, street, neighborhood). These measures typically address the ease of accessing daily services. The tools include, for example, auditing, field surveys, GIS mapping, and cluster analysis. The outputs indicate the degree to which the unit of analysis promotes walking based on residential density, intersection density, land use mix, and retail floor area (Su et al., 2017).

The benefits of land-use mix in the forms of TOD and/or walkability are reviewed in a range of planning documents but these lack the understanding of implementation outcomes (Moos, Vinodrai, Revington, & Seasons, 2018). TOD's impact on development is expected to be positive if "all the right conditions are in place", these include political, service improvement, land availability, suitable physical characteristics, and a growing metropolitan (Loukaitou-Sideris & Banerjee, 2000). It is also expected that the planning process is recognized in its importance to bring stakeholders together and receive community support. But in order to ensure equitable benefits to all (and especially to transit users who are largely low-income) rather than merely illustrations of "bombastic transit villages" (Loukaitou-Sideris & Banerjee, 2000) – participation from private and public sectors is needed. Moreover, specific measures need to be included such as affordable housing policies and rail integration with other transport modes (e.g., bicycles and buses) (Chava et al., 2018).

The dissertation examines a full range of built environment features (including transit- and pedestrian-orientation) captured in the MUPOD score and its relationship with other critical aspects including health and social well-being, housing prices, and the demographic and socioeconomic makeup of neighborhoods.

2.1.1.1 Neighborhood Design and Health

Obesity has become one of the biggest, fastest growing health threats of the 21st century. It is associated with a number of negative health outcomes, including hypertension, osteoarthritis, type 2 diabetes, coronary heart disease, and stroke (Li et al., 2009; Renalds et al., 2010). Obesity is caused by a number of interrelated factors, including genetic, behavioral, and environmental. Therefore, built environment features, such as housing location, density, access to amenities, walkability, and the quality of transportation, play a role in obesity incidence (Chiu et al., 2016; Collins, Tait, Fein, & Dunn, 2018; Li et al., 2009; Su et al., 2017). It is well-known that physical inactivity is a key contributor to obesity and many chronic diseases.

In fact, in 2010, the World Health Organization reported physical inactivity as one of the five main factors of death globally and it is considered to be one of the biggest challenges for public health practitioners (Boehmer et al., 2007; Eid et al., 2008; Frank & Engelke, 2001; Jongeneel-Grimen et al., 2014).

In contrast, physical activity's positive impact on health is well documented in the literature (Braun et al., 2016; Frank et al., 2016). Even though these benefits are well known, only one-fifth of North American adults meet current physical activity recommendations and levels of physical activity have not significantly risen over the past decade (Braun et al., 2016; Renalds et al., 2010).

The last decade has shown a growing interest within public health, transportation, and urban planning on neighborhood features impact on residents health (Berrigan & Troiano, 2002; Braun et al., 2016; Catlin et al., 2003; Ewing et al., 2006; Ewing et al., 2003; Frank et al., 2016; Sööt et al., 2006). Even though these findings were sometimes inconclusive, most agree that different neighborhood context was found to have great impact on the health and well-being of residents mainly through walking (Boyle et al., 2014a; Lund, 2003; Saelens & Handy, 2008; Talen & Koschinsky, 2014). Walking is the most prevalent form of physical activity and enabling walking has become a priority among public health practitioners (Feuillet et al., 2016; Su et al., 2017; Wasfi, Steinmetz-Wood, & Kestens, 2017).

A Canadian longitudinal study showed that moving to a highly walkable neighborhood was significantly associated with a 54% lower risk of hypertension than moving to a low walkable neighborhood. Moreover, their findings suggest a significant positive relationship between living in a highly walkable neighborhood (measured by Walk Score™) and utilitarian walking and a negative correlation with obesity (Chiu et al., 2016). Another longitudinal study found that movers were more likely to walk and bike if the neighborhood they moved into had a diverse pool of shops within a walking distance (ibid).

On the other hand, sprawling environments, designed for the automobile were shown to be positively associated with overweight and/or obesity as well as with other negative physical and mental health results, whereas walkable neighborhoods, with more pedestrian-oriented design, were found associated with higher levels of physical activity and lower levels of obesity (Boyle et al., 2014; Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Giles-Corti et al., 2016; Li et al., 2009; Renalds et al., 2010; Talen & Koschinsky, 2014).

Frank et al. (2005) show, for example, that having many accessible local destinations results in increased likelihood to engage in moderate physical activity for 30 minutes or more per day. Doyle et al. (2006) found that more walkable environments with lower crime rates were associated with more walking, lower body mass index and better self-rated health compared with less walkable, crime-prone environments even after controlling for an individual's health-related variables (though gender differences were also found to impact this relationship). Li et al. (2009) examine longitudinally the relationship between fast-food restaurant density and walkability at the neighborhood scale and changes in body weight and waist circumference in a 50-75-year-old age group sample. They included individual behavioral factors (i.e. eating at fast-food restaurants, engaging in physical activity) as modifiers. Their results show that 18%-19% of weight change and 15%-18% in waist circumference were attributed to neighborhood differences. A research of Canadian cities has reported an energy expenditure increase of 1.7 kcal/kg per day resulting from utilitarian walking among residents of highly walkable environments compared with low walkable ones (Thielman et al., 2015).

A longitudinal research of older adults in the US showed that moving to a more walkable environment (a 10-point higher Walk Score^{TM}) was linked with 11% increased likelihood of meeting walking goals of a minimum 150 minutes per week (Hirsch et al., 2014). Wasfi et al. (2016) further developed this longitudinal examination of the built environment's impact on walking for utilitarian purposes, comparing people who moved during the 12 years of the survey's follow up and those who stayed in the same neighborhood in this time. Their research results showed that an increase in 15 to 45 Walk Score^{TM} points was correlated with a 59%

increase in likelihood of utilitarian walking of at least 60 minutes per week. This was true for both people who were active in their leisure time and for those who were not. Moreover, moving to higher walkable environments increased walking while moving to lower walkable neighborhoods was not linked with a significant decrease in walking (Wasfi et al., 2016).

Different age groups are examined in a Canadian study that shows walkable neighborhood association with utilitarian walking among young adults (results are slightly different when entering locales of different populations size into the equation). Results also showed that moving to a neighborhood with a 10-point higher Walk Score™ was correlated with an average 17.51 more minutes walking for transport per week (Wasfi et al., 2017). Another study of 3,890 British Columbians older adults concluded that a 10-point higher Walk Score™ was linked with 34% increase of walking for transport and a 10-point higher Transit Score™ was associated with 37% increase in walking for transport (Frank et al., 2016). This literature shows that a person living in a walkable, safe, environment, using active transportation mode, is likely to be healthier (Doyle et al., 2006; Frank et al., 2016; Li et al., 2009).

Decreased mobility, lower levels of physical activity and transit use, and increased car use, on the other hand, were found to be associated with environments characterized by low density, lower levels of land use mix, reduced connectivity and accessibility to public transportation and increased car-oriented development which, in turn, was linked with poor perception of safety and neighborhood upkeep (Braun et al., 2016; Calthorpe, 1993; Renalds et al., 2010; Talen & Koschinsky, 2014).

Importantly, specific built environment features were shown to be positively correlated with walking and transit use, and negatively with car use. These features include land-use mix, housing and population density, accessibility, connectivity (e.g., short blocks and intersections), quality (e.g., sidewalk width, air quality, presence of trees), and perception (e.g., familiarity with the neighborhood) (Braun et al., 2016; Christiansen et al., 2016; Giles-Corti et al., 2016; Golan et al., 2019; Langdon, 1997; Lund, 2003; Plas & Lewis, 1996; Renalds et al., 2010; Saelens & Handy, 2008; Stevenson et al., 2016; Talen & Koschinsky, 2014). Dense urban environments, however, were also found to be related to cardiometabolic stressors (e.g., noise, overcrowding, and air pollution) (Braun et al., 2016; Chiu et al., 2016).

In addition, the negative implications of an active transportation mode should also be noted. While there are health benefits related with walking and cycling, it has been shown that some places have incurred an increase in road injuries where demand for active travel has risen. This challenge can be handled by specific practices and regulations, such as 30mph speed limits in cities, emphasis on transport system quality and improved traffic signals. These strategies have been implemented in several European countries and have been shown to reduce injury and fatality rates resulting from active transport by more than 70% (Giles-Corti et al., 2016).

Although the built environment is consistently shown to be related to walking, the specific nature of this relationship is not entirely clear (Chiu et al., 2016). While some argue for self-selection (i.e., people prone to physical activity will choose to live in walkable environments) others assert that the relationship is causal: walkable environments induce people to be more physically active than if they were living in less walkable areas. The majority of studies in this area rely on cross-sectional analysis (in which data are collected from the population at one specific point in time) so that even if a statistically significant association between the built environment and physical activity is documented it is often not sufficient to argue for a causal effect. One cannot conclude whether a change in the built environment will lead to a more physically active community.

Some studies did not confirm the above-mentioned positive associations. It is suggested that differences in research design and measures (e.g., neighborhood scale, sample, environmental variables, statistical model) might be the cause for these equivocal results (Feuillet et al., 2016; Rao et al., 2007).

The majority of existing evidence indeed supports planning and policy initiatives, including compact communities, smart growth and/or new urbanism, across different cities aimed at increasing walking through investments in the built environment (Christiansen et al., 2016; Giles-Corti et al., 2016; Saelens & Handy, 2008). Urban planning plays a central role - somewhat similar to its role in the 19th century when the profession emerged in the Western world as a response to health issues resulting from industrialized, congested, slum-like cities (Giles-Corti et al., 2016; Northridge, Sclar, & Biswas, 2003; Riggs, 2011; Su et al., 2017).

Figure 2.2 summarizes this subsection about the impact of residential environments on the provision of public transportation, walking, and health implications. Planning policies shape built environment (BE) characteristics that potentially enable access to active transportation mode, which in turn encourages more walking.

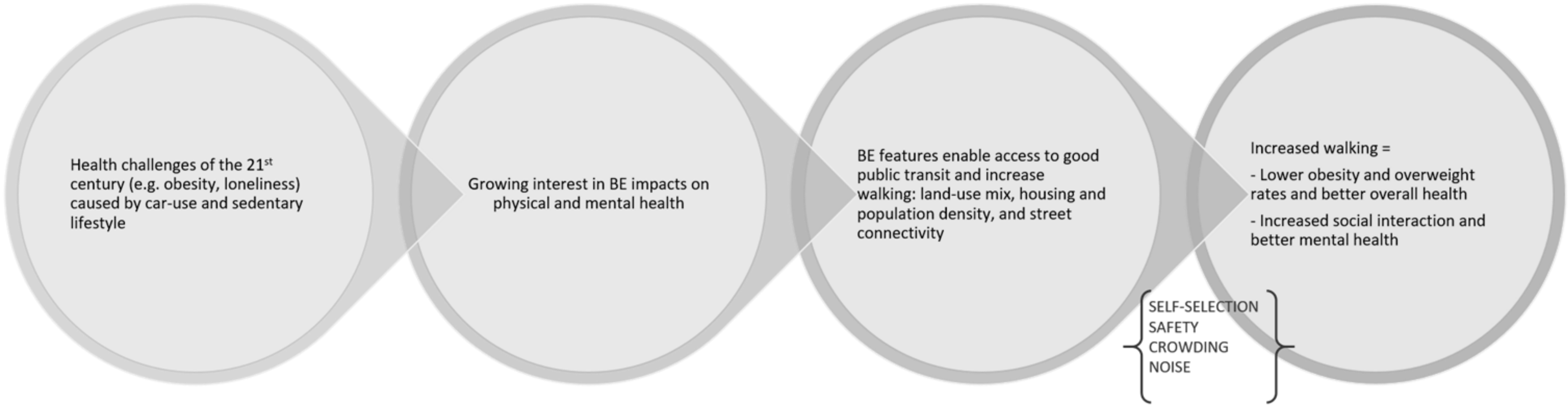

Figure 2.2 The built environment and health outcomes
Source: Friedler (2017)

Public health researchers have emphasized the need to expand the exploration of neighborhood environments and health to include local level physical and social factors such as transit access, social networks, disorder, crime, economic activities, or unemployment. Importantly, it is indicated that processes of gentrification were associated with improved health outcomes for privileged populations while presenting no links or even negative associations for vulnerable populations (Anguelovski, Triguero-Mas, et al., 2020). This finding will be further discussed when reviewing this dissertation's results.

2.1.1.2 Social Well-being

The nature of urban social relationships has been a topic of inquiry in urban research for quite a time. In particular, planners and urban designers have been interested in the ways in which the physical environment shapes neighborhoods' social capital[7] (Lund, 2002). Social capital is found to be linked with quality of life, improved well-being and mental health, achieving community goals, trust, resilience in times of crisis and economic conditions (Renalds et al., 2010; Rogers, Halstead, Gardner, & Carlson, 2011). It is thus an asset for every community. The notion that spatial characteristics affect social interaction was examined as early as the 1920's by Chicago School sociologists, who pointed out specific built environment features that impact interaction, including spatial boundaries, housing type, density, and land use diversity (Talen & Koschinsky, 2014).

[7] A proxy of social contacts among community members.

Moreover, urban sociology research predicted that characteristics of the urban environment such as population growth and density, mobility, and heterogeneity, will have a negative impact on life quality, society cohesiveness, social networks, sense of community, neighborliness, mental health, and social organization and engagement (Adams, 1992; Greenbaum & Greenbaum, 1985; Hunter, 1975; Sampson, 1988; Talen, 1999; Wirth, 1938). Indeed, in recent decades there has been a decline in social capital resulting from suburbanization, long commutes, lifestyle (e.g., increased use of television and computers), and time and money constraints that challenge the formation of social life and contribute to isolation and loneliness (Leyden, 2003; Talen & Koschinsky, 2014).

Wirth (1938) hypothesized that population size limits the possibility of personal acquaintance: this does not mean that urban dwellers have fewer contacts than rural inhabitants (maybe the converse is true), rather that the number of people with whom they have close relationships with is relatively small. This is exacerbated when competitiveness replaces social solidarity.

Hunter (1975) replicates a study from the 1950's examining the hypothesized "loss of community" in Rochester, an urban neighborhood in New York. His findings suggest that while there has been a significant decline in functional use of local spaces; informal contacts between neighbors has increased somewhat and that resident identification with the locale has increased as well. He thus repudiates Wirth's assumptions about the social outcomes of urbanized areas.

Walking in public spaces promotes opportunities to exercise social capacities through awareness of social behaviors, interaction, sense of community and feelings of trust (Ferdman, 2019; Renalds et al., 2010; Rogers et al., 2011). Thus its contribution to happiness, life satisfaction and overall well-being (Allen & Farber, 2019). Some studies have tried to argue for a connection between neighborhoods' walkability and sense of community. While early studies were not able to prove this relationship, more recent research, focused on specific design elements, was more successful in this regard (Talen & Koschinsky, 2014). Ferdman (2019) argues for ways to integrate the ethical grounds of objective well-being into planning and built environment design. While fresh, this approach fits into previous conceptualizations of public space and built environments' contribution to objective deliverables such as civic engagement, cultural character, pluralism, and diversity.

Ferdman (2019) theorizes well-being as stemming from the intrinsic objective value of certain aspects (rather than how individuals perceive it). Walking can be valued by its intrinsic value: it broadens the way we know by providing opportunities to observe and immerse in the built and social environment. Moreover, knowledge is gained at a pace conducive to understanding, as it allows reflection of the surroundings. The pace also enables creativity by freeing up time/mental space unlike the experience of other transport modes such as driving. Third, when engaged in walking, knowledge is gained through experience, it is therefore different from gaining theoretical knowledge. Finally, walking can be viewed as an actual achievement that requires effort and persistence compared to alternative travel modes.

Walking creates an atmosphere in which trust building is more spontaneous compared to driving. For example, voluntary coordination is naturally acknowledged between pedestrians compared to the more regulated, top-down motorized environment. These conditions are more favorable to creating trust and sociability (Ferdman, 2019). Single use environments on the other hand, can be perceived as boring. Boring environments are shown to contribute to stress, impulsive action, lower levels of positive feelings, lower cognitive performance, and engagement in risky behavior such as jaywalking. These have a negative impact on well-being in relation to the exercise of human capacities: they discourage walking because the environment does not offer exciting opportunities to linger or engage and they reduce opportunities for social engagement. Moreover, single use environments do not promote learning because of their limited provision of new information (ibid).

It has been shown that increased social contacts among neighbors is linked with physical characteristics of the built environment that enhance walking, including *land use mix*[8], *walkability*, and *population density*[9] (Boyle et al., 2014; Brown & Cropper, 2001; Jacobs, 1961; Kim & Kaplan, 2004; Langdon, 1997; Leyden, 2003; Plas & Lewis, 1996; Podobnik, 2011; Renalds & Smith, 2010; Srinivasan, O'Fallon, & Dearry, 2003; Talen & Koschinsky, 2014; Wood, Frank, & Giles-Corti, 2010).

Superficial contacts, including random interactions with neighbors, informal chats, or just greetings, are assumed to enhance place attachment, and senses of familiarity and certainty that many find important. Moreover, over time, these can develop into trust, and neighborly mutual support, though some argue that this depends on resident predisposition[10] (Leyden, 2003; Podobnik, 2011; Talen & Koschinsky, 2014).

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[8] The character of a shopping area also matters as some might attract non-local customers and their impact on neighborliness is thus limited (Lund, 2003; Wood et al., 2010).

[9] However, finding an optimum level of density to promote walking and social interaction while avoiding negative results is challenging (e.g., noise, stress) (Stevenson et al., 2016). Further, some research suggests that the relationship between density and social contact at the neighborhood scale is not linear. Meaning that density can only positively impact interactions up to a certain point (Talen & Koschinsky, 2014).

[10] Some doubt that these spontaneous interactions and supportive gestures among neighbors develop into deeper social contacts that can be more influenced by neighboring attitudes, demographics, homogeneity, and/or integration in the community (Lund, 2003; Wirth, 1938).

In contrast, suburban environment characteristics, such as privacy, lack of sidewalks, and cul-de-sac design have been shown to increase social isolation, decrease walking, and increase driving (Podobnik, 2011).

Feeling of safety was also found to be an important factor linking the built environment with neighborliness and walking frequency (Renalds et al., 2010; Talen & Koschinsky, 2014). Jacobs (1961) discusses this issue extensively, arguing that busy streets encourage neighbors to look out of their windows and after each other, participate in street life, and in turn generate safer streets (Greenbaum & Greenbaum, 1985; Jacobs, 1961) which promotes sense of community (Wood, Frank, & Giles-Corti, 2010). This ‘natural surveillance’ is enabled by land use diversity which attracts different populations at different times of day. A study in Los Angeles, for example, associated land use mix with decreased crime levels (Anderson et al., 2013). Since crime is perceived to have a negative effect on social and physical activities, unsafe places tend to be avoided (especially impacting vulnerable populations) (Golan et al., 2019; Stevenson et al., 2016). Moreover, traffic and car parking were seen as negatively affecting perceptions of safety, friendliness and helpfulness (Wood et al., 2010). Yet more recent conversations have contemplated on the implications of the ‘eyes on the street’ concept. Planners and urbanist are urged to reflect on how community building practices led to increased Black community harassment and physical attacks in public spaces by public representatives. Systemic racism must be acknowledged when advocating for streets for “everyone”. Moreover, the history of anti-Blackness urbanism and transportation planning and patterns of racial and economic segregation evident in legislation and policies and promoted by settler colonial culture is necessary for analyzing the concept and its real life implications (Yasin, 2020).

Here is some evidence supporting the above-mentioned relationships. A 1950 study by Festinger, Back, & Schachter, for example, examined the relationship among married residents between environmental characteristics and opportunities for social interaction. These interactions were shown to be affected by distance from other residences, walkway design, and staircases. Local friendships have been shown to contribute to community attachment, and participation in local activities; results that hold true across a number of specifications and using a range of controls. Greenbaum & Greenbaum (1985) show that residence proximity was associated with the number of acquaintances that sometimes led to more meaningful relationships. Nasar & Julian (1995) showed that single-use environments had lower sense of community compared with multi-use areas.

Kim & Kaplan (2004) support the hypothesis of a positive relationship between neighborhood design and sense of community: residents of Kentland, an alternative development, were shown to rate their community as enabling a sense of community higher compared with their suburban resident counterparts. Kentland's residents were also shown to identify more with their community, were more satisfied with the neighborhood, had a stronger attachment to their community, and had appreciated more amenities and parks within walking distance.

Podobnik (2011) studied four neighborhoods in Portland, Oregon, in which Orenco Station follows new urbanist design. Residents of Orenco Station reported higher levels of sense of community, participation in community activities (which had risen even further in a follow-up survey 5 years after the initial sampling), walking to local shops, and increased activity levels compared with more typically designed urban neighborhoods included in the study. Further, longitudinal data shows that moving into Orenco Station was significantly associated with increased likelihood of using transit and decreased car commutes. However, these findings should be interpreted cautiously since residents mentioned 'socially-interactive community' as one of the reasons for wanting to live there. Their predisposition is thus likely to have impacted results.

A study of Oslo's metropolitan area showed that residents of compact environments had an improved overall well-being compared to suburban counterparts. The study suggests that proximity to the city center, higher density, and mixed-land use facilitate social well-being (Mouratidis, 2018).

A number of socio-demographic factors were shown to be related to sense of community, these include: *length of residency* - positively linked (Sampson, 1988) [though some did not find this relationship to hold true (Greenbaum & Greenbaum, 1985; Wood et al., 2010)], *tenure* (home-ownership was linked with sense of community and is explained by greater caring for property values and other community issues) (Talen, 1999; Wood et al., 2010), *marital status* [married couples reported a significantly higher sense of community (Nasar & Julian, 1995)], and having *children in the household* - positively linked with sense of community (Nasar & Julian, 1995; Talen, 1999).

Social diversity in residential environments has been a subject of debate for years (Greenbaum & Greenbaum, 1985; Talen, 1999; Talen & Koschinsky, 2014) and deserves specific attention. While some advocate for housing mix and planned integration as means to foster social interaction among neighbors (the rationale being that if people from different backgrounds interact on a daily basis they will get to know and accept each other); others have argued that this notion is not realistic and ignores the fact that residents are more satisfied with and report greater social cohesiveness in homogeneous neighborhoods (Gans, 1967). Further, this ‘forced’ interaction between different populations might even result in avoidance and intolerance (Gans, 1967; Lees, 2008; Lenzi et al., 2013). Some would also argue that superficial contact between neighbors does not necessarily generate strong social relationships among neighbors from distinctly different backgrounds, whereas others suggest that over time these weak contacts have been found to support stronger social affiliation (Greenbaum & Greenbaum, 1985; Talen, 1999).

Importantly, compact, mixed-use environments can trigger gentrification and displacement, and promotion of this neighborhood type invites examining the sociodemographic and economic context which is missing from the literature. Segregation is one impact of gentrification and displacement processes - it weakens opportunities to address urban challenges and has larger social well-being impacts. In segregated communities there is less tolerance, less compromise, and less mutual learning. Segregation therefore contributes to widening social gaps because of the added challenge to bridging differences (Grengs, 2005).

2.2 Housing Preferences and Choice

Urban economics and behavioral studies often discuss residential location and travel mode in terms of preferences and choice. These terms fail to recognize households who lack choice due to financial constraints (Kramer, 2018). Similarly, travel mode choice is shown in the transportation planning literature to be impacted by land use characteristics such as diversity and density, but it is often discussed without reference to cost and affordability and we still lack an understanding of the motivation behind people’s choice to live in these environments (Luckey et al., 2018; Riggs, 2011).

Traditionally, the spatial configuration of cities was explained in terms of supply/demand of aging housing stock and newly built dwellings in the city's periphery, or transport/land costs trade-off. Early models depicted wealthier households relocating from the inner-city core while lower-income households continued to occupy the older housing stock in city centers. The 1960's saw a renewed interest in inner city investment and related processes (i.e., gentrification) received scholarly attention. Some proposed that postmodern cities no longer adhere to a neat arrangement around city centers, generating a more chaotic spatial structure (Delmelle, 2016).

In the context of this dissertation, it is important to understand demand for TOD among low-income households as they have been shown to be the main transit users and benefit the most from accessibility (Barton & Gibbons, 2017). It is also important to examine whether their housing preferences align with supply or more specifically, if low-income households can afford to live near transit (Luckey et al., 2018). Accessibility benefits of living near transit are argued to overcome the nuisance from transit operation, parking congestions, and potentially increased crime. Theoretically, the benefits translate to increased demand followed by rising land values. According to this logic, it is expected to see housing price appreciation as a result of new transit infrastructure. These investments might result in socioeconomic segregation because communities will sort themselves based on preference and economic ability to pay for these public services (Nilsson & Delmnelle, 2018).

Lower-income households are shown to depend on transit the most because they often cannot afford a car, even so, some low-income neighborhoods do not provide sufficient transit accessibility (Allen & Farber, 2019). Allen & Farber (2019) show that while residents with lower socioeconomic status tend to live in central locations with higher levels of transit accessibility; a considerable 5% of Canadians in eight of the largest cities earn low wages and live in areas with limited transit accessibility.

Housing constitutes more than the physical structure itself: it includes a bundle of attributes such as neighborhood characteristics (e.g., safety, green space availability, quality of schools, neighborliness) and access to services (Bina & Kockelman, 2009; Clark et al., 2006; Hinshaw & Allott, 1972). Housing choice research tries to identify the priorities given to different housing features in the search process and associated trade-offs (Ahluwalia, 1999; Bina & Kockelman, 2009; Hinshaw & Allott, 1972).

Specific neighborhood features are attractive to different socioeconomic groups (these can be sorted by age, marital status, education, income, and tenure). This explains why those with limited resources tend to live in poorer neighborhoods (Hinshaw & Allott, 1972). Proximity to shops, for example, was more significant for low-income people and for high-rise residents. Shlay's (1985) empirical investigation of housing preferences supported the notion that suburban environments typically have higher-income households with children, whereas lower-income and single households tend to reside in city centers where smaller dwellings are available. Singles and smaller households preferred more walkable environments (Audirac & Shermyen, 1994). Moreover, Myers & Gearin (2001) suggest that a significant preference for single-family homes reflects a specific stage in the dynamic life cycle of a household. They show that preferences depend on respondent age: young couples, for example, might care more about school quality, while older adults consider proximity to amenities more important. Another study has shown that older people were found to care less about availability of parks compared with younger populations; and more educated households were more receptive to increased density and street connectivity design (Morrow-Jones et al., 2004). Bina & Kockelman (2009) used a multinomial logit model to show the impact of gender: men were found to be more concerned with housing size and less with access to highways and shopping centers; non-Caucasians, and older people preferred transit access over toll road access and a larger house; married couples cared more about shopping accessibility compared to the unmarried; finally, an increase in household size and income were positively correlated with choosing a single-detached home whereas single-person households with lower-incomes were less likely to choose this type of housing (76% vs. 1%, respectively). In addition, for high-income individuals, availability of local destinations increased attractiveness of residential location whereas street block density was negatively associated with residential location choice (Pinjari et al., 2011).

Changes in household characteristics, particularly new household formation, marital status, and change in household size, are significant factors in household moving decisions (Clark & Onaka, 1985). Research revolving around the decision to move has mostly focused on the events that impact household’s preferences and needs and some measures of the dwelling itself, whereas less research has been done on the neighborhood environment (e.g., composition of the housing stock, housing prices) even though this has proven to be a significant reason in a decision to move (Lee, 2012).

Transit-oriented housing developments attract higher-income households as well, reflecting their preference for transit accessibility and higher density (Nilsson & Delmnelle, 2018). Greater demand for transit-oriented environments by wealthier households is explained by employment opportunities, and availability of bars, restaurants and other amenities (Barton & Gibbons, 2017). Barton & Gibbons's (2017) New York study found, for example, that higher income residents tend to live in areas with more subway stops in 2000 and 2010 while density of bus stops predicted high-income residents in 2010. These trends support research on gentrifying neighborhoods indicating that in-movers are typically wealthier than existing residents (Nilsson & Delmnelle, 2018).

Preference towards walkable, transit-oriented environments is documented in 2011 and 2014 surveys among Americans. But both surveys also indicate strong preference for car-oriented neighborhoods, including easy access to highways, a strong preference for longer commutes and single-family homes (57%) over short commutes and multi-family housing (39%). These contradictory results appear in other studies and reflect internal inconsistency. The discrepancy might be attributed to stated preference methods[11] where a large set of independent factors are introduced to a respondent when asking for their housing preferences, making it difficult to disentangle the more complex nature of housing, public transit, and built environment design trade-offs (Luckey et al., 2018). Stated preferences models can incorporate many pieces of information to describe the product's attributes. They are estimated by addressing different housing characteristics separately and measuring the relative importance of each attribute. A choice-based approach on the other hand, presents complete sets of residential locations, each with its associated perceived benefits and tradeoffs. This method has been used in marketing fields to model consumer choice between competing goods.

Revealed preferences methods use economic consumption data to determine willingness to pay for different products. Their biggest strength is that they rely on actual choice; they are thus most commonly used in housing choice research (Bartholomew & Ewing, 2011; Morrow-Jones et al., 2004). Revealed preferences models are typically analyzed using utility

[11] There are varied methodological approaches to measuring housing preferences, including revealed preferences and stated preferences models. Whereas revealed preferences rely on observations of actual housing choice, stated preferences are based on household ranking of hypothetical housing alternatives (Collen & Hoekstra, 2001; Earnhart, 2001; Timmermans et al., 1994).

maximization theory assuming that choice reliably reflects preferences and that individuals can choose the most beneficial alternative considering all options (a problematic assumption in reality) (Earnhart, 2001; Timmermans et al., 1994).

Moreover, one basic shortcoming of this approach is that it cannot measure demand for a good that does not yet exist (or that people are not yet aware of). This method is in fact only useful in measuring the past. Moreover, since revealed preferences captures the final decision, they fail to explain the relative importance of the different features characterizing this decision. That is, it is difficult to isolate the effect of a specific feature on choice (Adamowicz et al., 1994; Morrow-Jones et al., 2004).

Using a choice based approach, Luckey et al. (2018) establish a strong preference for pedestrian- and transit-oriented design among all household types. The implication is particularly important in view of TODs because low- and high-income households seem to have similar preferences for housing in transit accessible neighborhoods. Low-income households are thus more vulnerable due to housing price increases in these neighborhoods and to processes of gentrification and displacement. Since demand for Tod’s projections are expected to increase in volume, it is important to provide affordable housing options near transit.

2.3 Gentrification and Displacement

Neighborhood decline and disinvestment prompted research on neighborhood change as early as the 1920’s (Burgess’s invasion and succession model) or Hoyt’s filtering model in the 1930’s describing the exodus of higher-income households from city centers resulting in inner city deterioration (Dong, 2017), and more recently, gentrification. Gentrification includes capital investment in previously deprived inner city neighborhoods which results in changes to neighborhood social, demographic, cultural, economic, and physical characteristics (Cole et al., 2020; Delmelle, 2016). The term was originally defined by Glass (1964) who described a process in which higher-income households (typically white, well-educated professionals) replace originally working-class (typically lower-income, poor and minority) in inner-city neighborhoods at a faster pace compared to the surrounding community or region, resulting in displacement of disadvantaged residents and a socioeconomic ‘upgrade’ of the neighborhood (Chava et al., 2018; Dooling, 2009; Elliott-Cooper et al., 2020; Marcuse, 1985; Slater, 2006; Stein, 2019).

Neighborhood enhancement efforts are increasingly shown to not necessarily benefit original residents who are at risk of being displaced by higher income households as a result of rising cost of living (Baker & Lee, 2019; Ellen & O’Regan, 2011). While it is viewed as a negative and socially unjust process due to its impact on displacement, a contemporary discourse often ameliorates its negative impacts by renaming the process “urban regeneration”, “reurbanization”, “renaissance”, “renewal” or “redevelopment” (Elliott-Cooper et al., 2020; Quastel, 2009). Studies adopting the latter discourse have mostly focused on gentrifiers and gentrified neighborhoods, emphasizing positive outcomes (Elliott-Cooper et al., 2020).

Both supply and demand are examined in gentrification literature around the production and consumption of residential environments. The rent gap theory focuses on the supply side: gentrification is viewed as a product of land transformation to meet its potential value. Demand side prospects account for gentrifiers, their specific socioeconomic and demographic characteristics, who are moving into gentrifying neighborhoods (Baker & Lee, 2019).

Gentrification is explained as being driven by intense tourism industry, short-term rentals, housing development and speculation, and urban greening initiatives that are accompanied by rising costs of living (Cole et al., 2020). Moreover, public investment can catalyze gentrification in the form of brownfield redevelopments, investment in schools and housing programs as well as transit systems (Baker & Lee, 2019). The scale and speed of gentrification processes need to be considered. Slow gentrification is associated with a gradual change which generates a steady increase in real estate values. It tends to be less obvious and therefore less problematized (Elliott-Cooper et al., 2020).

Some suggest that poor households who manage to stay in neighborhoods undergoing improvement benefit from wealthier household contributions. These suggest that gentrification does not necessarily have negative impacts on low-income households at the expense of higher income ones, especially in the context of predominantly Black communities in the U.S. (Ellen & O'Regan, 2011; Elliott-Cooper et al., 2020; McKinnish et al., 2010). However, Slater (2006) argues that those who stay do so because they do not have a viable alternative. Moreover, they are not exempt from displacement pressures. He therefore broadens the conceptualization of displacement.

Elliott-Cooper and colleagues' 2020 view suggests both physical and psychological displacement as gentrification outcomes. They stress the importance of place attachment and home. This is emphasized by the working-class's understanding of their living environments as comfortable spaces rather than a fiscal asset (Elliott-Cooper et al., 2020). Desmond (2017) contemplates the meaning of home in his scholarly work on eight struggling families going through evictions in Milwaukee, Wisconsin: *The home is the center of life. It is a refuge from the* *grind of work, the pressure of school, and the menace of the streets. We say that at home, we can "be ourselves". Everywhere else, we are someone else. At home, we remove our masks. The home is the wellspring of personhood. It is where our identity takes root and blossoms, where as children, we imagine, play, and question, and as adolescents, we retreat and try. As we grow older, we hope to settle into a place to raise a family or pursue work. When we try to understand ourselves, we often begin by considering the kind of home in which we were raised* (293). The emotional range of psychological displacement includes anxiety, loss of hope, misunderstanding, fear, loss, anticipation, shame, and stress, among others. When such households stay, they lose interest in investing in their environments, and think about the future. They are stuck in the present and are effectively displaced (Elliott-Cooper et al., 2020).

Displacement is viewed in Baker & Lee (2019) as a continuation of gentrification. When households are displaced, they might never feel at home, even if they manage to integrate, there will always be memories of what they have lost. In infrastructure induced displacement such as the 2012 London Olympics, the pain of moving is associated with isolation and anxiety. These investments and forced displacement of working-class people were justified by arguments referring to the common interest, and beneficial health and economic outcomes resulting from the sports events that were promised to residents in those neighborhoods. But ultimately, it was working class communities that were displaced (Elliott-Cooper et al., 2020). The Olympic reinvested neighborhoods in London have become out of reach for local communities. Previously social housing on these lands have been replaced by market-rate housing. Impacted by speculative expectations for future developments, prices keep increasing. It is important to understand that displacement is attributed to a series of events and not just an instance in time (ibid).

Canada's regions and cities have seen an increase in socioeconomic gaps and segregation (Allen & Farber, 2019). Poverty has spread to the suburbs as it seems that increased housing values in city centers is forcing lower-income households to relocate to more affordable locations – that are also less accessible (Allen & Farber, 2019; Elliott-Cooper et al., 2020). Displaced households who move from the city to the suburbs lose access to public transit, but also to other health and well-being benefits associated with centrally located environments. Moreover, auto-oriented environments require a car in order to conduct daily routines which introduces an additional barrier to lower-income households (Kramer, 2018).

Different approaches are used to measure gentrification and displacement. Gentrification processes in the 1990's were examined using census data in McKinnish, Walsh, & White (2010). Their results suggest a disproportionately high rate of in-moves of highly educated white, younger adults with no children[12]. A study in the 2000's in London used changes in the occupational composition as a gentrification indicator. Another study examined property value changes (Baker & Lee, 2019). The common sociodemographic and economic traits identified with gentrification are race (white), age (young), education (high level), income (middle/high), family structure (fewer children), and occupation (skilled) (Dong, 2017; Nilsson & Delmnelle, 2018). Moreover, a positive association was documented between the presence of Hispanic and

[12] Out movers however are not shown to be disproportionally low-educated or minority groups.

Asian communities and gentrification in U.S. neighborhoods, implying that “race-based residential preferences of gentrifiers may be at work” (Hwang, 2016).

Measuring displacement has proven to be somewhat challenging. First, the wide use of the term ‘displacement’ and its reference in different contexts confounds its meaning. This is particularly apparent in the urban gentrification literature, where displacement and gentrification are often used interchangeably or describe overlapping or similar processes (Elliott-Cooper et al., 2020). While the authors accept the notion that gentrification and displacement are linked, they argue that the latter is “undertheorized” and “poorly specified in gentrification studies” (Elliott-Cooper et al., 2020; 2). Elliott-Cooper et al. (2020) propose to move beyond Marcuse’s 1980’s conceptualization of displacement (i.e., neighborhoods becoming too pricy for residents) to a dated definition which sees displacement as ‘un-homing’ and addresses more broadly the relationships between people and their respective communities.

The first studies aiming to quantify displacement generally used two types of methods (Freeman, 2005): the first used a succession methodology where the second included surveying households for their reasons to move.

Succession studies focus on examining the differences between in- and out-movers’ characteristics. However, the succession approach can only identify the departure of low-income households, but it does not explain the possible reasons for their move. The distinction between forced and voluntary displacement is particularly challenging. Population movement is normal even in stable communities. Housing transactions are unremarkable when properties are typically sold or rented to households of similar socioeconomic characteristics. However, some of this movement might be involuntary. For example, due to inability to pay the mortgage or the rent. When cumulative evictions provide options for higher-income households to move into a neighborhood this creates opportunities for gentrification. *Indirect displacement* is also possible where residents do not feel welcome in their own neighborhoods any longer because of cultural and social changes and a decline in residents of similar characteristics (Elliott-Cooper et al., 2020). Displacement studies are also missing a reference point or some context to indicate how much displacement would have occurred if the neighborhood were not gentrified.

The second approach defines displaced households as those who were forced to move for reasons beyond their control. Atkinson (2000) refers to “measuring the invisible”. Those who were displaced cannot be reached by researchers interested in learning about their motives. Moreover, the problem with inquiring about reasons to move is that this method usually does not identify the former residence location. So, information on household reasons for moving, and other longitudinal data are often missing and when they do exist, they might fail to reflect the actual displacement process (Ding et al., 2016). For instance, it is impossible to conclude whether movers end up relocating within the same neighborhood or elsewhere. Doubling up (which is argued to be the most common way to cope with displacement) is also left uncaptured. In addition, business displacement which is argued to be an important phenomenon of displacement is not documented. Finally, the timeline for measuring displacement processes is inconsistent across studies (Rayle, 2014). There is a need to expand research tools to define and measure this phenomenon.

More recent studies employ other methodologies to measure displacement. Freeman (2005), for example, used a longitudinal dataset to follow the same households over time. This enables examination of households’ socioeconomic data with respect to neighborhood characteristics. It also allows examination of households who relocated from a gentrifying neighborhood[13]. His study could therefore model the likelihood of moving or being displaced as a result of living in a gentrifying neighborhood. This method enabled comparing displacement between gentrifying and non-gentrifying neighborhoods (Freeman, 2005). Newman & Wyly (2006) measured residential displacement using a longitudinal sample that included household demographics, employment status, housing information, and mobility. Their study focused on local mobility. Their dataset also included a question for residents who had recently relocated about their reason to move. Respondents were provided with a list of 30 options. The analysis, however, could not identify households who moved to a different city or those who had to move in with family or friends. Another limitation was that respondents could only choose one reason for moving, perhaps oversimplifying what could have been more complicated circumstances. This produced a partial view of the processes of gentrification and displacement and established the need for further examination using a qualitative approach (Newman & Wyly, 2006).

The 2018 Canadian Housing Survey public use microdata file is analyzed by Lauster & Bergmann (2021) to achieve a finer grained picture of up to 10 years of moving. The dataset enables exploration of reasons for moving including a distinction between voluntary and involuntary moves. Different patterns of mobility for owners and renters are detected, where the latter expectedly show greater mobility. Renters are also more likely to move for reasons beyond their control. BC, in particular, has shown the highest rate of forced move among renters. Further, the risk of forced move significantly increases with time spent in a rental unit.

[13] The first step of the analysis treated everyone who moved as being displaced while the second considered only those whose response to the question about their reason to move was that they wanted a smaller residence; wanted to pay less rent; or moved because of external circumstances, such as eviction, health reasons, changes in marital status, or other reasons beyond their control (Freeman, 2005).

Increasing rental vacancy rate to enable location choice among renters in addition to tenant displacement protection policies is necessary going forward (Lauster & Bergmann, 2021).

Smart growth and new urbanism planning strategies are promoted in Vancouver including MUPOD, transit accessibility, and density. These are aimed at increasing desirability by those who can afford the rising housing costs. The Omni Garden in Downtown south, for example, was developed in a previously industrial area that was replaced by high density housing, with emphasis on street views, livability, services and transit accessibility. In the process, the area went through cleaning and upgrading. This community, even though some low-cost housing remained, has gradually became gentrified. This is evident in the locale's socio-economic status and housing and shop inventory (Quastel, 2009).

Housing affordability is typically measured by the percentage of household income spent on housing. It is therefore affected by changes in housing prices or rents, or changes in income. Mixed-use zoning, for instance, influences affordability by increasing housing supply and diversity. By not addressing the consequences of gentrifying mixed-use developments, lower-income and unskilled workers are increasingly prevented from living in these environments thus leading to more exclusion, segregation and inequity (Chava et al., 2018). It is the responsibility of planners to address these challenges by offering explicit housing affordability policies integrated into mixed-use zoning plans. These policies, which are not a common practice in Canadian cities, can include inclusionary zoning, density bonuses, or affordable housing trusts, for example (Moos et al., 2018).

2.3.1 Transit-Induced and Green Gentrification

Transit investment is place specific and as such it generates costs and benefits that are spatially fixed. When a new transit line is built, for example, residents of nearby neighborhoods are expected to benefit from transportation accessibility. The impact of these developments on housing values and gentrification is still unclear since studies produce mixed or contradicting results[14] (Dong, 2017).

The majority of studies, however, suggest that because transit infrastructure investments (and related policies) improve transit accessibility, reduce commute times and cost, they produce monetary gains and land value increase in areas proximate to development. They are therefore seen as a useful redevelopment tool (Chava et al., 2018; Rayle, 2014). These studies found increased housing values as well as higher-income residents, higher educational attainment, more working professionals, fewer children (or childless) households, increased share of the population that owns a car and more owner-occupied units in transit-oriented neighborhoods relative to the metropolitan/regional average[15] (Brown, 2016; Nilsson & Delmnelle, 2018; Rayle, 2014).

A 2010 study in the United States, for example, showed more rapid increases in housing values, monthly rents, and median household income in census block groups near transit compared with the metropolitan area. Similar results were presented in another study which measured the share of college graduates within one mile of a transit station (Rayle, 2014).

[14] The transit induced gentrification literature uses similar gentrification indicators to those used in other gentrification studies, but it focuses on neighborhoods near transit developments rather than inner city locations.
[15] Racial composition of neighborhoods, however, did not always indicate transit induced gentrification.

Brown's (2016) study of local Bus Rapid Transit (BRT) investment indicates real estate value increase in proximity to BRT.

Paradoxically, these investments translate into housing cost and rent value increase and can potentially lead to gentrification and displacement [due to housing (un)affordability] of low-income households who are expected to benefit the most from transit improvement (Baker & Lee, 2019; Brown, 2016; Dong, 2017; Kramer, 2018; Rayle, 2014). This becomes an even greater problem when tax revenues from increased real estate values are reinvested in transit instead of affordable housing for these same households who are being (directly or indirectly) displaced (Edelson et al., 2019). Some of these households then move to neighborhoods that have had less investment in mixed-use, transit-oriented design, where housing is more affordable, but then become dependent on private cars to access opportunities in the city. This process is described as the ‘affordability paradox’ (Kramer, 2018). Kramer (2018) suggests a mismatch between housing affordability and transit access which is amplified by existing income and racial inequalities. Her study demonstrated that some households are forced to decide between affordable housing and affordable transportation (Kramer, 2018).

Further, an American study of 14 cities established associations between transit investment and gentrification, where walk-and-ride stations showed greater gentrification impact compared to park-and-ride stations (Dong, 2017). Canadian research found a statistically significant positive association between proximity to rail transit and gentrification in Toronto and Montreal but not in Vancouver (Grube-Cavers & Patterson, 2015). Gentrification in this study is treated as an event or the time when relevant census tract’s variables are increasing at a higher rate compared to its proximate surrounding (Grube-Cavers & Patterson, 2015). The analysis timeframe ranges between 1986 and 2006 and does not include proximity to Bus Rapid Transit stops. In fact, the only variable found statistically negatively significantly associated with gentrification in Vancouver was distance from water. This result is explained by the study's timeframe and earlier gentrification processes in neighborhoods proximate to the water (ibid). A longitudinal study in Portland, however, did not find evidence of rail transit investment and gentrification and proposes the study's limited time frame as an explanation (Dong, 2017). It is suggested that Portland's specific planning policies and tax reductions aimed at building multifamily and affordable units near transit explain its inclusivity and the more equitable results found there (Baker & Lee, 2019).

Nilsson & Delmnelle (2018) compare neighborhood changes between 1980 and 2010 across the U.S. using Walk Score™ and residential density as TOD proxies. A set of twelve indicators are used to examine the social, demographic and economic neighborhood change experienced around TOD's. Their results do not produce a consistent pattern. Their results are consistent with other studies and emphasize that transit investment itself is not a sufficient predictor of economic development and gentrification and that local context matters (Nilsson & Delmnelle, 2018). Moreover, in locales where high crime and poverty levels pertain, property values are not likely to rise as a result of transit revitalization. Finally, it might be that real estate value increases because of other related investments in street and landscape design and not directly in transit (Rayle, 2014).

One of the key benefits of quality public transit is access to opportunities such as jobs and amenities (Nilsson & Delmnelle, 2018). Not all residents, however, enjoy similar accessibility levels due to the geography of cities, including central and peripheral locations. Low-income households are more likely to depend on public transit and therefore often face greater travel challenges. In addition, transit cost presents another barrier given a limited budget (El-Geneidy et al., 2016).

Transportation planning typically assesses two types of equity based on transit accessibility, namely horizontal and vertical. Horizontal equity refers to universal costs and benefits spread among group members. This approach does not prioritize one person or group over another. The horizontal view focuses on spatial distribution of transit development. Because low-income households, minority groups and women are more likely to use and are more dependent on transit, these aspects are not addressed in the horizontal approach. The vertical approach, on the other hand, proposes a fair distribution that provides more to those who are in greater need. That is, low-income environments require higher transit service quality (Allen & Farber, 2019; El-Geneidy et al., 2016). This definition is further expanded to include transit cost impact on accessibility (El-Geneidy et al., 2016).

It is argued in the dominant neoliberal discourse, in which economic benefits and revitalizing declining neighborhoods are key, that the social benefits resulting from transit accessibility are becoming less important. Neoliberal jargon is especially prominent in TOD's promotion which endorses increased density, mixed land use, and pedestrian accessibility near transit stations (Nilsson & Delmnelle, 2018).

Some studies showed that neighborhoods with quality transit service are appealing to low-income households who are less likely to own a car and are more likely to be transit users compared to wealthier households. Others propose that transit accessibility serves as means to attract middle-income households by addressing social and environmental goals – they prefer to drive less and reside in compact, mixed-use communities (Dong, 2017).

Yet, the impact of transit development on gentrification is understudied. Most studies analyze property value but changes in neighborhoods socioeconomic and demographic composition is mostly not considered. This information can be useful for policy makers wanting to understand neighborhood change resulting from transit investment (Baker & Lee, 2019).

The term ecological gentrification stresses the paradoxes that arise from the clashing interests of the environmental discourse, its ecological rationale and ethics, and the injustices the environmental discourse produces to politically and economically weak populations (Dooling, 2009; Nilsson & Delmnelle, 2018). Low-income residents often need to move from revitalized urban environments (green, in particular) as a result of rising housing costs, and social and cultural changes (Nilsson & Delmnelle, 2018). Ecological gentrification therefore questions planning practices that use revitalized urban spaces to promote social and health goals, and as mechanisms to increase economic values of privately owned properties (Dooling, 2009).

Urban greening is defined by Anguelovski, Brand, et al. (2020) as investment in nature-centered infrastructure and services including parks, urban green spaces (such as community gardens and walls, greenways, parks, ecological corridors, or waterfront restoration), or restored waterways (Anguelovski et al., 2018). All projects require a ramp-up of previously underutilized urban environments or infrastructure such as highways and bridges, and their transformation into green developments. These efforts include redefining the original purpose and vision of space. It is argued that only a few of these projects embody an "equity lens" that promises these green efforts deliver benefits to all residents, and particularly to vulnerable populations who are historically subjected to environmental racism (e.g., pollution exposure, limited access to green spaces and health-promoting neighborhoods) and displacement. In most cases, it is just assumed that the "greening" effect will improve all residents' well-being. These implicit assumptions provide a strong justification for greening projects that is widely used in cities globally (Anguelovski, Brand, et al., 2020).

When the multiple benefits are considered, urban greening becomes central in utopian planning discourses for imagining new spaces, and thus provides moral and economic grounds for cities to strive to be green. Planning approaches that promote communication and democratic processes encourage participation and inclusion. While embedded in greening projects, these processes promote sustainability but this portrait of the desirable green city can potentially have harmful effects for equitable environmental planning (Anguelovski et al., 2018).

Furthermore, Fainstein argues that in our segregated society, even if a democratic discussion can be achieved it does not guarantee that the desired results will be delivered. She stresses that powerless participants with limited resources cannot genuinely influence discussion content nor the decision making itself (Fainstein, 1999).

The 'communicative' approach (associated, among others, with Patsy Healey, Fischer, Forester, and Innes) emphasizes inclusive processes. Communicative theorists believe that good democratic processes including negotiation and decision-making produce equitable results. On the other hand, the political economy approach (associated, among others, with Fainstein, Harvey, and Gans) emphasizes outcomes. Focused on unfair distribution of goods, Fainstein stresses that: *The ideal that everyone's opinion should be respectfully heard and that no particular group should be privileged in an interchange is an important normative argument. But it is not sufficient one, and it does not deal adequately with the classic conundrums of democracy. These include ensuring adequate representation of all interests in a large, socially divided group, protecting against demagoguery, achieving more than token public participation, preventing economically or institutionally powerful interests from defining the agenda, and* *maintaining minority rights.* (Fainstein, 2010; 29). Fainstein criticizes communicative planning theorists for not taking a stand as to what is a good city, rather they just focus on right and good actions – about which consensus can be built. She considers the communicative approach as neglecting "*structural inequalities and hierarchies of power*." (ibid; 30). Another counterclaim is that people can often be "prisoners" of existing social norms: they evaluate specific situations according to accepted norms, even if they are not aware of what "guided" their judgment. This becomes even more acute when the strongest in society control the discourse (Fainstein, 2010).

Decision makers reference research promoting green projects to brand their cities as lively, healthy, environmentally friendly, and attractive to the knowledge-based industry. Positive outcomes are used in an allegedly apolitical discourse to validate city investment in greening projects, describing those as beneficial to all residents, without addressing social and health equity issues (Anguelovski, Connolly, Garcia-Lamarca, Cole, & Pearsall, 2019; Anguelovski, Irazábal-Zurita, & Connolly, 2019; Cole et al., 2017; Quastel, 2009).

Support for greening projects include three fronts (Anguelovski, Brand, et al., 2020):

(1) Economic: economic growth is expected as a result of implementing green or smart growth strategies through real estate development, new businesses, and growth in tourism. Urban green spaces are expected to increase neighborhood desirability and therefore demand which will translate to property value increases. Higher income residents are likely to be attracted to such reinvested neighborhoods. This impact is typically framed positively often neglecting the challenges produced to socially, economically, and racially weak populations.

(2) Environmental: the positive associations between urban greening and ecosystem diversity are emphasized in discussions around the environmental and ecological benefits (e.g., lower carbon dioxide and other pollutant emissions, natural risk hazards prevention and mitigation) of greening projects. Urban community gardens have also been linked to additional recreation choices, environmental learning, strengthening social relationships, stronger sense of belonging, and improved social capital.

(3) Physical and mental health: greening projects are portrayed in their contribution to one's overall health and well-being. Referenced studies often ignore the potential unfavorable health and mental well-being outcomes of urban greening to specific populations because those studies are mostly focused on the neighborhood level and results are reported as part of wider political/environmental/health concerns and hardly ever consider social implications.

Increasingly, critical urban researchers refer to urban greening efforts as a leading contribution to displacement of vulnerable communities notwithstanding its marketing as generating benefits to all residents. Like other environmental injustices, green environmental injustices are argued to disproportionally affect vulnerable populations including minorities and low-income households (Quastel, 2009). Greening aspirations, similar to the 'public good', presume benefits to all, but exemplify uneven power relations and limited resource competition which contribute to unfair distribution. That is, so called government-led, politically neutral and utopian justifications that elaborate positive implications, reproduce or exacerbate social inequality. In this typical discourse, the advantages of green projects are raised without appropriate consideration for the deeper social and spatial implications (Anguelovski et al., 2018;

Anguelovski, Brand, et al., 2020). Exclusion, polarization, segregation, and invisibilities of vulnerable communities are overlooked (Anguelovski et al., 2018).

In one of the early urban greening studies, Quastel, (2009) examines Vancouver's Omni Garden. Densification goals for downtown neighborhoods in Vancouver is associated with environmental awareness. The author shows how projects, including the Omni Garden, are advertised as promoting environmental and sustainability goals while also contributing to gentrification.

Another example that lies somewhere between transit-induced and green gentrification is described in Grengs (2005) where an investment in mass transit system is argued to exacerbate social inequities. Government representatives are shown to cite economic gains resulting from transit developments to justify investments. Improved accessibility, improved congestion, travel time, transit mode links, and transit affordability are referenced in this discourse (Grengs, 2005).

In Medellin, Colombia, ideas of urban containment, aesthetics, and resilience help to justify greening of low-income neighborhoods while employing land grabbing and converting poor environments into structured nature accessible only to the already well off. In the name of the ‘greatest public good’, low-income populations are prevented from accessing community amenities and nature, they suffer from a loss of social capital, and loss of power throughout the greening process (Anguelovski, Irazábal-Zurita, et al., 2019). Unlike more familiar gentrification processes where low-income households are replaced by higher-income families, in the Medellin context, the dispossessors are visitors who shape, control, and take advantage of the new environment (Anguelovski et al., 2018).

A recent study found that 84% of men and 91% of women threatened by displacement have negative mental health impacts, including anxiety and depression (Anguelovski, Triguero-

Mas, et al., 2020). This was especially true of youth in East Boston, who reported fear from displacement due to rent increase, an influx of tourist-oriented short-term rentals, and more generally, because of dwindling life opportunities. Other factors were found related to the negative impact of gentrification on physical health in East Boston and Barcelona, including sleep deprivation from air and noise pollution. Pollution was linked to construction of new residential sites, and to loud visitors and tourists. Neglect of existing dwellings by landlords wishing to sell or rent to higher income gentrifiers was also linked to the observed negative health impacts of gentrification. Poor health outcomes were also attributed to lack of affordable fresh food buying options. It is indicated that low-income residents can rarely afford the type of "healthy" food shops in their gentrifying neighborhoods (Anguelovski, Triguero-Mas, et al., 2020).

Even though some public health studies illustrate how health outcomes of green spaces are impacted by a range of socioeconomic and political factors, and how these differences contribute to health inequities, research is still scarce and there is a need to fill this gap and further explore how neighborhood change affects fair distribution of health and well-being outcomes associated with green spaces. Moreover, specific values, preferences, and needs of different groups, including women, the aging, children, low-income and minorities should be considered (Anguelovski, Brand, et al., 2020).

Analysis of the role of planners, investors, consumers, and grassroot organizations in processes of gentrification helps to illustrate how environmental language and policies often reveals where power actually lies and how unfair distribution and inequities persist (Quastel, 2009). This is not to argue that green planners deliberately aim to displace low-income and minority households for the sake of increased gains from real estate developers. But they tend to disregard the negative implications of real estate market exchanges as they are often confined to inter-city competitiveness discourses (Anguelovski et al., 2018).

Instead of simply rejecting urban greening initiatives, the authors suggest promoting a more complex discourse, in order to understand how these investments/policies might produce different results for vulnerable populations while considering equity and sustainability for all residents (Cole, Lamarca, Connolly, & Anguelovski, 2017). In particular, rising rent values are a concern as they can lead to displacement of low-income households in the absence of rent-control policies. Rents could also increase once units are vacated leading to a less tangible but still very real displacement by reducing the affordable housing supply (Brown, 2016). Practitioners aiming to avoid gentrification or those wanting to develop without risking displacement, need to strive to sustain social and economic diversity and therefore need to address housing affordability in early stages of the planning process (Immergluck & Balan, 2018). Planning is suggested as a tool to take actions against inequality - planners with their interdisciplinary qualifications can bridge between theory and practice and between government and social movements, in order to promote fair outcomes (Grengs, 2005).

2.4 Redevelopment for Whom? Research Gaps

While different improvements to the built environment typically target physical conditions, availability of services, real estate values and overall quality of life - for some populations, these efforts often translate to gentrification, without providing equitable results to vulnerable households (e.g., low-income, elderly, minorities) (Anguelovski, Triguero-Mas, et al., 2020). Yet, there is limited research to date on the impacts of gentrification on the *health* outcomes of more socially vulnerable individuals. There is a need to expand the exploration of built environments and health. Researchers have acknowledged the importance of physical and social features (e.g., social opportunities, crime rates, and employment levels) for health, there is a need to better understand these and other factors (Anguelovski, Triguero-Mas, et al., 2020).

What sort of investment is beneficial and for whom? Should it be assumed that increased MUPOD is beneficial for all? Or perhaps investment in infrastructure to increase the neighborhood's MUPOD character can be viewed as "locally unwanted"?[16] Is MUPOD associated with increased housing prices and gentrification? Are low-income households forced to move and how does this relate to health and well-being? These are the research gaps this dissertation aims to fill (see Figure 2.3).

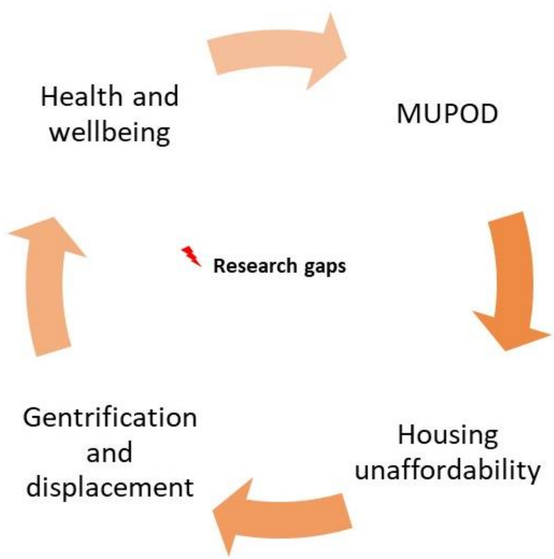

Figure 2.3 Research gaps

Canadian government invests significantly in public transit infrastructure but without exploring the effects on injustice. Vancouver is ranked highest in the number of locations at risk

[16] Anguelovski et al. (2018) use the acronym GreenLULUs: Green Locally Unwanted Land Uses.

of public transit poverty. Not having access to quality transit among disadvantaged households can limit their ability to access jobs and services and increases social disparities, exclusion, and has a harmful effect on social equity and distribution of goods (Allen & Farber, 2019). There is a need to incorporate both horizontal and vertical equity approaches into transportation planning to create more inclusive environments and reduce inequalities. In China, it was found that the emphasis on overall average pedestrian-oriented development (instead of local improvements in deprived neighborhoods) is disempowering to some populations and it in fact created additional social inequalities (Su et al., 2017).

Social justice issues have not been sufficiently examined in relation to walkability in the planning literature. On the other hand, in the environmental justice literature, equitable access to amenities is increasingly emphasized with a focus on vulnerable populations. Considering both increasing concerns about health outcomes from a sedentary lifestyle and awareness for built-environment design and the extent to which pedestrian-oriented design encourages physical activity, social interactions, social capital, safety, and economic development, there is a greater need to examine who gets to benefit from these high-quality accessible environments. Moreover, travel mode choice can improve the well-being of individuals through experiences/activities during commute (e.g., meeting people, reading, physical activity), and participation in activities made possible by traveling in a certain way (e.g., reduced commute time enables more disposable free time). Improved well-being seems to be a meaningful indicator of happiness, among other things. This has been shown to be easier to realize in higher density, urbanized environments compared to suburban ones. However, here again, there is a need to consider the local context (e.g., crime, crowdedness, housing quality, employment opportunities) when applying these conclusions to promote alternative developments (De Vos et al., 2013).

These more “successful” environments are indeed critiqued for becoming increasingly expensive for all but the rich and thus contributing to social inequality. Households that could potentially benefit the most from more walkable environments (e.g., the elderly, low-income, minorities, low education and low skill jobs that have fewer resources and depend more on transit) are excluded due to affordability. The existing evidence is limited and produces mixed results (Bereitschaft, 2017).

There is a need to better understand the relationship between neighborhood investment, benefits of compact, walkable environments, and health in order to produce adequate planning policies that reduce social inequalities and improve health and well-being for residents (Bereitschaft, 2017).

Anguelovski, Brand, et al. (2020) propose some principles to evaluate urban greening projects, including using an equity lens in analyzing urban greening outcomes with an explicit recognition of inequity and power structures embedded in capitalism and neoliberalism. In addition, the impact of colonial history and systemic racism on current policies needs to be acknowledged. New policies should actively seek to eliminate existing gaps and prioritize vulnerable communities in order to reduce inequity. This includes a commitment to more just processes that truly commit to listening, compensate for the losses of the less fortunate and ensure they enjoy the future benefits of urban greening.

Ultimately, this research will contribute to the understanding of how living in a pedestrian-oriented neighborhood impacts health? Who can afford living in a neighborhood with a higher degree of MUPOD? Can individuals who are most likely to use transit live nearby? Is there an equity distribution problem? Insights could potentially help to explain these processes, and what decision makers can do to build more inclusive environments.

Chapter 3: Methods and Design

This chapter discusses the methods and research design used to explore the four research questions. The chapter is structured as follows: Section 1 introduces the research's purpose and the research questions. The analytical approach is described in Section 2. Section 3 provides information about the study's location and historical context. The data sets used to analyze the research questions are presented in Section 4. Section 5 reviews geography techniques used to compare data from different sources. Sections 6, 7 and 8 are devoted to descriptions of the independent, dependent and control variables, respectively. Section 9 and 10 outline the choice of statistical tests used to examine the research questions. Finally, the data organization and cleaning process is described in Section 11.

3.1 Purpose and Questions

The research's primary purpose is to study whether mixed-use, pedestrian-oriented environments are accessible to all. This will contribute to the understanding of how neighborhood design has significant environmental, health, social, and economic consequences. Table 3.1 describes the research questions examined in the dissertation.

Table 3.1 Research questions

Question #	Research Question
1	Controlling for relevant personal characteristics, is there a significant association between the degree of neighborhood MUPOD and health and social well-being outcomes?
2	Controlling for relevant neighborhood characteristics, is there a significant association between the degree of neighborhood MUPOD and housing costs?

Question #	Research Question
3	Does housing affordability play a significant factor in household decisions to move to neighborhoods characterized by lower levels of MUPOD?
4	Controlling for relevant personal characteristics, is there a significant association between the degree of neighborhood MUPOD and the share of households earning $40,000 or less?

The conceptual framework for the dissertation is described in Figure 3.1.

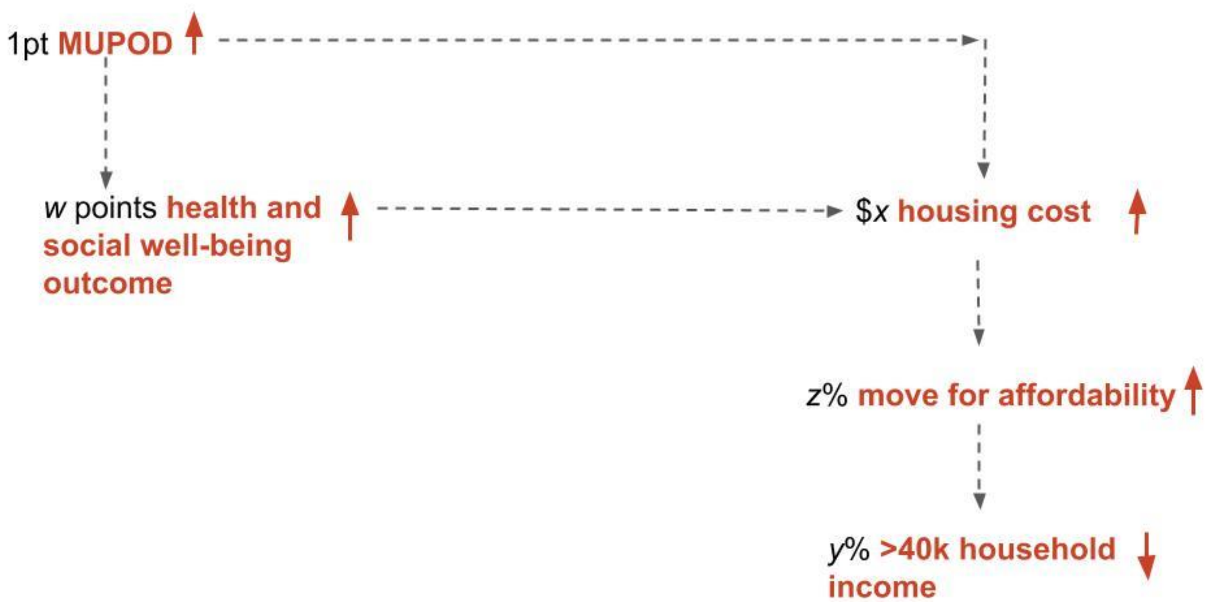

Figure 3.1 Conceptual framework

Research has shown that infrastructure to promote active transportation mode improves accessibility and thus the desirability of these residential environments and in turn leads to housing price appreciation (Bartholomew & Ewing, 2011; Leinberger, 2008; Leinberger & Alfonzo, 2012; Stokenberga, 2014; Wang & Immergluck, 2015; Zuk, Bierbaum, Chapple, Gorska, & Loukaitou-Sideris, 2018). Moreover, increased MUPOD is associated with improved health and social well-being outcomes which I suspect is also associated with increased housing values[17]. According to the classic filtering model, low-income residents are expected to be displaced by high-income households who are willing to pay for accessibility (McKinnish et al., 2010). I hypothesize that increases in housing costs produce neighborhood change and displacement of low- and moderate-income households to more car-oriented, affordable environments. It is therefore expected that affordability is a significant factor in household moving decisions to neighborhoods characterized by low MUPOD, and that fewer low-income households (earning under $40,000 annually) reside in neighborhoods characterized by a higher degree of MUPOD.

It needs to be noted, however, that this research's intent is not to prove causation rather relational associations between variables. Since the data used in this study is cross-sectional and because of endogeneity (or that it is impossible to isolate specific characteristics of the built environment and learn their impact) - causality cannot be proven.

It is important to note that there are unobserved factors which are expected to significantly impact the identified relationships described here and the dependent variables estimated in the models. These unobserved, or latent factors, consist of a range of features which impact health and housing and are not included in the models.

Moreover, Walk and Transit Score™ were used to structure the independent variable (i.e., MUPOD). Walk Score™ objectively measures the shortest walking route for each address to nearby destinations, including thirteen category nearby destination such as grocery stores, schools, parks, restaurants, and retail. However, there are additional characteristics, some

[17] The health/housing value relationship, however, is outside the scope of this research and will not be examined here.

measurable and some are not, that influence MUPOD (for example, the presence of trees and benches, safety, and the number of people occupying a public space). It is impossible to perfectly capture all relevant neighborhood characteristics in a survey questionnaire. Clearly, an estimation model simplifies reality but the extent of this simplification and its impact on the study findings is not entirely clear.

3.2 Analysis Approach

The dissertation utilized housing and health data collected at the household, DA, and neighborhood levels to explore trends related to MUPOD and infrastructure. In particular, the study examined the spatial distribution of MUPOD in the Metro Vancouver region (BC) and the health, housing, and demographic makeup of neighborhoods, with the hypothesis that low-income households[18] are less able to live in neighborhoods characterized by higher MUPOD levels.

Data for this research was obtained from several sources, including: (1) Canada Census and NHS, (2) MHMC survey, (3) CMHC's annual RMS, (4) BCAA, and (5) Walk Score™. The timeframe of the analysis ranges from 2011 to 2020 and is described in Figure 3.2.

A quantitative approach is chosen to address the research questions in order to leverage existing large data sets for the Metro Vancouver region. The five different data sources are typically studied separately so that relationships between these data are often overlooked.

[18] Household income under $40,000 reflects low-income cut-off used in the analysis. While 2016 Census definition refers to $40,000 for two-person households, household size is not considered here. This decision was made based on data availability. While it is difficult to afford housing on this annual income (< $40,000), there are certainly worse circumstances.

Integration of these sources is in fact one of the major contributions of this dissertation. While a mixed-methods approach, including a qualitative aspect to the analysis (e.g., surveying households who had moved for affordability reasons), would have contributed to the analysis, it is beyond the scope of this study. This is an important topic for future research to explore.

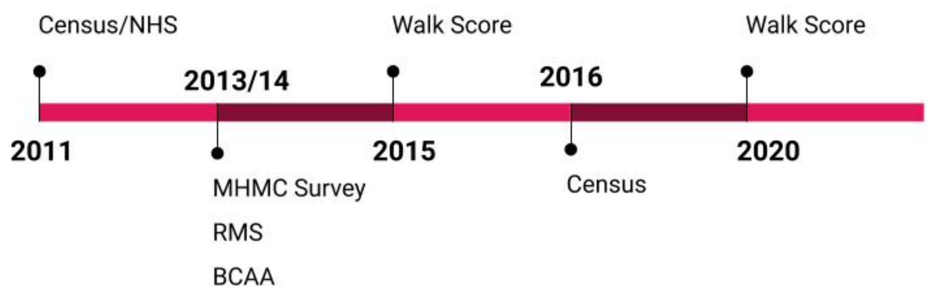

Figure 3.2 Data sources and timeline

Demographic data at the DA level were extracted from the 2011 and 2016 Canada Census and NHS in order to examine neighborhood change over time. Metro Vancouver included 3,451 DAs[19]. DAs were matched to MHMC neighborhood geography using GIS software (see Section 3.5 for more detail).

Because DA boundaries change over time to reflect population changes, 2011 DAs were adjusted to 2016 boundaries by using weights (see Section 3.5). Percentage changes between the years were calculated for education and employment across MHMC neighborhoods. A social status index, developed by Ley (1994) was used to determine where gentrification occurred. Higher index scores indicate higher levels of aggregate neighborhood social change while lower scores indicate lower rates of change (Brown, 2016).

[19] 3,439 DAs in 2011 due to a slight difference in geographical boundaries.

Personal information on household health, demographic and socioeconomic status was obtained from the 2013/14 MHMC survey which included 33,075 responses (31,193 of which are within the study area). Responses were classified into 106 MHMC neighborhood profiles which are used in the analysis (N=106)[20].

Rent information for 2011 was derived from the Canada Census (DA level) as well as from the 2014 annual RMS, conducted by CMHC in areas with population higher than 10,000. CMHC information is available at the neighborhood level (N=68). Both Census DAs and CMHC neighborhood division were matched to correspond to MHMC neighborhood geography (N=106) using GIS while employing areal weighting techniques (see Section 3.5 for more detail).

2014 BCAA data included 947,110 parcel-level observations on the structural attributes of Metro Vancouver residential properties (710,985 of which were within the MHMC geographical boundaries, and are used in the analysis, N=710,985). Average and median house prices by structure type, floor area, and number of bedrooms were calculated for each of the 106 MHMC local profiles.

Walk and Transit Score™ were accessed via Redfin Real Estate agency and were used to create a 2015 and 2020 MUPOD indices. MUPOD is the independent variable. MUPOD is a continuous variable ranging from 0 to 100 (N=106) and it was compared to other variables of interest using a series of multiple linear regression models to test for relationships between variables.

[20] See Appendix B for a list of the Health Authority and Associated MHMC Community Profile.

All data were spatially linked at the MHMC neighborhood level and differences were controlled for age (a continuous variable ranging from 0 to 100 indicating the percentage of individuals of 65 years old and up), gender (a continuous variable ranging from 0 to 100 indicating the percentage of male individuals), education (a continuous variable ranging from 0 to 100 indicating the percentage of individuals holding a university degree), marital status (a continuous variable ranging from 0 to 100 indicating the percentage of married individuals), living arrangement (a continuous variable ranging from 0 to 100 indicating the percentage of individuals who live alone), lot area (a continuous variable ranging from 0 to 1.301e+09 meter squared[21]), floor area (a continuous variable ranging from 1 to 17,672 meter squared), number of stories (a discrete value ranging from 0 to 918[22]), number of bathrooms (a sum of full- and part-bathrooms, it is a discrete value ranging from 0 to 48[23]), basement (a dummy variable where 1 equals basement and 0 indicates no basement), garage (a dummy variable where 1 equals garage and 0 indicates no garage), structure age (a continuous variable ranging from 0 to 114), housing size (studio, one bedroom, two bedrooms, and more than three bed rooms) and type (a dummy variable where 1 equals townhouse and 0 indicates other high-density unit types), and distance from Vancouver Downtown[24] (a continuous variable ranging from 0 km to 47 km) and were considered statistically significant if 95% confidence intervals were non-overlapping.

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[21] This property is listed in BCAA dataset as a single-family home on Graham Dr in Tsawwassen.
[22] This is likely a BCAA typo. The second high floor number documented is 634 (typo as well?). The third and fourth highest numbers are 121 and 52 stories, respectively. As a result of these inaccuracies, number of stories is only used as a control variable when estimating hedonic regressions for single-family homes.
[23] This property is listed in BCAA dataset as having 47 full bathrooms and 1 part-bathroom in a two-bedroom condo in downtown Richmond which does not seem possible and is therefore likely to be a typo in the original dataset.
[24] The region's CBD.

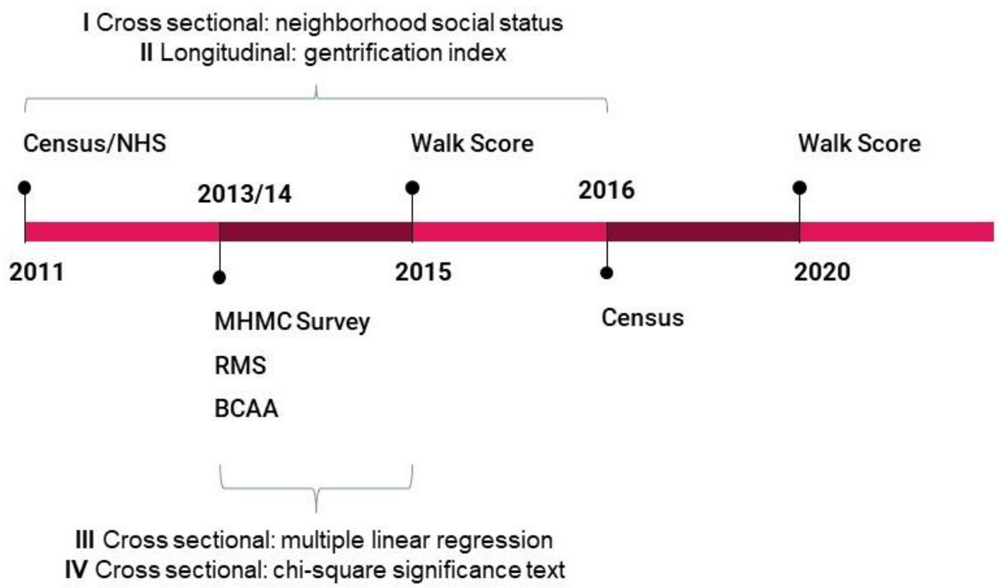

Figure 3.3 Data sources and statistical analysis approach

As shown in Figure 3.3, the first and second analysis phases included a cross-sectional and longitudinal examination of neighborhood social status and gentrification, respectively. I proceeded with implementation of multiple regression analysis using cross-sectional data for 2013/14 to determine whether MUPOD can be used to predict any of the following: (1) health and social well-being, (2) housing/rent values, (3) reason for moving, and (4) household income under $40,000. Finally, neighborhoods were classified into low and high MUPOD levels to perform the chi-square significance test. This established a dependency between MUPOD and (1) reason for moving (‘affordability’ or ‘other’) and (2) household income (‘under $40,000’ or ‘$100,000 or more’).

Finally, the issue of autocorrelation or similarity between nearby observations needs to be addressed. More particularly, Spatial autocorrelation is used to describe the presence of systematic spatial variation in a variable or the tendency for areas that are close together to have similar values (in our case municipalities or neighborhoods) that might impact the estimation model results. The estimation models therefore included: (1) a "city fixed effects" argument which allows to control for some of the differences across the Metro's municipalities rather than variation within cities; and (2) "clustered standard errors" (using R packages 'lmtest' and 'sandwich'), implying that errors within each cluster (or MHMC neighborhood) are correlated.

Moreover, in the hedonic models, where sample size justifies another interpolation, samples are split into (1) core urban area[25], and (2) suburban periphery observations[26] and regressions are run separately for each subset to present more accurate estimations and because of significant built environment design differences between urban and suburban neighborhoods.

3.3 Location and Historical Context

There can be no other way to begin this book on planning than to remind the reader that the city commonly known as Vancouver was built on the unceded ancestral lands of the Musqueam, Squamish, and Tsleil-Waututh Nations. [27]. … *The Musqueam people have been stewards of the lands and waters of their traditional territory since time immemorial* (Grant, Sparrow, Grant, & Scoble, 2019; 25, 43).

Situated in what is known as the Pacific Northwest, the Metro Vancouver region includes 21 municipalities, one electoral area, and one Treaty First Nation with roughly 2.5 million residents. Metro Vancouver is part of the Lower Mainland, located in the province of British

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[25] Core urban observations are based on distance from Vancouver's CBD and include: "Burnaby", "City of North Vancouver", "Richmond", and "Vancouver".
[26] Suburban periphery observations include: "Anmore/Belcarra", "Bowen Island", "Coquitlam", "Delta", "Langley City", "Langley Township", "Maple Ridge", "New Westminster", "Pitt Meadows", "Port Coquitlam", "Port Moody", "Surrey", "White Rock", "District of North Vancouver", and "West Vancouver".
[27] Nation names are written in both Indigenous language and in English in the original publication.

Columbia (BC). It is positioned between the Pacific Ocean to the west, the Fraser Valley Regional District to the east, the Canadian Coastal Mountains to the north, and the U.S. border to the south (see Figure 3.4 and Figure 3.5).

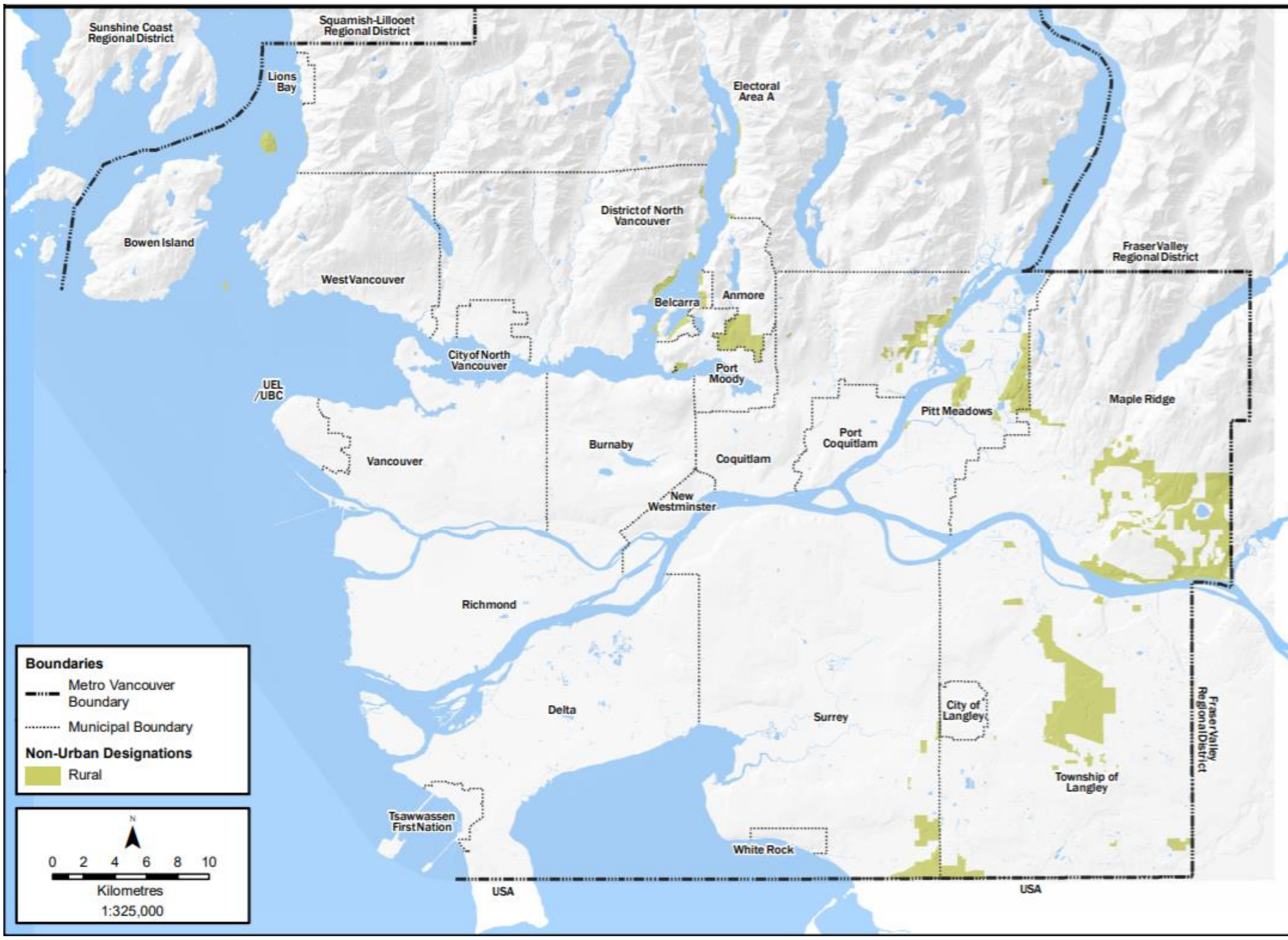

Figure 3.4 Metro Vancouver rural areas
Source: *Metro Vancouver 2040* (2017)

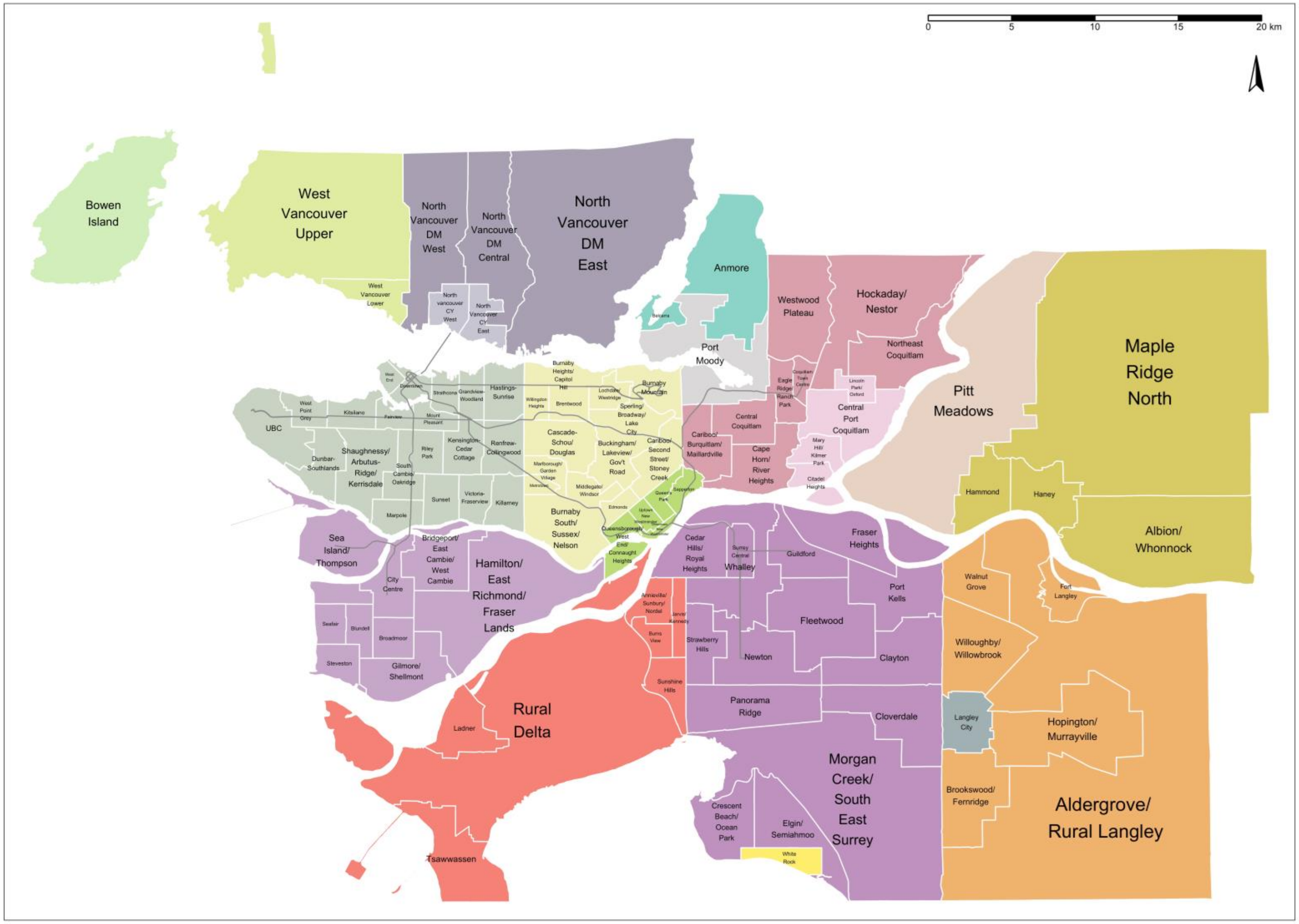

Figure 3.5. Metro Vancouver municipalities and MHMC neighborhoods

Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

Metro Vancouver is the third largest census metropolitan area (CMA) in Canada in 2016 with a 6.5% population increase from 2011 (compared to the provincial and national averages of 5.6% and 5%, respectively) (2016 Census). Population growth, however, was lower than past census periods. This is explained by lower rates of immigration to BC and to Metro Vancouver. Figure 3.6 shows Metro Vancouver population growth by subregions.

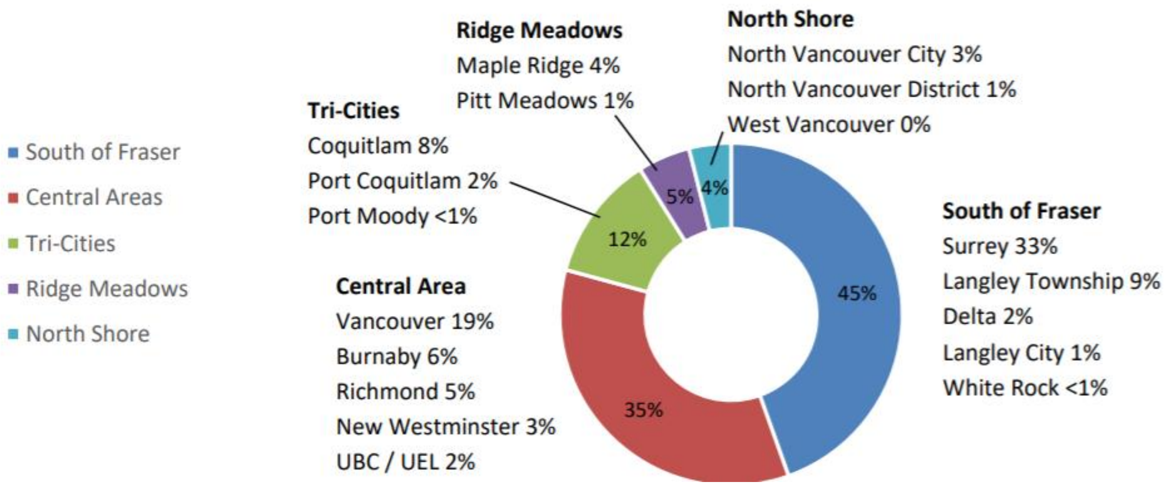

Figure 3.6 Metro Vancouver population growth from 2011-2016 by subregions
Source: *2016 Census Bulletin: Population* (2017).

In 2016 the Metro Vancouver area had the highest population density in Canada with approximately 855 people per square kilometer (this includes the north shore mountains and agricultural land). The density measure is 3,130 per square kilometer for residential-only uses and it is roughly twice denser when roads/parks/institutional/commercial/industrial areas are removed from the calculation. This density measure, however, is not representative of Canada where 66% of the population lives within 100 kilometers of the southern border with the U.S. in an area that equals roughly 4% of Canada's land (2016 Census Bulletin; Population Size and Growth in Canada, 2017). Moreover, density levels vary between Vancouver's Downtown core, the city's neighborhoods and its suburbs.

Residential growth is approximated at 80% through infill and redevelopment of existing neighborhoods, and 20% through development of new or undeveloped areas in the Metro Vancouver region (2016 Census Bulletin).

The City of Vancouver (COV) is the region's main urban center with a population of 600,000. The City was founded in 1885 as the western terminus of the Canadian Pacific Railroad (CPR), connecting Canada by rail to global trade. Vancouver's location by the Pacific Ocean and its abundant natural resources have long made this city attractive to migrants and real estate investors. However, over time the province's natural resource sector has become less relevant to Vancouver's urban development (Siemiatycki et al., 2016). The sale of Expo 86 World's Fair lands on the edge of downtown Vancouver to a Hong Kong-based family marks the beginning of today's reputation of Vancouver as a hotspot for global real estate investors. It is also argued that the 1980s is when Vancouver's urban policy shifted from social liberalism to neoliberalism (evident at all government levels) which enabled one of the largest redevelopment projects in North America, namely the Expo lands. The neoliberal point of view facilitated trade, global capital investment and labor flows, and immigration (Ley, 2017; Moos & Skaburskis, 2010). The Canadian government, and especially BC, created policies to support trans-Pacific economic real-estate activity and wealth migration (e.g., the Business Immigration Program) enabling household and corporate capital to arrive from Greater China starting in the early 1980's. Major investments were directed at the real-estate market as a result. Provincial-government, as well, initiated market-oriented reforms including privatization, deregulation, welfare cuts and anti-union guidelines (Ley, 2017).

Vancouver is also known for its inner-city MUPOD. The Agricultural Land Reserve (ALR), enforced in the 1970s by the NDP government (Lauster, 2016; 107), restricted nonagricultural uses in all of the region's municipalities peripheries in order to protect its natural surroundings and agricultural land (the ALR later defined the city's urban growth boundaries) (Quastel et al., 2012). As a result, the Vancouver metropolitan area successfully managed to focus development in existing neighborhoods and limit sprawl. These built form patterns have contributed to a unique urban design and architecture reality, known around the globe as Vancouverism (Lauster, 2016; 59). In particular, Vancouverism describes a significant downtown population, mixed-use development, high density housing or tall high-rises, reliance on public transit, green spaces, and protection of view strips (Douay, 2015; *Urban Planning, Sustainable Zoning, and Development*, 2018).

Vancouver offers high quality community centers which are financed and operated by the City. These are extensively used by the public, contribute to neighborhood sense of belonging and enable opportunities for new resident assimilation. Moreover, Vancouver is known for its functioning neighborhood association and citizen involvement. The latter was reinforced by the CityPlan process in the 1990s which engaged developers, planners, and citizen negotiations that contributed to the creation of public amenities. Both its urban design and citizen engagement contribute to the city's "livable" reputation (Gurstein, 2018).

3.3.1 Regional Vision

The Metro Vancouver regional vision that serves as its planning point of departure was first outlined in 1966 in the *Official Regional Plan of the Lower Mainland Regional Planning Board, the Municipalities of the Region, and the Province of British Columbia*. It described the region as a sequence of cities (Gurstein & Yan, 2019).

More recently, sustainable planning and stewardship have been stated priorities in the Metro Vancouver 2040 report[28]. Adopted in 2011, it outlines the regional growth strategy. The strategy includes five main goals all related to promoting "complete communities" within the Urban Containment Boundary, within urban centers, and along major corridors (2016 Census Bulletin; Metro Vancouver, 2017). "Complete communities" are characterized by compact design. The vision includes housing, jobs, services and amenities distributed and accessible to all residents in different life stages across the region. People residing in complete communities can self-manage social, cultural, and educational activities. Housing diversity is critical and includes not only housing type mix but tenure options and flexibility in response to changing household needs and financial ability. MUPOD is argued to facilitate environmental protection by efficient use of land, active transportation modes and pollution reduction. Importantly, the Strategy acknowledges the need for a collaborative land use and transportation effort to accomplish its goals (Metro Vancouver, 2017).

3.3.1.1 Housing

Rising housing cost is a major concern in the Metro Vancouver region. The 1990s have seen a decrease in provincial and federal government intervention in providing financial support to households experiencing affordability needs and to funding public housing. Subsidies to build new affordable rental housing and maintain existing public housing stock were severely cut and left to the market and local municipalities (Moos et al., 2018). While the market does provide housing to most residents, affordability is a key issue. In particular, households earning less than

[28] This commitment to sustainable future is known as the Sustainable Region Initiative (SRI).

$50,000 per year face an extremely unaffordable market (*Regional Affordable Housing Strategy Update*, 2015).

The new Regional Affordable Housing Strategy, created by various stakeholders to guide housing affordability actions, was accepted by the Greater Vancouver Regional District Board of Directors in May 2016. The Strategy provides leadership on the region's housing needs and tracks progress of the Metro 2040 goals (*Regional Affordable Housing Strategy Update*, 2015). The Strategy's main focus is rental housing supply, and it aims to increase supply and diversity to meet different needs, balance protection of existing rental stock with redevelopment, meet demand for very low- and low-income households, increase supply around TransLink's Frequent Transit Network[29] (FTN), and end homelessness in the region. The Metro 2040 objectives are consistent with actual housing data published in the 2016 Census. Roughly 98% of housing unit growth was within the Urban Containment Boundary and about 50% happened near to the FTN (2016 Census Bulletin).

Known globally for its livability, sustainable leadership and rich urban life, practitioners and others learn from Vancouver's planning policies and implementation which arguably have created a lively, diverse region. Nevertheless, Vancouver is now known as the most difficult city in Canada (and one of the worst worldwide) for young adults to make a home: this threatens its image as one of the 'most livable' cities globally (Gurstein, 2018). Metro Vancouver's housing prices have tripled since the 1970's while full-time earnings for an average Canadian aged 25-34

[29] The Metro's FTN is a network of main passages served by transit (including buses or SkyTrain) at high frequency every day until 9pm (*Frequent Transit Network*, 2020).

have actually decreased (more significantly in BC than in other provinces) (Kershaw & Anderson, 2011; Kershaw & Minh, 2016).

The Metro's reputation has fallen as housing unaffordability and housing insecurity, high numbers of homelessness, and deep gaps between the have and have-nots threaten to change its landscape (Gurstein, 2018). As put by Cox & Pavletich in the 2017 Demographia International Housing Affordability Survey (p. 3): …"*a city cannot be livable, nor can it be a best city to middle-income households that cannot afford to live there. Households need adequate housing*."

While detached home prices in Vancouver East and in Vancouver West saw a 5% and 10% decrease, respectively between October 2017 and October 2018, these prices are still unaffordable to most residents. Home prices in Vancouver East have spiked up 141% in the last decade whereas local median household incomes increased by less than 40% (Housing Vancouver Strategy, 2019).

In 2016 roughly 40% rented their homes in Metro Vancouver. In some parts of the region, renter households are the majority. This is true of the COV and the UBC area where more than 50% of households rent (Gurstein & Yan, 2019). These proportions are significantly higher compared to other cities in Canada. Rents are not affordable either. With the highest rents in the country, Vancouver's one- and two-bedroom average rent rate in 2016 is $1,900 and $3,130, respectively, per month. Rents were estimated at half these rates in 2006 and at one third in 1996. Another striking observation shows that about 43% of Metro Vancouver renters live in unaffordable housing where expenses exceed the 30% affordability threshold. In a market with the highest rent prices in Canada, 12% live in overcrowded and health-compromising housing conditions (ibid).

The *Regional Affordable Housing Strategy Update* (2015) estimated a gap of 1,600 units between new rental supply and rental demand from 2011-2014. The mismatch between new housing supply and the economic ability of prospective households is very problematic. A review of approved building permits over a period of two years (2017-2018) in the COV demonstrates this. Two-thirds of the building permits were for units only affordable by households earning a minimum of $80,000 per year and are in the top 40% of the City's household incomes (Gurstein & Yan, 2019).

Worryingly, vacant units are more expensive by approximately 20% than occupied private purpose-built apartments in 2018 in the COV. Affordability severely impacts vulnerable populations, with dozens additional sheltered and unsheltered homeless residents from 2017 to 2018[30] (Housing Vancouver Strategy, 2019). Vancouver poses a severe homelessness and housing insecurity challenge for those not able to enter the housing market.

In 2016 the percentage of total occupied dwelling units in the region was 93.5% (2016 Census Bulletin). Vacancy rates in the COV reached a low of 0.7%. This is attributed to insufficient construction of purpose-built rental units.

The reasons for this crisis are varied: some are shared with other "desirable" global cities as well, while some are unique to Metro Vancouver's local setting including a flow of external capital, low interest rates, geographical boundaries limiting expansion, population increase driven by large immigrant flow, and non-occupied residences (Gordon, 2016; Ley, 2017; Moos & Skaburskis, 2010). Lee (2016) suggests that one of the major problems is that housing in

[30] In 2017, Metro Vancouver saw a 30% increase in homeless count since 2014, including 3,605 identified as homeless (whereas in reality the numbers are known to be even higher) (Gurstein, 2018).

Vancouver is viewed more as a commodity (or "*exchange-value*") and less as a home (or "*use-value*" as defined in Logan & Molotch, 2007). Vancouver, Moos & Skaburskis (2010) explain, has become a gateway city for wealthy and skilled migrants. Their income sources, however, are located outside the country, resulting in a dissociation between local income and participation in the local work force and actual levels of housing consumption compared with the rest of the population. Moreover, since these wealthier immigrants mostly move directly into home ownership, they increase housing demand in local markets such as Vancouver and Toronto. Finally, its stable political atmosphere and other characteristics discussed here have turned Vancouver into a "hedge city" where real estate investments are safe for the upper class (Gurstein, 2018).

The affordability challenge is impacted by transportation cost as well as housing cost (see Figure 3.7). It is shown that working households residing in places served by public transportation, or where jobs are nearby, have lower transportation costs compared with households in other locations. In order to improve overall affordability, it is important to provide housing opportunities near transit for low- to moderate-income households. This will allow for a strong regional economy by accommodating a range of working household needs (*Regional Affordable Housing Strategy Update*, 2015).

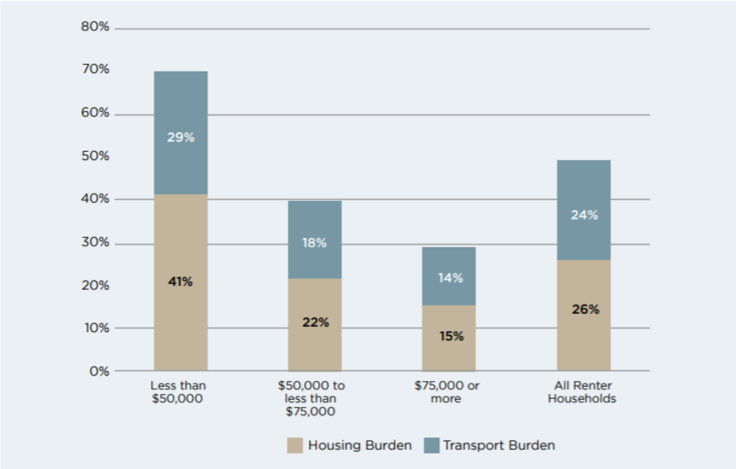

Figure 3.7 Housing and transportation cost burden by income for renters
Source: *Regional Affordable Housing Strategy Update* (2015).

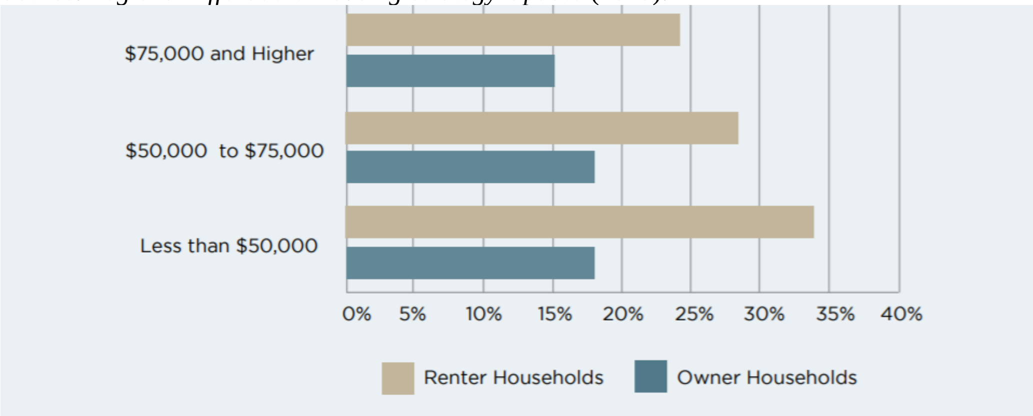

Figure 3.8 Metro Vancouver households using transit by household tenure and income
Source: *Regional Affordable Housing Strategy Update* (2015).

Importantly, both the new *Regional Affordable Housing Strategy* (2015) and *Metro 2040* (2017) emphasize the need to observe housing holistically with relationship to transportation and access to jobs, services and amenities. Figure 3.8 Metro Vancouver households using transit by household tenure and income. Notably, renter households with an annual income under $50,000 depend on transit the most. The connection then between housing affordability and transit is important.

In practice though, due to lack of affordable housing partly induced by investments in transit-oriented development and building compact communities, moderate-income households are pushed out of the central core into suburban neighborhoods in the Metro region (Edelson et al., 2019; Kloepper, 2017). This process reinforces private-car use, long commutes, and negatively impacts life-work balance which is evident in Vancouver's rank as the most congested city in Canada and 34th globally (Gurstein, 2018).

The 1928 and 1945 Bartholomew Plans for Vancouver served as foundation for the City's zoning. The plans included many neighborhoods where low-density, single family housing prevail, a pattern which has proved difficult to change. Alarmingly, current zoning laws created a land use division so that 35% of Vancouver's residents occupy 80% of detached and duplex home neighborhoods, whereas 65% live in multifamily housing in the remaining 19% area (ibid). Even though Vancouver changed dramatically from being one of the leading North American metropolitans dominated by single-family houses to one with the least of this type; it still leaves many of the metropolitan's neighborhoods un-densified, typically dominated by single-family houses (Lauster, 2016).

While successfully using redevelopment strategies to create livable neighborhoods in Vancouver's waterfront and city center, efforts to densify existing low-density neighborhoods have been less productive. There were 960,000 housing units in the Metro Vancouver region in 2016, with 42% apartment dwellings (a 5% increase in its share of the total housing stock from 2011). Row housing comprised 10% (a slight increase in its share of the total housing stock from 8% in 2011). The share of detached housing[31] decreased from 55% in 2011 to 49% in 2016 (2016 Census Profile).

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[31] This category includes single unit detached homes and a range of multi-unit detached housing types.

Housing Vancouver is the COV ten year strategy (2018-2027) that aims to create adequate housing supply, protect existing affordable housing stock, and support the housing needs of vulnerable populations (Housing Vancouver Strategy, 2019). The 2019 Progress Report describes a 12% decrease in low-income renters over a ten-year period (2005-2015). With a 15% increase in the share of renters earning more than $80,000 per year in the same period. These trends threaten the future diversity and resiliency of the COV.

Moreover, it is suggested that the COV has seen a 16,755 net loss of residents to intra-regional migration between 2011 and 2016. Meaning that more people moved out of the City to other municipalities in the region than moving in. This is most significant for 30-44 years old individuals (Housing Vancouver Strategy, 2019).

Even though Canada provides social safety by ensuring medical care and services for its citizens, nonetheless there is much inequality. BC is second high in the country's gradually increasing poverty rate at 13.4%. Poverty rate is 15.3% for children aged 18 and under, and it is 49% for single mother households. 33% of Indigenous children in Vancouver are poor. Metro Vancouver's working poor share of the population is 8.7% (second high in Canada). The income gap between the rich and the poor in Vancouver is fast growing creating the most unequal city in Canada (Gurstein, 2018).

The decoupling of incomes from housing prices and other essentials adds additional burden to low-income households. Substance use is another main challenge in the region: it results in high crime rates related to drug dealing and use. The count of overdose deaths is growing every year. Moreover, roughly 10% of BC's GDP is unreported and untaxed. This share represents the underground economic activity which is significant in BC as in the rest of Canada. Money laundering is associated with real estate activity in Vancouver, where almost half of the most expensive house owners are unknown and some report shell company ownership (Gurstein, 2018; Maloney et al., 2019). Money laundering is estimated at $6.3 billion, or 2.5 percent of GDP for BC in 2015 ($7.4 billion for 2018). It contributes to rising house prices in the province and to the unaffordable housing problem (Maloney et al., 2019).

Planning has political implications just as political decisions do; they essentially influence the distribution of public goods (or "who gets what") or as Rittel and Webber (1973; 169) put it: "*...Planning is a component of politics. There is no escaping that truism*." While Vancouverism is associated with sustainable development and progressive planning, growth in the region has led to industry and employment relocating outside the city core thus increasing cost of living, and displacement of low- and moderate-income households. Planning is a strong tool for the Metro residents to oppose global economic processes that turn their home to an unequal one where life and work are impossible for low- and moderate-income households (Gurstein, 2018). Social sustainability must be a priority in the Metro Vancouver Planning efforts to achieve a just community for all residents.

Lack of affordability, social justice issues, limited boundaries for expansion, combined with mixed-use, pedestrian-oriented policies and inner-city investments make Vancouver an ideal case study to explore the proposed research questions, namely: how does living in a pedestrian-oriented neighborhood impact one's health? Who can afford living in a neighborhood with a higher degree of MUPOD? Can individuals who are most likely to use transit live near it? Is there an equity distribution problem? Finally, access to data and local experts and researcher location further support the decision to focus on the Metro Vancouver market.

3.4 Data Sources

A decision was made to focus on the most suitable existing large datasets to explore the research questions. As Table 3.2 shows, Census/NHS are reported at the DA level, using Census geography. MHMC data are reported at the postal code level and summarized at the neighborhood level using the health authority boundary. MHMC data defined the geography in which the MUPOD variable was constructed. RMS is also reported using Census geography. BCAA data are reported at the postal code level. All data were spatially linked at the MHMC neighborhood level. Each source is described in more detail in the following subsections.

Table 3.2 Data sources, level of geography and sample size

Data Source	Raw Data Level of Geography	Utilized Sample Size
Census/NHS	DA (Census geography)	(2011) N=3,439 (2016) N=3,451 converted to 106 neighborhoods
MHMC Survey	Neighborhood (health authority geography)	31,193 grouped into (N=)106 neighborhoods
RMS	Neighborhood (Census geography)	68 converted to (N=)106 neighborhoods
BCAA	Parcel	N=710,985
Walk Score^{TM}	Neighborhood	N=106

3.4.1 2011 and 2016 Canada Census and National Household Survey

Drawing on similar studies I chose a quantitative approach to consider the spatial dynamics of the Metro Vancouver region in terms of its neighborhood composition and housing market (Quastel et al., 2012). The work therefore begins with exploring standard cross-sectional 2011 and 2016 census data to understand neighborhood demographic and socioeconomic composition. I use DA geography as this is the smallest geographical scale for which the required data are collected. 2016 data was reported at the DA level and included 3,451 “units”.

Each unit (or DA) consists of an average of 714 residents, 298 private dwellings, and an area of 0.83 square kilometer. DAs were then aggregated to neighborhoods as suggested by the literature[32] (see Section 3.5).

Various studies of gentrification consistently show that income, education, housing and rent prices, and employment category (i.e. professionals, managers, administrators, and technical workers) are associated with gentrification and displacement (Atkinson, 2000; Danyluk & Ley, 2007; Ding & Hwang, 2016; Grube-Cavers & Patterson, 2015; Moos et al., 2018; Quastel et al., 2012; Zuk et al., 2018).

Based on a theoretical examination of the literature (Danyluk & Ley, 2007; Ley, 1994), a social status index was built to point to neighborhoods where gentrification has occurred. In particular, two key variables were examined: education (*Percent_PSdegree*) and quaternary sector employment (*Percent_54_55*) (see Table 3.3).

Table 3.3 Social status index categories

Category	Variable	Source	Years	Improvement
Education (*Percent_PSdegree*)	Diploma; University degree	MHMC	2014[33]	Increase
	Postsecondary certificate, diploma, or degree	Census	2016	Increase
Employment (*Percent_54_55*)	Employment category 54 (Professional,	Census	2011; 2016	Increase

[32] Research on gentrification and displacement typically uses Census Tract (CT) as the basic unit for analysis (as a proxy to neighborhood) (Grube-Cavers & Patterson, 2015).
[33] Weighted against 2011 Canada Census.

	scientific, and technical services)			
	Employment category 55 (Management of companies and enterprises)	Census	2011; 2016	Increase

To measure social change, these proxy indicators of gentrification are examined in each neighborhood against the area median to indicate percentage point variations, as follows:

1. Education: $\{[(\mathit{Percent\_PSdegree\_2016} - 67.6) / 67.6] * 100\} = \mathit{Improve\_Edu2016}$
2. Employment: $\{[(\mathit{Percent\_54\_55\_2016} - 10.1) / 10.1] * 100\} = \mathit{Improve\_Empl2016}$

These are then weighted by the metropolitan's indicators over the same period (Atkinson, 2000). The percent difference between neighborhood value and Metro Vancouver value is calculated for each variable as follows:

$$[(\text{Neighborhood value} - \text{Metro Vancouver Value}) / \text{Metro Vancouver}) * 100]$$

Neighborhoods that experienced above average increase in all indicators are defined "improved"[34]. These values are added and divided by two to generate a social status index:

$$\mathit{SocialStatusIndex2016} = (\mathit{Percent\_PSdegree\_2016} + \mathit{Percent\_54\_55\_2016}) / 2$$

$$\mathit{SocialStatusIndex2011} = (\mathit{Percent\_PSdegree\_2011} + \mathit{Percent\_54\_55\_2011}) / 2$$

The 2011 social status index is then subtracted from the 2016 index values for a longitudinal examination of gentrification in each neighborhood:

[34] "Improvement" implies that both education and employment values are higher than the Metro Vancouver's.

GentrificationIndex = SocialStatusIndex2016 - SocialStatusIndex2011

It needs to be noted that the 2011 NHS, unlike previous surveys until 2006, was voluntary (as opposed to the traditional mandatory 20% sample). The validity of the 2011 NHS has been questioned by researchers who argue that response rates were not satisfying compared to previous censuses. Sampling for the 2011 NHS was done in two phases: first the voluntary survey was assigned to 30% of Canadian households; the second phase included a follow-up send out phase that aimed at a random non-responding subsample of households (Verret, 2013). 43.2% response rate was achieved in the targeted sub-sample, adding to 77.4% total response rate compared to 94% from the previous long form census[35]. Information was suppressed where the non-response rate was greater than 50% of targeted households. It is therefore argued that the income data in the 2011 NHS is not valid[36] (Hulchanski, 2014; Hulchanski et al., 2013).

Even so, a decision was made to use the 2011 Census data along with 2016 results despite its disadvantages. The MHMC survey used comparable weights and an additional data time point proved valuable for the dissertation analysis.

3.4.2 My Health My Community Survey

MHMC data was collected through an online survey in 2013 and 2014 to address the data gap in health-status, needs, and well-being required at the local level. The survey was developed in a partnership between Vancouver Coastal Health (VCH), Fraser Health (FH), and the UBC

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[35] The 2011 average total non-response rate was 26.1% which is higher than 25% - the traditional census cut-off standard (it was 24.5% and 24.4% for the COV and Vancouver CMA, respectively).
[36] NHS reported income for 2011 is higher on average compared to Canada revenue Agency's Taxfiler data for the same year.

Faculty of Medicine eHealth Strategy Office and included consultations with stakeholders and partners. It comprised people aged 18 or older residing in the VCH or FH regions and included 33,075 responses (representing 77% of the initial 2% of the target response rate of the overall population over 18 years of age[37]) (*Technical Notes for Community Profiles*, n.d.). While there was no pilot for the 2013/14 MHMC survey, two surveys were conducted using similar methods prior to the MHMC survey distribution, including: the Richmond Health Survey and the Northshore Health Survey, both conducted in 2012 (personal communication with Demlow, E. via E-mail, July 3 2020).

The MHMC dataset included cross-sectional, self-reported information on demographics, social and economic status, health status, health behaviors, health care access and utilization, built environment, and community resiliency. MHMC analysts grouped the individual responses to produce 118 local area profiles, a 106 of which fall in the Metro Vancouver region and are therefore within the scope of the dissertation (including 31,193 responses) (*Technical Notes for Community Profiles*, n.d.).

The survey covered 80 questions designed based on well-established sources, such as the Canadian Community Health Survey, Canadian Health Measures Survey, and national census (ibid). All survey questions were optional and included a "prefer not to answer" option, except for age and municipality which were mandatory. The introductory documents to the survey, including the information and consent statement, privacy statement, prize draw rules for survey participants, and survey registration page are in 0. All of these were made available to every participant and each participant had to complete registration in order to take the questionnaire.

[37] See Appendix C for MHMC survey progress by neighborhood.

MHMC survey methodology included socio-demographic targets for each geographic area of interest to achieve a more focused participant recruitment. This was done to guarantee that the sample reliably represents the overall target population and minimize the need for statistical weighting to compensate for the fact that some demographics are less likely to participate in surveys. MHMC professionals catalogued community stakeholders who work with specific populations and reached out to them to boost response for some groups. Other outreach tactics included setting up booths at events that either cater to certain demographic groups or in certain neighborhoods where responses were needed[38] (personal communication with Demlow, E. via E-mail, July 3 2020).

The final MHMC sample was weighted using 2011 Statistics Canada Census and NHS data by municipality for age, gender, education, and ethnicity to ensure that the sample was as representative as possible of the overall population. Outliers were removed during data cleaning dependent on the question. Most questions had limits in the response to limit outliers at the data collection stage, but for the most part this was question specific and based on literature. For example, weight and height had extreme outliers removed based on population distributions (ibid). Finally, coefficient variations (CV's) were calculated for each variable and for each category. Estimates with CV's greater than 33.3% were considered unreliable and were suppressed in the profiles. A number of communities with a small sample size were aggregated to generate an integrated profile of a large enough sample (*Technical Notes for Community Profiles*, n.d.).

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[38] The survey was available in print in English, Chinese (online as well), and Punjabi.

The 2013/14 MHMC data has been utilized in different studies to investigate relationships between health, demographic, and economic factors. Some findings were presented at peer-reviewed scientific conferences. Klar et al. (2017), for example, found a significant adverse association between obesity rates and walkable areas. In another study, built environment perception was shown to be associated with positive lifestyle factors, stronger sense of community belonging and better health outcomes (Gully et al., 2017).

Access to the MHMC local neighborhood profiles enabled to examine how built environment design affects health and social well-being outcomes across the Metro Vancouver region. However, access to the more granular individual data would have made for a richer analysis. Other limitations include aggregation and suppression of the data which also limit the ability to reach potentially meaningful conclusions for some locales. Moreover, since the MHMC survey used health authority boundaries to report the data it was challenging to match results to other available information such as the NHS, reported at the DA level using census geography.

Other limitations include that the data is cross-sectional (in which data are collected from the population at one specific point in time) rather than longitudinal so that even if a significant association between the built environment and other factors is documented it is often not sufficient to argue for a causal effect. Finally, asking individuals to reflect about their health can be referred to as a direct methods approach (Adamowicz et al., 1994; Bartholomew & Ewing, 2011). While the benefit of the self-reporting approach is its simplicity and fairly easy implementation, these models are critiqued for a number of reasons, namely: they do not necessarily represent actual behavior, and are susceptible to a possible affirmation bias when respondents might reply based on what they think the researcher wants to hear (Adamowicz et al., 1997; Arrow et al., 1993; Blackburn et al., 1994; Earnhart, 2001; Timmermans et al., 1994).

Even so, after considering these limitations, individual perceptions are shown to be a significant factor in decision making (Adamowicz et al., 1997). Moreover, the fact that the MHMC data is publicly available online and access is free are noteworthy research advantages.

3.4.3 Canada Mortgage and Housing Corporation's National Rent Market Survey

Rent information for 2014 was derived from the annual RMS, conducted by CMHC in areas with populations higher than 10,000 (as well as from the 2011 Census). The RMS surveys market-units in buildings with a minimum of three rental units which have been on the market for a minimum period of three months. Information is available at the neighborhood level (N=68). It was joined to MHMC neighborhood dataset geography using GIS while employing areal weighting techniques (see Section 3.5).

The RMS is conducted yearly in October and it reflects rent values, availability, turnover, and vacancy data for the sampled structures. Information is collected from dwelling owners or building managers by both phone, interviews, and on-site visits.

To ensure reliability of average rent estimates, CMHC methodology uses a 10% cut-off CV. It assigns levels of reliability ranging from A (if the CV is greater than 0 and less than or equal to 2.5 then the level of reliability is Excellent) to D (if the CV is greater than 7.5 and less than or equal to 10 then the level of reliability is Fair) (*Methodology for Rental Market Survey*, n.d.).

Some limitations to the RMS data include its underestimation of rents as a result of surveying purpose built rental apartments which typically have rent controls. On the other hand, the survey includes vacant units which are shown to list significantly higher rents compared with occupied units. Market rents from Craigslist would have been ideal for rent exploration and for a more reliable reflection of rent levels. However, access to these data was not feasible considering the limited resources available.

3.4.4 BC Assessment Authority Data

BCAA works in compliance with the BC Assessment Act to develop and maintain real property assessments throughout the province. The Assessment Act requires that properties be assessed as of July 1st on an annual basis. The assessed value is based on the value that the property would have sold for on or about the previous July 1st, based on *comparable* sales within a market area with similar potential uses based on the most relevant Community Official Plan (COP). The COP contains information about potential uses, density, building heights, and more. The assessment considers property type, physical condition, use, size, age, quality, location, availability of services, topography, original cost, replacement cost, rental value, land improvements, and other factors impacting the property value.

The BCAA database contains over 1.9 million property records with property assessment at market value rolls generated annually. The information is provided to local governments, tax authorities, and to all property owners (the latter receive individual assessments). The organization's goal is to provide a constant base for taxation purposes in BC. The assessments support local and provincial taxing authorities to calculate their tax revenue that funds billions of dollars' worth of community services as well as the school system. The assessment information is supported by GIS applications and other mapping tools to keep the dataset accurate and updated (*About BC Assessment*, 2019; *How BC Assessment Works*, 2019).

The BCAA dataset constitutes the most comprehensive information of Metro Vancouver residential properties. Importantly, it provides spatial information which can be entered into GIS to perform spatial analysis and access to the BCAA data is publicly free[39].

Some limitations, however, need to be noted. The data refers to rental apartment buildings as a single unit. This means that the inside floor space, number of bedrooms per unit, or the value of individual apartment units could not be determined. Property values, the number of bedrooms per unit, and the rental apartment unit size were therefore assigned missing values. In areas where there is a large number of rental apartment units (such as in the COV, North Vancouver, and Burnaby) this might have an impact on the study's analysis. As a result, existing data only enabled an examination of housing data for owner-occupied dwellings, but it did not include rent values. Since rent values are important, especially in the context of this dissertation that investigates patterns of gentrification and displacement (typically low- to moderate-income households) who are more likely to rent, additional information is derived from the 2011 Census and from the 2014 annual RMS.

Finally, BCAA property valuation could be somewhat biased as it relies on hedonic regressions of *estimated* sale prices of nearby properties with similar characteristics which might differ from *actual* sale prices when they enter the housing market. The actual sale price is the most important measure, being the value that home buyers pay. In practice, not all homes are sold and some with specific attributes sell more than others, the actual value of all housing units is then unknown.

[39] Access required signing an agreement to use the data under the terms and conditions these were supplied to the UBC Centre for Urban Economics and Real Estate.

3.4.5 Walk Score^{TM}

Open data sources such as Google and OpenStreetMap are used by the Walk Score^{TM} patented system (www.walkscore.com) to assign points for specific locations based on walking routes to nearby destinations. The algorithm calculates the shortest walking route for each address to thirteen category nearby destination such as grocery stores, schools, parks, restaurants, and retail. Amenities within a 5-minute walk (.25 miles) are given maximum points where zero points are given after a 30-minute walk. The categories are equally weighted, and the points are summed and normalized on a continuous scale from 0 to 100. Higher scores indicate higher walkability (*Walk Score Data Services*, 2018).

A neighborhood and/or city Walk Score^{TM} is ranked according to a calculation of approximately every city block (technically a grid of latitude and longitude points spaced roughly 500 feet apart). Each point is weighted by population density so that the rankings reflect where people actually live and so that neighborhoods and cities do not have lower scores due to lower densities in areas of parks and/or bodies of water, for example (personal communication with Jacobson, A. via E-mail, June 16 2020).

While a number of walkability indices have been developed for different studies (Frank et al., 2007; Wood et al., 2010), Walk Score^{TM} is the only one that is publicly available for all postal codes in Canada, the United States, and Australia. Its reliability and validity in measuring neighborhood walkability has been demonstrated across multiple geographical locations and at multiple spatial scales (Carr, Dunsinger, & Marcus, 2010, 2011; Chiu et al., 2016; Cole, Dunn, Hunter, Owen, & Sugiyama, 2015; Duncan, Aldstadt, Whalen, Melly, & Gortmaker, 2011; Koohsari et al., 2018; Sriram et al., 2016).

The Walk Score™ index is widely used in academic research in the fields of urban planning, and public health (Collins et al., 2018) (see, for example: Chiu et al., 2016; Cole, Dunn, Hunter, Owen, & Sugiyama, 2015; Gilderbloom, Riggs, & Meares, 2015; Sriram et al., 2016; Yu et al., 2017). Chiu et al. (2015) for example, linked Walk Score™ and overweight and obesity and physical activity adjusting for demographic, socioeconomic and lifestyle characteristics among Ontarians. Their findings showed that residents of neighborhoods characterized by heavy reliance on private cars had increased likelihood of being overweight or obese compared to residents of more walkable neighborhoods. The latter were also more likely to walk for utilitarian purposes and reported weighing average 3 kg less than their car-reliant counterparts.

Su et al. (2017) performed spatial regression to prove significant negative associations between Walk Score™ and three health indicators (cardiopathy, hypertension, and liver cancer). Moreover, Walk Score™ was shown by Carr et al. (2010) to significantly correlate with numerous measures of the built environment, including street connectivity, residential density, and access to public transportation.

The advantages of using the Walk Score™ tool is that it is a simple, access is free, and it is a replicable undergoing of walkability measurement that contains geospatial and land use attributes (Bereitschaft, 2017; Carr et al., 2010, 2011; Chiu et al., 2016; Cole et al., 2015; Golan et al., 2019; Sriram et al., 2016). Moreover, the geographic data used by the Walk Score™ algorithm is based upon a Google service and is therefore regularly updated (this, however, can also be viewed as an obstacle to longitudinal examination as the methodology is not entirely consistent).

Using Google API also implies that its basic database potentially has some errors in the exact geographical location, population density, and land use classification that are typically based on contributor information (Bereitschaft, 2017). Moreover, the tool does not consider quality and access characteristics of the street and/or amenities such as the presence of trees, sidewalk width, safety, and topography. A higher MUPOD score captures walking and transit accessibility which hints to actual investment in infrastructure. However, high score might often reflect historically contingent place characteristics. The final score does not differentiate between actual investment and those intrinsic place characteristics. The lack of differentiation makes the implications for public investment in infrastructure more challenging. This could be a topic for future research.

In addition, critiques of the measure include its focus on leisure activities rather than a focus on fixed activities such as work and family care and that it does not adequately represent gender differences in walking behavior. Importantly, Golan et al. (2019) found that a key factor in women's walkability is fear of crime (both in day and night). Low-women's walkability areas were found in large commercial stripes, near highway intersections and under bridges – all characterized by higher crime levels, homelessness, and uncleanliness. Finally, Walk Score^{TM} is based on an aggregate .25 mile buffer as the unit of spatial analysis and might suffer from errors as opposed to using a smaller measurement scale (Bereitschaft, 2017; Gilderbloom et al., 2015).

Because the Walk Score^{TM} methodology was further improved in 2014, most neighborhood and city scores pre- and post-update have changed due to longer routed distances, intersection density, block length, and mixed-use development that were not considered in the old method. The analysis in this dissertation, therefore, uses comparable Walk Score^{TM} data from 2015 and 2020. It is possible that changes have occurred to the physical environment between the time participants completed the MHMC survey (2013/14) and when the Walk Score^{TM} were calculated (2015).

The Transit Score^{TM} algorithm measures transit accessibility by considering distance to closest stop on each route, the frequency of the route and its type. The raw score is calculated by summing up all the nearby routes. A route's value is defined as the service level (frequency per week) multiplied by the mode weight (heavy/light rail is weighted 2X, ferry/cable car/other are 1.5X, and bus is 1X) multiplied by a distance penalty. The score is then normalized on a scale from 0 to 100 (*Transit Score Methodology*, 2019). Higher score implies increased transit accessibility.

MUPOD aims to capture as much information as possible to describe the built environment, and therefore incorporates both Walk and Transit Score^{TM} input. However, Transit Score^{TM} was only available for 2020. In order not to lose valuable information about the built environment, several data interpolation strategies were employed to predict 2015 Transit Score^{TM} for the 106 MHMC neighborhoods. These strategies included: (1) regressing the relationship between 2020 Walk and Transit Score^{TM} and using the regression equation for prediction, (2) tracking the 2020 Walk/Transit relationship and using absolute point deduction and (3) tracking the 2020 Walk/Transit relationship and using percentage difference. However, the results were not satisfying when validated with on-ground reality. Finally, a decision was made to use a similar Transit Score^{TM} for 2015 as that of 2020. This decision suggests that even if improvements have occurred in transit availability and/or accessibility from 2015 to 2020 (which would have resulted in lower 2015 Transit Score^{TM}) they have had no effect. The potential overestimation of 2015 Transit Score^{TM}, however, is eventually compensated for when calculating the MUPOD index by the fact that overall Walk Score^{TM} decreased in most neighborhoods from 2015 to 2020, which can only be explained by methodology contribution. This statement is made based on familiarity with the Vancouver local context and an exploration of specific sites where public investment in walkable infrastructure has been made during the study's timeline. Critically, further use of Walk Score™ in longitudinal analysis will require improved transparency to the changes in factors that determine the score – a reference to this limitation is only mentioned in Hall & Ram (2018) despite wide adoption.

3.5 Geography Conversion

Population estimates are widely used in social sciences to study longitudinal changes. Social statistics estimation, an intersection of statistical science and computational geography, is used to "transfer" data from one set of geographical units to another. It is a valuable tool for central governments with many applications, including: aggregating data in order to provide reliable results, presenting results for locations not familiar to the audience of the research, longitudinal estimation on a consistent basis, and merging datasets from different sources (Simpson, 2002). A familiar example includes the U.S. Census tract data used in urban and regional research to provide small scale information (Logan, Stults, & Xu, 2016).

Typical challenges of analysis of spatial data, as in the case of U.S. Census data, include differences in reporting units from diverse data sources and changes in unit boundaries over time. For example, population data can be reported in census tracts whereas police boundaries are used for crime reports. Additional examples include school data which can be reported in school attendance zones and voting data which is reported in voting districts. The main problem then is how to match data to the same geographical unit so that information from different sources and times can be comparable and analyzed. Cross-sectional analysis is not entirely useful when the purpose is to study changes in specific locations and can introduce estimation errors that lead to incorrect conclusions (ibid).

General approaches have been used in research to address geography discrepancies since the 1980s. Most commonly, GIS is utilized to compare tract layers in two time points and proportionally assign population to a tract from another tract/s to the degree of overlap. This method is known as areal weighting (ibid).

Weighting criteria is used to measure the overlap between units of different geographical boundaries. The relationship between the different measurement units is computerized by GIS. Areal weighting is, however, subject to estimation errors. It is generally assumed that all population and housing characteristics can be allocated across tracts in similar proportions as the total population. Since population and housing patterns tend to extend beyond tract boundary, adjacent tracts are likely to be similar and estimation of their composition will not be significantly affected by interpolation. Yet, errors in total population estimates can be more significant for specific communities or for specific personal characteristics. It is suggested that some tracts need to be more carefully observed (ibid).

Essentially, a review is needed to determine which boundaries have undergone a change. The first step includes an overlay of the different geographical boundaries using GIS into a single layer. For areas that fully overlap the result is a single polygon and data record. For areas that differ, multiple layers will show in the new layer. The different data sources are then merged, and the divergent target units are apportioned using the area proportions as weights.

This process might result in interpolation error. Advanced methods include a count of events within each overlap of two data sources of spatial boundaries. These take into account other factors, such as address points, rather than just the surface area in the overlap in order to improve estimation of geography conversion (this way the geography conversion is more relevant to where people live) (Logan et al., 2014; Simpson, 2002).

Informed by Simpson (2002) and Logan et al. (2014), GIS is used to perform areal weighting to Census DAs from 2011 and 2016 (that is, two sets of non-overlapping units of *source* geography) for MHMC neighborhood (i.e. a set of non-overlapping units of *target* geography). The process included the following steps:

1. Intersect DAs and MHMC neighborhood boundaries (see Figure 3.9).
2. Derive weights by dividing the area of each newly created intersect polygon from the area of its respective original DA. Weight values range from zero (no overlap between source and target units) to one (area in source unit is fully contained in target unit). The weights indicate the proportion of the surface area of the source geography that is covered in the target geography unit (e.g., if a new polygon represented 25% of the area of a DA, it would receive a weight of .25).
3. Join census variable data tables to intersected DA/MHMC polygons.
4. Multiply variable of interest by weight to create weighted variable of interest.
5. Sum all values of weighted variable of interest for each MHMC neighborhood to get the total value for that neighborhood. For population proportions, divide weighted value by weighted population.

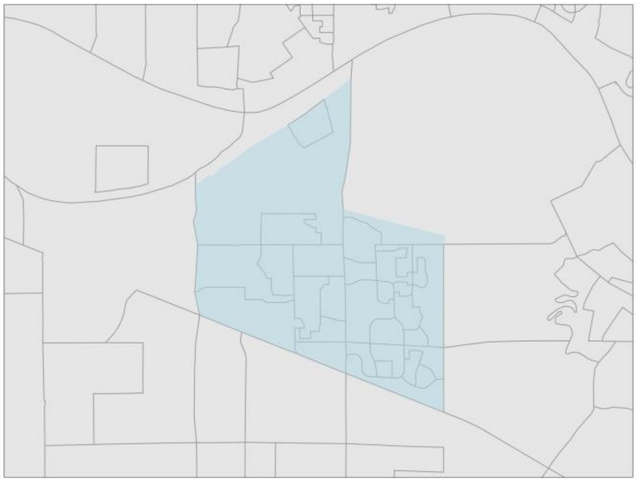

Figure 3.9 Areal weighting - intersection example*
Notes: *From *source* geography of Census DA's - in grey to *target* geography of MHMC nbhd. - in blue.
Image created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

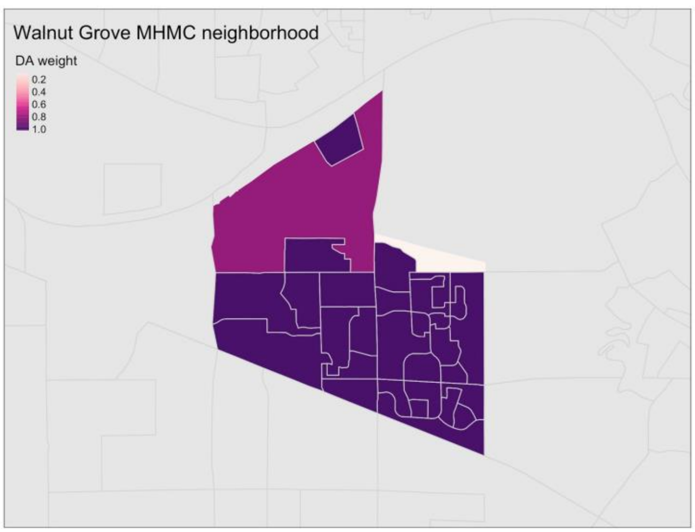

Figure 3.10 Areal weighting – assign wights example*
Notes: *From *source* geography of Census DAs for *target* geography of Walnut Grove MHMC neighborhood.
Image created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

Weights resulting from intersection of MHMC neighborhood and overlapping DAs are shown in Figure 3.10. Most DAs were given a weight of one (dark purple) as they were completely contained within the neighborhood[40]. Several DAs are partially weighted because they span across multiple neighborhoods. DAs are weighted by the percent of DA area contained by the MHMC neighborhood.

Next, an areal weighting process with GIS is performed to CMHC data (i.e., a set of non-overlapping units of *source* geography) for MHMC neighborhoods (i.e. a set of non-overlapping units of *target* geography). The process included the following steps:

1. CMHC boundaries included large areas of water. To remove large water bodies and correctly assign data weights, the CMHC boundaries were clipped by the outer boundary of 2016 Greater Vancouver DAs before interpolation to MHMC neighborhoods. Though the Fraser River was not clipped from the data set, removing saltwater bodies should significantly reduce potential misclassifications during interpolation.
2. Clip CMHC boundaries by the boundary of Metro Vancouver CMA to restrict CMHC to land areas.
3. Intersect CMHC boundaries and MHMC boundaries.
4. Derive weights by dividing the area of each newly created intersect polygon from the area of its respective original (clipped by Metro Vancouver) CMHC polygon, then multiply each fraction by the original population count of that CMHC area.
5. Assign CMHC tabular data to intersected CMHC/MHMC polygons.

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[40] 15 DAs were in two MHMC neighborhoods, but weights for one neighborhood were still calculated as 1 (due to rounding). This should have a negligible effect on the final data interpolation as the area of each DA in the second neighborhood was extremely small (well under 1 meter) and represented a very small percentage of that DA area (and therefore a very small weight).

6. Filter out N/A values for each variable of interest (e.g., 2014 median rent for bachelor apartments).
7. Multiply variable of interest (e.g., 2014 median rent for bachelor apartments) by weight to create a weighted variable of interest.
8. Sum all values of the weighted variable of interest for each MHMC neighborhood and divide by the sum of the weights.
9. CMHC's tenure data was weighted with area weights, median rent was weighted by population (2011 by 2011 population, 2016 by 2016 population)[41].

3.6 Independent Variable

The independent variable used in the estimation models is mixed-use, pedestrian-oriented design (*MUPOD15*). Walk and Transit Score™ data for 2015 and 2020 are used as MUPOD proxies as these describe distances from any address to nearby amenities or the ability to manage daily routines without using a car. Quastel, Moos, and Lynch (2012) similarly use Walk Score™ data to reflect implementation of environmental policies.

MUPOD15 is a sum of Walk and Transit Score™ divided by two, it is a continuous variable ranging from 0 to 100. Because the dependent variables in the models rely on MHMC survey from 2013/14, my focus is mainly on the 2015 MUPOD index[42]. Data are measured at the neighborhood level and are spatially matched to MHMC local areas (N=106).

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[41] The population, the number of households or addresses make for a more accurate comparison.
[42] Every effort was made into obtaining comparable MUPOD, however, the possibility exists that changes have occurred to the physical environment between the time participants completed the MHMC survey (2013/14) and when Walk Score™ were documented (2015).

For visualization purposes, Walk and Transit Score(s)™ are classified to reflect the level of neighborhood MUPOD. The five categories rely on Walk Score™ methodology and range from very low (Car-Dependent/Minimal Transit) to high (Walker's/Rider's Paradise) as described in Table 3.4.

Table 3.4 MUPOD scale

Total Walk and Transit Score	*MUPOD*	Walk/Transit Score™ Description (www.walkscore.com)
0-24	Very Low	Car-Dependent: almost all errands require a car Minimal Transit: it is possible to get on a bus
25-49	Low	Car-Dependent: a few amenities within walking distance Some Transit: a few nearby public transportation options
50-69	Medium Low	Somewhat Walkable: some amenities within walking distance Good Transit: many nearby public transportation options
70-89	Medium High	Very Walkable: most errands can be accomplished on foot Excellent Transit: transit is convenient for most trip
90-100	High	Walker's Paradise: daily errands do not require a car Rider's Paradise: world-class public transportation

3.7 Dependent Variables

Table 3.5 describes the dependent variables included in the dissertation's estimation models, the associated MHMC survey question, and the applicable research question.

Table 3.5 Dependent variables, associated MHMC survey question, and applicable research question

Abbreviation	Variable Description	MHMC Survey Question	Applicable Research Question
Gen.Health.Exc	Dependent variable 1.a: respondent who rated their	*In general, how would you rate your health?*	1

Abbreviation	Variable Description	MHMC Survey Question	Applicable Research Question
	general health as excellent or very good.		
Ment.Health.Exc	Dependent variable 1.b: respondent who rated their mental health as excellent or very good.	*In general, how would you rate your mental health?*	1
Obese	Dependent variable 1.c: respondent who their BMI (calculated based on respondent's weight and height) indicates obesity and is equal to 30 or higher.	- *What is your weight (without shoes, heavy clothing, or heavy jewelry)?* - *What is your height (without shoes)?*	1
Blood.pres	Dependent variable 1.d: respondent who were diagnosed with a high blood pressure.	*Has a doctor ever diagnosed you with any of the following other conditions? Do not include any misdiagnoses (check all that apply)* … □ *High blood pressure*	1
Confide4more	Dependent variable 1.e: respondent who indicated to have 4+ people to confide in/turn to for help.	*How many people do you have in your network that you could confide in, tell your problems to, or call when you really need help?*	1
SOB.Strong	Dependent variable 1.f: respondent who rated their community belonging as strong/somewhat strong.	*How would you describe your sense of belonging to your local community?*	1
Census_total_2011MedRent	Dependent variable 2.a: reflects the median rent total value for 2011.	N/A[43]	2
CMHC_total_2014MedRent	Dependent variable 2.b: reflects the median rent total value for 2014.	N/A[44]	2

[43] Data obtained from Canada Census.
[44] Data obtained from CMHC.

Abbreviation	Variable Description	MHMC Survey Question	Applicable Research Question
Assessed.value	Dependent variable 2.c: reflects the housing assessed value for 2014.	N/A[45]	2
Move.for.Afford	Dependent variable 3: respondent who checked 'Affordability' as the reason to move to the neighborhood they are in (restricted to those who had moved in the past two years).	*Why did you move to the neighborhood you are in? (check all that apply)* … □ *Affordability*	3
HI.Under40k	Dependent variable 4: Respondent who checked either under $20,000 or $20,000 to $39,999 as their annual household income.	*Can you estimate your household income, before taxes and deductions, from all sources for the last calendar (tax) year? Household refers to all family (related) members of your household (exclude roommates). If you live alone, enter your personal income.*	4

The following sections provide more details to each of the dependent variable.

3.7.1 Health and Social Well-Being

MHMC data includes information on the following six health and social well-being-related indicators (Technical Notes for Community Profiles, n.d.):

a. General health (*Gen.Health.Exc*): participants were asked: "*In general, how would you rate your health?*" on a five-point scale from excellent to poor. MHMC neighborhood profiles

[45] Data obtained from BCAA.

included aggregated information for those who rated their general health as very good or excellent.

b. Mental health (*Ment.Health.Exc*): respondents were asked "*In general, how would you rate your mental health?*" on a five-point scale from excellent to poor. MHMC neighborhood profiles included aggregated information for those who rated their mental health as very good or excellent.

c. Obesity (*Obese*): MHMC participants were asked to report their height and weight. This information was used to calculate BMI using the formula: BMI = weight in kilograms / (height in meters)^2. BMI values were adjusted based on Statistic Canada methodology to account for reporting bias. BMI was missing for 9% to 38% of respondents depending on the municipality. Pregnant women were excluded from the BMI calculation. The focus of this study is on cases of obesity (that is, BMI of 30 or higher).

d. High blood pressure (*Blood.pres*): MHMC participants were asked "*Has a doctor ever diagnosed you with any of the following other conditions? Do not include any misdiagnoses (check all that apply)*". The list included high blood pressure, other specific chronic conditions, and none of the above. Those who skipped the question or checked 'prefer not to answer' were excluded from the analysis.

e. Social network (*Confide4more*): respondents were asked "*How many people do you have in your network that you could confide in, tell your problems to, or call when you really need help?*". MHMC neighborhood profiles included aggregated information on respondents who indicated to have 4 or more people in their network.

f. Community belonging (*SOB.Strong*): respondents were asked "*How would you describe your sense of belonging to your local community?*" on a 4-point scale ranging from very strong to very weak. MHMC neighborhood profiles included aggregated information on respondents who indicated to have a strong/very strong sense of belonging.

3.7.1.1 Health and Social Well-Being Index

A second approach to treating the health and social well-being indicators was to create a single index summarizing the six variables. Equal weights were given to the variables as there does not seem to be one of more significance in terms of its contribution to one's general health and well-being[46]. Moreover, the BMI 30+ (*Obese*) and high blood pressure (*Blood.pres*) scales were inversed so that lower percentages lead to a higher index score.

3.7.1.2 Principal Component Analysis

Principal Component Analysis (PCA) is a tool to explain the maximum amount of common variance in a correlation matrix using the smallest number of explanatory constructs. This is achieved by reducing the dataset from a group of interrelated variables into a smaller set of factors. Data reduction is done by looking for variables that highly correlate with a group of other variables, but do not correlate with variables outside of that group (Field et al., 2012). In this research, a PCA was done on the health and social well-being-related variables.

Principal components are the data's underlying structure. They indicate where the data is most spread out. The first principal component is the straight line that best shows where the data spreads out, it indicates the most significant variance in the data. Each subsequent coordinate is orthogonal to the previous and has less variance. The data is then transformed into a set of x

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[46] Perhaps future research could explore this assumption further.

correlated variables over y samples to a set of p uncorrelated principal components over the same samples. Where many variables correlate with one another, they will all contribute strongly to the same principal component. Each principal component sums up a certain percentage of the total variation in the dataset.

When some data is missing, it is important to understand why since it affects the PCA approach. Most commonly, observations containing missing information are deleted from the data set in order to perform a standard PCA. This approach, however, can result in information loss that might impact findings and can also produce biases in case data is incomplete for other reasons. Another approach simply estimates the missing values and then applies PCA on the complete dataset. For example, missing values can be replaced by the average of all the current values or more accurately by using a JointM strategy when variables are highly correlated (this method is only possible when the number of observations is greater than the number of estimated parameters and it assumes a multivariate normal distribution). Alternatively, the standard PCA algorithm is adjusted (Dray & Josse, 2015). I used R package missMDA (Josse & Husson, 2016) to predict missing values and perform PCA as described in Section 4.4.3.

3.7.2 Housing Value

2011 rent value (*Census_total_2011MedRent*) data is derived from the Canada Census. It is used to reflect Metro Vancouver neighborhoods median rent total value. *Census_total_2011MedRent* is a continuous variable ranging from $548 to $2,011 (CAD).

2014 rent value (*CMHC_total_2014MedRent*) data is derived from CMHC's annual RMS. It is used as a second measure to reflect the Metro Vancouver neighborhoods median rent total value (information is also stratified by dwelling size using the following categories:

bachelor, 1 bedroom, 2 bedrooms, 3+ bedrooms). *CMHC_total_2014MedRent* is a continuous variable ranging from $750 to $1,575 (CAD).

2014 housing value (*Assessed.value_med*) information is obtained from BCAA and reflects Metro Vancouver neighborhood median house total value. *Assessed.value_med* is a continuous variable ranging from $ 221,900 to $ 1,913,000 (CAD). Information is stratified by structure type (Single Family homes, other "Ground-Oriented" Single Family homes, Multifamily homes, and Others) and size (bachelor, 1 bedroom, 2 bedrooms, 3+ bedrooms). Property type categories are described in Table 3.6. These rely on a somewhat similar categorization used by Statistics Canada Census. The categorization into these groups included aggregation of existing BCAA categories as detailed in column Actual Use Name in Table 3.6. Finally, the Property Type categories mentioned in Table 3.6 were aggregated to generate two distinct groups, namely: single family units and high-density units. This was done to improve the hedonic estimation model predictions.

Table 3.6 Housing categories used

Property Type	Actual Use Name	Actual Use Code
Single Family	"Single Family Dwelling"	0
	"Vacant Residential Less Than 2 Acres" (Single Family Residential)	1
	"Single Family Dwelling – Property Subject to Section 19(8)"	2
	"Residential Outbuilding Only" (Single Family Residential)	20
	"Single Family Dwelling with Basement Suite"	32
	"Seasonal Dwelling" (Single Family Residential)	40
	"Single Family Dwelling, Duplex – 2 acres or more"	60

Property Type	Actual Use Name	Actual Use Code
Ground-Oriented Single Family	"Duplex (Single Unit Occupancy – Front)"	33
	"Duplex (Single Unit Occupancy – Bottom)"	34
	"Duplex (Single Unit Occupancy – Side)"	35
	"Duplex (Single Unit Occupancy – Back)"	36
	"Row Housing (Single Unit Ownership) – Strata Ownership"	39
	"Duplex (Single Unit Occupancy – Top)"	41
	"Triplex"	47
	"Fourplex"	49
	"Multi-family Conversion"	53
	"Stratified Rental Townhouse"	57
Multifamily	"Strata-lot Residence (Condominium) – Strata Apartment – Frame"	30
	"Strata-lot Residence (Condominium) – Strata Apartment – Hi-Rise"	30
	"Multi-family (Apartment Block) – Apt Walk up – Owner Pays Heat"	50
	"Multi-family (Apartment Block) – Apartment – Tenant Pays Heat"	50
	"Multi-family (Apartment Block) – Apartment – Owner Pays Heat"	50
	"Multi-family (Apartment Block) – Apartment – Frame"	50
	"Multi-Family (Vacant)"	51
	"Multi-family (Garden Apartment & Row Housing)"	52
	"Multi-family (Garden Apartment & Row Housing) – Townhouse"	52
	"Multi-family (Garden Apartment & Row Housing) – Apartment over Commercial"	52
	"Multi-family (Garden Apartment & Row Housing) –Apartment with Elevator"	52
	"Multi-family (Garden Apartment & Row Housing) – Apt Walk up – Owner Pays Heat"	52
	"Multi-family (Garden Apartment & Row Housing) – Apt Walk up – Tenant Pays Heat"	52
	"Multi-family (Garden Apartment & Row Housing) – Apartment Frame"	52
	"Multi-family (High Rise) – Apartment (Reinforced Concrete)"	54
	"Multi-family (High Rise) – Apartment (High Rise)"	54
	"Multi-family (Minimal Commercial) – Apartment (High Rise)"	55
	"Multi-family (Minimal Commercial) – Apartment over Commercial"	55

Property Type	Actual Use Name	Actual Use Code
	"Multi-family (Minimal Commercial) – Apartment – Owner Pays Heat"	55
	"Multi-family (Minimal Commercial) – Apartment over Commercial"	55
	"Multi-family (Minimal Commercial) – Multiple Residence"	55
	"Stratified Rental Apartment (Frame Construction) – Strata Apartment – Frame"	58
	"Stratified Rental Apartment (Hi-Rise Construction) – Strata Apartment – Hi-Rise"	59
	"Store(s) and Living Quarters – Apartment over Commercial"	202
	"Store(s) and Living Quarters – Apartment over Commercial"	202
Other	"Manufactured Home (Within Manufactured Home Park)"	37
	"Manufactured Home (Not In Manufactured Home Park)"	38
	"Multi-Family (Residential Hotel)"	56
	"2 Acres Or More (Vacant)"	61
	"2 Acres Or More (Seasonal Dwelling)"	62
	"2 Acres Or More (Manufactured Home)"	63
	"2 Acres Or More (Outbuilding)"	70

3.7.3 Affordability as Main Reason for Moving

The "affordability as the main reason for moving" (*Move.for.Afford*) variable reflects MHMC respondents who checked 'Affordability' as the reason to move to the neighborhood they are in (in percentages). That is, the variable represents households who had moved from their origin neighborhood because it was less affordable than their current one (however, one cannot conclude that these households were effectively displaced). Only respondents who had moved in the past two years answered this question. Consistent with MHMC methodology, small sample size (less than 20 responses) or coefficient of variation greater than 33% were considered unreliable and were suppressed (*Technical Notes for Community Profiles*, n.d.). Roughly a third of neighborhood information for this question was suppressed due to small sample size.

3.7.4 Household Income

MHMC participants were asked to estimate their household income, before taxes and deductions, from all sources for the last calendar (tax) year. The following ranges were offered: Under $20,000; $20,000 to $39,999; $40,000 to $59,999; $60,000 to $79,999; $80,000 to $99,999; $100,000 to $119,999; $120,000 to $139,999; $140,000 to $159,999; $160,000 to $179,999; $180,000 to $199,999; $200,000 and over; “I don’t know”; and “Prefer not to answer”.

MHMC neighborhood profiles included *aggregated* information which were used to create the following continuous variables:

- Household annual income equal or under $40,000 (*HI.Under40k*),
- Household annual income between $40,000 and $100,000 (*HIbetween40k100k*),

Household annual income equal or over $100,000 (*HIover100k*).

Like other large surveys, many MHMC participants did not report their income. The non-response for this question ranged from 16% to 32% depending on the community.

3.8 Control Variables

Several control variables are used in the various models. Control variables were chosen based on similar studies in the areas of health[47], housing[48], and displacement[49]. Moreover,

[47] See, for example: Bernard, 2013; Cornwell and Waite, 2009; Doyle et al., 2006; Hawkley et al., 2006; Li et al., 2009; Luo et al., 2012; Van Den Berg et al., 2016.
[48] See, for example: Boyle et al., 2014; Bramley, 1993; Cervero and Kang, 2011; Cortright, 2009; Dong, 2017; Gilderbloom et al., 2015; Green, 1999; Haas et al., 2016; Mulley et al., 2016; Renne et al., 2016.
[49] See, for example: Atkinson, 2000; Danyluk and Ley, 2007; Ding et al., 2016; Freeman, 2005; Newman and Wyly, 2006; Quastel et al., 2012; Shaw, 2008.

inclusion of control variables was determined by MHMC and BCAA data availability. Table 3.7 lists them as well as the data sources from which they are obtained.

Table 3.7 Control variables used

Abbreviation	Variable Description	Type	Data Source	Applicable Research Question
Age.65+	Respondent is over 65 years of age	Continuous [50]	MHMC	1, 3, 4
Gender.Male	Gender of respondent is male	Continuous	MHMC	1, 4
Edu.Uni	Respondent reports university degree as highest level of education	Continuous	MHMC	1, 3, 4
Marital.Married	Respondent reports married or common law	Continuous	MHMC	1
Live.Alone	Respondent lives alone	Continuous	MHMC	1
Lot.area	Represent the lot area (units in squared meter)	Continuous	BCAA	2
Hsg.Size.FA	Represents the unit size or floor area (units in squared meter)	Continuous	BCAA	2
Stories	Represents the number of stories	Discrete	BCAA	2
Bathrooms	Represents the sum of full- and part-bathrooms in the unit	Discrete	BCAA	2
Basement	Unit has a basement	Dummy	BCAA	2
Garage	Unit has a garage	Dummy	BCAA	2
Struc.Age	Represents the year in which the structure was built	Continuous	BCAA	2
Hsg.Size.Studio	Housing size is studio	Dummy	BCAA	2
Hsg.Size.1BR	Housing size is one bedroom	Dummy	BCAA	2
Hsg.Size.2BR	Housing size is two bedrooms	Dummy	BCAA	2
Hsg.Size.3+BR	Housing size is three or more bedrooms	Dummy	BCAA	2
Hsg.Type. GroundAttached	Housing type is ground-oriented attached dwelling (i.e. semi-detached house, row/townhouse, duplex/triplex/quadplex)	Dummy	BCAA	2

[50] MHMC data is given as a percentage of the total population and ranges from 0 to 100 (see, for example, in Figure 4.10).

Abbreviation	Variable Description	Type	Data Source	Applicable Research Question
HsgType. Multifamily	Housing type is multifamily home (apartment or condo)	Dummy	BCAA	2
HsgType. SingleFam	Housing type is single family detached home	Dummy	BCAA	2
Hsg.Type.2.SF	Housing type is single family detached home	Dummy	BCAA	2
Hsg.Type.2.High Dense	Housing type is high-density units (apartment/condo/townhouse/etc.)	Dummy	BCAA	2
Townhouse	Housing type is townhouse	Dummy	BCAA	2
Dist.VanDT	Entry indicates distance from Vancouver Downtown	Continuous	N/A	2

3.9 Estimation Models

Guided by the research questions, a set of multiple linear regression models were used to examine associations between MUPOD (*MUPOD15*), or the independent variable, and the following dependent variables: (1) health and well-being; (2) rent/housing value; (3) affordability as reason to move; and (4) household income under $40,000. The models' unit of analysis is neighborhood (boundaries are defined by the VHA and FH). The models are fitted using a model-fitting function in R, in this case a linear model function: lm().

The following assumptions about the data were made to fit a multiple linear regression model:

1. Linearity: dependent values can be expressed as a linear function of the independent (or explanatory) variable.
2. Homoscedasticity: the variance of residual is the same for any value of the independent variable.

3. Normality: for any given value of X (or independent variable), Y values (or the error) are normally distributed.
4. Independence: dependent variable observations (or the errors) are independent of each other.

Assumption 1 is inherent to the study design. Assumptions 2-4 are examined by observing the distribution of residual errors. A review of the diagnostic plots below shows that there is no pattern in the residual plot (see Figure 3.11-Figure 3.16: *top left*). This suggests that we can assume linear relationships between the independent and the dependent variables.

The *bottom left* graphs (Figure 3.11-Figure 3.16) show if residuals are spread equally along the ranges of predictors – we can see a line with roughly equally spread points. This means that the variability of the residual points increases with the value of the fitted outcome variable, suggesting constant variances in the residual errors.

The quantile-quantile (QQ) plot of residuals (see Figure 3.11-Figure 3.16: *top right*) can be used to visually check the normality assumption. The normal probability plots show that all the points fall approximately along this reference line (except Figure 3.14), so normality can be assumed.

Outliers can be identified by examining the standardized residual, which is the residual divided by its estimated standard error. Standardized residuals can be interpreted as the number of standard errors away from the regression line. Moreover, a data point has high leverage if it has extreme independent values (X). Both outliers and high leverage points can be detected by inspecting the Residuals vs Leverage graph (see Figure 3.11-Figure 3.16: *bottom right*). The figures below highlight the top 3 most extreme points, with a standardized residual below -2. The Figures bellow indicate outliers that exceed 3 standard deviations. In addition, the graphs suggest high leverage points in the data. That is, some data points, have a leverage statistic above 2(p + 1)/n = 4/200 = 0.02. These values are expected to influence the regression results.

Statistical analysis was done using R version 4.0.2 (“R: A Language and Environment for Statistical Computing,” 2016).

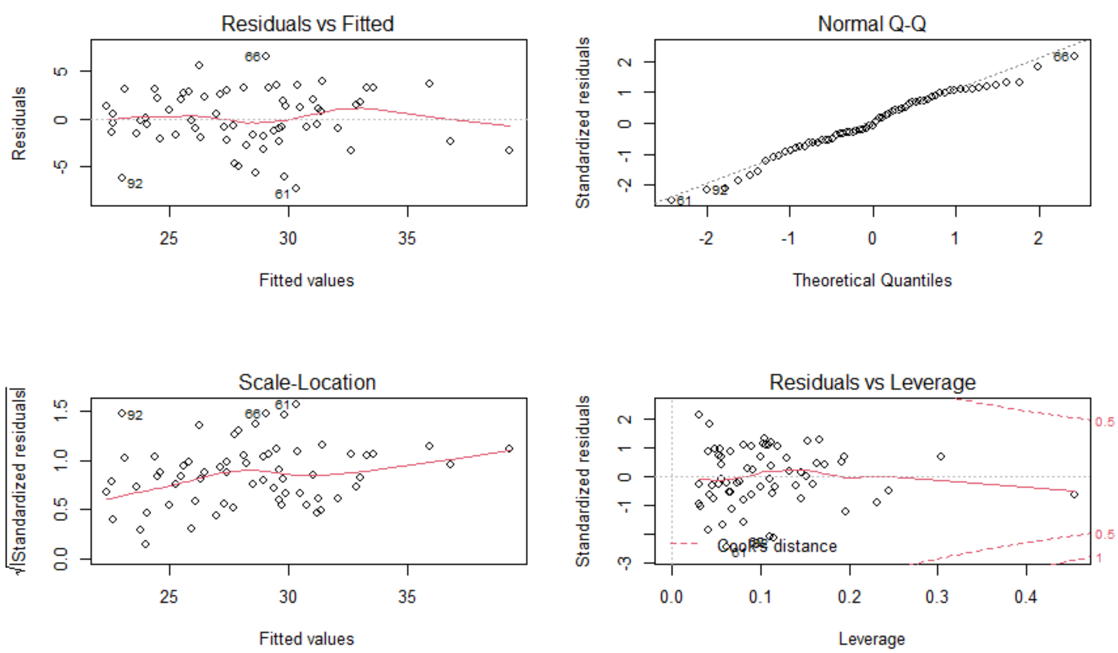

Figure 3.11 Linear regression diagnostic plots: MUPOD ~ health & social well-being index[51]

[51] The model was also run with individual health and well-being indicators and with the PC’s but the health and social well-being index performed better.

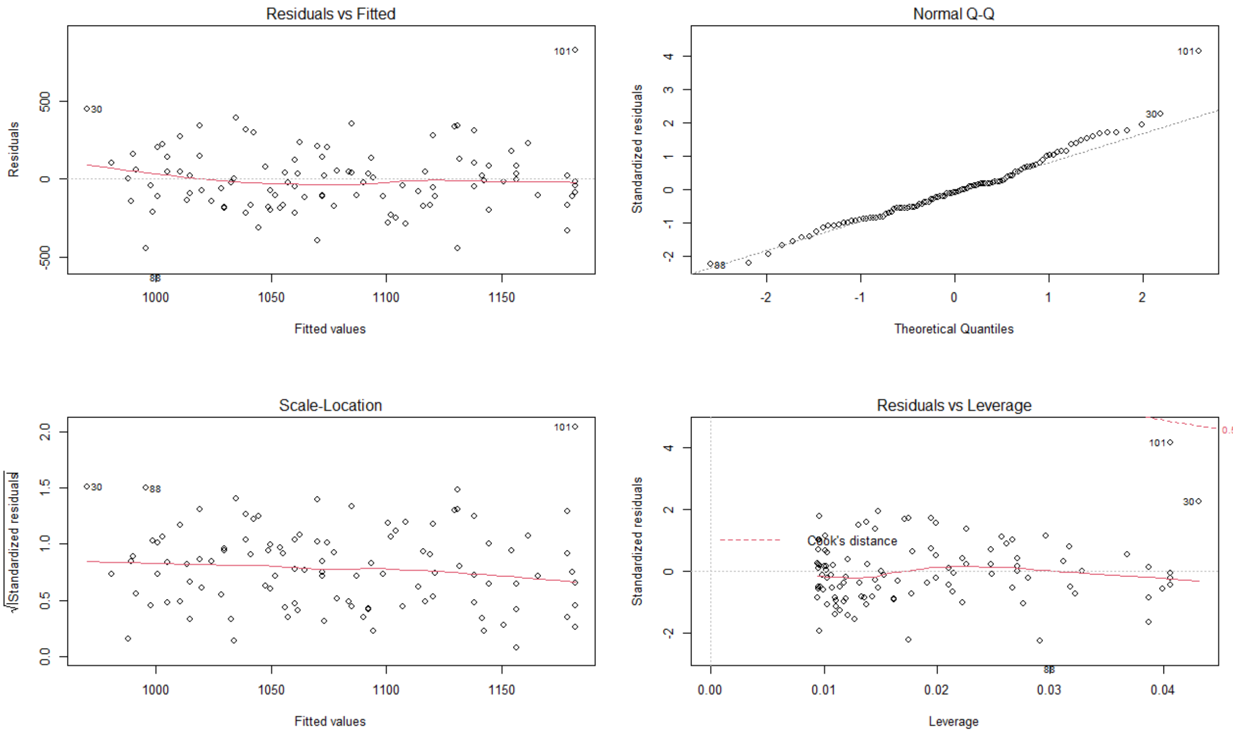

Figure 3.12 Linear regression diagnostic plots: MUPOD ~ median 2011 rent value total

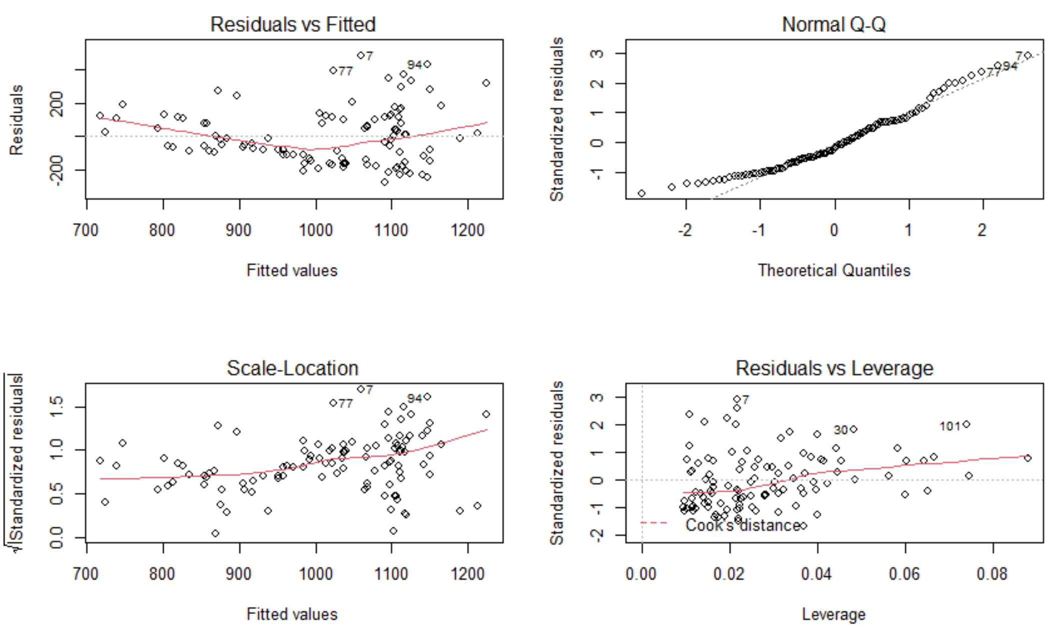

Figure 3.13 Linear regression diagnostic plots: MUPOD ~ median 2014 rent value total

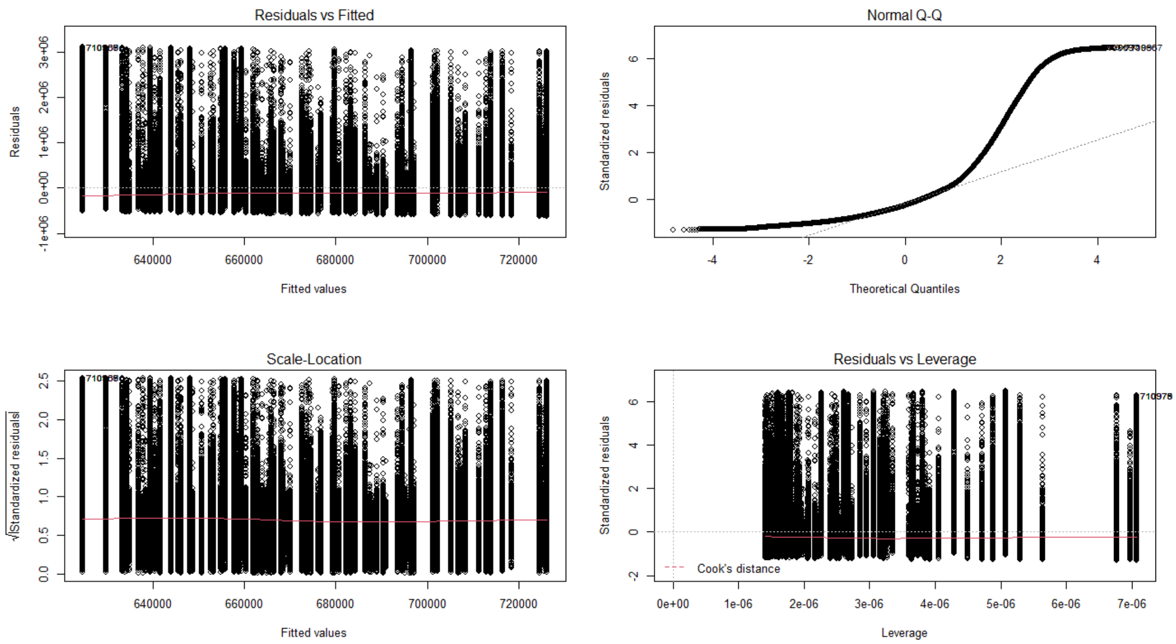

Figure 3.14 Linear regression diagnostic plots: MUPOD ~ 2014 assessed house value

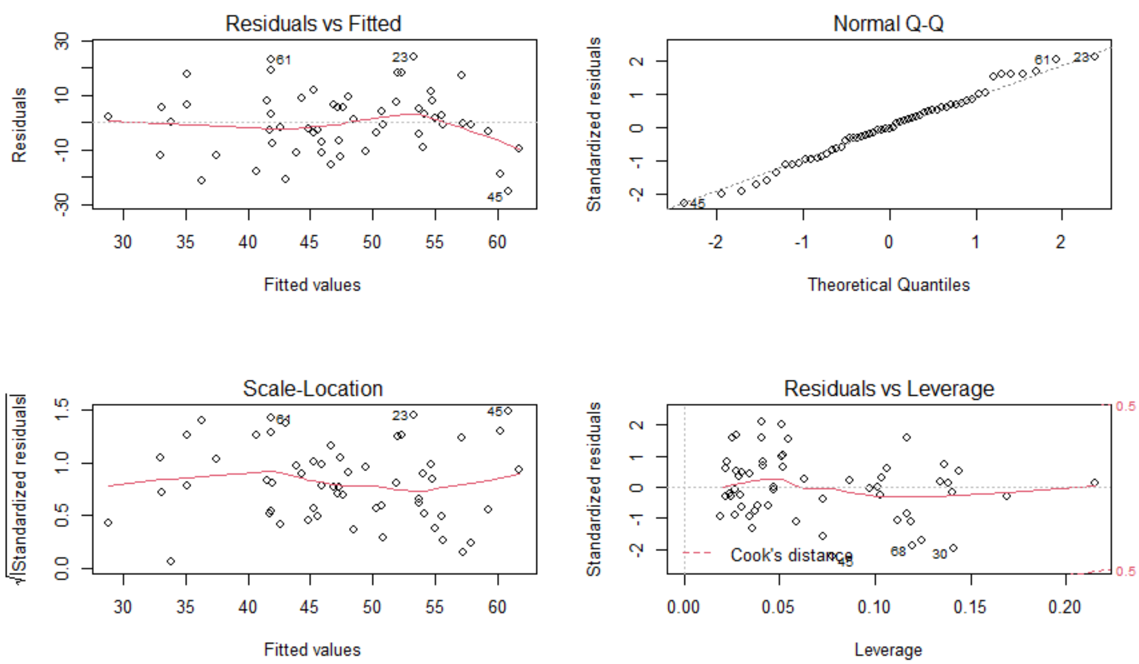

Figure 3.15 Linear regression diagnostic plots: MUPOD ~ "moved for affordability reasons"

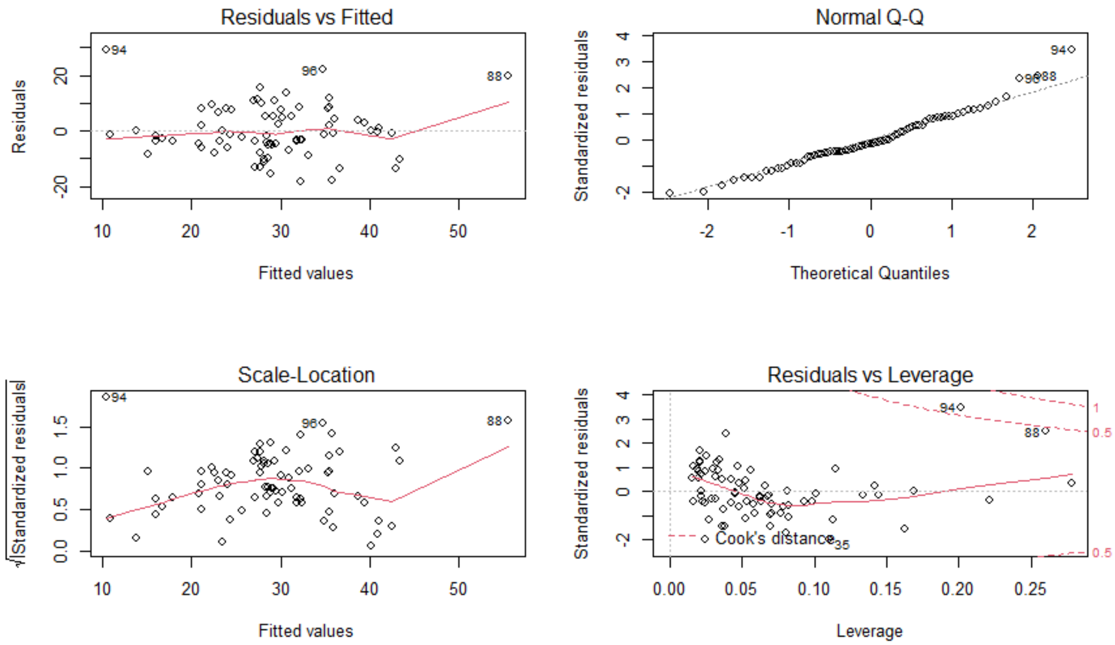

Figure 3.16 Linear regression diagnostic plots: MUPOD ~ household income under $40,000

Finally, the following equations were estimated:

Equation 3.1 Estimation model of the relationship between MUPOD and health & social well-being index

$$Health.SWB.Index_i = \alpha_0 + \alpha_1 MUPOD15_i + \bar{\alpha}Control + \varepsilon_{1i}$$

Where $_i$ is an index representing the 106 unique MHMC neighborhoods, *Health.SWB.Index* is the health and social well-being index score for a specific locale [52], and *MUPOD15* is a measure of built environment design. In addition, Control is a matrix of demographic parameters (including age, gender, education, marital status, and living arrangement), and ε_1 is the random error. α_0 and α_1 are the estimated parameters.

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[52] The model was also run with individual health and well-being indicators and with the PC's but the health and social well-being index performed better.

Health and social well-being information were derived from MHMC survey. *Health.SWB.Index* is a continuous variable ranging from 0 to 100. My hypothesis is that an increase in *MUPOD15* will be positively associated with a *Health.SWB.Index* increase.

Equation 3.2 Hedonic estimation model of the relationship between MUPOD and house values

$$\begin{aligned} House.value_i = {} & \beta_0 + \beta_1 MUPOD15_{1i} + \beta_2 Lot.area_{2i} + \beta_3 Lot.area\_squared_{3i} \\ & + \beta_4 Hsg.Size.FA_{4i} + \beta_5 Hsg.Size.FA\_squared_{5i} + \beta_6 bedrooms14_{6i} \\ & + \beta_7 Stories_{7i} + \beta_8 Bathrooms_{8i} + \beta_9 Full.basement_{9i} + \beta_{10} Garage_{10i} \\ & + \beta_{11} Struc.Age_{11i} + \bar{\beta} Control + (factor(MHMC\_Mun) - 1) + \varepsilon_{1i} \end{aligned}$$

Where $_i$ is an index representing the 106 unique MHMC neighborhoods when rent values are entered in the model or the 710,985 BCAA housing observations when the assessed housing value is entered in the model. *House.value* is the median housing value in a specific locale (both rent total value and house total value are estimated), and *MUPOD15* is a measure of built environment design. The following structural characteristics are included in the model: lot area, floor area (FA), number of bedrooms, number of stories, number of bathrooms, basement, garage, and structure age[53]. In addition, Control is a matrix of parameters (including housing type – whether townhouse or not, city dummy for the COV and distance from Vancouver Downtown), and ε_1 is the random error. β_0, β_1,…, β_{11} are the estimated parameters.

The *Assessed.value* regression models include a “city fixed effects” argument [*(factor(MHMC_Mun) -1)*] which allows to control for some of the housing supply differences across the Metro’s municipalities rather than variation within cities. Moreover, samples are split

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[53] However, lot area, stories, basement, and garage information are typically missing for strata units and were therefore removed from the high-density regressions. Moreover, the rent supply datasets were missing these detailed structural characteristics and were therefore not included in the specification of the rent value estimation models.

into (1) core urban area[54], and (2) suburban periphery observations[55] and regressions are run separately for each subset to present more accurate estimations and because of significant built environment design differences between urban and suburban neighborhoods.

When BCAA data are used in the model, the regressions are run separately for: (1) single family properties (*SF*) and (2) higher density properties (*HighDense*).

Finally, the models are adjusted for "clustered standard errors" (using R packages '<u>lmtest</u>' and '<u>sandwich</u>'), implying that errors within each cluster (or MHMC neighborhood) are correlated.

My hypothesis is that an increase in *MUPOD15* will be positively associated with an increase in all *House.value* measures, including: *Census_total_2011MedRent* (obtained from the 2011 Canada Census), *CMHC_total_2014MedRent* (obtained from CMHC), and *Assessed.value* (obtained from BCAA).

Equation 3.3 Estimation model of the relationship between MUPOD "moved for affordability reasons"

$$\boldsymbol{Move.for.Afford_i = \gamma_0 + \gamma MUPOD15_i + \bar{\gamma}Control + \varepsilon_{1i}}$$

Where $_i$ is an index representing the 106 unique MHMC neighborhoods, *Move.for.Afford* is the percentage of people who moved due to affordability reasons, and *MUPOD15* is a measure of built environment design. In addition, Control is a matrix of demographic parameters (including age, and education), and ε_1 is the random error. γ_0 and γ_1 are the estimated parameters.

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[54] Core urban observations are based on distance from Vancouver's CBD and include: "Burnaby", "City of North Vancouver", "Richmond", and "Vancouver".
[55] Suburban periphery observations include: "Anmore/Belcarra", "Bowen Island", "Coquitlam", "Delta", "Langley City", "Langley Township", "Maple Ridge", "New Westminster", "Pitt Meadows", "Port Coquitlam", "Port Moody", "Surrey", "White Rock", "District of North Vancouver", and "West Vancouver".

Moved for affordability information is derived from MHMC survey. It is a continuous variable ranging from 0 to 100. My hypothesis is that a decrease in *MUPOD15* will be positively associated with a *Move.for.Afford* increase.

Equation 3.4 Estimation model of the relationship between MUPOD and household income under $40,000

$$\boldsymbol{HI.Under40k_i = \delta_0 + \delta MUPOD15_i + \bar{\delta}Control + \varepsilon_{1i}}$$

Where $_i$ is an index representing the 106 unique MHMC neighborhoods, *HI.Under40k* is the percentage of people with an annual household income under $40,000 in a specific locale, and *MUPOD15* is a measure of built environment design. In addition, Control is a matrix of demographic parameters (including age, gender, and education), and ε_1 is the random error. δ_0 and δ_1 are the estimated parameters.

Household income information is derived from the MHMC survey. It is a continuous variable ranging from 0 to 100. My hypothesis is that an increase in *MUPOD15* will be negatively associated with *HI.Under40k.*

3.10 The Chi-Square Test of Independence

The chi-square test of independence is used to examine whether MUPOD score can predict the variables: (1) reason to move to current neighborhood and (2) household income. This will help to determine whether the variables under consideration are independent or not. The test makes use of contingency tables[56] and it is therefore also known as 'Contingency Analysis'.

[56] Data for this exploration is arranged in categories and summarized in contingency tables, see: Table 4.2 and Table 4.12.

The null hypothesis of the test is that the two variables are independent, and the alternative hypothesis is that the two variables are not independent. The Chi-square test of independence compares the observed counts to the expected counts. The expected counts are what we expect the contingency table to look like if the two categorical variables are independent. From probability theory, it is known that two events are said to be independent if their joint probability is equal to the product of their marginal probabilities. Therefore, if the observed value of the test statistic exceeds its critical value or if the p-value is less than or equal to the significance level then the null hypothesis can be rejected and it is fair to conclude that there is a statistically significant relationship between the two categorical variables: that is, they are not independent.

The Chi-square test of independence was performed using R programming language.

3.11 Data Cleaning and Joining

In order to link 2013/14 MHMC data with Walk Score^{TM} data, I contacted a VCH regional epidemiologist who provided a spatial file for the MHMC round 1 neighborhood and municipal boundaries (personal communication with Demlow, E. via E-mail, June 17 2019). Irrelevant data such as information on locales outside the Metro Vancouver region was removed from the MHMC data file.

Neighborhood level Walk and Transit Score^{TM} data for Canadian cities were obtained from Redfin Real Estate agency and were used to create a 2015 and 2020 MUPOD indices. These were provided using specific latitudes and longitudes detailed in the MHMC spatial file, and with the guidance of a Redfin agent (personal communication with Jacobson, A. via E-mail, May 28 2019; July 10 2020).

BCAA housing data file (‘BCA LM Roll 2014’) was cleaned to match the dissertation’s data framework. The original file included 947,110 observations. The cleaning process involved the following steps:

1. Remove irrelevant columns (for example, “foundation”).
2. Remove observations for which spatial data was not available (36,187 rows removed)[57].
3. Remove observations not included in the MHMC geography[58] (for example, observations under Sechelt Indian Govt Dist and City of Abbotsford) (134,013 rows removed).
4. Remove observations within MHMC geography with irrelevant ‘actual use’ categories (51,415 rows removed), including:
    a. Civic (8,852 observations)
    b. Commercial (39, 837 observations)
    c. Industry (2,098 observations)
    d. Parking (27 observations)
    e. Utility (601 observations)
5. Remove properties in the top and bottom 1% of assessed value (14,510 rows removed from the 725,495 properties remaining).

It needs to be noted that the MHMC and Walk Score™ boundaries do not entirely overlap. While MHMC uses health authority boundaries, Walk Score™ worked directly with cities for neighborhood names and boundaries in Canada (shape files could not have been

[57] BCAA data included spatial data (i.e., longitudes and latitudes) for some but not all observations.
[58] MHMC, Walk Score™ and BCAA data sets were joined using GIS software.

produced by request, but based on the Walk Score™ website, boundaries resemble Census boundaries).

Finally, an understanding that a longitudinal analysis of neighborhood change would be valuable for the analysis prompted the use of Census/NHS and CMHC data. Areal weighting (as explained in Section 3.5) was used to merge datasets from different sources with the purpose of a longitudinal estimation on a consistent basis.

Chapter 4: Data Distribution and Descriptive Statistics

This chapter is devoted to sample description including the geographic and demographic and socioeconomic representation of the data (Section 1). Section 2 provides a glance into the social status and gentrification indices, indicating the demographic makeup of neighborhoods in the Metro Vancouver region. Sections 3-8 provide a descriptive analysis of the data for all independent, dependent, and control variables in the study. This includes reporting of measures of central tendency, normality distribution, and frequency.

4.1 Sample Description

In order to be able to draw conclusions from the study's outcomes, it is important to understand the representativeness of the MHMC survey compared to the Metro Vancouver region population. Studies using samples substantially different from the general population violate a fundamental assumption of the positivist's approach to generalizability. Conclusions are therefore limited as they cannot be linked to broader behavioral patterns of the population and have limited applicability to planners and policymakers. For example, if MUPOD level is shown to be a significant factor in predicting health and social well-being outcomes but the sample used for the analysis does not reliably represent the population, it would be impossible to argue that MUPOD is linked to health and social well-being across all Metro Vancouver neighborhoods. The study's findings are therefore not likely to serve planners working in the region. Both geographic and demographic and socioeconomic representation of the data are considered here.

4.1.1 Geographic Distribution of the Data

It is important that the sample includes a range of neighborhoods characterized by different levels of MUPOD extending from very low ("Car-Dependent: almost all errands require a car"/" Minimal Transit: it is possible to get on a bus") to high ("Walker's Paradise: daily errands do not require a car"/"Rider's Paradise: world-class public transportation") (www.walkscore.com), since the purpose of the study is to examine how MUPOD is spatially dispersed and its relationship to different factors.

As evident in Figure 4.1, neighborhoods characterized by higher MUPOD levels are located near Metro Vancouver's CBD. This might indicate low resident resistance to creating compact communities and therefore an opportunity to promote such land use policies. It also indicates that a range of MUPOD scores exists in almost all the Region's municipalities.

Moreover, Figure 4.1 shows the geographical distribution of MHMC survey responses across Metro Vancouver neighborhoods. It is possible that multiple responses were collected from the same household so the survey response distribution may not completely correspond to the household distribution in Metro Vancouver (personal communication with Demlow, E. via E-mail, July 3 2020). 77% responses of the initial 2% target of the 18+ years population residing in VCH and FH authorities were collected (a total of 33,075). In the VCH authority response progress ranged from 55% in the District of West Vancouver to 96% in Vancouver (99% was achieved in VCH overall)[59]. In the FH authority, progress towards response targets ranged from 50% in White Rock and Coquitlam to 99% in Hope (62% was achieved in FH overall)

[59] Rural areas had slightly different targets and are not included in the dissertation's analysis.

(*Technical Notes for Community Profiles*, n.d.) (for final progress reports by municipality see Appendix C).

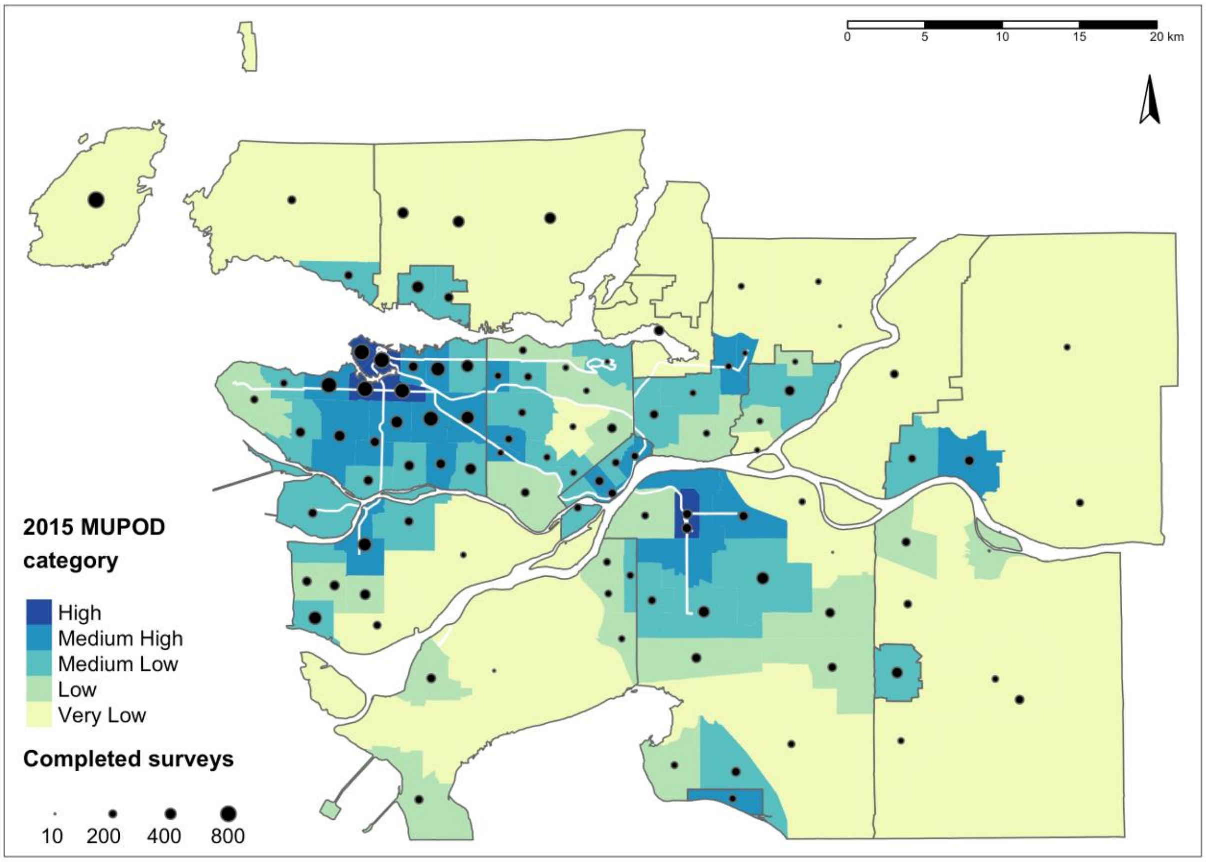

Figure 4.1 2015 MUPOD and MHMC survey response distribution, Metro Vancouver region
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

As shown in Figure 4.1. higher MUPOD scores are not confined to Vancouver's inner-city neighborhoods, rather these are documented in some of the neighboring local profiles as well such as Burnaby's Cariboo and Sperling; Surrey's Cedar Hills and Clayton; Delta's Annieville and Sunshine Hills; Central Port Coquitlam; and New West's Queensborough and Downtown.

4.1.2 Demographic and Socioeconomic Distribution of MHMC Survey Responses

The demographic and socioeconomic distribution of MHMC survey respondents needs to be considered to ensure representativeness of the population. MHMC sampling methodology included socio-demographic targets for each geographic area of interest to achieve more focused participant recruitment. This was done to guarantee that the sample reliably represents the overall target population and to minimize the need for statistical weighting to compensate for the fact that some demographics are less likely to participate in surveys. Statistical weighting is typically used in surveys to ensure a reliable representation of the overall target population. For example, female representation in general surveys tends to be higher than its proportion of the general population (often 60% female vs 50% in the population). A weight was thus used to compensate for this particular over-representation. The final MHMC sample was weighted using 2011 Statistics Canada Census and NHS data by municipality for age, gender, education, and ethnicity to ensure that the sample is as representative as possible of the overall target population (*Technical Notes for Community Profiles*, n.d.).

Table 4.1 highlights demographic and socioeconomic characteristics of MHMC survey respondents compared to 2011 Census/NHS by region. Gender, age, education, born in Canada, and household income were adjusted for in the MHMC sample. Gender, age, and education fall within a percentage point of the 2011 Census/NHS against which they were weighted. Born in Canada was comparable, and household income was within half a percentage point.

Moreover, the dwelling typologies that respondents resided in were somewhat similar to the Metro Vancouver housing stock. The percentage of respondents living in a single-family house was higher in the MHMC sample compared to the Metro Vancouver housing stock, whereas it was lower for those living in multi-family housing. The tenure breakdown, or whether households own (with or without a mortgage) or rent their homes, is roughly similar in the sample compared to the general population.

Table 4.1 Demographic and socioeconomic characteristics of MHMC survey respondents compared to 2011 Census, Metro Vancouver region

Indicator		Metro Vancouver	
		MHMC	2011 Census/NHS
Female 18+/18+		51.52%	51.76%
18+ University Educated		29.35%	28.92%
Aged 18-44 years/18+		48.02%	48.08%
Born in Canada		63.64%	57.69%
Household income <$40,000		31.69%	31.39%
Dwelling Typology			
	Single Family	44.2%	33.8%
	Ground-Oriented Single Family	21.31%	25.51%
	Multifamily	29.3%	40.15%
	Other	2.38%	0.56%
Tenure			
	Owned		65.5%
	Owned without A Mortgage	24.0%	
	Owned with A Mortgage	37.8%	
	Rent	36.4%	34.5%

Source: "Census Local Area Profiles 2011 and 2016" (n.d.); (*Technical Notes for Community Profiles*, n.d.)

Table 4.2 details the share of household income earning under $40,000, between $40,000 and $100,000 and over $100,000[60] by 2015 MUPOD level. MHMC survey responses are spread across all MUPOD levels/household income ranges.

[60] The non-response for the household income question ranged from 16% to 32% depending on the community.

Table 4.2 2015 MUPOD and household income contingency table

MUPOD/HH Income	HHI Under $40k (%)	HHI Between $40k-$100k (%)	HHI Over $100k (%)	Total Number of Respondents
Very Low	678 (2.52%)	1,415 (5.26%)	2,068 (7.69%)	4,161 (15.48%)
Low	948 (3.53%)	1,602 (5.96%)	1,593 (5.92%)	4,144 (15.41%)
Medium Low	2,420 (9%)	2,889 (10.75%)	2,301 (8.56%)	7,610 (28.30%)
Medium High	2,718 (10.11%)	2,837 (10.55%)	1,998 (7.43%)	7,553 (28.09%)
High	1,054 (3.92%)	1,488 (5.54%)	876 (3.26%)	3,418 (12.71%)
Total Number of Respondents	7,818 (29.08%)	10,233 (38.06%)	8,835 (32.86%)	26,886 (100%)

4.2 Gentrification Index

A cross-sectional analysis is done using 2016 data to examine neighborhoods that show “improvement” (that is, both neighborhood highest level of education and employment in quaternary sector values are higher than the Metro Vancouver values) (see Section 3.4.1). The results are shown in Figure 4.2.

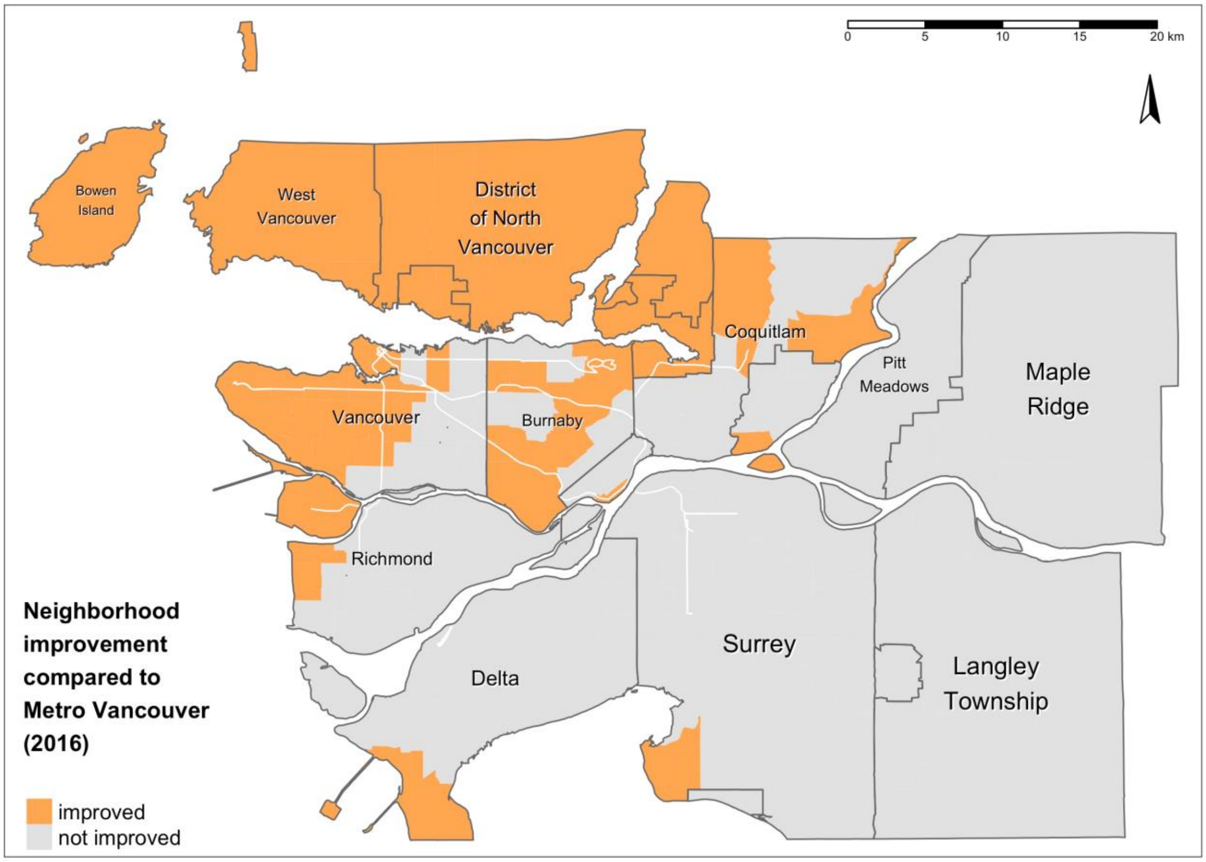

Figure 4.2 Social status index: cross-sectional examination, 2016 Metro Vancouver
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

A 2011/16 longitudinal analysis of social status change is then performed to identify "gentrified" neighborhoods (that is, neighborhoods that experienced social status change at a higher rate compared to the Metro's average from 2011 to 2016) as shown in Figure 4.3. These include the following neighborhoods in the COV: Strathcona, Sunset, Mount Pleasant, Kensington-Cedar Cottage, and Grandview-Woodland (from high to low).

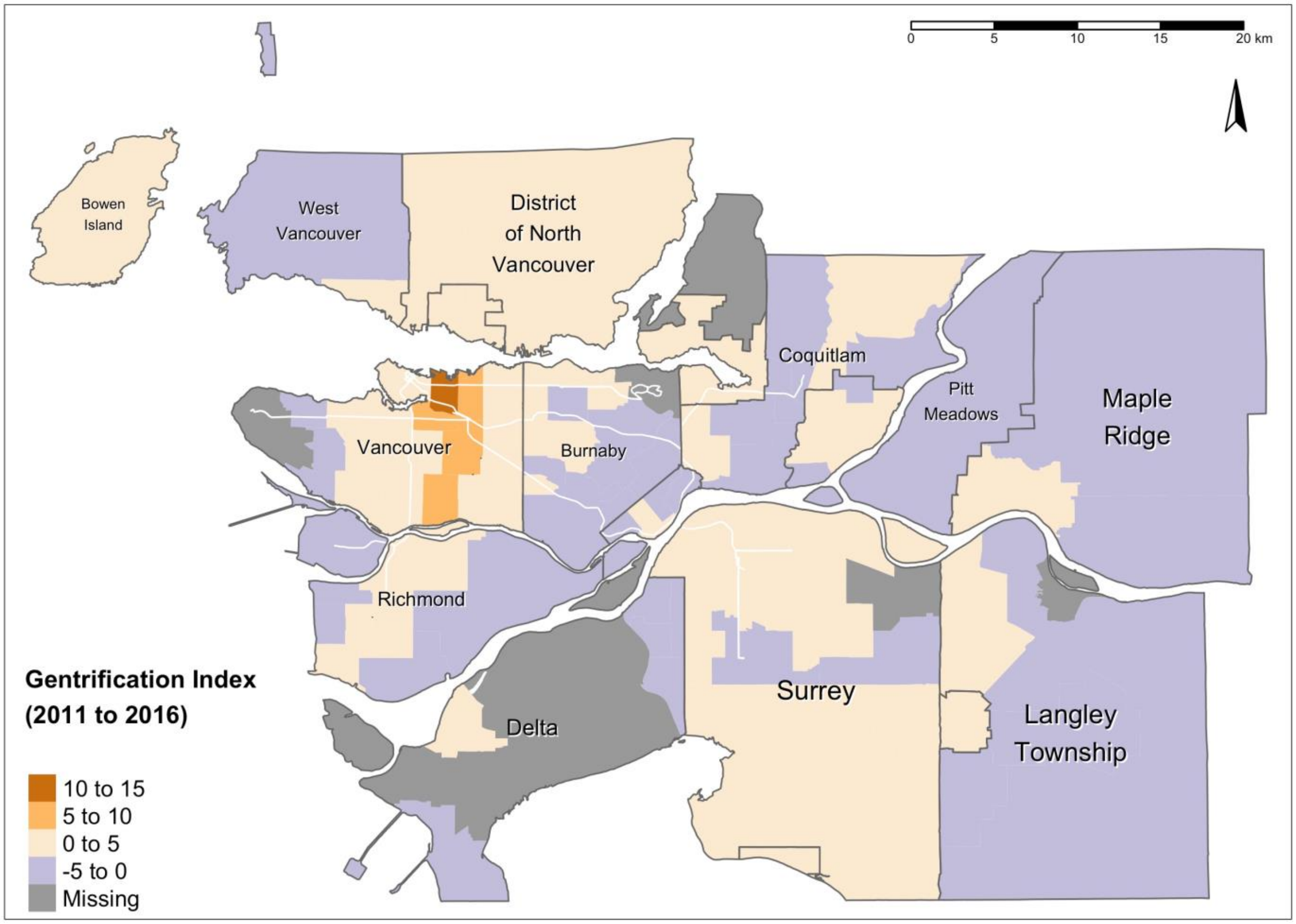

Figure 4.3 Gentrification index, 2011-2016 Metro Vancouver
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

4.3 MUPOD

Walk and Transit Score^{TM} data are used as MUPOD proxies. Figure 4.4 and Figure 4.5 describe the distribution of 2020 Walk and Transit Score^{TM} for Metro Vanover neighborhoods, respectively. As shown in the boxplots, 2020 Walk Score^{TM} ranges from 0 (minimum score) to 99 (maximum score). 46.50 is the median 2020 Walk Score^{TM} (mean = 41.89, sd = 31.92, N=106). 2020 Transit Score ranges from 0 (minimum score) to 100 (maximum score). There are

8 missing Transit Score™ observations. 53 is the median 2020 Transit Score™ (mean = 51.33, sd = 23.87, N=98).

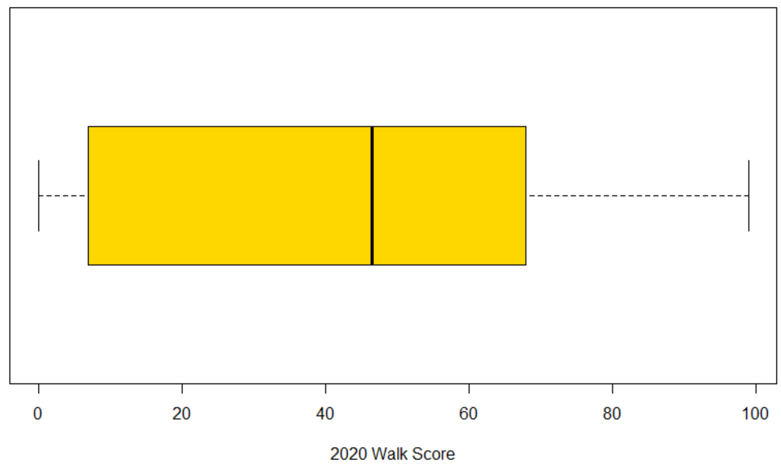

Figure 4.4 2020 Walk Score™ distribution, Metro Vancouver (N=106)

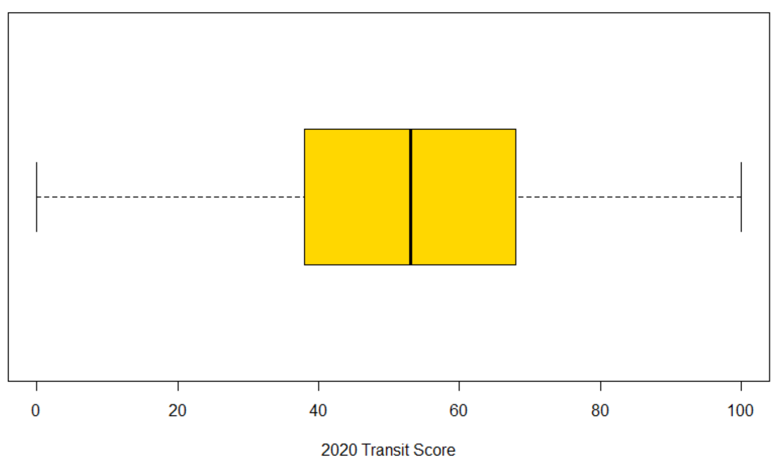

Figure 4.5 2020 Transit Score™ distribution, Metro Vancouver (N=98)

The scatterplot in Figure 4.6 describes the relationship between 2020 Walk and Transit Score™. A Pearson correlation test was done to evaluate the association between the variables. The correlation coefficient is equal to 0.66 and the p-value is < 2.2e-16, at a 95% confidence level. The results indicate a strong positive linear relationship between 2020 Walk Score™ and 2020 Transit Score™.

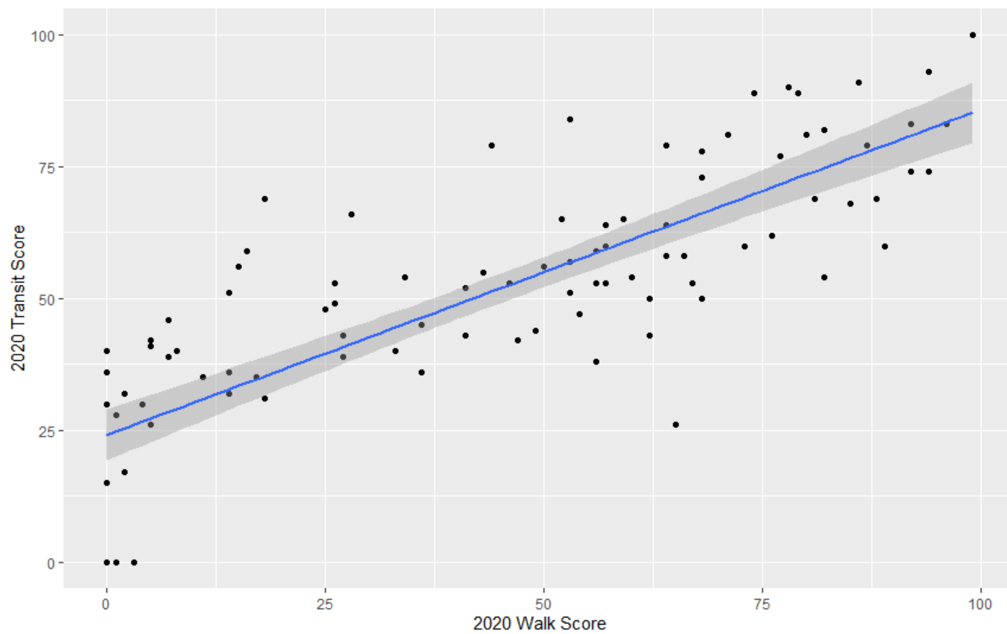

Figure 4.6 2020 Walk and Transit Score ™ relationship, Metro Vancouver (N=106, 98)

Equation 4.1 is used to estimate the relationship between 2020 Walk Score™ and 2020 Transit Score™. The model is statistically significant at a 99% confidence level and can be used to predict the missing 2020 Transit Score™ values (the model conforms to the assumptions of linear regression as shown in Figure 4.7).

Equation 4.1: Estimation model of the relationship between 2020 Walk Score™ and Transit Score™

$$TransitScore2020 = Intercept + (\beta * WalkScore2020)$$

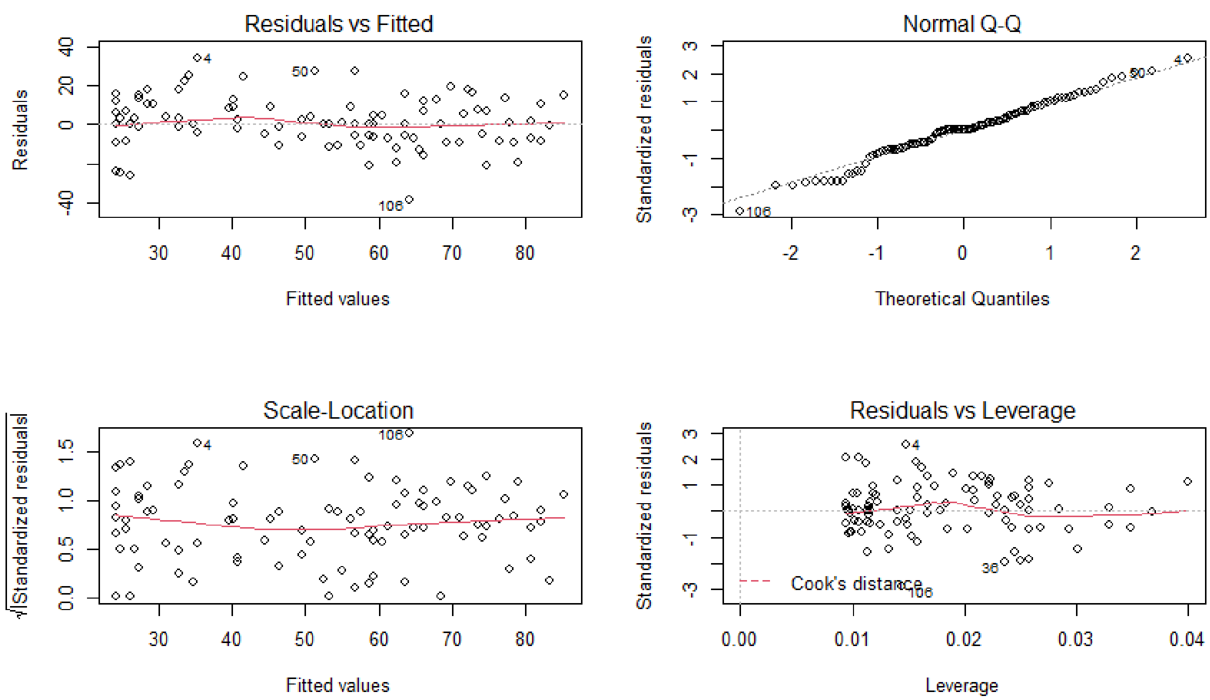

Figure 4.7 Linear regression diagnostic plots: 2020 Walk Score ~ 2020 Transit Score

Since 2015 Transit Score™ was not available, and for the purpose of constructing a 2015 MUPOD index without losing valuable existing information of the built environment –similar Transit Score(s)™ were used for 2015 and 2020. This decision suggests that even if improvements had occurred in transit availability and/or accessibility from 2015 to 2020 (which would have resulted in lower 2015 Transit Score™) they had no effect. The potential overestimation of 2015 Transit Score™, however, is eventually compensated for when calculating the MUPOD index by the fact that overall Walk Score™ decreased in most neighborhoods from 2015 to 2020, which can only be explained by methodology contribution[61].

[61] This statement is made based on familiarity with the Vancouver local context and an exploration of specific sites where public investment in walkable infrastructure has been made during the study's timeline. Critically, further use of Walk Score™ in longitudinal analysis will require improved transparency to the changes in factors that determine the score – a reference to this limitation is only mentioned in Hall & Ram (2018) despite wide adoption.

Equation 4.2 is similarly used to estimate the relationship between 2015 Walk Score™ and 2015 Transit Score™. The model is statistically significant and can be used to predict the missing 2015 Walk Score™ values.

Equation 4.2: Estimation model of the relationship between 2015 Walk Score™ and Transit Score™

$$TransitScore2015 = Intercept + (\beta * WalkScore2015)$$

Finally, a single variable summing up 2015 Walk Score™ and Transit Score™ and divided by two is created to indicate MUPOD levels on a scale between 0 and 100 (as the two are highly correlated) (namely *MUPOD15*).

Figure 4.8 shows that 51.5 is the median 2015 MUPOD level[62] (mean=48.77, min=0, max=99.5, sd=26.97, N=106). MUPOD frequency is also shown in Figure 4.8.

[62] I focus on 2015 data as this is the timeframe used in the dissertation's estimation models.

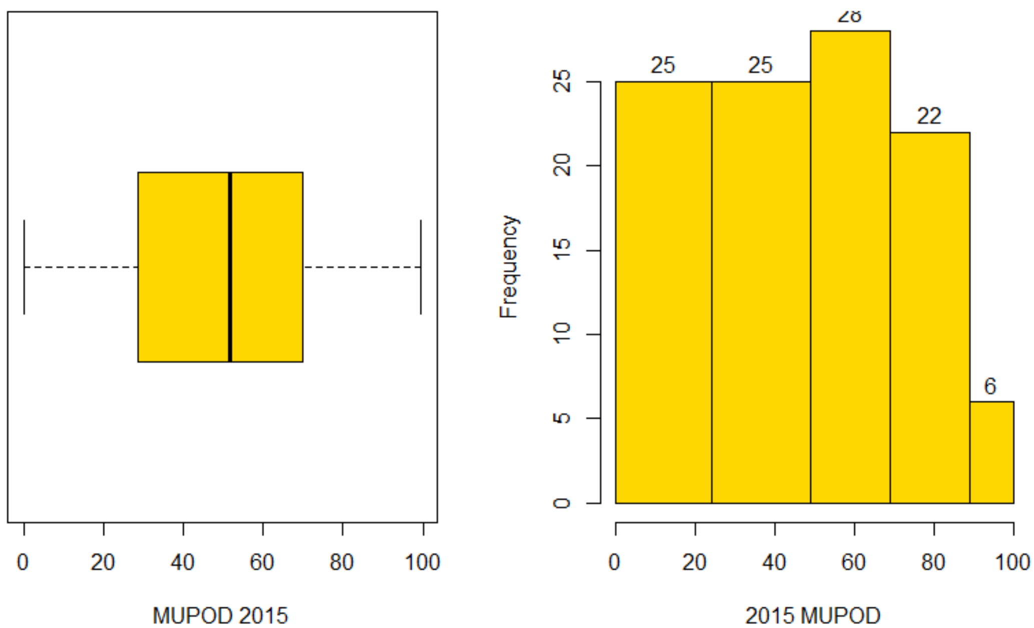

Figure 4.8 2015 MUPOD distribution (left) and frequency (right), Metro Vancouver (N=106)

Subsequently, and for visualization purposes, MUPOD is turned into a categorical variable with five levels. Table 4.3 shows the number of neighborhoods in the Metro Vancouver region under each category.

Table 4.3 MUPOD scale and frequency

Total Walk and Transit Score	*MUPOD*	Frequency (2015)
0-24	Very Low	26 (24.53%)
25-49	Low	24 (22.64%)
50-69	Medium Low	29 (27.36%)
70-89	Medium High	22 (20.75%)
90-100	High	5 (4.72%)

Figure 4.9 shows neighborhood MUPOD levels in the Metro Vancouver region for the 106 unique local areas included in the MHMC survey.

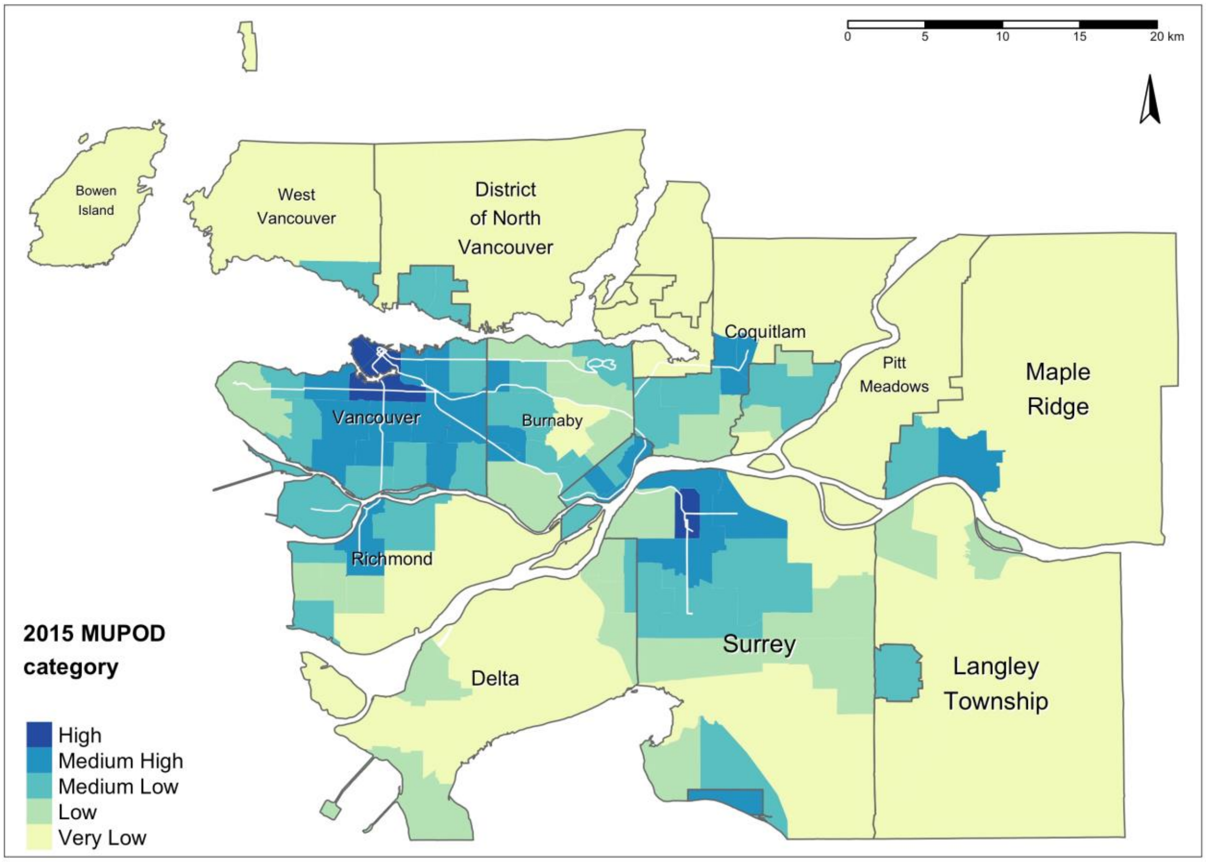

Figure 4.9 2015 MUPOD, Metro Vancouver region (N=106)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

4.4 Health and Social Well-Being

The MHMC dataset contains 31,193 responses. Neighborhood profiles are available for 106 local areas in the Metro Vancouver region (N=106). The aggregated quantitative data provided by MHMC includes a spine chart to describe the percentage of the total responses for each factor compared to the municipality, and region (see Figure 4.10). In Renfrew-Collingwood, for example, 39% of respondents rated their general health as excellent or very good (n=561), compared to 50% in Vancouver and 48.5% in the Metro Vancouver region. The worst result in the Region for the 'General health' indicator was 34.3% and the best was 73.1% (see Appendix D).

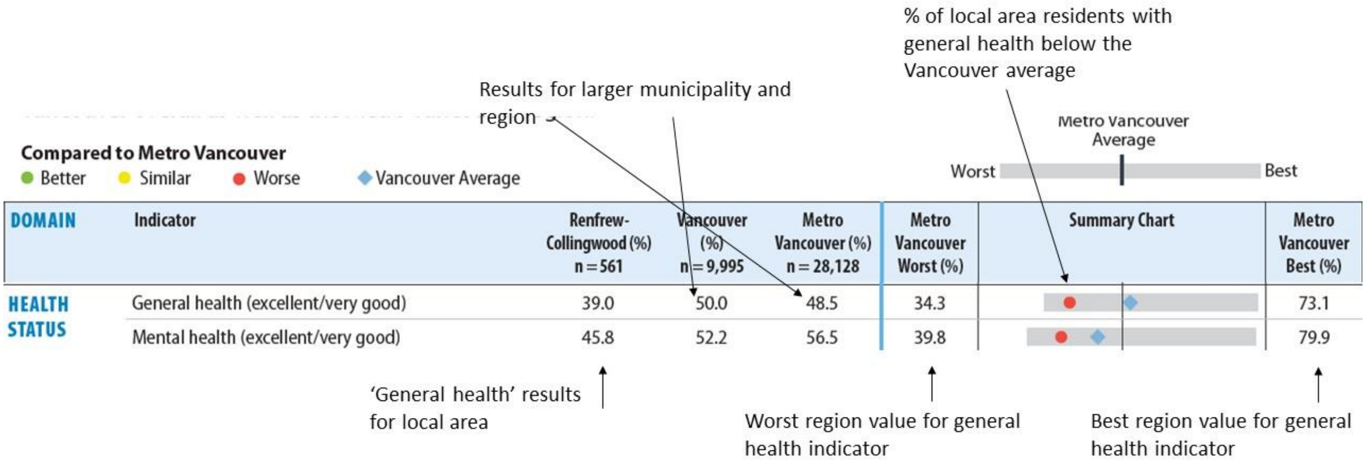

Figure 4.10 MHMC spine chart example

Different strategies were employed to explore the relationship between MUPOD and the health and social well-being indicators, including treating the health/social well-being variables as individual measures, creating a health and social well-being index, and performing a principal component analysis. The following subsections discuss each strategy's descriptive findings.

4.4.1 Individual Health and Social Well-Being Indicators

Four health-related and two social well-being-related variables are of interest and are described in Table 4.4. Data interpretation examples are also provided. Descriptive statistics and non-response rates are detailed in Table 4.5. Data distribution is shown in Figure 4.11.

Table 4.4 Health and social well-being indicator descriptions and examples

Abbreviation	Variable Description	Data Interpretation Example for Renfrew-Collingwood (n=561) (see Appendix D)
Gen.Health.Exc	Respondent who rated their general health as excellent or very good	39% rated their general health as excellent or very good

Abbreviation	Variable Description	Data Interpretation Example for Renfrew-Collingwood (n=561) (see Appendix D)
Ment.Health.Exc	Respondent who rated their mental health as excellent or very good	45.8% rated their mental health as excellent or very good
Obese	Respondent who their BMI (calculated based on respondent's weight and height) indicates obesity and is equal to 30 or higher	20.3% had BMIs 30+ and were considered obese
Blood.pres	Respondent who were diagnosed with a high blood pressure	21.4% were diagnosed with a high blood pressure
Confide4more	Respondent who indicated to have 4+ people to confide in/turn to for help	43.5% indicated to have 4+ people to confide in/turn to for help
SOB.Strong	Respondent who rated their community belonging as strong/somewhat strong	45.9% rated their community belonging as strong/somewhat strong

Table 4.5 Descriptive statistics of the health and social well-being indicators

Abbreviation	N	Range (%)	Mean (%) (sd)	Non-Response Rate (Unweighted)	
				% of People Who did not Answer the Question	Not answered + "I don't know" + "Prefer not to answer"
Gen.Health.Exc	100	34.30/73.10	50.54 (8.83)	1.0%	1.3%
Ment.Health.Exc	100	39.80/79.90	57.50 (6.83)	2.0%	2.4%
Obese	97	6.6/39.7	22.5 (7.67)	BMI was missing for 9%-38 % of respondents depending on the municipality[63].	
Blood.pres	91	8.00/29.20	17.54 (4.73)	4.2%	6%
Confide4more	100	26.80/60.60	45.16 (6.91)	5.2%	6.6%
SOB.Strong	100	29.00/82.60	56.30 (9.27)	5.3%	12.5%

[63] Pregnant women were excluded from BMI calculation.

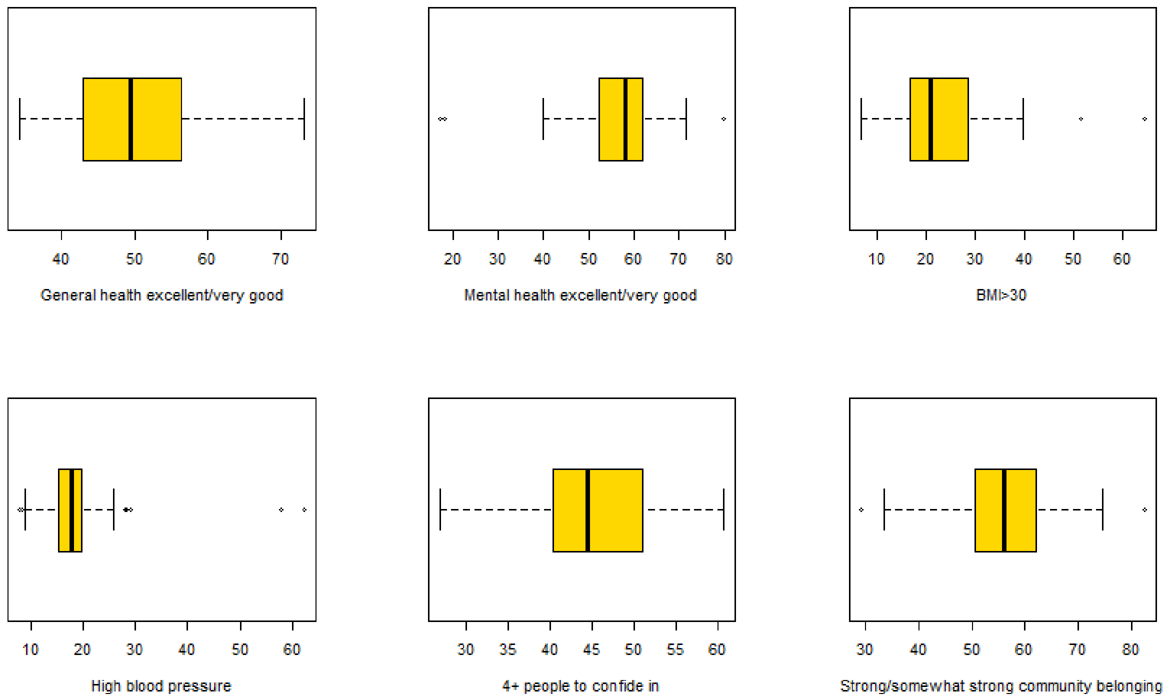

Figure 4.11 Health and social well-being indicator distributions

Lastly, the relationships between *MUPOD15* and the health and social well-being variables are shown in six scatterplots in Figure 4.12. Aligned with the research's assumptions, the relationship between MUPOD and obesity (BMI 30+) and high blood pressure is negative, and positive between MUPOD and "people to confide in". The relationship, however, is only statistically significant between MUPOD and obesity (at a 95% confidence level). That is, increased MUPOD level is associated with lower percentages of households with BMI of 30 or more. Contrary to the research's hypothesis, the relationship between MUPOD and excellent general health is negative (the relationship is not found to be statistically significant); it is negative between MUPOD and excellent mental health, and between MUPOD and strong SOB (both are statistically significant at a 95% confidence level). The estimation model results are further discussed in Section 5.1.

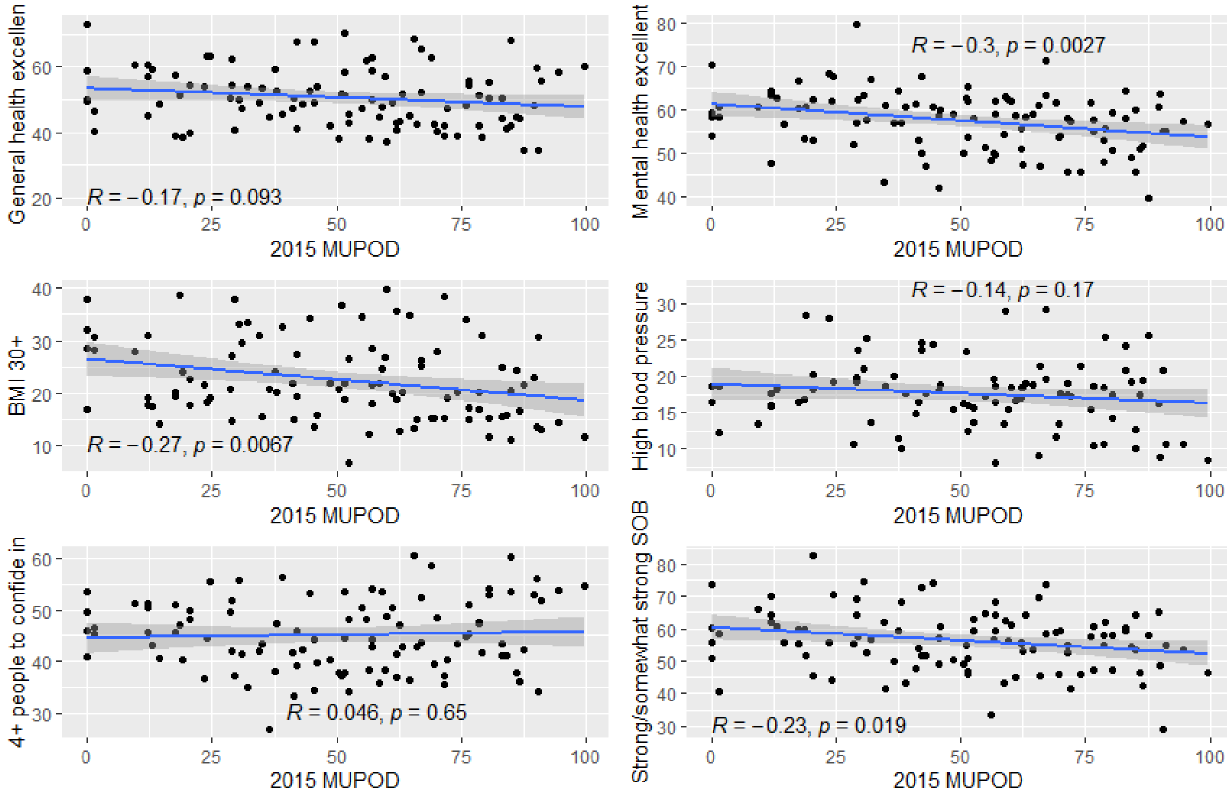

Figure 4.12 MUPOD/health well-being indicators associations, Metro Vancouver (N=106)

4.4.2 Health and Social Well-Being Index

A second approach to analyzing the health and social well-being indicators is to create a single index summarizing the six variables. Equal weights are given to the variables as there does not seem to be one of more significance in terms of its contribution to general health and well-being[64]. Moreover, the BMI 30+ (*Obese*) and high blood pressure (*Blood.pres*) scales were inverted so that lower percentages contribute to a higher index score.

The health and social well-being index (*Health.SWB.Index*) is a continuous variable ranging from 0 to 67 (a higher score indicates improved health and well-being). As Figure 4.13

[64] Perhaps future research could explore this assumption further.

shows, the median score is 27.54 (min=16.83, max=39.63, sd=4.52). Observations where one or more of the health/social well-being data were missing, were removed from the analysis (NA's=16).

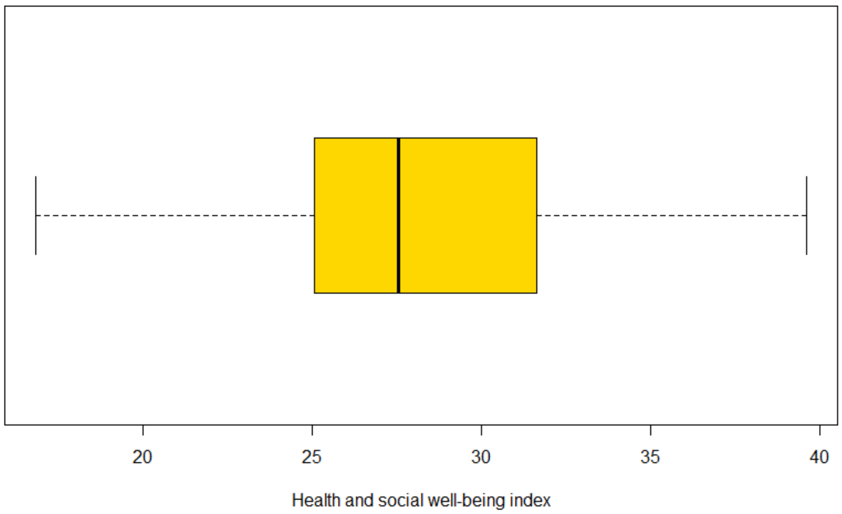

Figure 4.13 Health and social well-being index distribution (N=90)

The relationship between MUPOD and the health and social well-being index is described in Figure 4.14. A lower MUPOD level is associated with a higher score on the health and social well-being index; however, the relationship is not statistically significant at a 95% confidence level. The health and social well-being index scores across the Metro Vancouver region is shown in Figure 4.15.

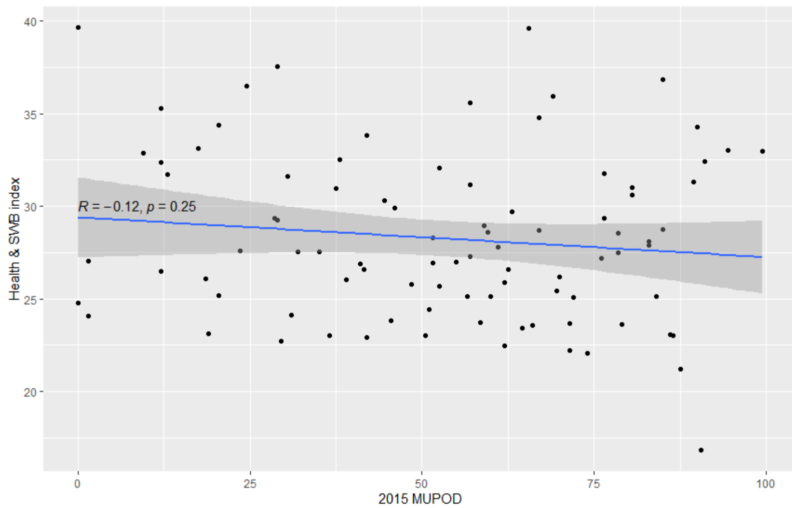

Figure 4.14 MUPOD/health and social well-being index association (N=90)

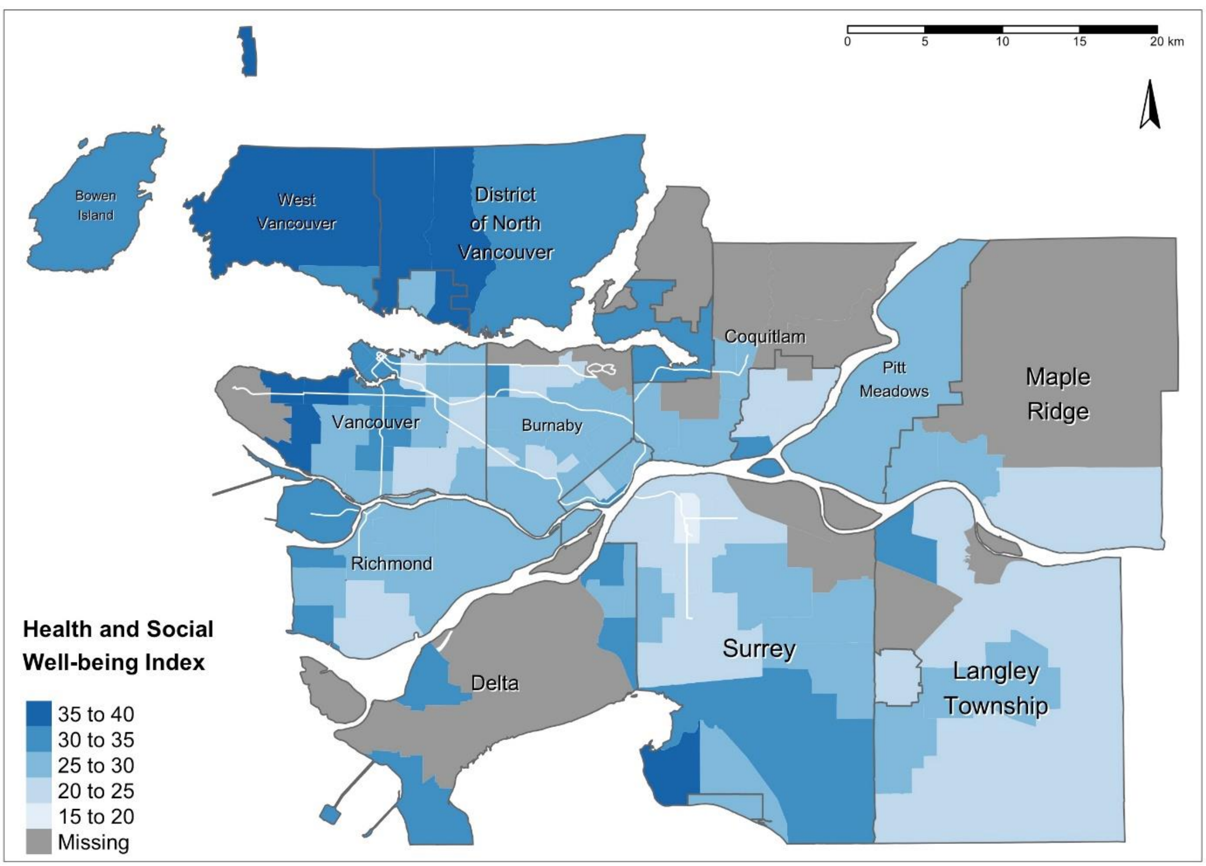

Figure 4.15 Health and social well-being index, Metro Vancouver region (N=90)

Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

Finally, it is reasonable to assume that the health and social well-being indicators are interrelated. To reduce the number of explanatory variables into a smaller set of factors, and examine improvement to the model's predictive power, a PCA is performed. Results are discussed in the following section.

4.4.3 Principal Component Analysis of the Health and Social Well-Being Indicators

Ignoring missing data due to incomplete observation deletion is another problem that arises from the health and social well-being index (discussed in the previous section). This can be dealt with by performing data imputation. A rather unsophisticated method includes replacing missing data with the mean. Alternatively, R package 'missMDA' allows the use of various imputation methods for an incomplete data set.

But first the patterns of missing values need to be explored. An examination of the proportion of missing values and combinations shows that *Blood.pres* data is missing from 14% of the 106 neighborhoods, followed by *Obese* which is missing from 8.5% of the neighborhoods, and *Gen.Health.Exc*, *Ment.Health.Exc*, *Confide4more*, and *SOB.Strong* data which is missing from 5% of the neighborhoods (see Figure 4.16).

85% of the neighborhoods have complete observations (that is, 90 neighborhoods with no missing values). 6% (or 7 neighborhoods) have 1 missing value; 5% (or 6 neighborhoods) have no records of health and social well-being indicators (that is, all values are missing); 1.89% (or 2 neighborhoods) have two missing values; and 0.94% (or 1 neighborhood) has 1 missing value.

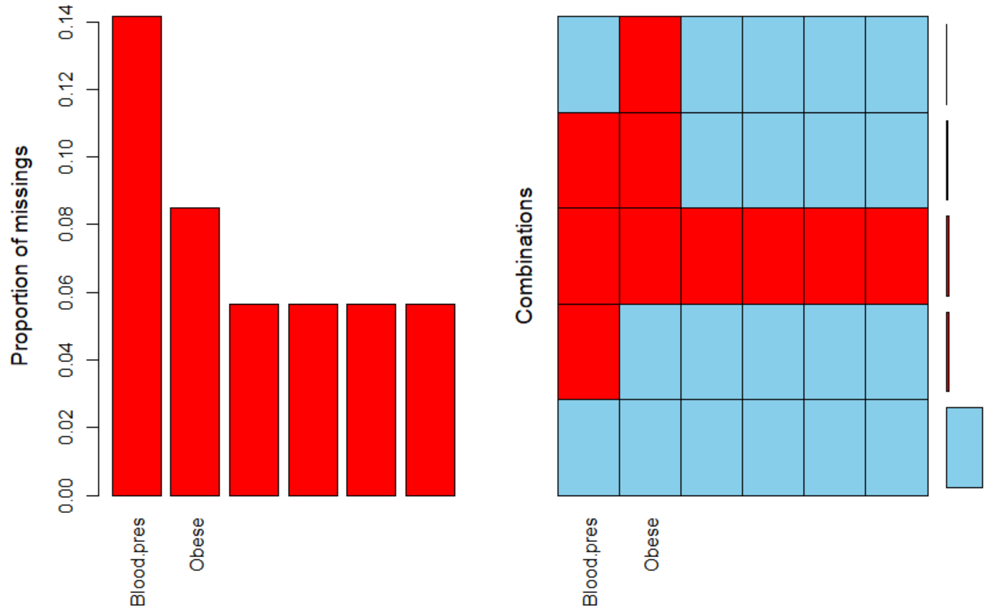

Figure 4.16 Proportion and combinations of missing health and social well-being values (N=106)

The missing values are then predicted using the iterative PCA algorithm for a predefined number of dimensions (Josse, 2018). A PCA is performed on the imputed data set.

Figure 4.17 visualizes eigenvalues (also known as a scree plot). It shows the percentage of variances explained by each principal component. The first two dimensions of analyses express 63.28% of the total data variability (see the cumulative percentage of variance in Table 4.6). This value is greater than the reference value that equals 44.32%[65], the variability explained by this plane is thus significant. This observation suggests that only these axes (or the first two dimensions) convey real information (Husson, 2020).

[65] The reference value is the 0.95-quantile of the inertia percentage distribution obtained by simulating 1,021 data tables of equivalent size on the basis of a normal distribution.

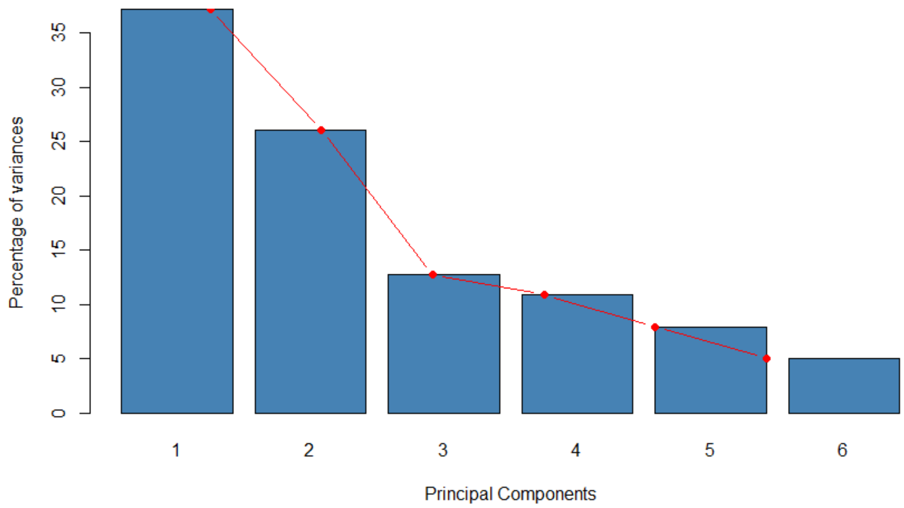

Figure 4.17 Decomposition of the total inertia variance explained by principal components (%)

Table 4.6 PCA eigenvalues output

Principal Components	Eigenvalue Percentage of Variance	Cumulative Percentage of Variance
comp 1	37.17	37.17
comp 2	26.10	**63.28**
comp 3	12.75	76.02
comp 4	10.91	86.94
comp 5	7.98	94.92
comp 6	5.08	100.00

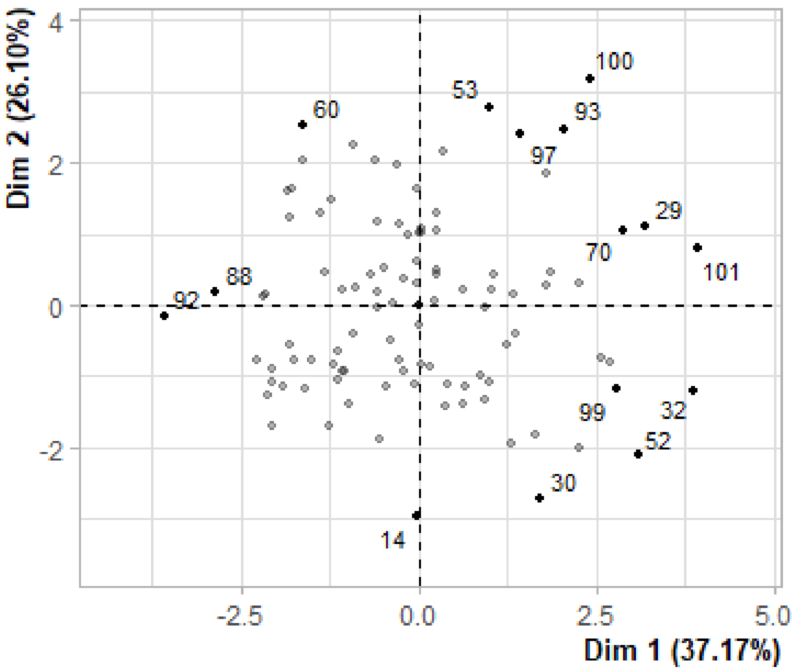

Figure 4.18 Output of the PCA function: individuals factor map

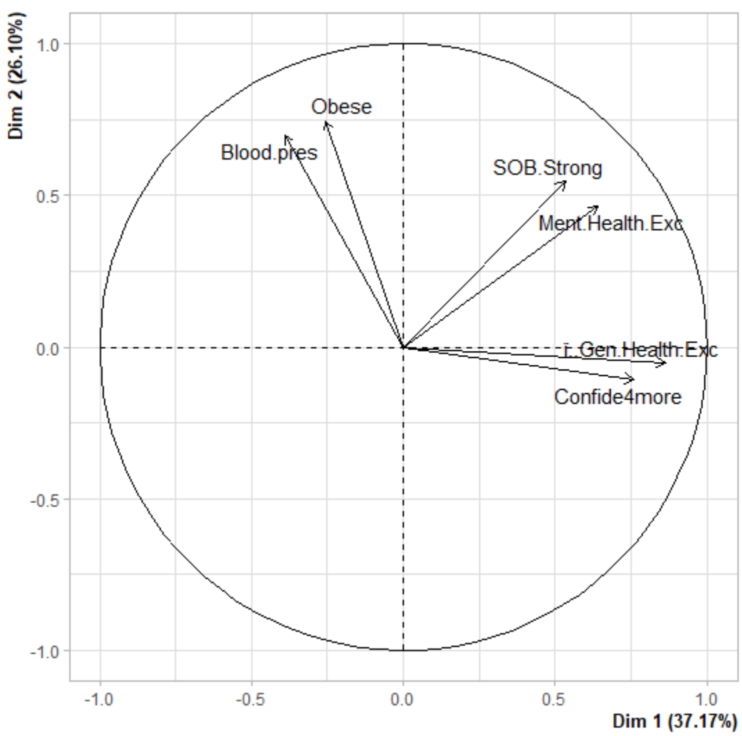

Figure 4.19 Output of the PCA function: correlation circle

The description of the plane is in Figure 4.18 and Figure 4.19. Figure 4.18 shows the individual observation factor map of the PCA function. The labeled observations[66] are those with the higher contribution to the plane construction.

Dimension 1 juxtaposes observations such as 99, 52, 30, 93, 100, 53 and 97 (to the right of the graph, characterized by a strongly positive coordinate on the axis) to observations such as 60, 92, and 88 (to the left of the graph, characterized by a strongly negative coordinate on the axis).

The upper right group shares:

- high values for the variables *SOB.Strong*, *Ment.Health.Exc*, *Gen.Health.Exc* and *Confide4more* (variables are sorted from the strongest).

The lower right group shares:

- high values for the variables *Confide4more* and *Gen.Health.Exc* (variables are sorted from the strongest).
- low values for the variables *Blood.pres* and *Obese* (variables are sorted from the weakest).

The lower left group shares:

- low values for the variables *Ment.Health.Exc*, *SOB.Strong*, *Gen.Health.Exc* and *Confide4more* (variables are sorted from the weakest).

The upper left group shares:

- high values for the variables *Obese* and *Blood.pres* (variables are sorted from the strongest).

[66] Numbers stand for observations (or MHMC neighborhoods).

- low values for the variables *Confide4more* and *Gen.Health.Exc* (variables are sorted from the weakest).

Dimension 2 juxtaposes observations such as 101, 60, 70, 93, 100, 53, 97 and 29 (to the top of the graph, characterized by a strongly positive coordinate on the axis) to observations such as 99, 52, 30, 32, 92 and 14 (to the bottom of the graph, characterized by a strongly negative coordinate on the axis).

The upper left group shares:

- high values for the variables *Obese* and *Blood.pres* (variables are sorted from the strongest).
- low values for the variables *Confide4more* and *Gen.Health.Exc* (variables are sorted from the weakest).

The upper right group shares:

- high values for the variables *SOB.Strong*, *Ment.Health.Exc*, *Gen.Health.Exc* and *Confide4more* (variables are sorted from the strongest).

The lower left group shares:

- low values for the variables *Ment.Health.Exc*, *SOB.Strong*, *Gen.Health.Exc* and *Confide4more* (variables are sorted from the weakest).

The lower right group shares:

- high values for the variables *Confide4more* and *Gen.Health.Exc* (variables are sorted from the strongest).
- low values for the variables *Blood.pres* and *Obese* (variables are sorted from the weakest).

Figure 4.19 visualizes variables with a similar profile (grouped together). Variables that point to the same side of the plot indicate a positive correlation, whereas variables pointing to opposite sides of the graph imply a negative correlation.

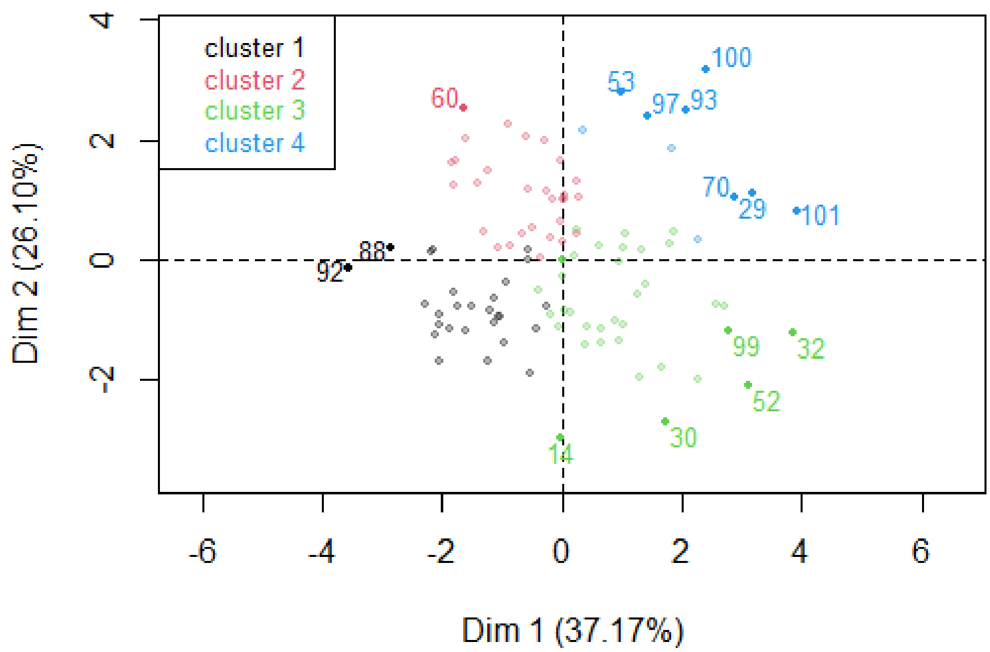

Figure 4.20 Output of the PCA function: ascending hierarchical classification of individual respondents

Figure 4.20 shows the classification made on individual respondents and it reveals 4 clusters.

The **cluster 1** group is characterized by:

- low values for the variables *Ment.Health.Exc*, *Gen.Health.Exc*, *Confide4more*, *SOB.Strong* and *Obese* (variables are sorted from the weakest).

The **cluster 2** group is characterized by:

- high values for the variables *Obese* and *Blood.pres* (variables are sorted from the strongest).

- low values for the variables *Confide4more* and *Gen.Health.Exc* (variables are sorted from the weakest).

The **cluster 3** group is characterized by:

- high values for the variables *Gen.Health.Exc* and *Confide4more* (variables are sorted from the strongest).
- low values for the variables *Blood.pres* and *Obese* (variables are sorted from the weakest).

The **cluster 4** group is characterized by:

- high values for the variables *SOB.Strong*, *Ment.Health.Exc*, *Confide4more*, *Gen.Health.Exc* and *Blood.pres* (variables are sorted from the strongest).

Principal component scores are shown in Table 4.7. These will later be used in the estimation model (see in Section 5.1). To enrich interpretation, I examine variable contributions to principal components and quality of representation as shown in Table 4.8 and Table 4.9, respectively. Based on these results, the first dimension (Dim.1) will be referred to as *Positive.Health.Impacts* and the second dimension (Dim.2) as *Negative.Health.Impacts*.

Table 4.7 Principal component scores

	Dim.1	Dim.2
Gen.Health.Exc	-0.58	1.18
Ment.Health.Exc	-0.88	2.36
Obese	0.00	6.36
Blood.pres	0.94	-2.66
Confide4more	0.00	6.36
SOB.Strong	-0.93	-3.88

Table 4.8 Contributions to principal components

	Dim.1	Dim.2
Gen.Health.Exc	**33.45**	0.17
Ment.Health.Exc	**18.42**	**13.74**
Obese	2.92	**35.44**
Blood.pres	6.80	**30.92**
Confide4more	**25.68**	0.74
SOB.Strong	12.73	18.99

Table 4.9 Principal components' quality of representation

	Dim.1	Dim.2
Gen.Health.Exc	0.75	0.00
Ment.Health.Exc	0.41	0.22
Obese	0.07	0.56
Blood.pres	0.15	0.48
Confide4more	0.57	0.01
SOB.Strong	0.28	0.30

It needs to be noted that uncertainty in the prediction cannot be identified since a value is predicted for a missing observation when using statistical methods to impute the data set. The missing value is predicted based on the observed data, which implies uncertainty associated with the prediction. It therefore needs to be assumed that the variance of the estimators is underestimated since variability resulting from missing observations is not taken into account (Josse & Husson, 2016).

4.5 Housing Value

2011 rent values (*Census_total_2011MedRent*) are taken from Canada Census. Areal weighting is used to match DAs geography to MHMC's (see Section 3.5) and a median value is calculated for each neighborhood (weighted by population size). Census data does not contain information about housing size. 2011 median rent values range between $548 to $2,011 (CAD) (N=106, median=$1,067, sd=210).

2014 rent values (*CMHC_total_2014MedRent*) are obtained from CMHC's annual RMS. Areal weighting is used to match CMHC geography to MHMC's (see Section 3.5). Table 4.10 outlines 2014 median rents by dwelling size.

Table 4.10 2014 median rent values (CAD), Metro Vancouver region

Dwelling Size	Range (CAD)	Median (sd)	N
Bachelor	600/1,235	738 (141)	94
1 BR	710/993	830 (82)	96
2 BR	850/2,078	1,118 (291)	106
3 BR	1,010/2,700	1,333 (373)	95
Total	750/ 1,575	919 (204)	106

The relationships between MUPOD and 2011 median rent total values and between MUPOD and 2014 total median rent values are described in Figure 4.21 and Figure 4.22, respectively. While associations between the two variables are opposite, only the MUPOD/2011 median rent values negative correlation is statistically significant at a 95% confidence level. Further discussion of the estimation model results is in Section 5.2.

Finally, 2011 median rent total across the Metro Vancouver region is shown in Figure 4.23. 2014 median total rent across the Metro Vancouver region is shown in Figure 4.24.

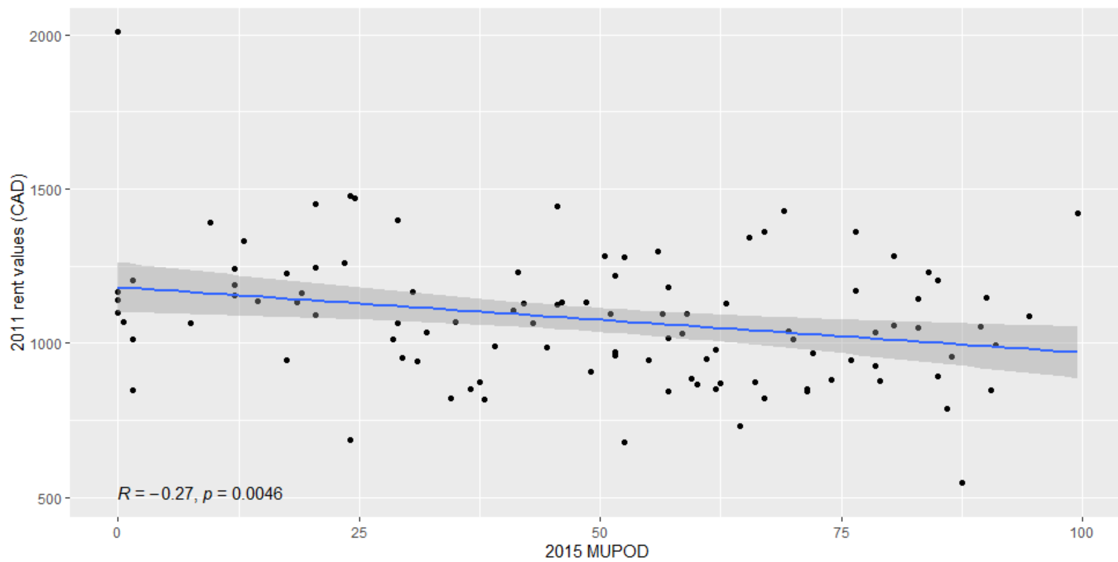

Figure 4.21 MUPOD/2011 total median rent association, Metro Vancouver (N=106)

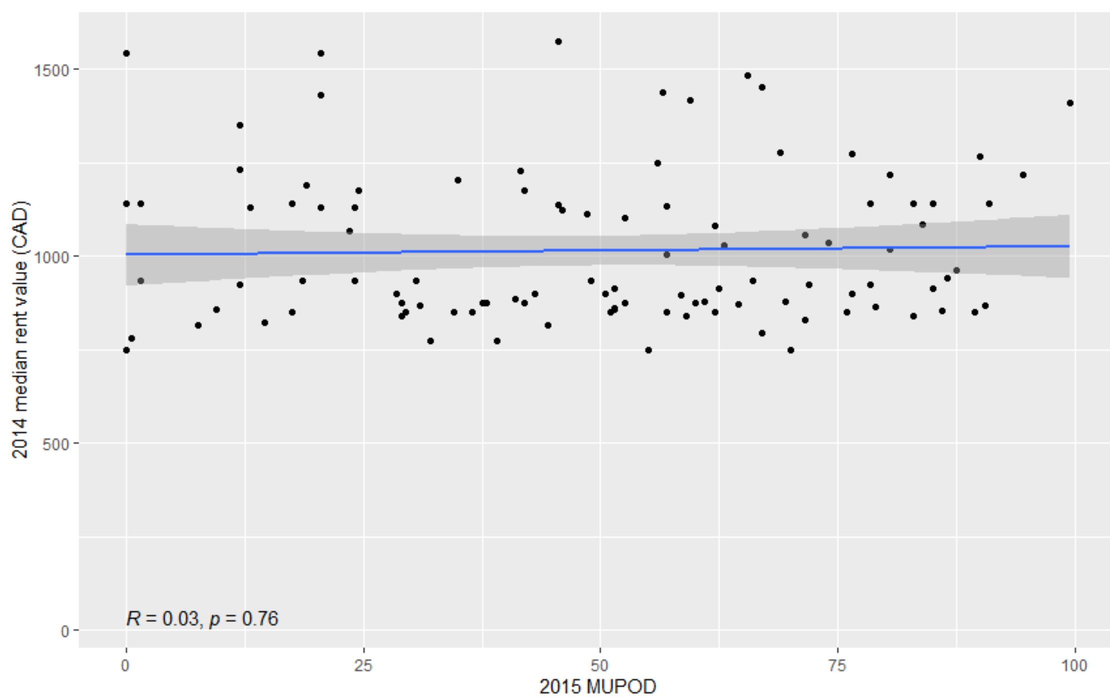

Figure 4.22 MUPOD/2014 total median rent association, Metro Vancouver (N=106)

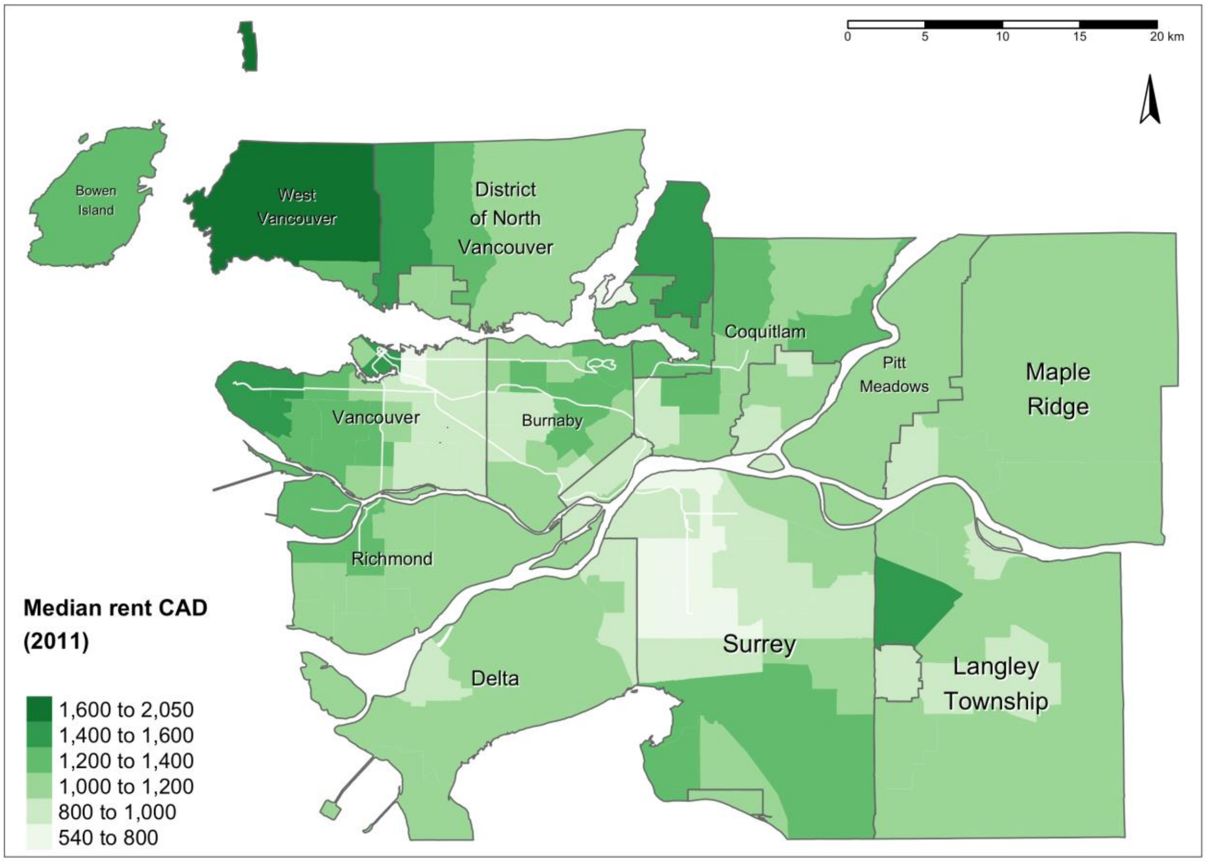

Figure 4.23 2011 median rent value total (CAD), Metro Vancouver (N=106)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

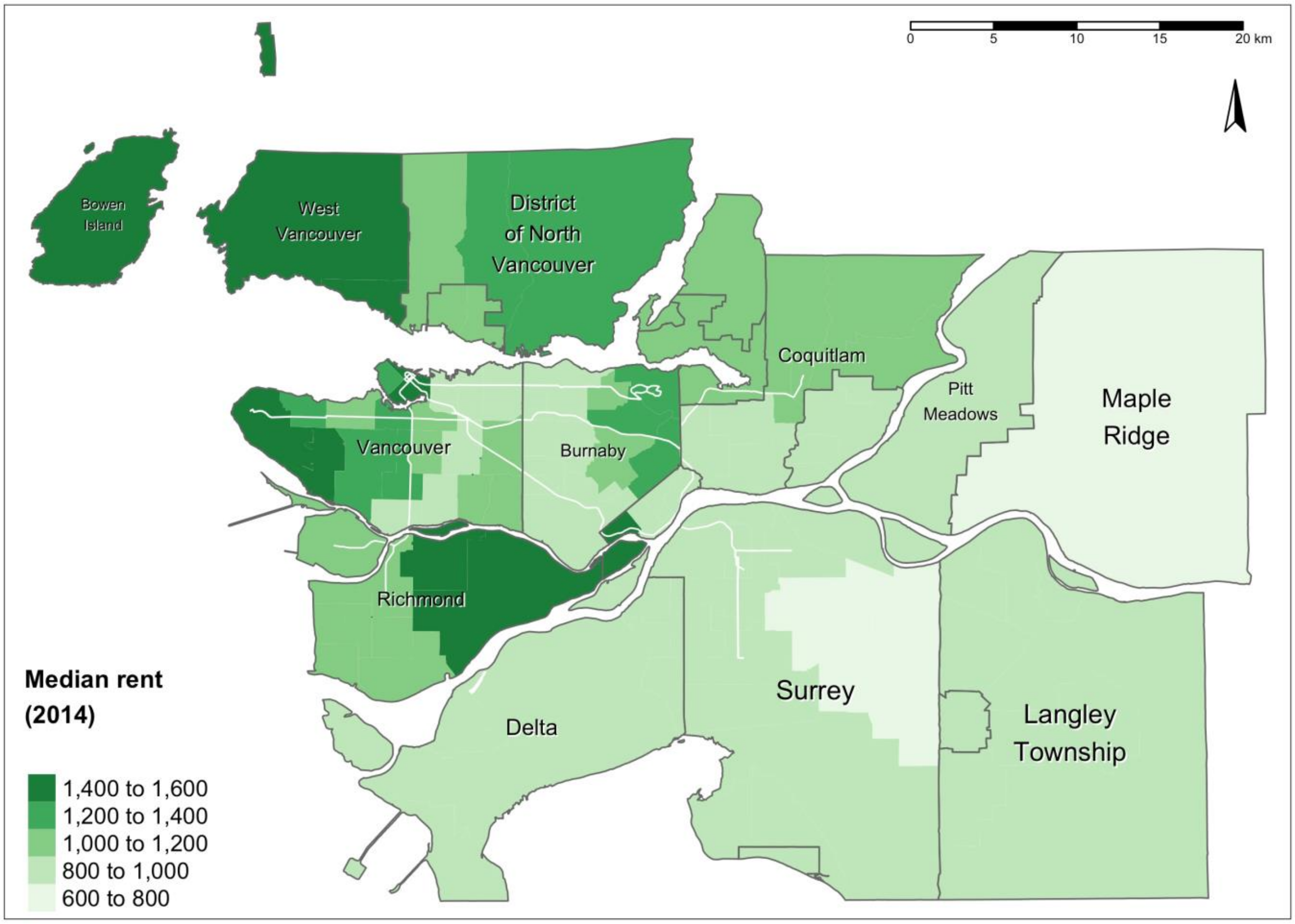

Figure 4.24 2014 median rent value total (CAD), Metro Vancouver (N=106)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

The assessed housing value (*Assessed.value*) is derived from 2014 BCAA. The BCAA sample includes a total of 725,495 observations. Outliers were removed from the dataset to prevent biased model results. A standard practice of removing the top and bottom 1% of observations was employed. A total of 14,510 observations were removed in the process.

Table 4.11 shows median assessed housing value by property type and size. 39,029 properties are missing number of bedrooms and are not included in Table 4.11. The single-family homes category includes the majority of property types in the dataset (55.09%). Three+ bedrooms is the vast majority of property house size (64.20%). The relationship between

MUPOD and 2014 assessed housing value median is described in Figure 4.25. The association between the two variables is negative. However, it is not statistically significant at a 95% confidence level. Further discussion of the estimation model results is in Section 5.2.

Finally, 2014 assessed housing values for single-family and high-density units are visualized in the Metro Vancouver context in Figure 4.26 and in Figure 4.27, respectively.

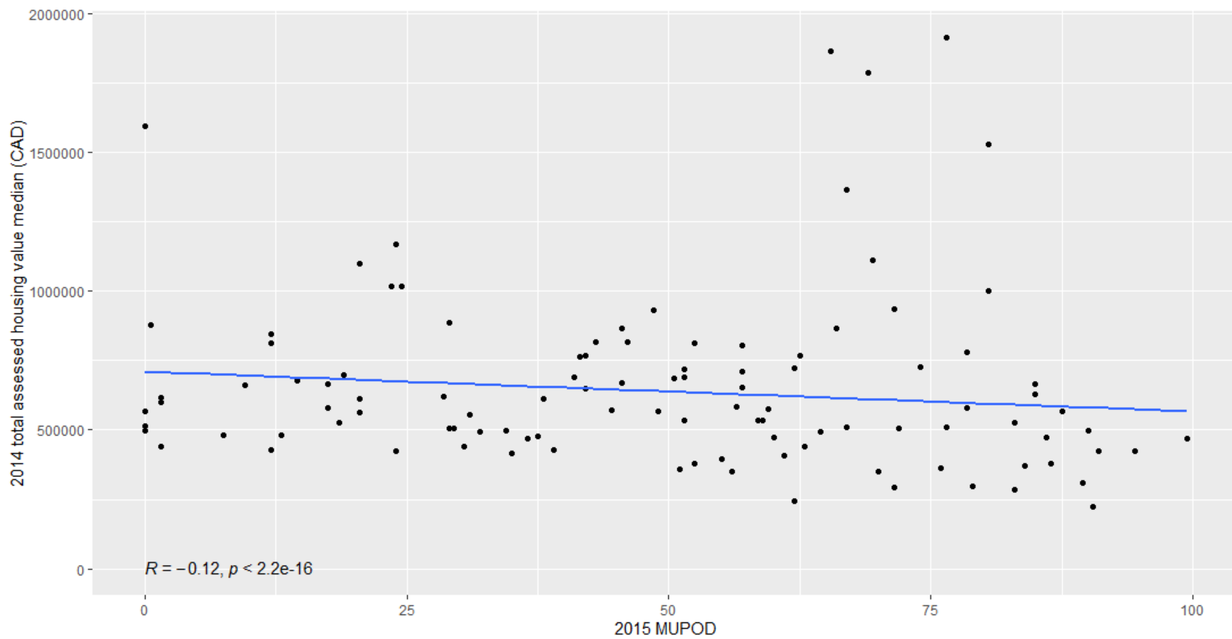

Figure 4.25 MUPOD/2014 assessed housing value median (CAD) association, Metro Vancouver (N=710,985)

Table 4.11 2014 housing type counts and values (outliers removed)

			Count				
Dwelling Size/Property Type	Single Family	Ground-Oriented Single Family	Multifamily	Other	Total	Price Range (CAD)	Median
Studio	37	66	1,888	12	2,003	105,400/3,407,000	305,645
% of sample	0.01%	0.01%	0.28%	0.002%	0.30%		
1 BR	2,349	1,701	71,588	18	75,656	105,000/3,720,200	308,432
% of sample	0.35%	0.25%	10.65%	0.003%	11.26%		
2 BR	20,402	26,311	115,811	367	162,891	104,900/3,730,000	463,066
% of sample	3.04%	3.92%	17.23%	0.055%	24.24%		
3+ BR	347,402	72,483	11,462	59	431,406	106,000/3,733,000	813,836
% of sample	51.7%	10.79%	1.71%	0.009%	64.20%		
Total	370,190	100,561	200,749	456	671,956[67]	-	221,900/1,913,000
% of sample	55.09%	14.97%	29.88%	0.07%	100%		
Price Range (CAD)	105,000/ 3,733,000	118,400/ 3,674,400	104,900/ 3,734,000	105,000/ 3,728,000	-	-	-

[67] 39,029 properties are missing number of bedrooms.

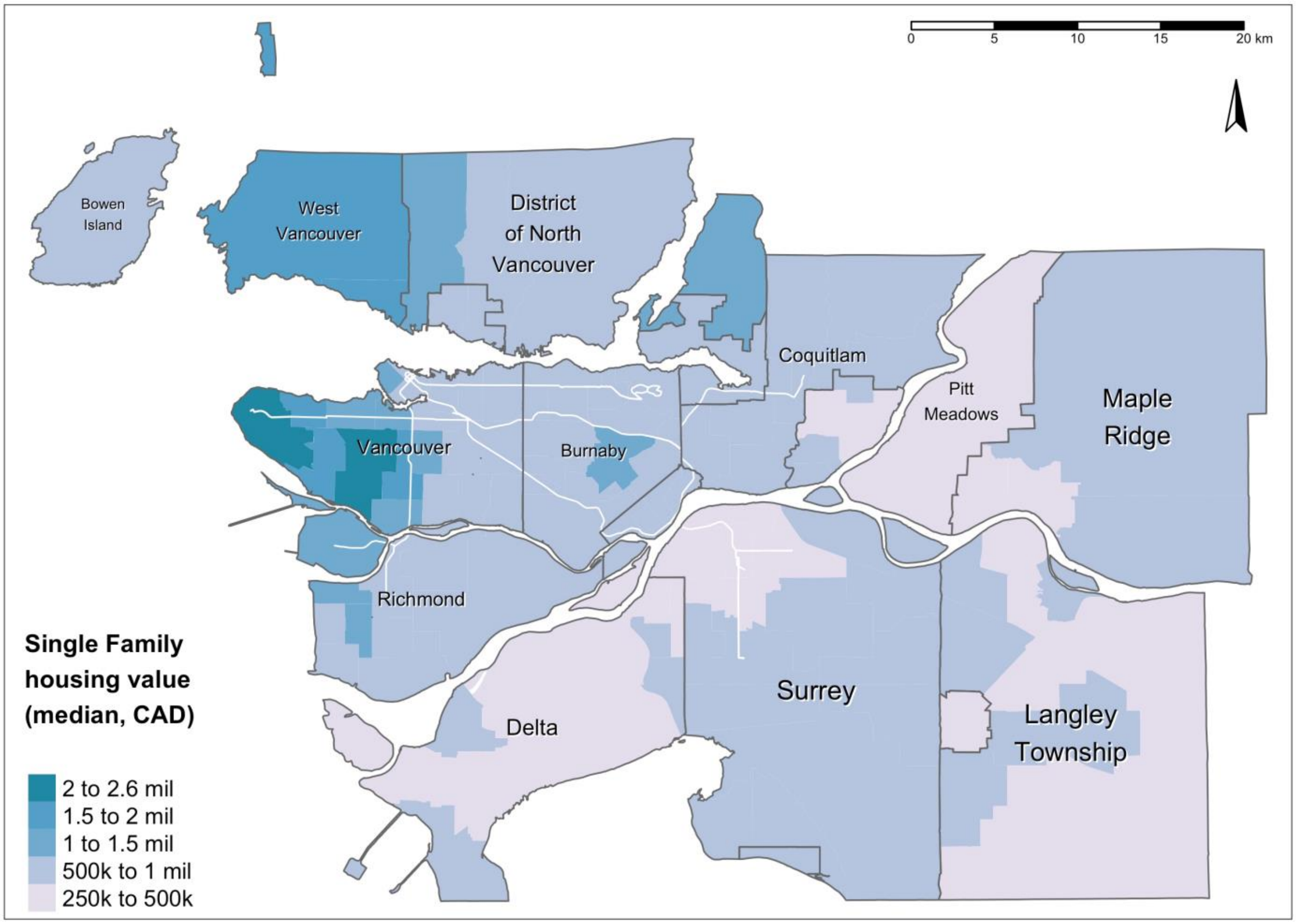

Figure 4.26 Single-family house value median (CAD), Metro Vancouver (N=380,861)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

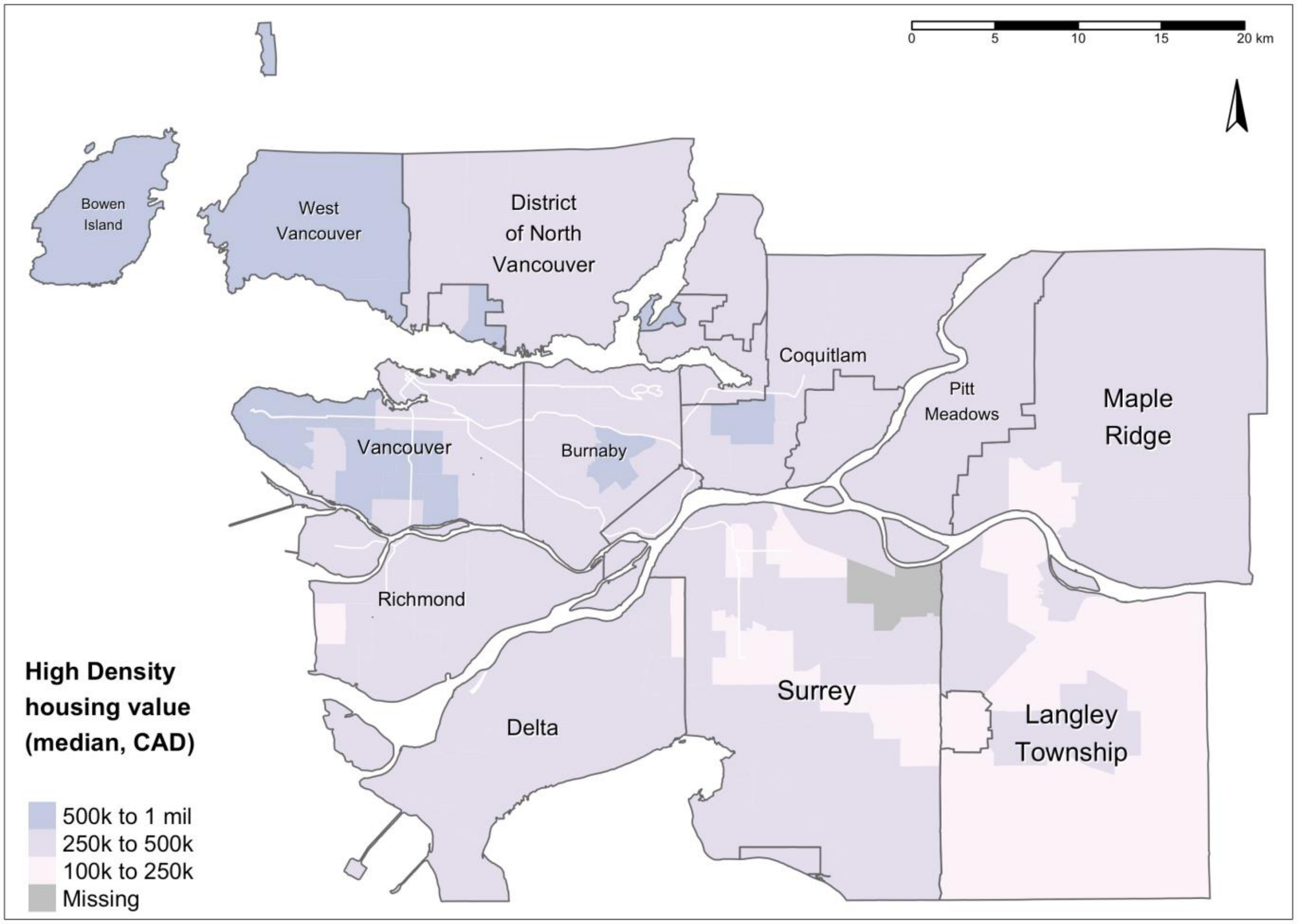

Figure 4.27 High-density unit value median (CAD), Metro Vancouver (N=330,124)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

4.6 Affordability as Main Reason for Moving

Moved for affordability (*Move.for.Afford*) information is generated from MHMC responses indicating 'housing affordability' as their main reason for moving to their current neighborhood[68]. This question was limited to people who had moved in the past two years to their current neighborhood. Other reasons to move included: close to friends or family, close to

[68] The data was produced by request from the MHMC data analyst team.

work or schools, close to transit, close to shops and restaurants, close to outdoor spaces (e.g., parks, beaches, community gardens), close to childcare facilities, close to recreation facilities, close to place of worship, neighborhood safety, diverse neighborhood, family friendly neighborhood, and good housing/residential features. Given that the data is aggregated to 106 neighborhood profiles, and that following MHMC methodology, data is suppressed where sample size is less than 20 and/or where variation coefficients were greater than 33.3%, all responses different from "affordability" were grouped under "Other".[69]

The boxplot in Figure 4.28 shows that the average of respondents in a locale who indicated affordability as their main reason for moving is 47.4 (%) (min=14.9, max=77.6, sd=13.57). The positive relationship between MUPOD and 'moved for affordability reasons' is shown in Figure 4.29. The relationship is not statistically significant at a 95% confidence level. Further discussion of the estimation model results is in Section 5.2. Figure 4.30 illustrates the 'move to current neighborhood for affordability reasons' in the Metro Vancouver region. Importantly, all neighborhoods that scored high on affordability as a reason for moving (that is, between 60% and 80% of respondents who moved in the past two years to their current neighborhood, did so for housing affordability) are located away from the Metro's CBD[70].

---

[69] Unfortunately, when data was pulled by MHMC analyst team, they had to suppress about a third of the neighborhoods for affordability as reason for moving due to small sample (NA's = 43).

[70] These include the following neighborhoods: Central Port Coquitlam, Port Coquitlam; Jarvis/Kennedy, Delta; Kensington-Cedar Cottage, Vancouver; Sunset, Vancouver; Renfrew; Collingwood, Vancouver; Metrotown, Burnaby; Surrey Central, Surrey; and Middlegate/Windsor, Burnaby.

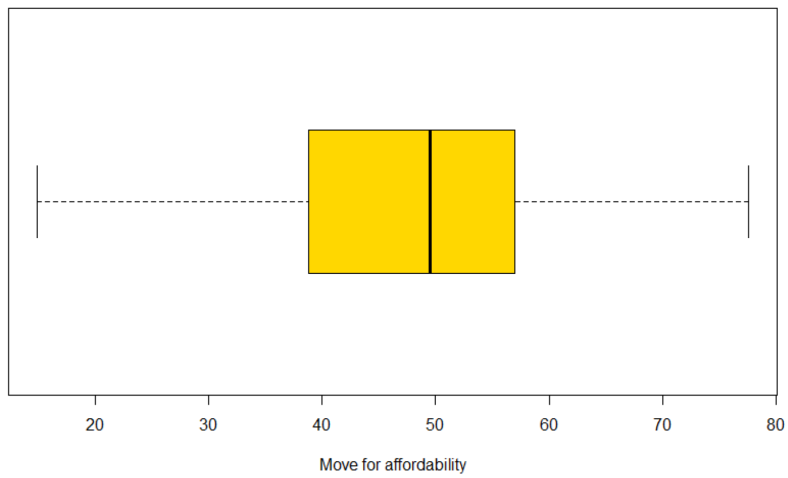

Figure 4.28 "Moved to current neighborhood for affordability" distribution, Metro Vancouver (N=63)

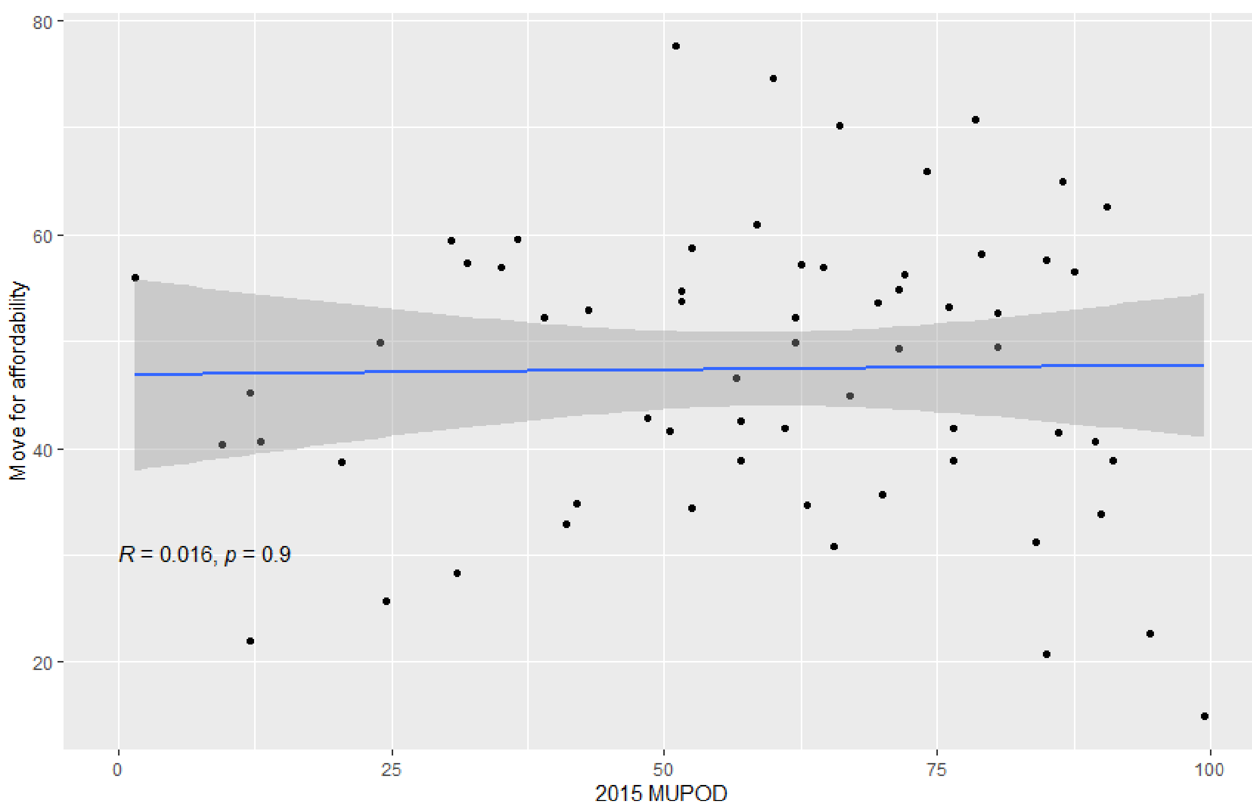

Figure 4.29 MUPOD/"moved to current neighborhood for affordability" association, Metro Vancouver (N=63)

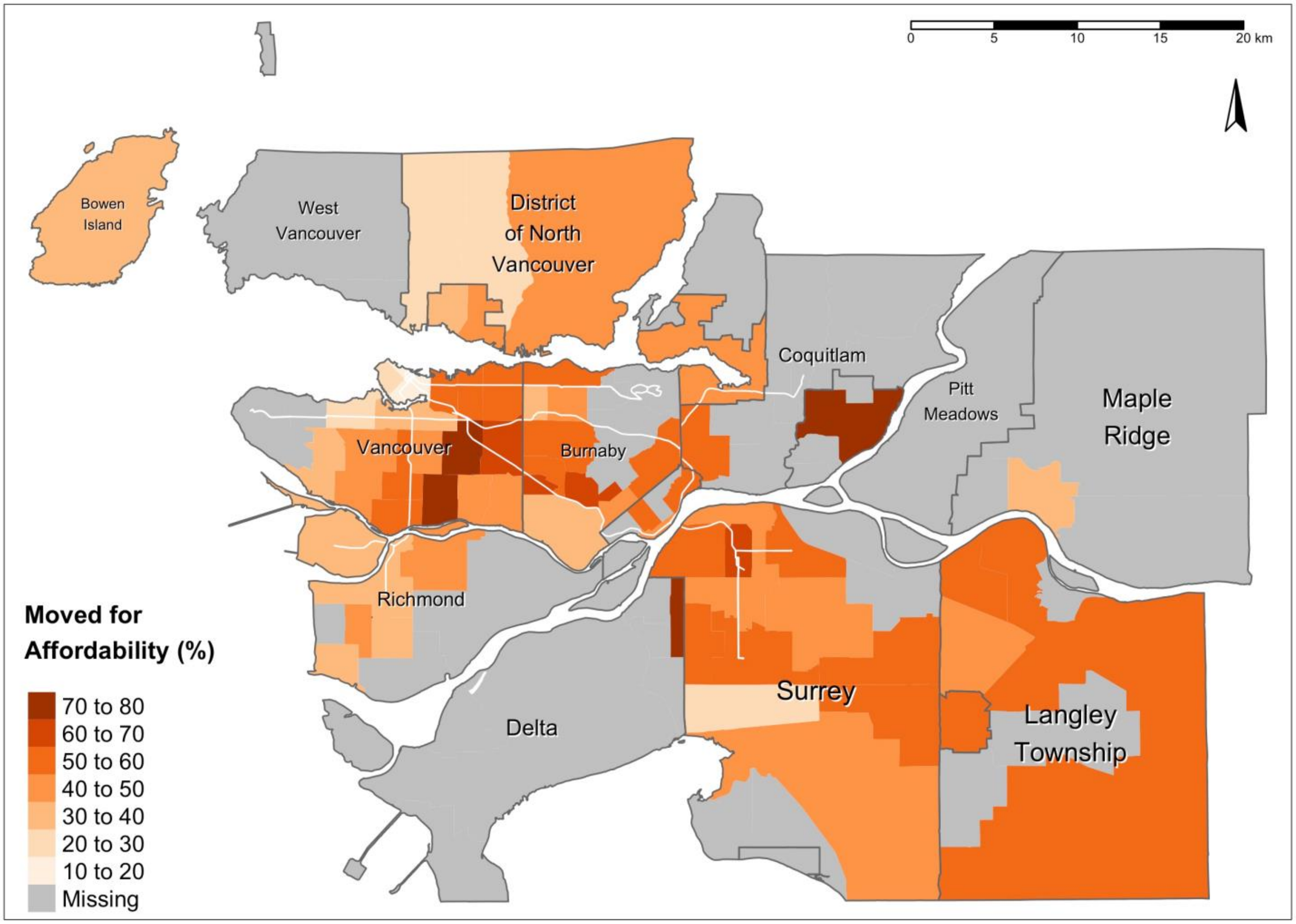

Figure 4.30 Moved to current neighborhood for affordability reasons, Metro Vancouver region (N=63)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

Finally, the relationship between the two variables is also examined using the Chi-square significance test, with information from Table 4.12.

Table 4.12 MUPOD/reason for moving to current neighborhood (restrict to those whose length in neighborhood <2 years) contingency table

MUPOD	Survey Respondents Who Moved to the Neighborhood for Affordability (%)	Survey Respondents who Moved to the Neighborhood for Other Reasons (%)	Total Number of Respondents (%)
Very Low	1,096 (4.94%)	1,782 (8.03%)	2,878 (12.97%)
Low	1,114 (5.02%)	1,285 (5.79%)	2,399 (10.81%)

MUPOD	Survey Respondents Who Moved to the Neighborhood for Affordability (%)	Survey Respondents who Moved to the Neighborhood for Other Reasons (%)	Total Number of Respondents (%)
Medium Low	3,153 (14.21%)	3,115 (14.03%)	6,268 (28.24%)
Medium High	3,523 (15.87%)	3,709 (16.71%)	7,232 (32.58%)
High	1,034 (4.66%)	2,384 (10.74%)	3,418 (15.40%)
Total Number of Respondents (%)	9,920 (44.69%)	12,275 (55.31%)	22,195 (100)

4.7 Household Income

Household income information was derived from MHMC survey responses to a reported income level question. The non-response for this question ranged from 16% to 32% depending on the community, the rate resembles similar large surveys.

MHMC neighborhood profiles included aggregated information which were used to create the following continuous variables:

- Household annual income equal or under $40,000 (*HI.Under40k*),
- Household annual income between $40,000 and $100,000 (*HIbetween40k100k*),
- Household annual income equal or over $100,000 (*HIover100k*).

Variable distributions are described in Figure 4.31. The variable *HI.Under40k* ranged from 6.9% in Port Moody to 75.6% in Strathcona (Vancouver) as illustrated in Figure 4.33. The median equals 28.35% (mean=28.84, sd=12.24, NA's=20) (see Figure 4.31). *HIover100k* ranged from a minimum of 9.6% in Surrey Central (Surrey) to 63.7% in Central Coquitlam (Coquitlam) as illustrated in Figure 4.34. The median equals 33.8% (mean=34.14, sd=12.56, NA's=6). Finally, the relationships between MUPOD and household income under $40,000 and over $100,000 are described in Figure 4.32. A higher MUPOD score is associated with the variable household income under $40,000 at a 95% confidence level, whereas there is a negative association between MUPOD and household income over $100,00 (also statistically significant at a 95% confidence level). These results are contrary to the dissertation conceptual model. Results of the estimation model are further discussed in Section 6.1.

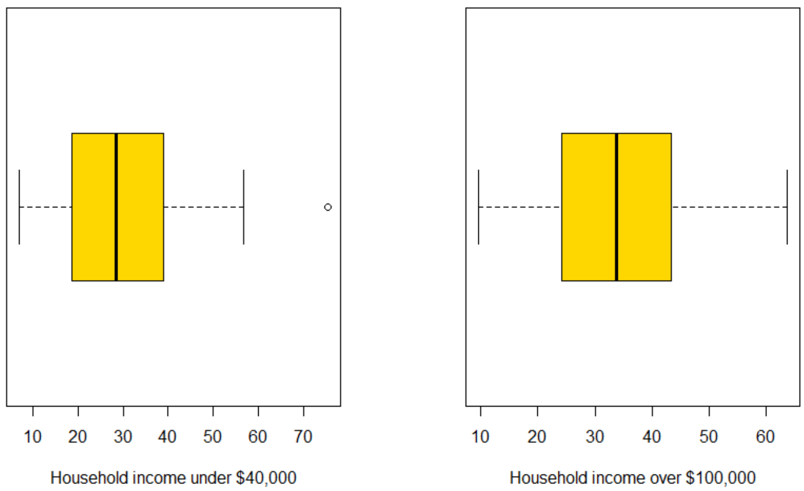

Figure 4.31 Household income under $40k (left) and over $100k (right) distributions, Metro Vancouver (N=86, 100; respectively)

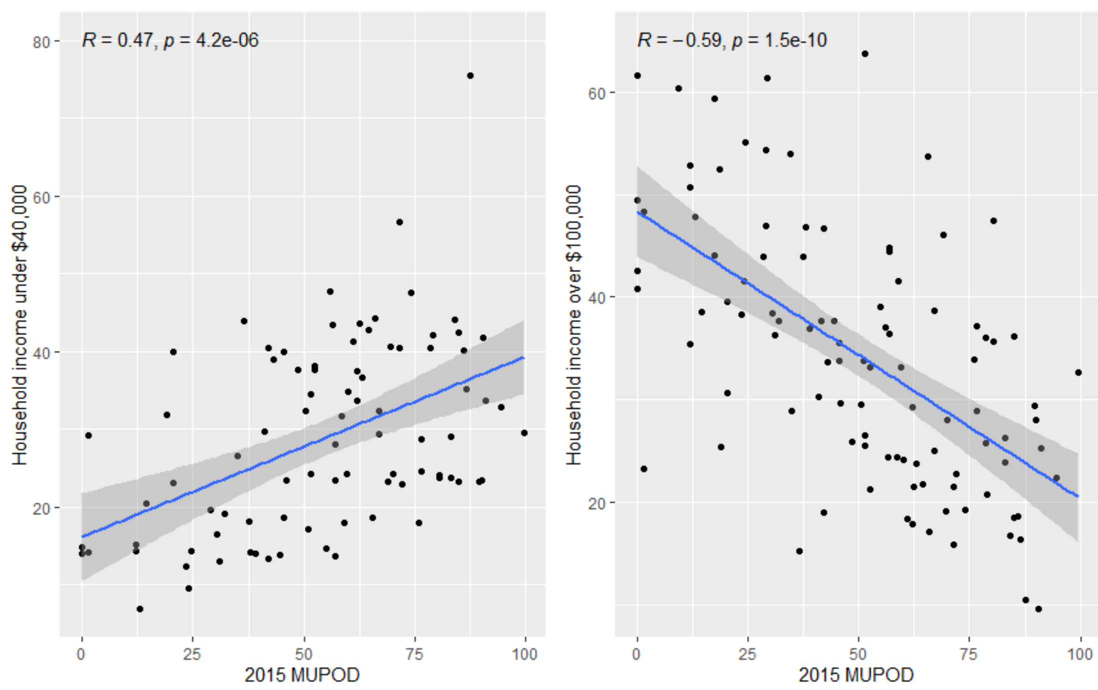

Figure 4.32 MUPOD associations with household income under $40k (left) and over $100k (right), Metro Vancouver (N=86, 100; respectively)

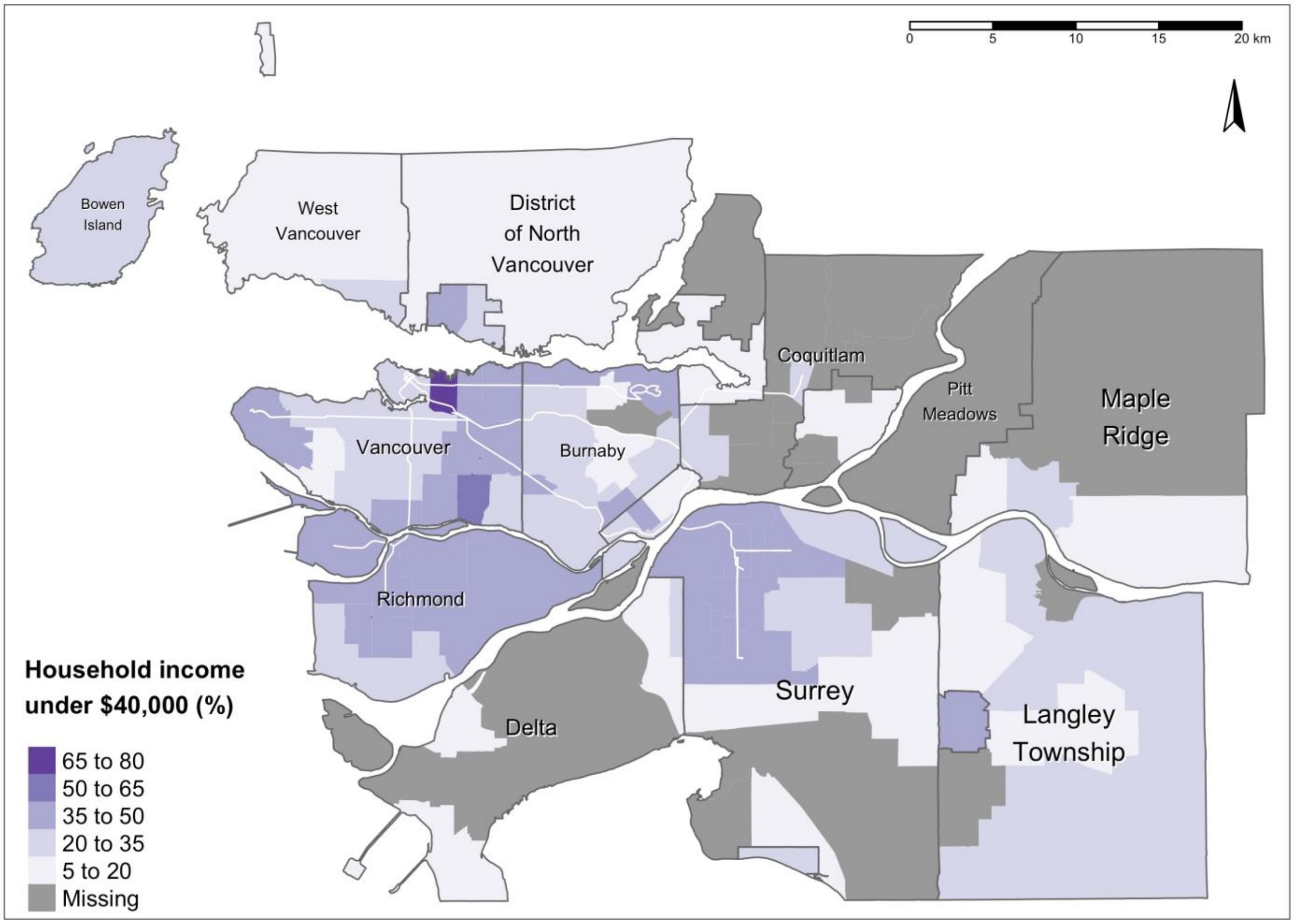

Figure 4.33 Household income under $40,000, Metro Vancouver region (N=86)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

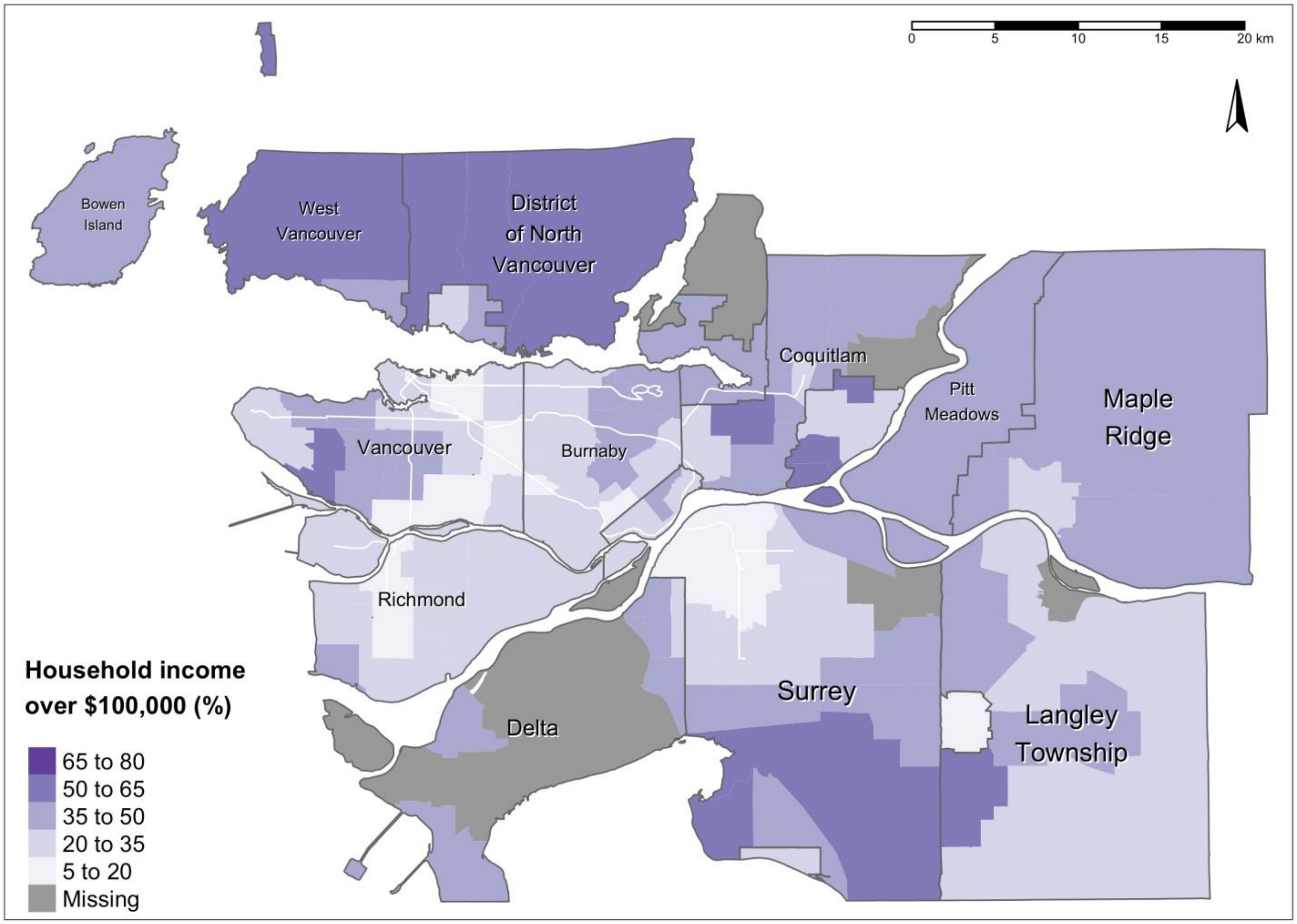

Figure 4.34 Household income over $100,000, Metro Vancouver region (N=100)
Notes: Map created for the purpose of this dissertation by Mielle Michaux, University of British Columbia

4.8 Control Variables

Table 4.13 provides summary statistics of the control variables used in the estimation models.

Table 4.13 Summary statistics of the control variables

Abbreviation	Variable Description	Range	Mean (sd)
Age.65+	Respondent is over 65 years of age	4.9/39.8 (%)	14.65 (5.92)
Gender.Male	Gender of respondent is male	36.40/ 56.60 (%)	45.53 (3.05)

Abbreviation	Variable Description	Range	Mean (sd)
Edu.Uni	Respondent reports university degree as highest level of education	11.70/ 73.50 (%)	32.81 (12.46)
Marital.Married	Respondent reports married or common law	28.50/ 81.10 (%)	61.68 (9.72)
Live.Alone	Respondent lives alone	5.40/ 50.70 (%)	18.66 (8.28)
Lot.area	Represent the lot area (units in squared meter)	0/1.301e+09[71] (sqm)	3.091e+04 (3,526,785)
Hsg.Size.FA	Represents the unit size or floor area (units in squared meter)	1/17,672 (sqm)	1,845 (1,085.4)
Stories	Represents the number of stories	0/918[72]	3.89 (6.97)
Bathrooms	Represents the sum of full- and part-bathrooms in the unit	0/48[73]	2.45 (1.25)
Basement	Unit has a basement	0/1	N/A
Garage	Unit has a garage	0/1	N/A
Struc.Age	Represents the year in which the structure was built	0/137	37.95 (23.73)
Hsg.Size.Studio	Housing size is studio	0/1	N/A
Hsg.Size.1BR	Housing size is one bedroom	0/1	N/A
Hsg.Size.2BR	Housing size is two bedrooms	0/1	N/A
Hsg.Size.3+BR	Housing size is three or more bedrooms	0/1	N/A
Hsg.Type.GroundAttached	Housing type is ground-oriented attached dwelling (i.e. semi-detached house, row/townhouse, duplex/triplex/quadplex)	0/1	N/A
HsgType.MFHhigh	Housing type is multifamily home (apartment or condo)	0/1	N/A

[71] This property is listed in BCAA dataset as a single-family home on Graham Dr in Tsawwassen.
[72] This is likely a BCAA typo. The second high floor number documented is 634 (typo as well?). The third and fourth highest numbers are 121 and 52 stories, respectively.
[73] This property is listed in BCAA dataset as having 47 full bathrooms and 1 part-bathrooms in a two-bedroom condo in downtown Richmond which does not seem possible and is therefore likely to be a typo in the original dataset.

Abbreviation	Variable Description	Range	Mean (sd)
HsgType.SingleFam	Housing type is single family detached home	0/1	N/A
Hsg.Type.2.SF	Housing type is single family detached home	0/1	N/A
Hsg.Type.2.HighDense	Housing type is high-density units (apartment/condo/townhouse/etc.)	0/1	N/A
Townhouse	Housing type is townhouse	0/1	N/A
Dist.VanDT	Entry indicates distance from Vancouver Downtown (km)	0/47	19 (12)

Chapter 5: Estimation Model Results

This chapter outlines the results stemming from the model estimations. The four relationships per each research question are described in separate sections. Section 1 discusses the relationship between MUPOD and health and social well-being, Section 2 discusses the relationship between MUPOD and housing value, Section 3 discusses the relationship between MUPOD and key reason for moving to current neighborhood, and Section 4 is on the relationship between MUPOD and household income under $40,000. Rejection or acceptance of the dissertation's conceptual model (or the hypotheses) is mentioned in each section. Section 5 summarizes the model results.

5.1 MUPOD and Health and Social Well-Being

Research question #1: *Controlling for Relevant Personal Characteristics, Is There A Significant Association Between the Degree of Neighborhood MUPOD and Health and Social Well-Being Outcomes?*

Estimation of Equation 3.1 of the relationship between MUPOD and health & social well-being index shows that approximately 61% of variation in the health and social well-being index can be explained by the model (see Table 5.1). The model associates a 1-point increase in MUPOD with a 0.01-point reduction in the health & social well-being index on average (holding age, gender, education, marital status, and living arrangement constant). The p-value of the F-statistics is 3.056e-10. Because the probability is greater than .05, the correlation coefficient is not statistically significantly different from zero and the alternative hypothesis is rejected. This means that, for a fixed neighborhood with a certain MUPOD score and of certain household personal characteristics which were adjusted for in the model, changes in MUPOD will not predict the *Health.SWB.Index* such that it cannot be attributed to anything other than a chance finding.

Separate linear relationships are modeled for *Ment.Health.Exc*, *Obese*, and *SOB.Strong* as these have shown to have associations with MUPOD (see Section 4.4.1) where the probability of obtaining the p-value is less than .05. None of these, however, demonstrate probabilities greater than .05 when adjusting for personal characteristics (see Appendix E).

Lastly, the first two dimensions from the PCA results are entered in the estimation model (see Table 5.2 and Table 5.3). While the second PC (namely *Negative.Health.Impact*s) produces negative associations with MUPOD such that the probability of obtaining our test statistics by chance is less than .05, the model explains only 11% of the variation in the negative health score (compared to 61% explained by the model when using the health and social well-being index). The correlation coefficient of the relationship between MUPOD and the positive health impacts component (*Positive.Health.Impacts*) is greater than .05 such that it cannot be attributed to anything other than a chance finding.

Table 5.1 Estimation model summary: MUPOD and health and social well-being index

Model Info				
Observations	65 (41 missing obs. deleted)			
Dependent Variable	*Health.SWB.Index*			
Type	OLS linear regression			
Model Fit				
	F(6,58)	14.94		
	R^2	0.61		
	Adj.R^2	0.57		
	Est.	S.E.	t val.	P
(Intercept)	3.77	10.97	.34	.73
MUPOD15	-.01	.02	-.38	.70
Age.Over65	.03	.08	.33	.74
Gender.Male	-.02	.17	-.13	.90
University	.24	.03	7.09	***
Marital.Married	.25	.08	3.15	**
Live.Alone	.15	.08	1.91	.
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

Table 5.2 Estimation model summary: MUPOD and positive health impacts principal component

Model Info				
Observations	106			
Dependent Variable	*Positive.Health.Impacts*			
Type	Linear regression			
Model Fit				
	$X^2(1) = 3.89$ $p = 0.19$			
	Pseudo-R^2 (Cragg-uhler) = 0.02			
	Pseudo-R^2 (McFadden) = 0.00			
	AIC = 390.08, BIC = 398.07			
	Est.	S.E.	t val.	P
(Intercept)	.35	.30	1.16	.25
MUPOD15	-.01	.01	-1.32	.19
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

Table 5.3 Estimation model summary: MUPOD and negative health impacts principal component

Model Info				
Observations	106			
Dependent Variable	*Negative.Health.Impacts*			
Type	OLS Linear regression			
Model Fit				
	F(1, 104)	13.48	p-value= 0.000383	
	R^2		.11	
	Adj.R^2		.11	
	Est.	S.E.	t val.	P
(Intercept)	.77	.24	3.22	***
MUPOD15	-.02	.00	-3.67	***
Standard errors: OLS Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

The lack of statistical evidence to suggest that the probability of obtaining a p-value less than .05 between MUPOD and health outcomes is consistent with a study of older adults in which neighborhood walkability did not explain obesity (measured by BMI) (Sriram et al., 2016). However, results from other cross-sectional studies have mostly established a positive association (Boyle et al., 2014; Doyle et al., 2006; Frank et al., 2005; Giles-Corti et al., 2016; Li et al., 2009; Renalds et al., 2010; Talen & Koschinsky, 2014). Possible explanations to the dissertation's estimation model results are discussed in Section 6.1.

5.2 MUPOD and Housing Value

Research question #2: *Controlling for Relevant Neighborhood Characteristics, Is There A Significant Association Between the Degree of Neighborhood MUPOD and Housing Costs?*

Estimation of Equation 3.2 of the relationship between MUPOD and house value shows that approximately 17% of variation in 2011 total median rent in the Metro Vancouver region is explained by the model (see Table 5.4, columns 2-5). The model associates an increase of 1 in

MUPOD score with a slight decrease ($4) in median rent on average in the Metro Vancouver region (adjusting for distance from Vancouver Downtown and including a dummy for COV) (though the effect is not big enough to be anything other than a chance finding). The second regression is limited to observations in Vancouver urban core[74] (Table 5.4, columns 6-9). It shows that approximately 4% of the variation in 2011 total median rent can be explained by the model's predictors. The model associates a 1-point MUPOD increase with approximately $2[75] decrease in median rent on average (p-value<.05). The third regression is run on observations in Vancouver's suburban periphery[76] (Table 5.4, columns 10-13). The model shows that 23% of the variability in 2011 total median rent is accounted for by the model. Further, the model associates a 1-point MUPOD increase with a $4 median rent decrease on average in neighborhoods in Vancouver suburban periphery (p-value>.05). The p-value indicates whether the F-statistics is statistically significant or whether the correlation coefficient is significantly different from zero.

2014 rent values are then entered in the model. Estimation of Equation 3.2 of the relationship between MUPOD and house value now shows that approximately 34% of variation in 2014 total median rent in the Metro Vancouver region can be explained by the model (see Table 5.5, columns 2-5). The model associates an increase of 1 in MUPOD score with a $3 decrease in median rent on average in the Metro Vancouver region (adjusting for distance from Vancouver Downtown and including a dummy for COV) (the probability of obtaining the value of the test statistics by chance is less than .05). The second regression is limited to observations

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[74] Including: Burnaby, City of North Vancouver, Richmond, and Vancouver.
[75] Table 5.4 – Table 5.8 present rounded figures.
[76] Including: Anmore/Belcarra, Bowen Island, Coquitlam, Delta, Langley City, Langley Township, Maple Ridge, New Westminster, Pitt Meadows, Port Coquitlam, Port Moody, Surrey, White Rock, District of North Vancouver, and West Vancouver.

in Vancouver urban core (Table 5.5, columns 6-9). It shows that approximately 11% of the variation in 2014 total median rent can be explained by the model's predictors. The model associates a 1-point MUPOD increase with a $3 decrease in median rent on average in neighborhoods in Vancouver urban core (p-value>.05). The third regression is run on observations in Vancouver's suburban periphery (Table 5.5, columns 10-13). The model shows that 37% of the variability in 2014 total median rent is accounted for by the model. The model associates a 1-point MUPOD increase with a slight decrease ($2) in median rent on average in neighborhoods in Vancouver suburban periphery (p-value<.05). The p-value of the F-statistics signifies whether the correlation coefficient is statistically significantly different from zero. A similar model was also estimated using the number of bedrooms (see Appendix F).

To conclude, results documented in Table 5.4 and in Table 5.5 indicate a negligible impact of MUPOD on rent values in the Metro Vancouver region, Vancouver urban core area or its suburban periphery. These results do not align with the dissertation's conceptual framework in which MUPOD is expected to be positively associated with house/rent values (Figure 3.1).

Table 5.4 Estimation model summary: MUPOD and 2011 median rent total

	Metro Vancouver				Vancouver Urban Core				Suburban Periphery			
Model Info												
Observations	N = 106				N = 45				N = 61			
Dependent Variable: *Census_total_2011MedRent*												
Type	OLS linear regression											
Step 1												
	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P
Constant	1182	40.90	28.90	***	1202	89.84	13.38	***	1202	46.66	25.75	***
MUPOD15	-2.13	.73	-2.90	**	-2	1.37	-1.17	.25	-4	1.00	-3.68	***
Step 2												
Model Fit												
	$F(3, 102) = 6.73$				$F(3, 41) = .59$				$F(2, 58) = 8.56$			
	$R^2 = 0.17$				$R^2 = 0.04$				$R^2 = 0.23$			
	Adj.$R^2 = 0.14$				Adj.$R^2 = -.03$				Adj.$R^2 = .20$			
MUPOD15	-4	.87	-4.24	***	-2	2.30	-1.02	.31	-4	1.01	-4.05	***
Dist.VanDT	0	.00	-2.88	**	0	.01	-.65	.52	0	.00	-1.76	.
Standard errors: OLS												
Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1												

Table 5.5 Estimation model summary: MUPOD and 2014 median rent total

	Metro Vancouver				Vancouver Urban Core				Suburban Periphery			
Model Info												
Observations	N = 106				N = 45				N = 61			
Dependent Variable *CMHC_total_2014MedRent*												
Type	OLS linear regression											
Step 1												
	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P
Constant	1004	41.22	24.35	***	1160	90.75	12.78	***	1004	43.57	23.06	***

	Metro Vancouver				Vancouver Urban Core				Suburban Periphery			
Model Info												
MUPOD15	0	.74	.31	.76	-1	1.38	-.67	.50	-1	.93	-1.51	.14
Step 2												
Model Fit												
	F(3, 102) = 17.78				F(3, 41) = 1.65				F(2, 58) = 16.79			
	R^2 = 0.34				R^2 = 0.11				R^2 = 0.37			
	Adj.R^2 = 0.32				Adj.R^2 = 0.04				Adj.R^2 = 0.34			
MUPOD15	-3	.75	-3.70	***	-3	2.22	-1.20	.24	-2	.78	-3.09	**
Dist.VanDT	0	.00	-6.13	***	0	.01	.40	.69	0	0	5.49	***
Standard errors: OLS												
Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1												

Assessed.value is used in the model as another housing value measure. Estimation of Equation 3.2 of the relationship between MUPOD and house value shows that 90% of the variation in assessed housing values for *single-family units* in the Metro Vancouver region can be explained by the model's predictors (columns 2-5 in Table 5.6) [77]. The model associates a 1-point MUPOD score increase with a $549 decrease in the assessed housing value for single-family units on average (holding lot area, floor area, number of bedrooms, number of stories, number of bathrooms, basement, garage, and structure age constant and controlling for city fixed effects) (however, the effect is not big enough to conclude that this impact can be attributed to anything other than a chance finding). Columns 6-9 in Table 5.6 present regression results for *high-density units* in the Metro Vancouver region. Similarly, the model indicates that 90% of the variation in assessed housing values can be explained by the model. The model associates a 1-point MUPOD score increase with a $994 increase in the assessed housing value for *high-density units* on average (holding floor area, number of bedrooms, number of bathrooms, and structure age constant[78]; including a dummy variable for "townhouse"; and controlling for city fixed effects) (p-value>.05). Only results for high-density units align with the conceptual framework of this dissertation (see Figure 3.1).

Next, Table 5.7 presents Equation 3.2 results of the relationship between MUPOD and house value for properties in Vancouver urban core. The model is run separately for single-family units (columns 2-5) and for high-density units (columns 6-9). The model indicates that

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[77] Hedonic regressions with *Assessed.value* as the independent variable included a "city fixed effects" argument to control for housing differences across the Metro's municipalities as well as a COV dummy and they are adjusted for "clustered standard errors".
[78] Lot area, basement, and garage are removed from the high-density regressions as many observations are missing. Moreover, the variable "Stories" is found inaccurate for high-density units and is also removed from the model.

90% of the variation in assessed housing values can be explained by the model's predictors for single-family units in Vancouver urban core. The model associates a 1-point MUPOD score increase with a $2,531 increase in the assessed housing value on average for single-family units (holding lot area, floor area, number of bedrooms, number of stories, number of bathrooms, basement, garage, and structure age constant and controlling for city fixed effects) (however, the effect is not big enough to conclude that this impact can be attributed to anything other than a chance finding). Columns 6-9 in Table 5.7 show regression results for high-density units in Vancouver urban core. The model indicates that 91% of the variation in assessed housing values can be explained by the model. The model associates a 1-point MUPOD score increase with a $1,894 increase in the assessed housing value for high-density units on average (holding floor area, number of bedrooms, number of bathrooms, and structure age constant; including a dummy for "townhouse"; and controlling for city fixed effects) (the probability of obtaining the value of the test statistics by chance is less than .05). The p-value of the F-statistics is < 2.2e-16 for both runs, which is statistically significant because the correlation coefficient is significantly different from zero. This means that, for a fixed neighborhood with certain MUPOD score and of certain structural and neighborhood characteristics which are adjusted for in the model, changes in MUPOD will predict assessed housing values of all housing types in Vancouver urban core.

The last set of hedonic regressions to estimate Equation 3.2 of the relationship between MUPOD and house values are in Table 5.8. Table 5.8 describes properties in Vancouver suburban periphery. The model is run separately for single-family units (columns 2-5) and for high-density units (columns 6-9). The model indicates that 92% of the variation in assessed housing values for *single-family units* in Vancouver suburban periphery can be explained by the model's predictors. The model associates a 1-point MUPOD score increase with a $1,593 decrease in the assessed housing value for single-family units on average (holding lot area, floor area, number of bedrooms, number of stories, number of bathrooms, basement, garage, and structure age constant and controlling for city fixed effects) (the probability of obtaining the value of the test statistics by chance is less than .05). Finally, columns 6-9 in Table 5.8 present regression results for *high-density units* in Vancouver suburban periphery. The model indicates that 94% of the variation in the assessed housing value can be explained by the model. The model associates a 1-point MUPOD score increase with a $210 decrease in the assessed housing value for high-density units on average (holding floor area, number of bedrooms, number of bathrooms, and structure age constant; including a dummy for "townhouse"; and controlling for city fixed effects. The p-value of the F-statistics is $< 2.2e-16$, which is statistically significant because the correlation coefficient is significantly different from zero. This means that, for a fixed neighborhood with a certain MUPOD score and of certain structural and neighborhood characteristics which are adjusted for in the model, changes in MUPOD will predict assessed housing values of all housing types in Vancouver suburban periphery. Possible explanations for the model results are provided in Section 6.1.

Table 5.6 Hedonic estimation model summary: MUPOD and 2014 assessed housing value[79], Metro Vancouver

	Single-Family Units				High-Density Units			
Model Info								
Dependent variable	*Assessed.value*							
Type	OLS linear regression							
	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P
Step 1								
N	380,861				330,124			
Constant	769368	1686.02	456.32	***	328728	1499.72	219.19	***
MUPOD15	2179	31.95	68.21	***	1684	21.29	79.10	***
Step 2								
N	350,276 (30,585 missing obs. deleted)				300,300 (29,824 missing obs. deleted)			
	F(30, 350,246) = 109,693.36				F(26, 300,274) = 107,461.44			
	R^2 = 0.90				R^2 = 0.90			
	Adj.R^2 = 0.90				Adj.R^2 = 0.90			
MUPOD15	-549	879.90	.28	.53	994	406.70	2.44	*
Lot.area	0	.00	1.34	.18	NA	NA	NA	NA
Lot.area_squared	0	.00	-1.30	.19	NA	NA	NA	NA
Hsg.Size.FA	251	49.69	5.05	***	568	110.46	5.14	***
Hsg.Size.FA_squared	0	.00	-.37	.71	0	.00	-1.89	.
Bedrooms	-47959	952.26	-4.90	***	-13026	11771	-1.11	.27
Stories	-16764	1699.10	-.99	.33	NA	NA	NA	NA
Bathrooms	39474	853.16	4.70	***	2985	5236.1	.57	.57
Basement	-159250	1924.90	-8.16	***	NA	NA	NA	NA
Garage	19331	662.04	2.82	**	NA	NA	NA	NA
Struc.Age	1546	83.84	2.00	.	-4204	517.22	-8.13	***
Townhouse	NA	NA	NA	NA	-63595	18519	-3.43	***
Standard errors: OLS								

[79] The estimation model included a city fixed effects argument as well as a COV dummy. Moreover, results were adjusted for clustered standard errors.

	Single-Family Units	High-Density Units
Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1		

Table 5.7 Hedonic estimation model summary: MUPOD and 2014 assessed housing value[80], Vancouver urban core

	Single-Family Units				High-Density Units			
Dependent Variable	*Assessed.value*							
Type	OLS linear regression							
	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P
Step 1								
N	326,052				189,647			
Constant	889875	3535.34	251.71	***	324362	3307.78	98.06	***
MUPOD15	-1642	48.66	-33.74	***	2533	42.20	60.03	***
Step 2								
Model Fit								
N	138,528 (187,524 missing obs. deleted)				168,760 (20,887 missing obs. deleted)			
	$F(15, 138{,}513) = 85{,}130.69$				$F(11, 168{,}749) = 157{,}051.95$			
	$R^2 = 0.90$				$R^2 = 0.91$			
	Adj.$R^2 = 0.90$				Adj.$R^2 = 0.91$			
MUPOD15	2531	3176	.80	.43	1894	626.50	3.02	**
Lot.area	1	.00	1.57	.12	NA	NA	NA	NA
Lot.area_squared	0	.00	-1.59	.11	NA	NA	NA	NA
Hsg.Size.FA	422	94.71	4.46	***	747	125.49	5.96	***
Hsg.Size.FA_squared	0	.00	-1.11	.27	0	.00	-2.37	*
Bedrooms	-70189	15003	-4.68	***	-41827	19374	-2.16	*
Stories	57971	36059	1.61	.11	NA	NA	NA	NA
Bathrooms	60613	8002	7.57	***	1782	7556.20	.24	.81
Basement	-91893	20464	-4.49	***	NA	NA	NA	NA
Garage	27108	13146	2.06	*	NA	NA	NA	NA
Struc.Age	4030	1247.90	3.23	**	-4682	723.92	-6.47	***
Townhouse	NA	NA	NA	NA	-60547	19237	-3.15	**
Standard errors: OLS								

[80] The estimation model included a city fixed effects argument as well as a COV dummy. Moreover, results were adjusted for clustered standard errors.

	Single-Family Units	High-Density Units
Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

Table 5.8 Hedonic estimation model summary: MUPOD and 2014 assessed housing value[81], Vancouver suburban periphery

	Single-Family Units				High-Density Units			
Dependent Variable	*Assessed.value*							
Type	OLS linear regression							
	Est.	S.E.	t val.	P	Est.	S.E.	t val.	P
Step 1								
N	244,456				140,477			
Constant	873274	1409.57	619.53	***	417311	1190.79	350.45	***
MUPOD15	-3998	31.02	-128.89	***	-1623	20.51	-79.11	***
Step 2								
Model Fit								
N	222,312 (22,144 missing obs. deleted)				131,540 (8,937 missing obs. deleted)			
	F(26, 222,286) = 104,289.20				F(22, 131,518) = 87,311.70			
	$R^2 = 0.92$				$R^2 = 0.94$			
	Adj.$R^2 = 0.92$				Adj.$R^2 = 0.94$			
MUPOD15	-1593	763.56	-2.09	*	-210	254.66	-.82	.41
Lot.area	0	.00	1.43	.15	NA	NA	NA	NA
Lot.area_squared	0	.00	-1.39	.16	NA	NA	NA	NA
Hsg.Size.FA	127	22.51	5.63	***	252	52.12	4.84	***
Hsg.Size.FA_squared	0	.00	4.91	***	0	.00	.25	.80
Bedrooms	-27014	5143.30	-5.25	***	-158	6532.20	-.02	.98
Stories	-47528	10699	-4.44	***	NA	NA	NA	NA
Bathrooms	5357	4506.90	1.19	.23	2173	4310.80	.50	.61
Basement	-110988	15114	-7.34	***	NA	NA	NA	NA

[81] The estimation model included a city fixed effects argument as well as a COV dummy. Moreover, results were adjusted for clustered standard errors.

	Single-Family Units				High-Density Units			
Garage	28652	5008.70	5.72	***	NA	NA	NA	NA
Struc.Age	34	580.74	.06	.95	-3205	332.65	-9.63	***
Townhouse	NA	NA	NA	NA	-9878	8792	-1.12	.26

Standard errors: OLS

Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

5.3 MUPOD and Affordability as Main Reason for Moving

Research Question #3: *Does Housing Affordability Play A Significant Factor in Household Decisions to Move to Neighborhoods That Have Less Investment in MUPOD?*

Estimation of Equation 3.3 Estimation model of the relationship between MUPOD “moved for affordability reason shows that approximately 32% of variation in *Move.for.Afford* can be explained by the model (see Table 5.9). The model associates a 1-point MUPOD increase with a 2% increase in the share of households moving for affordability reasons on average (holding age and education constant). The p-value of the F-statistics is 0.0001438, which is not statistically significantly different from zero. This means that, for a fixed neighborhood with a certain MUPOD score and of certain households’ personal characteristics which are adjusted for in the model, changes in MUPOD will not help predict the share of households who *Move.for.Afford*.

Table 5.9 Estimation model summary: MUPOD and moved for affordability reasons

Model Info				
Observations	57 (49 missing obs. deleted)			
Dependent Variable	*Move.for.Afford*			
Type	OLS linear regression			
Model Fit				
	F(3,53)	8.18		
	R^2	0.32		
	Adj.R^2	0.28		
	Est.	S.E.	t val.	P
(Intercept)	68.11	7.89	8.63	***
MUPOD15	.02	.07	.28	.78
Age.Over65	.02	.38	.05	.96
University	-.67	.14	-4.95	***
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

Contingency Table 4.12 MUPOD/reason for moving to current neighborhood is used to perform the Chi-square test of independence. Results of the Pearson's Chi-squared test with Yates' continuity correction, show that the p-value is equal to 4.449e-08, and is more than the significance level (0.05). Therefore, we cannot reject the null hypothesis and conclude that the two variables are independent. Possible explanations for the lack of association found between MUPOD and “moved for affordability” is discussed in Section 6.1.

5.4 MUPOD and Household Income

Research Question #4: *Controlling for Relevant Personal Characteristics, Is There A Significant Association Between the Degree of Neighborhood MUPOD and the Share of Households Earning $40,000 Or Less?*

Estimation of Equation 3.4 of the relationship between MUPOD and household income under $40,000 shows that approximately 43% of variation in household income under $40,000 can be explained by the model (see Table 5.10). The model associates a 1-point increase in MUPOD score with a 22% increase in the share of households earning under $40,000 on average (holding age, gender, and education constant). The p-value of the F-statistics is 5.224e-08, which is significantly different from zero. This means that, for a fixed neighborhood with a certain

MUPOD score and of certain household personal characteristics which are adjusted for in the model, changes in MUPOD will predict the share of households earning $40,000 or less.

Table 5.10 Estimation model summary: MUPOD and household income under $40,000

Model Info				
Observations	75 (31 missing obs. deleted)			
Dependent Variable	*HI.Under40k*			
Type	OLS linear regression			
Model Fit				
	F(4, 70)	13.08		
	R^2	0.43		
	Adj.R^2	0.40		
	Est.	S.E.	t val.	P
(Intercept)	-53.60	21.48	-2.49	*
MUPOD15	.22	.05	4.82	***
Age.Over65	.49	.20	2.47	*
Gender.Male	1.54	.45	3.45	***
University	-.22	.09	-2.55	*
Standard errors: OLS Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

This result does not align with the dissertation's conceptual framework according to which increased MUPOD is negatively associated with household income under $40,000 as I expected low-income households to be displaced to neighborhoods characterized by lower MUPOD levels. Possible explanations are discussed in 6.1.

Finally, contingency Table 4.2 MUPOD/household income is used to perform the Chi-square test of independence. Results of the Pearson's Chi-squared test show that the p-value is < 2.2e-16 and is less than the significance level (0.05). Therefore, we can reject the null hypothesis and conclude that the two variables are not independent.

5.5 Estimation Model Results Summary

Table 5.11, Table 5.12 and Table 5.13 summarize the model results. In Table 5.11 the dependent variables are in the first row and the predictors (or independent variables) are in the first column. Step1 shows the model outputs of the relationships between MUPOD and the dependent variables *before* adjusting for personal characteristics. Step 2 describes the model outputs of the relationships between MUPOD and the dependent variables *after* adjusting for personal characteristics. Significant relationships (where the value of obtaining the test statistics by chance is less than .05) are marked with stars. Prior to personal characteristics adjustment (Step 1), I find negative associations between MUPOD and general health, mental health, obesity, and strong sense of belonging; and a statistically significant positive association between MUPOD and household income under $40,000 (the latter holds true after adjusting for personal characteristics).

2011 and 2014 median rent values (first row) are the dependent variables in the three subsets (Metro Vancouver, Vancouver urban core, and suburban periphery) described in Table 5.12. The predictors (or independent variables) are in the first column. Step1 shows the model outputs of the relationships between MUPOD and 2011/2014 median rent *before* adjusting for neighborhood characteristics. Step 2 describes the model outputs *after* adjusting for neighborhood characteristics and including a COV dummy. Significant relationships (where the value of obtaining the test statistics by chance is less than .05) are marked with stars.

Table 5.13 presents the relationship between MUPOD and 2014 assessed house value (or the dependent variable – first row) for three separate subsets (Metro Vancouver, Vancouver urban core, and Vancouver suburban periphery) and two house-type categories (single-family units, and high-density units). The predictors (or independent variables) are in the first column.

Significant relationships (where the value of obtaining the test statistics by chance is less than .05) are marked with stars. Step1 describes the model outputs *before* adjusting for neighborhood characteristics. Step 2 describes the model outputs *after* adjusting for neighborhood characteristics and controlling for city fixed effects. The probability of obtaining a p-value by chance is shown to be less than .05 when estimating the MUPOD/assessed value relationships (Step 2) for *high-density* units in Metro Vancouver and Vancouver urban core (positive); and for *single-family* units in Vancouver suburban periphery (negative).

Finally, to simplify, Table 5.14 indicates the direction of relationships between MUPOD and house value for the various categories examined in the hedonic regression models. That is, Table 5.14 shows whether increased MUPOD score predicts a positive (↑) or negative (↓)change (-) in rent/house values. Significant relationships at a 95% confidence level (where the value of obtaining the test statistics by chance is less than .05) after adjusting the model for neighborhood characteristics and controlling for city fixed effects are marked with a bold font.

Table 5.11 Estimation model results summary: MUPOD and health, moved for affordability and household income under $40,000

	Health & Social Well-Being Index		General Health (Exc.)		Mental Health (Exc.)		Obesity		Blood Pressure		Strong SOB		Confide 4+		Move for Affordability		HI Under $40k	
	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p
Step 1																		
MUPOD	-.02	.25	-.06	.	-.08	***	-.08	**	-.03	.17	-.08	*	.01	.65	.01	.90	.23	***
Step 2																		
MUPOD	-.01	.70													.02	.78	.22	***
Age 65+	.03	.74													.02	.96	.49	*
Male	-.02	.90													-.67	***	1.54	***
Uni Educ	.24	***															-.22	*
Married	.25	**																
Live Alone	.15	.																
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1																		

Table 5.12 Estimation model results summary: MUPOD and rent value

	2011 Median Rent						2014 Median Rent					
	Metro Vancouver		Vancouver Urban Core		Suburban Periphery		Metro Vancouver		Vancouver Urban Core		Suburban Periphery	
	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p
Step 1												
MUPOD	-2	**	-2	.25	-4	***	0	.76	-1	.50	-1	.14
Step 2												
MUPOD	-4	***	-2	.31	-4	***	-3	***	-3	.24	-2	**

	2011 Median Rent						2014 Median Rent					
Distance Van DT	0	**	0	.52	0	.	0	***	0	.69	0	***
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1												

Table 5.13 Estimation model results summary: MUPOD and house value

	Metro Vancouver				Vancouver Urban Core				Suburban Periphery			
	Single-Family		High-Density		Single-Family		High-Density		Single-Family		High-Density	
	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p	Est.	p
Step 1												
MUPOD	2179	***	1684	***	-1642	***	2533	***	-3998	***	-1623	***
Step 2												
MUPOD	-549	.53	994	*	2531	.43	1894	**	-1593	*	-210	.41
Lot area	0	.18	NA	NA	1	.12	NA	NA	0	.15	NA	NA
Lot area^2	0	.19	NA	NA	0	.11	NA	NA	0	.16	NA	NA
FA	251	***	568	***	422	***	747	***	127	***	252	***
FA^2	0	.71	0	.	0	.27	0	*	0	***	0	.80
BRs	-47959	***	-13026	.27	-70189	***	-41827	*	-27014	***	-158	.98
Stories	-16764	.33	NA	NA	57971	.11	NA	NA	-47528	***	NA	NA
Bathrooms	39474	***	2985	.57	60613	***	1782	.81	5357	.23	2173	.61
Basement	-159250	***	NA	NA	-91893	***	NA	NA	-110988	***	NA	NA
Garage	19331	**	NA	NA	27108	*	NA	NA	28652	***	NA	NA
Structure Age	1546	.	-4204	***	4030	**	-4682	***	34	.95	-3205	***
Townhouse	NA	NA	-63595	***	NA	NA	-60547	**	NA	NA	-9878	.26
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1												

Table 5.14 MUPOD/house value summary: direction of relationships

MUPOD	2011 rent			2014 rent			2014 assessed value					
							Metro Van		Urban core		Suburban periphery	
	Metro Van	Urban core	Suburban periphery	Metro Van	Urban core	Suburban periphery	Single-Family	High-density	Single-Family	High-density	Single-Family	High-density
↑	↓ **$2**	↓ $2	↓ **$4**	↓ **$3**	↓ $3	↓ **$2**	↓ $549	↑ **$994**	↑ $2531	↑ **$1894**	↓ **$1593**	↓ $210

Chapter 6: Discussion

This chapter reviews the overarching goal of the dissertation to contribute to the understanding of increased MUPOD and potential displacement of low-income households. The research asks how does living in a pedestrian-oriented neighborhood impacts one's health? Who can afford living in a neighborhood with a higher degree of MUPOD? Can individuals who are most likely to use transit live near it? Is there an equity distribution problem? The relationship between the independent and dependent variables are discussed in this framework considering the estimation model results. Possible explanations are given based on a review of the literature and discussions with fellow scholars (Section 1). Section 2 outlines the study's limitations. Policy implications such as the urgency to consider the local context of people, institutions, and political process in designing strategies aimed at increased walking (and thereby increased MUPOD) are brought in Section 3. Finally, and since this document is written in unprecedented times, Section 4 raises questions to MUPOD's meaning in a global pandemic context.

6.1 Walk and Thrive?

A longitudinal analysis of 2011 and 2016 Census/NHS data generated a view of gentrification processes in the Metro Vancouver region. The COV "leads" with the highest gentrification index scores in six of its neighborhoods (including, from high to low: Strathcona, Kensington-Cedar Cottage, Sunset, Grandview-Woodland, Mount Pleasant, and Riley Park). Interestingly, these neighborhoods also rate high on the MUPOD scale with scores ranging from 79 to 91 (except for Sunset with a slightly lower MUPOD index of 66). An examination of the correlation between the two indicators (that is, MUPOD and gentrification index), produces a positive correlation (where the value of obtaining the test statistics by chance is less than .05)

(R_s=.43; $p<0.05$; N=99). In the Metro Vancouver context, it can therefore be deduced that environments with high MUPOD levels are associated with gentrification processes[82].

It is hypothesized that residents of neighborhoods characterized by high MUPOD levels are associated with improved overall health and social well-being for residents. The dissertation's findings, however, question this relationship: I find a negative relationship between MUPOD and the health and social well-being index (though p-value>.05). This finding contradicts the understanding that residents of MUPOD environments benefit from improved health and social well-being which is generally treated as conventional wisdom.

While the lack of statistically significant association between MUPOD and health and social well-being is consistent with a study of older adults in which neighborhood walkability did not explain obesity (measured by BMI) (Sriram et al., 2016); my hypothesis was based on the majority of studies indicating that walkable neighborhoods, with more pedestrian-oriented design, have been found to be associated with higher levels of physical activity and lower levels of obesity (Boyle et al., 2014; Doyle et al., 2006; Frank et al., 2005; Giles-Corti et al., 2016; Li et al., 2009; Renalds et al., 2010; Talen & Koschinsky, 2014). The majority of studies also identified a negative correlation between sprawling, car-oriented environments and different health outcomes (Boyle et al., 2014a; Doyle et al., 2006; Frank et al., 2005; Giles-Corti et al., 2016; Li et al., 2009; Arlene Renalds et al., 2010; Talen & Koschinsky, 2014).

There are some important challenges that must be acknowledged in the discussion about the ways in which the built environment affects walking, and in turn the health and well-being of

[82] When studying gentrification or any other dynamic phenomena for that matter, there will always be unobserved or confounding variables that are likely to impact the estimation model (Creswell, 2008). An estimation model simplifies reality but the extent of this simplification and its impact on the study findings is not entirely clear.

residents. First, this research area typically focuses on wealthier environments (Giles-Corti et al., 2016; Talen & Koschinsky, 2014). In the Metro Vancouver context, where walkable environments (or those with high MUPOD levels) are found correlated with an increase in the share of low-income households[83] (this is statistically significant), the hypothesized health and social well-being benefits might not be applicable. Because most studies did not examine the effect of the built environment on specific population segments, the distinction by different socioeconomic characteristics is challenging (Saelens & Handy, 2008). One longitudinal study, for example, found that neighborhood poverty levels were associated with detrimental health outcomes (in particular, more poverty was linked to higher rates of obesity and diabetes) (Chiu et al., 2016).

Very little has been written on the health impacts of displacement and of living in gentrifying environments. Social network disruption, and the ongoing impacts of geographically segregated low-income communities, combined with increased chronic stress from displacement might result in exacerbated health outcomes to residents who are ultimately excluded from green improvements[84] (Anguelovski, Irazábal-Zurita, et al., 2019). Anguelovski, Connolly, Garcia-Lamarca, Cole, & Pearsall (2019) describe a paradox created at the intersection of urban redevelopment and greening initiatives: while greening produces economic, environmental and health benefits to many, it also introduces new or worsens existing challenges for some. To those who are not displaced, the disruption and negative impacts of gentrification processes and fear of displacement, might mask the potential positive impacts of urban greening (Anguelovski,

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[83] In particular, a 1-point MUPOD score increase is associated with a 22% increase in the share of households earning $40,000 annually.
[84] I argue that MUPOD can be viewed as “green improvement”.

Connolly, et al., 2019; Cole et al., 2017). Additional observation that might prove relevant in the Vancouver context relates to drug abuse. In gentrifying neighborhoods, the presence of drug culture draws gentrifiers (where drug trade attracts tourists or upper-class residents) but results in additional challenges to vulnerable individuals living in these environments who often must deal with high levels of stress and insecurity. Avoiding certain streets because of insecurity and fear of crime were also found to negatively impact mental health in gentrifying neighborhoods (Anguelovski, Triguero-Mas, et al., 2020).

While the green gentrification literature focuses on nature-based projects, perhaps expanding the framework to other sustainable neighborhood features such as walkability is appropriate. Walkability has been similarly shown to be associated with gentrification in Quastel, Moos, & Lynch (2012). The conceptual model developed by Cole et al. (2017) (see Figure 6.1) considers pedestrian infrastructure a New Greening Initiative. Greening impacts are argued to extend beyond the projects themselves into nearby environments, and are claimed to increase an active lifestyle, walkability and density (Immergluck & Balan, 2018). Similarly, green spaces are perceived as health inducing and are used in the new urbanism discourse (Dooling, 2009). It could potentially result in disruption to social networks, increased stress, and negative physical and mental health outcomes.

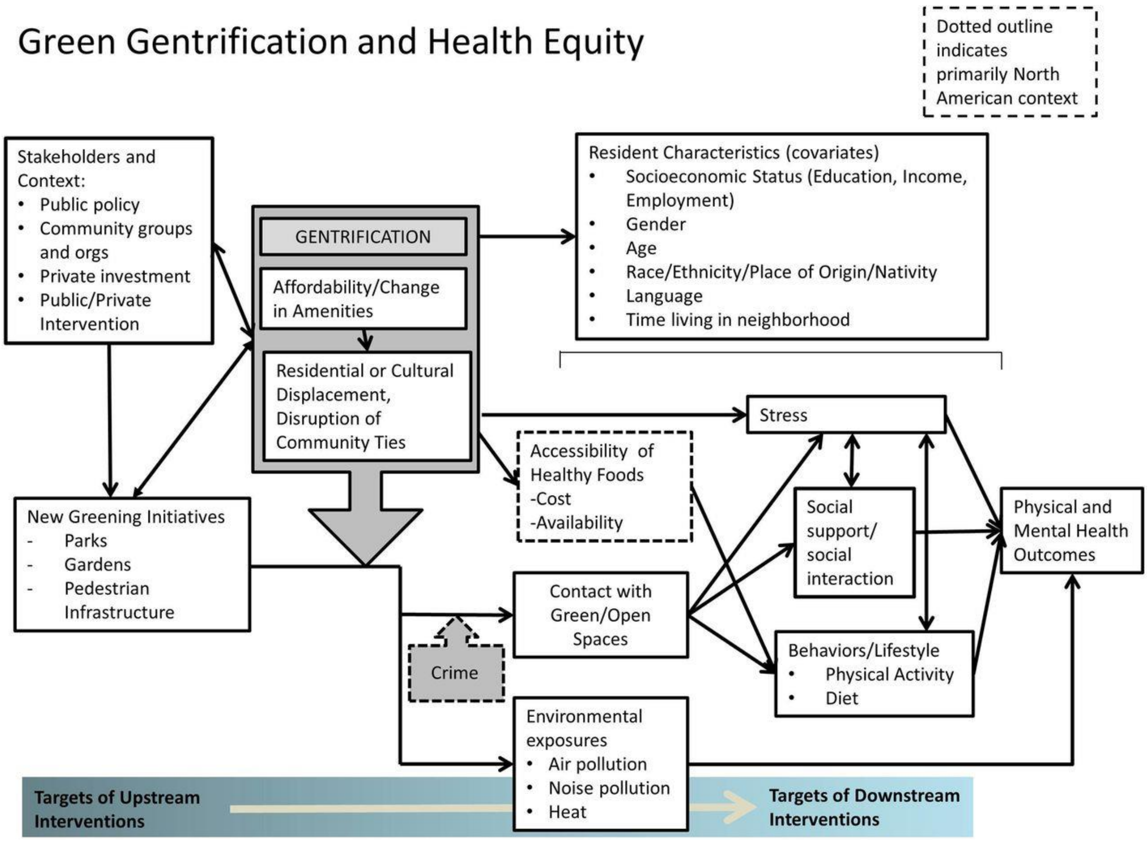

Figure 6.1 The green gentrification and health equity model
Source: Cole et al. (2017)

Classifying MUPOD under greening improvements makes the assumption that past research insights on walkability and health are not relevant to the context of this dissertation. Instead, transit-induced and the green gentrification literature need to be used to explain the processes observed in Vancouver.

Other challenges make it difficult to generate a strong body of evidence around walkability and health including inconsistency across studies which is often due to use of different research methods (e.g., different measures for the built environment, different buffers that define neighborhoods) (Christiansen et al., 2016; Myers & Gearin, 2001; Saelens & Handy, 2008; Talen & Koschinsky, 2014). While health-related studies typically utilize walkability indices as a built environment measure; the transit-induced gentrification literature focuses on investment in transit infrastructure. This dissertation leverages both: MUPOD captures Walk and Transit Score™. Capturing a wider range of built environment characteristics is a methodological contribution to the field.

Another important issue is the lack of ability to prove a causal relationship due to cross-sectional data, self-selection and confounding socioeconomic variables (i.e. people who are prone to walking/social interaction choose to live in more walkable/social environments) (Braun et al., 2016; Giles-Corti et al., 2016; Kim & Kaplan, 2004; Rao et al., 2007; Rogers et al., 2011; Saelens & Handy, 2008; Talen & Koschinsky, 2014; Wasfi et al., 2016). It is possible that in the Metro Vancouver case, and because we observe a statistically significant positive relationship between MUPOD and the share of low-income households, such low-income households cannot afford to choose to live anywhere else, regardless of their travel preferences. Some individuals with certain housing preferences (such as, a preference to live close to downtown or alternatively in less-dense environments) find it challenging to obtain such housing despite their preferences and so they might be forced to live in neighborhoods with different characteristics (Stevens, 2017). The health benefits that were expected in more walkable, mixed-use environments are therefore not documented here.

Stevens (2017) summarizes some possible explanations for the reported confounding finding on the topic of compact neighborhood design and driving that are relevant to the context of this dissertation. He suggests variations in sample size, self-selection, and importantly, selective reporting – a common practice where only statistically significant results and those matching to conventional knowledge are being reported. His paper concludes that even though compact design (including: density, diversity, destination accessibility and distance to transit) is found positively associated with less driving (that is, more compactly deigned spaces suggest that people will drive less), the magnitude of this association or the impact on actual driving is not strong (Stevens, 2017).

Further, it is indicated that immigrant women often choose amenities based on ethnic and cultural background and not proximity. For example, women interviewed in a Vancouver study on immigrant perceptions of walkability chose to bus/drive a further distance from their homes to certain shops where the staff speaks their language or where the selection on offer caters their tastes/needs (personal communication with Ebneshahidi, M. via Zoom, October 29, 2020[85]). This is especially important in the Metro Vancouver region: a home to over 37,000 recent immigrants between 2011 and 2016 (82% of the province's recent immigrant population) (*Immigrant Demographics, Vancouver, B.C.*, 2018).

Public health researchers have emphasized the need to expand the investigation of neighborhood environments and health to include local level physical and social factors such as transit access, social networks, disorder, crime, economic activities, or unemployment. This is particularly important in studying gentrification where dynamic neighborhood processes impacts the health of communities and individuals. Anguelovski et al. (2020), for example, reported an association between gentrification and improved health outcomes for privileged populations while identifying neutral or negative associations for vulnerable populations. Research on obstacles to walking for different populations is thus needed.

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[85] Marjan Ebneshahidi is a researcher at UBC that studies walkability perceptions among immigrant women.

While it becomes clear that different built environments contribute to uneven health outcomes for communities of different socioeconomic status, the exacerbated health impacts resulting from increased demand for inner city neighborhoods need to be acknowledged. A complementary qualitative investigation is necessary in the Metro Vancouver context to better understand the underlying cultural, social, and physical impacts of gentrification (or fear of) and its impact on the health of individuals. This will help to explain how different planning strategies aimed at neighborhood enhancement unevenly affect health. Moreover, longitudinal research will provide a broader view of these processes and will also help to shed light on gentrification effects.

The dissertation's findings indicate a negligible impact of MUPOD on rent values. These results somewhat contradict current literature pointing to housing price appreciation in areas where infrastructure to promote active transportation mode is put in place (suggesting that improved accessibility results in increased desirability of these residential environments) (Bartholomew & Ewing, 2011; Leinberger, 2008; Leinberger & Alfonzo, 2012; Stokenberga, 2014; Wang & Immergluck, 2015; Zuk, Bierbaum, Chapple, Gorska, & Loukaitou-Sideris, 2018).

In alignment with the dissertation's conceptual framework (see Figure 3.1), I find positive associations between MUPOD and 2014 assessed house values when using BCAA data as the independent variable in the hedonic estimation models in the Metro Vancouver region for high-density units (this is statistically significant at a 95% confidence level) but an insignificant negative relationship for single-family units in the Metro Vancouver region as a whole. Positive MUPOD/house value relationships are observed in the Vancouver urban core for both house types (though only statistically significant at a 95% confidence level for high-density units).

However, when modeling the MUPOD/assessed house value relationship in Vancouver's suburban periphery, the relationship turns negative for both single-family and high-density units (that is, a higher MUPOD score predicts *reductions* in assessed house values in Vancouver's suburban periphery neighborhoods). It is fair to conclude then, that MUPOD predicts increased housing values in high demand areas, but it is less so at further distances from the downtown core. These findings reinforce Edelson et al.'s (2019) observation that increased transit investment at one locale might contribute only to the already well-off by not considering affordable housing measures for middle- and low-income households. And that due to lack of affordable housing partly induced by investments in transit-oriented development and building compact communities, moderate-income households are pushed out of the central core into suburban neighborhoods in the Metro region (Edelson et al., 2019; Kloepper, 2017).

The estimation model results produced an positive correlation between MUPOD and households moving for affordability reasons (p-value>.05). Ding et al. (2016), as well, did not find support to increased rate of movers from gentrifying neighborhoods to lower-income neighborhoods compared to non-gentrifying neighborhoods.

Even so, neighborhoods that scored high on affordability as a reason for moving are located away from the Metro's CBD. My motivation to research this topic was prompted by a story of a close friend who was forced to move away from the City upon buying a house because of affordability reasons and the moving's questionable impacts on his family's mental health and social well-being. This narrative is familiar to those living in Vancouver and in other global cities as well. It is worth noting that the sample size was limited (N=57) because data was suppressed where sample size was smaller than 20 (the survey question was limited to households who had moved in the past two years) and/or where variation coefficients were greater than 33.3%. Moreover, the variable "moved for affordability" tells us who moved from their origin neighborhood because it was less affordable than their current one for affordability reasons. However, one cannot conclude that these households were effectively displaced. A qualitative approach to explore this research question is necessary. I believe that locating and interviewing such households who had moved for affordability would inform this area of investigation.

It remains to be asked whether an examination in 5- or 10-years' time will produce different results that will support the hypothesis that investments to increase MUPOD in inner city neighborhoods lead to displacement? Or perhaps there are more suitable measures than MUPOD to test this relationship? Future studies can explore these questions further.

Lastly, I present evidence that MUPOD and household income under $40,000 are both dependent and positively correlated (that is, increased MUPOD levels predict higher percentages of low-income households) (R_s =.47; $p<0.05$). This clashes with my conceptual framework according to which affordability is a significant factor in household moving decisions to low MUPOD neighborhoods, and that fewer low-income households[86] reside in high MUPOD neighborhoods. Existing research indeed has produced mixed results as to the relationship between transit spatial infrastructure and income distribution. A study involving several cities including New York, found that areas with greater concentration of public transit were more likely to contain lower-income households. Public transit is less expensive than car ownership which can help explain this finding. Moreover, it is suggested that neighborhoods with more

[86] Household income under $40,000 reflects low-income cut-off used in the analysis. While 2016 Census definition refers to $40,000 for two-person households, household size is not considered here. This decision was made based on data availability. While it is difficult to afford housing on this annual income, there are certainly worse circumstances and results need to be interpreted accordingly.

transit stops resulted in slower travel times which impacted its desirability and therefore attracted less wealth. On the other hand, neighborhoods with high concentration of rapid transit stops were found associated with higher wealth in another study because of the way these were perceived as efficient and shortened travel times (Barton & Gibbons, 2017).

Considering Vancouver's low-income geographical context might contribute to further understanding of this dissertation results. Increased housing and rent costs along with a near-zero vacancy rate in the COV have resulted in severely unaffordable housing market and stress for households across the housing continuum, but especially for those with extremely low incomes. It is known that a significant portion of those earning under $30,000 are spending more than half of their income on housing and are at increased risk of losing their homes. Single Room Occupancy (SROs) hotels which contain very small single rooms and shared bathrooms, and kitchen are part of Vancouver's low-income housing stock as a final solution before becoming homeless for many of the most vulnerable community members. SROs comprise of roughly 7,000 units which are in the Downtown Core (94% of which in the Downtown Eastside) – where MUPOD is very high (*Single Room Occupancy (SRO) Revitalization Action Plan*, 2017).

Research so far has mostly focused on interactions between built form, and either health outcomes, or housing prices. The proposed contribution of this research lays in bridging these areas of research together. By linking data from different sources, this dissertation tells a broader, more holistic story. While results cannot be used to explain causation, they encourage conversation on relevant correlational associations of closely connected factors namely accessibility, health, housing, social inequality, and displacement

Maybe the answer, more broadly, is that it is not those households earning under $40k who are being displaced? Maybe those earning under $40k cannot even afford to move?

Considering Vancouver's Downtown core large low-income population provides some explanation. What are the costs of their staying then?

6.2 Limitations

This study is limited in several ways. Data had to be derived from different sources to explore the research questions[87] and as a result some compromises had to be made. Access to the MHMC health data guided the process and the timeline was therefore restricted to the years 2013/2014. Because Walk Score™ methodology was improved in 2014, most neighborhood and city scores pre- and post-update have changed due to longer routed distances, intersection density, block length, and mixed-use development that were not considered in the old method. The dissertation analysis, therefore, uses comparable Walk Score™ data from 2015 and 2020. The possibility exists that changes have occurred to the physical environment between the time participants completed the MHMC survey (2013/14) and when Walk Score™ was documented (2015). It also meant that rather than including same year data in two sides of the estimation models as per common practice in cross-sectional analysis, some estimations included older information in the right hand-side specifications.

In addition, specific latitudes and longitudes were used to match each MHMC neighborhood with a Walk and Transit Score™. Spatial information provided by the MHMC team represents the center point of each neighborhood using health authority boundaries. Walk Score™, however, utilizes census boundaries which introduced an element of mismatch.

[87] It was decided to use *existing* data sets instead of collecting data which I thought to be an unrealistic task considering the limited resources available to a PhD student.

Moreover, because the MHMC survey uses health authority boundaries, matching results to other available information such as the NHS and RMS was challenging and required integration of areal weighting methods. Areal weighting is subjected to estimation errors. It is generally assumed that all population and housing characteristics can be allocated across tracts in similar proportions as the total population. Yet, errors in total population estimates can be more significant for specific communities or for specific personal characteristics (Logan et al., 2014) as shown to be the case in Vancouver's Downtown Eastside, for example.

Matching data from different sources enabled a comprehensive examination of neighborhood-built environment features and demographic and socioeconomic composition. It is, in fact, despite its limitations, one of the major contributions of this dissertation – leveraging the impact of existing data sets in a way that broadens each individual source's implications.

MHMC methodology included aggregation and suppression of the data where sample size was smaller than 20 and/or where variation coefficients were greater than 33.3% (a number of aggregate profiles were generated for smaller communities where the community on its own did not have a large enough sample size to inform its own profile). Access to the MHMC neighborhood profiles enabled examination of built environment design effect on health and social well-being across the Metro Vancouver region. As neighborhoods serve as the MHMC measurement unit, individual responses are grouped. This limited the ability to reach potentially meaningful conclusions for some locales. Household income under $40,000 reflects low-income cut-off used in the analysis. While 2016 Census definition refers to $40,000 for two-person households, household size is not considered here. This decision was made based on data availability. While it is difficult to afford housing on this annual income, there are certainly worse circumstances. Important diversity is potentially hidden within these neighborhoods. This is especially problematic when examining displacement patterns which happen at a smaller scale. Access to the more granular data would have made for a richer analysis. Furthermore, as the MHMC neighborhood defined the unit of analysis, this might have hidden smaller scale land value patterns, especially relevant in Vancouver's downtown core.

More generally, Slater (2006) emphasizes the importance of understanding gentrification processes and displacement of low-income and working-class households from their neighborhoods. He mentions the challenges around measuring gentrification and tracking down displaced households which contribute to the lack of research on this phenomenon. Displacement is extremely hard to measure because of the difficulty to distinguish between involuntary and voluntary moves. Moreover, it is challenging to follow a large number of displaced families and measure conditions and satisfaction after the move, especially if these are low-income households (Newman & Wyly, 2006; Shaw, 2008). This study explores key reasons for moving among MHMC survey respondents who moved to their neighborhoods in the past two years. While it implies that households who had moved from their origin neighborhood did so because it was less affordable than their current location, it does not tell us that households were effectively displaced. There is still a long way to go to fully measure displacement.

Moreover, the MHMC survey used a direct method approach to measure an individual’s health and social well-being. While the benefit of the self-report approach is its simplicity and fairly easy implementation, these models are critiqued for not necessarily representing actual health, and a possible affirmation bias when respondents might reply based on what they think the researcher wants to hear (Adamowicz et al., 1997; Arrow et al., 1993; Blackburn et al., 1994; Earnhart, 2001; Timmermans et al., 1994).

Another concern relates to BCAA data. This is a valuable resource to learn about owner-occupied properties, but it is limited in its usefulness to inform on rents. This is once again especially relevant when studying displacement of low- to moderate-income households who are more likely to rent. Websites such as Craigslist (https://geo.craigslist.org/iso/ca) could have helped to bridge this information gap but manually scraping 2013/14 rent data was a tedious task beyond this doctoral project's capacity. Instead, the Census and the RMS surveys are analyzed. Some limitations to the RMS data include its underestimation of rents as a result of surveying purpose built rental apartments which typically have rent controls. On the other hand, the survey includes vacant units which are shown to list significantly higher rents compared with occupied units.

In addition to representing owner-occupied properties, BCAA housing values are not adjusted to household size so that actual affordability (or the ratio between housing price to household income which is dependent on household size) cannot be deduced.

Walk and Transit Score™ were used to structure the independent variable (i.e. MUPOD). Walk Score™ objectively measures the shortest walking route for each address to thirteen category nearby destinations. However, there are additional characteristics, some measurable and some are not, that influence MUPOD (for example, the presence of trees and benches, safety, historically contingent characteristics of the built environment, and the number of people occupying a public space). Walk Score™ does not capture the destination size nor does it capture diversity (Duncan, Aldstadt, Whalen, & Melly, 2013).

In addition, because the geographic data used by the Walk Score™ algorithm is based on a Google service, it is regularly updated. It therefore did not prove useful for a longitudinal examination as the methodology is not entirely consistent over time. Critically, the use of Walk

Score^{TM} in longitudinal analysis will require improved transparency of the changes in factors that determine Walk Score^{TM} – a reference to this limitation is only mentioned in Hall & Ram (2018) despite wide adoption. Since the Google API service includes contributor information, it therefore also implies that its basic database potentially has some errors in the exact geographical location, population density, and land use classification (Bereitschaft, 2017). Furthermore, Walk Score^{TM} is based on an aggregate .25 mile buffer as the unit of spatial analysis and might suffer from errors as opposed to using a smaller measurement scale (Bereitschaft, 2017; Gilderbloom et al., 2015). However, it is indicated that the tool more accurately predicts walk/transit accessibility when using larger geographical scale as the unit of analysis (Duncan et al., 2013).

Moreover, Walk Score^{TM} data is produced as a real-estate tool (it provides location specific information for renters and buyers when choosing where to live) and is therefore driven by the housing market (Hall & Ram, 2018). Note that this aligns with this dissertation's goal which explores property values. Transit expenses are not accounted for in the analysis rather just access to transit (captured in MUPOD). Transit fare and ridership information would have made for an even more comprehensive analysis of affordability as it also has implications for accessibility (El-Geneidy et al., 2016).

Importantly, cross-sectional data (used in this study's estimation models) cannot be used to explain causation and can only imply correlation between variables. It does, however, help to provide a clearer picture of these processes.

Finally, when studying displacement or any other dynamic phenomena for that matter, there will always be unobserved or confounding variables that are likely to impact the estimation model (Creswell, 2008). A range of features could potentially impact housing values and health and are not included in this study. An estimation model simplifies reality but the extent of this simplification and its impact on the study findings is not entirely clear. Interest rates, for example, have been shown to have a significant impact on housing values as well as the type of available mortgages which in turn influence housing location and choice. Controlling for some of these factors in the estimation model helps to produce more reliable results. Clearly, some compromises needed to be done in this study to provide a comprehensive analysis of the relationship between built environment design, health, housing, and socioeconomic status.

These limitations are compensated for by the study's ability to provide a robust, meaningful, large-scale comparative analysis of neighborhoods in the Metro Vancouver region. This study supports MHMC's goal to address a real gap in local level health and wellness information (*Technical Notes for Community Profiles*, n.d.).

6.3 Policy Implications

It is important that scholars integrate ways to actively promote individual and societal transformation. The transformative approach to research design provides a philosophical context to advance meaningful change. This context pushed me to design research that could potentially challenge the status quo, that tends to dismiss vulnerable communities (Mertens, 2018). It is therefore important to reflect on how the study's theoretical framework and findings can support the design of fairer policies.

The immediate implication for public policy is that strategies aimed at increasing walking (and thereby increase MUPOD) should address local context but research on walkability seems to miss these potential 'risks' in urban environments (e.g., crime rates, noise, air pollution, and stress). Some interventions to improve walkability might not prove useful to certain neighborhoods or communities (Braun et al., 2016; Feuillet et al., 2016; Talen & Koschinsky, 2014). It is planning scholars and practitioners' responsibility to prove that planning strategies, including compact design, improve existing conditions and that these are economically worthwhile. Both benefits and investments need to be quantified and considered (Stevens, 2017).

The Metro Vancouver Regional Growth Strategy (*Metro Vancouver 2040,* 2017) states more compact communities[88] as its goal. It alludes to the environmental benefits resulting from compact, transit-oriented development approach. This goal aligns with TransLink's *Transport 2040* plan to prioritize efficient, compact transit networks. TransLink, however, relies on capitalization of real-estate revenues to fund this system. This funding mechanism can prove problematic by putting poor households at risk. The proposed funding model can intensify inequality by facilitating displacement and by not proposing government funding for social and rental housing. It does not support low-income individuals or inclusive community planning and it is likely to result in fewer available resources to replace existing or build more affordable units (Edelson et al., 2019).

Paradoxically, planning principles to create complete, compact communities near transit, increases the vulnerability of low-income households as these strategies promote redevelopment of neighborhoods around transit infrastructure.

There is an urgent need for regional governments to facilitate appropriate policies such as one-to-one replacement policies, protection of existing affordable housing stock, or replacement of existing stock by housing affordable by low-income residents. Moreover, transit funding mechanisms need to be developed to capture long-term revenues created by the system at a regional or provincial scale (rather than revenues created at the time of redevelopment) and to

[88] Compact communities provide access to diverse housing options, jobs, amenities, and services.

redistribute the funds to affordable housing. Funding strategies could also benefit from a provincial poverty reduction plan that targets low-income households (Edelson et al., 2019). In Hong Kong, for example, land near future transit development was sold to private developers where it was prorated at its future value capturing its proximity to transit. The negotiation included public and subsidized housing requirements as part of the development (Chava et al., 2018).

It needs to be clear that there should be combined efforts to increase transit availability and accessibility and affordable housing to low- and moderate-income households in the same locations. Only then will it be possible to prevent transit development that only benefits the rich (Luckey et al., 2018).

One of the most cited interventions to prevent residential displacement and encourage diversity near transit developments are housing policies designed to create or maintain the supply of public housing. Affordable housing policies reduce the risk of potential displacement because of increased housing costs. Housing policies include rent controls, eviction controls, and building cooperative housing around transit (Brown, 2016). Rent control laws used to be a strong tool and still exist in some older buildings and in certain cities but their potential positive impact has lessened over time. When enforced by the state instead of the city, these rent controls cater less and less to tenant needs. Moreover, some conditions have evolved over time that allowed more frequent and higher rent increases (Stein, 2019). Also, the law has developed to permit withdrawal from the system after reaching a certain rent threshold (ibid). Strengthening rent controls in high MUPOD environments needs to be considered.

Inclusionary zoning or conditional use permits are also used by cities to increase or protect affordable housing supply (Brown, 2016). Inclusionary zoning relies on private developers to produce affordable housing which is considered a ‘social good’. This neoliberal policy allows developers to build more and therefore increase their rent revenues. In Montgomery County (Maryland, U.S.), for example, developers provided 12.5-15% affordable housing for a 22% density bonus thereby leveraging development incentives (Chava et al., 2018). These policies are essentially aimed at protecting low-income households - the main users of public transit (Brown, 2016), but implementing inclusionary zoning in rich communities rather than in neighborhoods at risk of gentrification would produce different results (Stein, 2019). Some existing policies can be adjusted to generate different outcomes.

Another strategy emphasizes improved affordability near transit infrastructure by government investment in land near transit where profits are then directed to a public land trust.

Land trusts are a complex form of land ownership by a non-profit organization (the organization could be a group of tenants). Housing is cooperatively owned by tenants themselves and contracts limit the sale of land/buildings/apartments for not much more than the amount paid by the original buyer. Cities can support policies to transfer private land to the public to increase the stock of such properties (Stein, 2019). This land could then be used for long-term affordable housing either as family rental units, social or supportive housing. Government purchase of the land removes land value speculation from housing costs, it considers the public good, and it enables increased access to transit so that the public can benefit from investment in MUPOD and infrastructure. It also leaves room for long-term, flexible land-use planning near transit (Kramer, 2018). In Bogota, for example, the government bought land near transit infrastructure to build social housing prior to the announcement of a transit network project. This step produced land value increase that the city benefited from (Chava et al., 2018).

Another policy can aim at extending MUPOD infrastructure to suburban locations accompanied by densification strategies and affordable housing. This can prove more challenging due to existing low densities which do not support development of new transit infrastructure but could be addressed by affordable housing intensification so that ridership increases over time (Kramer, 2018).

Metro Vancouver and the COV are mostly independent of the province when it comes to planning decision-making due to financial stability, political and demographic contribution, and the City's unique legal status[89]. British Columbia has earned a progressive planning reputation, where 'good planning' agendas such as those promoting sustainability, smart growth, and urbanism are advocated. City councils hold the most power in planning decisions where there is no "supervision" from a provincial appeal board, nor do court intervention or provincial-level plans supervision (as some other planning systems have in place). The province's planning structure, however, lacks inner checks and balances and the only way to object to local council decisions is through elections (Razin, 2020) (see Figure 6.2 British Columbia's planning system checks and balances).

The minimal intervention approach of the BC province can be explained by the COV efficiency and lack of scandals. It seems that most adhere to unwritten norms and a well-functioning planning system. A culture of trust in elected officials, where corruption is rare, facilitates consensus seeking at the local and regional level that depends on horizontal checks and balances as opposed to centralized mechanisms. Importantly, public engagement is key in such a system (ibid). Even so, it seems that most interventions intended to increase MUPOD and

[89] The Vancouver Charter enables the City different powers than neighboring communities in the region.

infrastructure are derived from top-down policies rather than strategies to increase community engagement (such as, public consultation as to what land use types are important for residents and are likely to increase their satisfaction). I suggest that recommendations to promote MUPOD should not be limited to the physical environment but also address the local context of people, institutions, and political processes (Chava et al., 2018; Talen, 1999; Talen & Koschinsky, 2013, 2014).

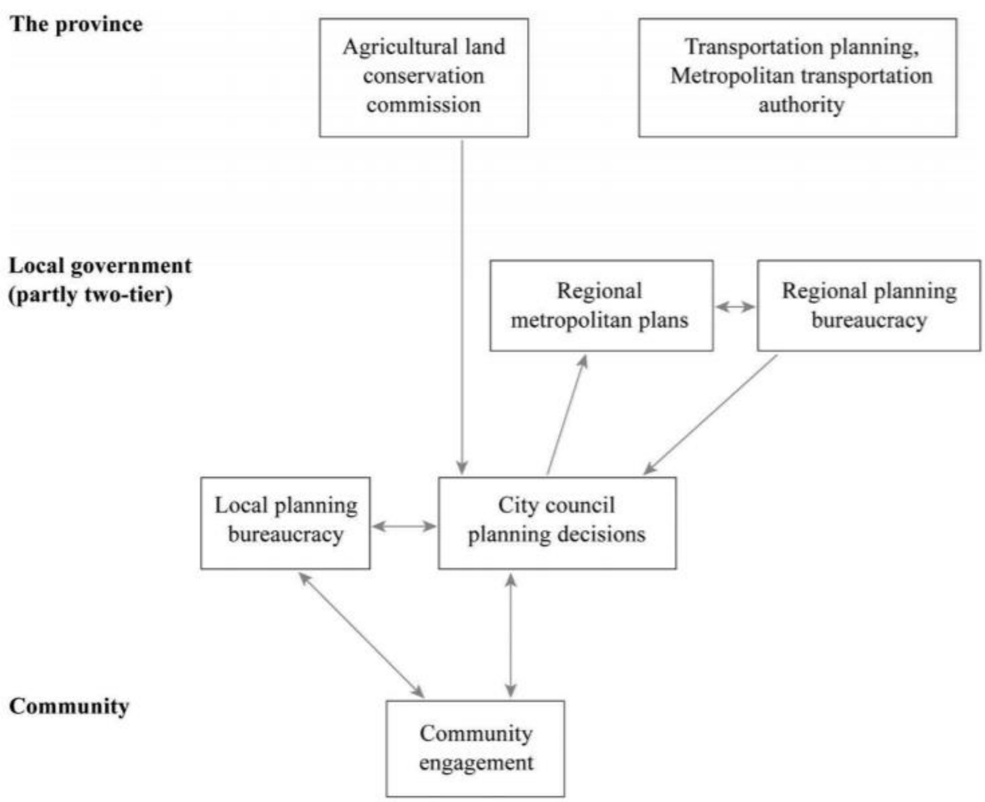

Figure 6.2 British Columbia's planning system checks and balances
Source: Razin (2020).

The province's top-down approach is illustrated in transportation planning. Since transportation planning decisions depend on funding, the province takes these decisions. This is evident in several debates over mass-transit development, including the 2015 provincial decision to vote against Metro Vancouver's mayors preference for a regional transportation plan estimated at $10 billion (CAD) (Razin, 2020).

Despite "good planning" practices, BC has failed to address the supply side of the affordable housing crisis which prompted few actions by the province, including foreign home-buyers taxation that started in 2016. While successfully using redevelopment strategies to create livable neighborhoods in Vancouver's waterfront and city center, efforts to densify existing low-density metropolitan neighborhoods have been less productive (Lauster, 2016). Local communities resist change and densification and their voices are strongly heard in a local planning system with limited checks and balances in place. While smart growth and new urbanism agendas are advocated for in large-scale developments in the suburbs, limited financial stance seems to constrain "good planning" application in practice (Razin, 2020).

Importantly, cities can tax increased revenues resulting from public investments. If this is implemented, the capital produced from the land itself, that is the profits made from location and proximity to transit and amenities, would be regarded as "*socially produced and therefore no one's to own*" (Stein, 2019; 167). All levels of government need to "*get back in the business of funding, acquiring and building public housing*" (165). Existing programs are failing because they are in constant need of financial support that is not provided by the federal government and not because of some inherent limitations of the policy itself. Dealing with the most urgent challenges of urban planning in the capitalist world requires going beyond familiar mechanisms and more socially just cities (Stein, 2019).

To propose local level programs and policies, a more fine-tuned understanding of community health status and needs is vital. Public health researchers have long acknowledged the importance of neighborhood-level physical and social environments – such as public transport, social networks, disorder, and crime – for health. But research is scarce. I provide a comprehensive analysis of the Metro Vancouver region that broadens the understanding of the connections between housing, health, and social inequality for individuals and communities. It is my hope that the study's findings will inform policy makers about some of the hidden costs of displacement associated with public promotion of MUPOD.

6.4 MUPOD in Times of COVID-19

A city cannot be safe if it is not equitable. This dissertation is being written in times of a global crisis resulting from the novel COVID-19 virus. It is unclear if policy fields such as planning can help address necessary changes needed to cope with the crisis and prevent future deterioration due to the pandemic.

This dissertation focuses on mixed-use, pedestrian-oriented environments that typically characterize inner city neighborhoods. It is also a call to explore whether these environments are accessible to all. Considering COVID-19, I raise some thoughts and concerns relevant to MUPOD, including job inequality, housing conditions, public space, and density. They are not mutually exclusive.

Job inequality

One of the first reactions to the pandemic was a dramatic fall in ridership. The instant reduced demand was a result of both workplace and business closure but also of perceptions of safety and likelihood of contracting the coronavirus. Some demographics, however, have had limited choice with regards to their travel behavior. These same demographics are more likely to have jobs in sectors with increased risk of contracting the virus because of increased exposure

(Litman, 2020). These include, for example, operators of transit services, grocery stores, and other essential workers.

Wealth and mobility differences have a wider impact than just personal comfort levels during lockdown that has been affecting more than half of the global population as of April 2020. While lower-income households in the U.S. continued to mobilize during the pandemic, higher income households, typically skilled workers with knowledge-based professions, were more likely to work from home as the transition to “online” was easier. The pandemic is exacerbating social inequities where low-income households do not have the option to work remotely, including minorities, homeless, and low-income communities that are disproportionately affected by COVID-19 (Honey-rosés et al., 2020). What is the added value in current conditions in living in mixed-use communities, where jobs and services are nearby?

Housing conditions

Wealthy residents have been seen leaving cities to the country for second homes or alternative residences, where vulnerable groups had no other option but staying in their often-overcrowded unsafe housing. It is argued that vulnerable communities are more likely to contract and die of the coronavirus partly because of housing and job inequalities. Moreover, they have reduced access to health care and fewer options to self-isolate when needed (Honey-rosés et al., 2020). The extreme differences shown by COVID-19 statistics exemplify existing urban health inequalities. As a result, there is an incentive to imagine more equitable, just cities (Cole et al., 2020).

Stress resulting from quarantine can be reduced by ensuring appropriate housing conditions. Dense housing forms can be designed to improve safety and ensure cleaning and sanitizing. Finally, removing homelessness is an excellent cause to address the issue of contagion and to increase resilience. While these require government intervention and funds, they will likely prove useful in the long run (Litman, 2020).

Public space

Public space utilization and social distancing restrictions are used as a means to control the spread and protect the health of residents. This reality has prompted planners and other professionals to think of necessary changes to the built environment to cope with the crisis. The current pandemic is not the first to engage planning and design to achieve improved health. Late 19th/early 20th century city conditions prompted planners, architects and engineers to think of how design can be used to improve sanitary conditions (Honey-rosés et al., 2020). The beginning of the current crisis referred to tactical urbanism strategies that were implemented globally by cities, reclaiming public space for safe, socially distanced walking and biking, taking advantage of restricted car traffic on roads during COVID-19 (Davies, 2020)[90]. Some cities took this opportunity to introduce permanent changes including road closures to prioritize pedestrians and bikers. Some suggest that this will promote long desired changes in built environments. Others are concerned about the impact on public transit use and its economic viability (or lack thereof) that might result in increased private car use, congestion, air pollution and increased social inequities (Honey-rosés et al., 2020).

Social distancing is claimed to be in opposition to a human basic need but also, in opposition to the design of cities, plazas, transit systems and high rises. They are meant to serve the crowd. Restrictions on social gatherings, in-person interactions, and self-isolation guidelines will most

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[90] These efforts have also been criticized for not considering racial equity issues in places like Chicago. As police presence is expected to increase in 'open streets' this will likely negatively impact communities of color.

definitely take a mental health toll, even more so on vulnerable populations (Kimmelman, 2020). Because loneliness and depression are more common in low-income groups, older adults, and the disabled, creative strategies need to be employed to deal with these challenges (ibid).

Walking and biking have the lowest infection risk compared to all other forms of transportation. Active travel mode is available to those who cannot drive, it supports physical activity, and is more affordable. Investing in MUPOD and infrastructure will increase resilience and health if it considers specific local context of individuals and communities.

Density

Litman (2020) suggests that while cities are denser compared to rural areas, they also provide better access to services (including health care), and that city residents are healthier to begin with: cities have lower mortality rates, people live longer than in rural areas, and response to emergency is faster in cities. Whereas rural residents die younger because of higher cardiovascular rates, respiratory and kidney diseases, different types of cancer, suicide, diabetes, Alzheimer's and birth deficiencies. These chances of having poor health are even more probable for low-income and minorities. Since these health conditions have greater impact on pandemic mortality rates than density does, cities are viewed as safer and healthier overall compared to rural areas.

Cities with high density levels such as Chicago, New York and Seattle are raised as examples of COVID-19 spread, but, as Litman (2020) argues, high infection rates reflect their global character. They attract tourists, trade, and migration more than they are dense. In fact, some (less dense) suburban areas near cities such as New York and Seattle recorded higher infection rates compared to neighboring city centers.

But what if, as the dissertation's findings suggest, residents of MUPOD environments are not associated with improved health and well-being outcomes? Is it still safer to live in dense, urban environments compared to rural ones? Social and economic inequities are said to exacerbate mental health effects of the pandemic. Children who already had mental health concerns before the pandemic, particularly anxiety and depression, are especially vulnerable. This is particularly worrying considering the dissertation findings.

The movement back to the city that characterized the latter half of the 20th century, is infused by capital and creativity. Life in close proximity to others has facilitated social interaction, ideas, and opportunities valued by people. It is important to see how we can preserve that, even when connecting remotely is the only option. If the physical distance to one's job becomes less of a consideration in housing location choice for some occupations, then urban/suburban differences become less obvious (Shenker, 2020). Meaningful ways need to be discussed to address these concerns such that vulnerable communities do not lose again.

Ironically, social distancing is said to bring people together across age groups and demographics like never before in the form of mutual aid groups. It is not clear, however, if and how these will continue to operate in a post pandemic reality (ibid).

While acknowledging these gaps, the current discourse in the nexus of urban planning, public spaces, and health and well-being of residents is an opportunity to imagine our world when this current crisis is a thing of the past (Honey-rosés et al., 2020).

Chapter 7: Conclusions

The last section of the dissertation provides final remarks to conclude the work.

7.1 Final Remarks

Inspired by Mertens (2010) this dissertation incorporates the “transformative spirit” by highlighting social and economic inequality issues. It pays specific attention to low-income[91], marginalized communities who often do not get full access to investments made for the public.

I conjectured that mixed-use, pedestrian-oriented development and displacement are related. That is, investment in means to promote active travel modes exacerbates housing (un)affordability which are associated not only to displacement but with additional negative health outcomes which existing policies do not address. While the results do not necessarily support these hypotheses, they provide insights that help explain these processes, and what can be done by decision makers to build more inclusive environments.

The six most gentrified neighborhoods in the Metro Vancouver region are east of the COV’s inner-city core. These neighborhoods are characterized by higher rates of social status change compared to the Metro’s (including a higher education and quaternary sector employment composition) from 2011 to 2016.

Notably, I find a *negative* relationship between MUPOD and health and social well-being among Metro Vancouver residents after controlling for personal characteristics (p-value>.05). This finding contradicts the understanding that residents of MUPOD environments benefit from

[91] Low-income cutoff used in the analysis was determined by MHMC data access and does not consider household size. Results should be interpreted accordingly.

improved health and social well-being which is generally treated as conventional wisdom. This can be explained by local neighborhood socioeconomic characteristics that are different from the context of previously researched walkable environments (research has focused mostly on wealthy environments). As it becomes clear that different built environments contribute to uneven health outcomes for communities of different socioeconomic status, the exacerbated negative health impacts associated with increased demand for inner city neighborhoods need to be acknowledged.

Importantly, research on walkability and health is often questioned due to its use of cross-sectional data and its limited ability to prove causality (because of self-selection). This is particularly relevant in a context where low-income households (who are found associated with higher MUPOD living) cannot afford to live anywhere else, regardless of their travel-mode or neighborhood preferences. Additionally, a large immigrant population that often chooses amenities based on ethnic and cultural background and not proximity has likely impacted the dissertation results.

The dissertation's findings indicate a positive MUPOD/house value association in Vancouver urban core neighborhoods (only statistically significant at a 95% confidence level for high-density units). However, in the Metro's suburban periphery, higher MUPOD scores predict *reductions* in housing values for all house types (p-value of the test statistics for the relationship is <.05 only for single-family units). This reinforces Edelson et al.'s (2019) observation that increased transit investment at one locale might contribute only to the already well-off by not considering affordable housing measures for middle- and low-income households. These investments might result in displacement and exacerbate existing inequalities (Edelson et al., 2019).

The estimation model results produced a statistically insignificant positive correlation between households MUPOD and “moving for affordability reasons”. The small sample size (N=57) might explain this result. A qualitative approach to explore this research question is necessary. I believe that locating and interviewing households who have moved for affordability would inform this area of investigation. It is also crucial to revisit this research question in 5- or 10-years’ time to improve our understanding of displacement processes.

Finally, there is evidence to indicate that MUPOD and low-income households earning under $40,000 are both dependent and positively correlated (that is, increased MUPOD levels can be used to predict higher percentages of low-income households) (R_s =.47; $p<0.05$). Perhaps, as opposed to my initial speculation, it is not those households earning under $40,000 who are being displaced? Maybe those earning under $40k cannot even afford to move? It then needs to be asked - what are the (health) costs of staying?

The research is limited in several ways, including: (1) data collection from different sources with different geographical boundaries; (2) potential changes to the physical environment between the time participants completed the MHMC survey (2013/14) and when Walk Score™ were documented (2015); (3) MHMC’s data aggregation and suppression methodology (especially problematic when examining displacement patterns which happen at a small scale); (4) MHMC’s self-report approach might not reflect objective health outcomes; (5) BCAA’s data limited usefulness to inform on rents; (6) underestimation of the RMS rent values; (7) MUPOD’s lack of ability to include all relevant built-environments characteristics such as quality of different amenities; (8) constant upgrade of Walk Score™ methodology that impacts its applicability as a longitudinal tool and potential errors in the exact geographical location, population density, and land use classification that are typically based on contributor information (Bereitschaft, 2017). As well as the unit of spatial analysis that might suffer from errors as opposed to using a smaller measurement scale (Bereitschaft, 2017; Gilderbloom et al., 2015); (9) cross-sectional data cannot be used to explain causation; and (10) unobserved or confounding variables that are likely to impact the observed relationships and are not included in the estimation models.

These limitations are compensated for by the study's robust, meaningful, large-scale comparative analysis of neighborhoods in the Metro Vancouver region. Matching data from different sources is, in fact, despite its limitations, one of the major contributions of this dissertation – leveraging the impact of existing data sets in a way that broadens the implications of each individual source. Illuminating associations between variables indeed helped to provide a clearer picture of gentrification and displacement processes.

The immediate implication for public policy is that strategies aimed at increasing walking (and thereby increasing MUPOD) should take into account the local context of people, institutions, and political processes. Strategies relying on capitalization of real-estate revenues to fund transit systems can prove problematic since they put poor households at risk.

Future studies need to address the potentially new health, social, and racial issues created by gentrification (and green gentrification in particular). The need for mixed-methods approach to study gentrification and health is stressed by Anguelovski, Triguero-Mas, et al. (2020).
A qualitative approach, in particular, is needed to understand the deeper cultural, social, and

personal physical aspects that are shaped by lived experiences and how these relate to urban processes and built environment design and eventually impact health outcomes. A quantitative approach can supplement this investigation by providing controlled data to quantify processes over time. The methodological challenges in measuring displacement, including tracking down displaced households which are often tagged under 'missing' in longitudinal studies (Anguelovski, Connolly, et al., 2019), is relevant here in understanding the health impacts of MUPOD improvements to low-income, often invisible, populations who continue living in gentrified neighborhoods.

There is an urgent need for regional governments to facilitate appropriate policies such as one-to-one replacement policies, protection of existing affordable housing stock, or replacement of existing stock by housing affordable to low-income residents. Moreover, transit funding mechanisms need to be developed to capture long-term revenues created by transit systems at a regional or provincial scale. I suggest that recommendations to promote MUPOD should not limit themselves to the physical environment but instead address the local context and adopt a social equity lens to promote inclusivity and just results. Dealing with the most urgent challenges of urban planning in the capitalist world requires beyond familiar mechanisms and more socially just cities (Stein, 2019).

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Appendices

Appendix A **MHMC Survey Package**

The following sub-appendices present the MHMC survey introductory documents, including: the information and consent statement, privacy statement, prize draw rules, and survey registration page. All of these were made available to every participant and each participant had to complete registration to take the questionnaire.

A.1 Information and Consent

FOR YOUR INFORMATION

My Health, My Community Survey

Information and Consent Form

Principal Investigator:
Dr. Jat Sandhu
Regional Director, Public Health Surveillance Unit
Vancouver Coastal Health Authority, Vancouver, BC
[redacted]

Co- Investigators

- **Dr. Kendall Ho**, Director, eHealth Strategy Office; and Professor, Dept. of Emergency Medicine, Faculty of Medicine, UBC
- **Dr. Victoria Lee**, Medical Health Officer, Fraser Health Authority
- **Dr. Helen Novak Lauscher**, Assistant Director for Research, eHealth Strategy Office, Faculty of Medicine, UBC

You are invited to participate in the My Health, My Community survey. This project is a partnership between the Vancouver Coastal Health Authority, Fraser Health Authority and the University of British Columbia.

You are being asked to participate because you are 18 or over, and you live in the Vancouver Coastal or Fraser Health regions. Please email info@myhealthmycommunity.org with any questions.

Purpose and Objectives

We want to learn more about the health and wellness of your community. This project is an important step toward understanding factors affecting health in your area and how we can improve health in your community.

Procedures

If you agree to participate in this project, you will be asked to complete a registration form and then fill out the My Health, My Community survey. The entire process should take 20-30 minutes to complete.

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FOR YOUR INFORMATION

Risks and Benefits

We do not think anything in this project could harm you. This survey may help you think about the things that affect your health. This information will also influence the planning of health and municipal services.

Confidentiality

Your confidentiality will be respected at all times. You will not be identified in any reports. The project findings will only report summary results.

Registration information is kept on secure computers at UBC. Survey information is kept on secure computers at Vancouver Coastal Health. Survey information from people living in the Fraser Health Region will be shared with Fraser Health. Anonymized data from the survey will be kept for public health planning and monitoring.

Results

Project results will be shared in a number of different formats with

- the public,
- community partners/agencies,
- health professionals, and
- the academic community.

The results will be used to understand the health of communities in Vancouver Coastal Health and Fraser Health.

Compensation

When registering in this project, you may choose to enter a draw. If you choose to take part, you can get up to 10 entries in the draw. You will get 1 entry by registering and 9 entries by completing the survey.

Contacts

If you have any questions about this project, you can contact Dr. Jat Sandhu at info@myhealthmycommunity.org or 604-675-3885. If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the University of British Columbia Office of Research Ethics by e-mail at RSIL@ors.ubc.ca or by phone at 604-822-8598 (Toll Free: 1-877-822-8598).

Participant Consent

Your participation in this project is entirely up to you. You are free to withdraw at any time. Your participation will not affect any health care services you receive currently or in the future.

By completing the registration and survey, you agree that consent has been given.

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A.2 Privacy Statement

FOR YOUR INFORMATION

my Health my Community

My Health, My Community Survey

Privacy Statement

My Health My Community is committed to maintaining your confidentiality, respecting your privacy and protecting personal information as outlined in the BC Freedom of Information and Protection of Privacy Act.

This Statement of Privacy applies to the My Health My Community website and governs data collection and usage. By using the My Health My Community website, you acknowledge reading this Privacy Statement and confirm your agreement with these terms and conditions.

We reserve the right to update this policy at any time. Users are responsible for reviewing this document periodically for changes.

This Privacy Statement, your access to and use of our website and its content, and any proceedings arising out of that access or use, will be governed by British Columbia law.

Collection, Use and Disclosure of your Personal Information

Personal information is any recorded information on an identifiable individual. This may include, but is not limited to, an individual's name, address, e-mail address telephone number, age, identifying number, health care history, education, financial, criminal or employment history.

My Health My Community does not automatically collect personal information from visitors to this website.

My Health My Community will request your information to operate our website and provide you with the services you have requested. The information you provide is voluntary.

My Health My Community requests your information to:

- confirm your eligibility to participate in this program
- to register you in this program
- to communicate with you about the My Health My Community program and the associated prize draws
- to complete the My Health My Community Survey

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fraserhealth Better health. Best in health care.

FOR YOUR INFORMATION

- to alert you to other products or services available from My Health My Community
- to request your opinion about the My Health My Community program or any of its services

Your consent is requested by My Health My Community to conduct our survey. This survey includes information that is used to inform planning for services and evaluation of public health programs by the Vancouver Coastal Health and Fraser Health authorities.

You may withdraw from My Health My Community at any time with no consequences to current or future healthcare needs.

Summary and aggregate level survey data may be disclosed to our project partners to inform community health programs, other publicly funded programs and research. Any identifying information about you will not be shared for these purposes.

My Health My Community does not sell, rent or lease its member or visitor lists to third parties. Any personal information that you provide will only be shared internally to fulfill the specific purpose for which you provided the information. My Health My Community will not share your information unless authorized by law.

Contact

If you have any questions about the My Health My Community project, please contact info@myhealthmycommunity.org.

We welcome your comments and questions about our Privacy Statement. If you have questions, please contact the overseeing Information Privacy Office at privacy@vch.ca or at 604-875-5568.

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fraserhealth Better health. Best in health care.

A.3 Prize Draw Rules and Regulations

FOR YOUR INFORMATION

my Health
my Community

My Health, My Community Survey

Official My Health, My Community Prize Draw Rules & Regulations

The winners of the My Health, My Community Prize Draws will be selected in the manner detailed below:

Prize Draw Period
The Prize Draw runs from approximately October 1st, 2013 (12:00:01 A.M. PST) until June 30th, 2014 (11:59:59 P.M. PST). Draws will be held every quarter.

Eligibility
To be eligible for the My Health, My Community Prize draws:

1. You must be 18 years of age or older.
2. You must reside in either the Vancouver Coastal Health or Fraser Health Regions.
3. You must answer a skill-testing question correctly.
4. You must comply with the Official Rules.
5. NO PURCHASE IS REQUIRED TO ENTER THIS DRAW.

Employees directly associated with the My Health, My Community program and their immediate family members are not eligible for the draw or prizes.

Prize winners may be asked to provide proof to establish that they are in compliance with the terms for eligibility.

How to Enter
To participate in the Prize Draw, you must register to participate in the My Health, My Community Survey. Registration may be done either:

- In person through an official My Health, My Community Field Outreach Team Member at events held across the Lower Mainland
- By registering electronically ("Online") via the Internet at: www.myhealthmycommunity.org
- By mailing in the attached registration and survey.

You can enter the Prize Draw by completing the registration and checking YES to agree to enter the Prize Draw.

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FOR YOUR INFORMATION

You must fully complete all of the information requested on the form (including correctly answering the skill-testing question).

All entries must be received no later than June 30th, 2014 to be eligible for the Prize Draw.

Odds of Winning
The number of prizes for each quarter will depend on participation. It will be set to achieve a 1 in 500 chance of winning for those who have registered and completed the survey.

Your chances of winning will increase if you complete the survey.

You get one (1) chance to win by filling out the registration. You can get nine (9) extra chances to win by filling out the survey and entering your registration user key when requested in the survey.

You can only register once (1 time) during the Prize Draw period. Repeated attempts and/or multiple entries to this Prize Draw may result in disqualification.

By registering, you are confirming your agreement with the rules of this Prize Draw.

My Health, My Community may remove any entry or refuse to allow an entry where it is suspected that Prize Draw rules are not being followed.

Announcing the Grand Prize Winner
All winners will be contacted by phone and/or email.

Winners will only be offered one prize, which cannot be exchanged for any of the other prizes.

If My Health, My Community is unable to contact a winner after three (3) attempts, the winning entry may be considered void and another winner may be selected.

My Health, My Community respects privacy and will only release the prize winners' names with their consent.

Prize Descriptions

- (Grand Prize) 16 GB Apple iPad mini (approximate value of $460)
- $200 Dollar Grocery Store Gift Card(s)
- Tickets to cultural events in your community (approximate value $50-$150)

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FOR YOUR INFORMATION

Important Considerations

- My Health, My Community is not responsible for late, lost, misdirected or unsuccessful efforts to notify the Winners.
- My Health, My Community is not responsible for technical, hardware or software issues that could limit your ability to participate in the Prize Draw.
- By registering with My Health, My Community you agrees not to purposefully corrupt or damage the My Health, My Community application, system or survey.
- My Health, My Community makes no guarantee or warranty regarding any of the prizes.
- My Health, My Community is not responsible for any errors in the offer or administration of the Prize draw, including the selection and announcement of winners or the distribution of prizes.
- My Health, My Community may terminate this Prize Draw, change these Official rules, at its sole discretion, without notice to participants.

Privacy

My Health, My Community collects, uses, and shares personal information only in accordance with the BC Freedom of Information and Protection of Privacy Act.

For questions or concerns related to your privacy, contact The Vancouver Coastal Health Privacy Office; Phone: 604-875-5568; Email: privacy@vch.ca

Contact

For questions regarding the Prize Draw, please contact info@myhealthmycommunity.org.

A.4 Registration

my Health *my Community*

My Health, My Community Survey

SURVEY REGISTRATION

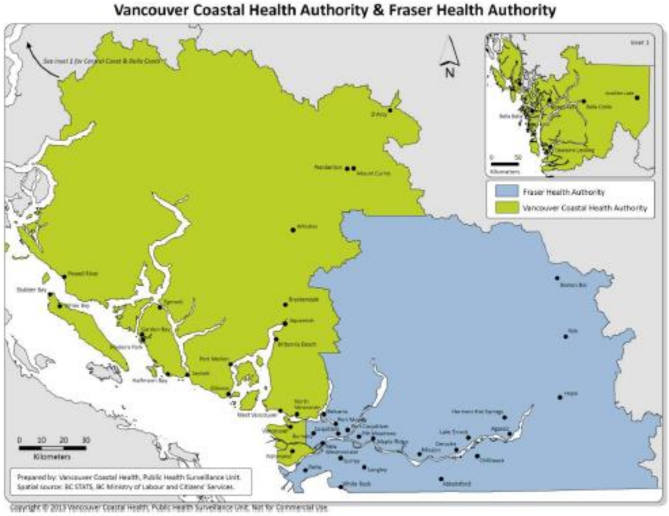
<u>Section 1:</u> Eligibility

You must be 18 years or older and currently reside in the Vancouver Coastal Health or Fraser Health region to be eligible to take the survey.

→Enter your date of birth and your current city/ place of residence : ***(required)***

Date of birth:	**City/place of residence:**
_______________ (YYYY-MM-DD)	_______________________

Vancouver Coastal Health Authority & Fraser Health Authority



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<u>Section 2:</u> Review the My Health My Community *Consent to Participate*

Please read the attached My Health My Community information consent form carefully.

My Health My Community collects, uses and shares your information in accordance with the Freedom of Information and Protection of Privacy Act (FIPPA).

The purposes for collecting your information are outlined in the *Consent to Participate*. If you have any questions about your privacy, please contact 604-875-5568 or contact privacy@vch.ca.

By continuing with the registration and survey, <u>you agree that consent has been given</u>.

<u>Section 3:</u> Enter into the Prize Draw

You are eligible to enter the prize draw. Please read the attached My Health My Community prize draw agreement carefully.

→ Do you want to enter into the prize draw? ☐ Yes ☐ No

If yes, please answer the following skill testing question:

What is (1+5) x (4-1)? __________

<u>Section 4:</u> Fill in Your Contact Information: (*required*)

First name: ______________ **Last name:** ______________

Email address: ______________ **Phone number:** ______________

☐ I do not have an email or phone number

→ Choose one of these security questions:

☐ The name of your first pet.
☐ The street you first lived on.
☐ The city/town where your mother was born.

→ **Security answer:** ______________

FOR ADMINISTRATION PURPOSES ONLY

User Key: ______________

Date received: ______________ **Date entered:** ______________

My Health My Community Survey Registration Page 2 of 2

Appendix B **Health Authority and Associated MHMC Community Profile in the Metro Vancouver Region**

Health Authority	MHMC Community Profile
Fraser Health	Burnaby
	Coquitlam
	Delta
	City of Langley
	Township of Langley
	Maple Ridge
	New Westminster
	Pitt Meadows
	Port Coquitlam
	Port Moody
	South Surrey/White Rock (Local Health Area)
	Surrey
Vancouver Coastal Health	Bowen Island
	City of North Vancouver
	District of North Vancouver
	District of West Vancouver and Village of Lions Bay (combined)
	Richmond
	Vancouver

Appendix C **MHMC Survey Progress by Neighborhood (Final Progress Date as of August 14, 2014)**

Health authority	MHMC Community Profile	MHMC neighborhood	Completed surveys	Target*	Progress (%)
Fraser Health	Burnaby		2,208	3,694	60%
		Brentwood	176	299	59%
		Buckingham/Lakeview	64	120	53%
		Burnaby Heights	85	124	69%
		Burnaby Mountain	74	68	109%
		Burnaby South	131	233	56%
		Capitol Hill	80	97	82%
		Cariboo/Second Street	109	199	55%
		Cascade-Schou	66	119	55%
		Douglas	107	155	69%
		Edmonds	141	242	58%
		Garden Village	88	149	59%
		Government Road	46	63	73%
		Lake City	48	50	96%
		Lochdale/Westridge	110	204	54%
		Marlborough	107	183	58%
		Metrotown	126	266	47%
		Middlegate	99	252	39%
		Sperling/Broadway	57	108	53%
		Stoney Creek	148	257	58%
		Sussex/Nelson	78	175	45%
		Willingdon Heights	163	223	73%
		Windsor	42	110	38%
	Coquitlam		998	2,008	50%
		Cape Horn	95	206	46%
		Cariboo/Burquitlam	158	355	45%
		Central Coquitlam	122	247	49%
		Coquitlam Town Centre	100	192	52%

	Eagle Ridge	89	153	58%
	Hockaday/Nestor	96	140	69%
	Maillardville	77	185	42%
	Northeast Coquitlam	25	54	46%
	Ranch Park	54	117	46%
	River Heights	37	45	82%
	Westwood Plateau	108	301	36%
Delta		1,137	1,575	72%
	Annieville/Sunbury	94	137	69%
	Burns View	150	185	81%
	Jarvis	91	135	67%
	Kennedy	69	114	61%
	Ladner	254	353	72%
	Nordel	66	71	93%
	Rural Delta	27	48	56%
	Sunshine Hills	126	183	69%
	Tsawwassen	220	349	63%
City of Langley		388	406	96%
Township of Langley		935	1,602	58%
	Aldergrove	90	182	49%
	Brookswood/Fernridge	119	214	56%
	Fort Langley	15	52	29%
	Hopington	49	98	50%
	Murrayville	83	131	63%
	North Langley Rural	107	144	74%
	South Langley Rural	41	133	31%

	Walnut Grove	222	345	64%
	Willoughby/Willowbrook	185	295	63%
Maple Ridge		789	1,175	67%
	Albion/Whonnock	162	248	65%
	Hammond	193	305	63%
	Haney	297	474	63%
	Maple Ridge North	111	175	63%
New Westminster		1,092	1,111	98%
	Downtown New Westminster	235	217	108%
	Queen's Park	183	155	118%
	Queensborough	85	110	77%
	Sapperton	184	174	106%
	Uptown New Westminster	266	328	81%
	West End/Connaught Heights	103	131	79%
Pitt Meadows		202	275	73%
Port Coquitlam		629	880	71%
	Citadel Heights	94	116	81%
	Downtown Port Coquitlam	106	124	85%
	Lincoln Park/Oxford	90	143	63%
	Mary Hill/Kilmer Park	115	146	79%
	Riverwood/Birchland	83	131	63%
	Woodlands/Glenwood	128	210	61%
Port Moody		307	510	60%
	Glenayre/College park	55	123	45%
	Heritage/Noons Creek	108	155	70%
	Moody Centre	43	66	65%
	Newport	74	118	63%

		Pleasantside	23	46	50%
	South Surrey/White Rock (Local Health Area)		3,888	7,533	52%
	White Rock		170	342	50%
	Surrey		3,718	7,187	52%
		Cedar Hills/Royal Heights	157	358	44%
		Clayton	266	375	71%
		Cloverdale	228	433	53%
		Crescent Beach/Ocean Park	149	282	53%
		Elgin/Semiahmoo	257	505	51%
		Fleetwood	477	901	53%
		Fraser Heights	124	284	44%
		Guildford	284	565	50%
		Morgan Creek/South East Surrey	156	330	47%
		Newton	405	866	47%
		Panorama Ridge	280	490	57%
		Port Kells	10	29	34%
		Strawberry Hills	205	590	35%
		Surrey Central	285	374	76%
		Whalley	316	792	40%
Vancouver Coastal Health	Bowen Island		832	821	101%
	City of North Vancouver		738	815	91%
		Zone 7 - Mahon	98	89	110%
		Zone 8 - Lonsdale Corridor	350	431	81%

	Zone 9 - Moodyville	94	115	82%
	Zone 10 - Grand Boulevard	163	180	91%
District of North Vancouver		1,196	1,352	88%
	Zone 6 - Norgate, Lower Capilano, Pemberton Heights	128	158	81%
	Zone 11 - Lynn Valley	259	287	90%
	Zone 12 - Carisbrooke, Braemar	141	175	81%
	Zone 13 - Hand h swort , Queens, Delb k	239	290	82%
	Zone 14 - Maplewood	136	159	86%
	Zone 15 - Blueridge	107	118	91%
	Zone 16 - Dollarton	49	50	98%
	Zone 17 - Indian Arm, Deep Cove	105	115	91%
District of West Vancouver and Village of Lions Bay (combined)		406 and 12	744 and 43	55% and 28%
	Zone 1 - Horseshoe Bay, Sunset Beach, Glen Eagles, Eagle Harbour, Eagle Island, Eagle Ridge	39	58	67%
	Zone 2 - Cypress, Caulfield, Bayridge, Westmount, Altamount	61	159	38%

	Zone 3 - Chartwell, Cammeray, Panorama, Wentworth, British Properties	72	208	35%
	Zone 4 - Ambleside, Cedardale, Dundarave, Sentinel Hill	189	274	69%
	Zone 5 - Park Royal, Capilano IR	25	46	54%
Richmond		2,896	3,115	93%
	Blundell	282	297	95%
	Bridgeport	42	51	82%
	Broadmoor	333	381	87%
	City Centre	586	823	71%
	East Cambie	98	176	56%
	East Richmond/Fraser Lands	37	57	65%
	Gilmore	9	8	113%
	Hamilton	57	77	74%
	Sea Island	16	12	133%
	Seafair	251	265	95%
	Shellmont	179	177	101%
	Steveston	543	406	134%
	Thompson	232	257	90%
	West Cambie	94	130	72%
Vancouver		10,083	10,534	96%
	Arbutus-Ridge	136	254	54%
	Downtown	794	1,016	78%
	Dunbar-Southlands	289	338	86%
	Fairview	792	578	137%

	Grandview-Woodland	664	476	139%
	Hastings-Sunrise	461	556	83%
	Kensington-Cedar Cottage	743	776	96%
	Kerrisdale	183	239	77%
	Killarney	390	461	85%
	Kitsilano	791	735	108%
	Marpole	277	400	69%
	Mount Pleasant	733	471	156%
	Oakridge	143	209	68%
	Renfrew-Collingwood	567	835	68%
	Riley Park	483	358	135%
	Shaughnessy	92	142	65%
	South Cambie	152	127	120%
	Strathcona	309	219	141%
	Sunset	310	572	54%
	UBC	176	202	87%
	Victoria-Fraserview	317	508	62%
	West End	814	850	96%
	West Point Grey	158	207	76%

Notes: Target sample size calculated using the Statistics Canada, 2011 Census
Source: (*My Health My Community Survey Progress, Fraser Health*, 2014; *My Health My Community Survey Progress, Vancouver Coastal Health*, 2014).

Appendix D **MHMC Neighborhood Profile Example (Renfrew-Collingwood)**

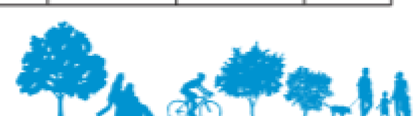
The chart below summarizes select indicators of health and well-being. Results for Renfrew-Collingwood are compared to Vancouver overall as well as the Metro Vancouver region.

Compared to Metro Vancouver
● Better ● Similar ● Worse ◆ Vancouver Average

Metro Vancouver Average
Worst — Best

DOMAIN	Indicator	Renfrew-Collingwood (%) n = 561	Vancouver (%) n = 9,995	Metro Vancouver (%) n = 28,128	Metro Vancouver Worst (%)	Summary Chart	Metro Vancouver Best (%)
SOCIO-ECONOMIC	Seniors aged 65+ years	16.9	15.4	16.2	4.9		39.8
	Education level high school or less	46.6	34.4	38.0	58.5		8.9
	Household income under $40,000	47.5	38.2	31.7	75.6		6.9
	Currently employed	61.1	64.5	64.7	39.4		90.5
HEALTH STATUS	General health (excellent/very good)	39.0	50.0	48.5	34.3		73.1
	Mental health (excellent/very good)	45.8	52.2	56.5	39.8		79.9
	Obesity (BMI 30+)	20.3	15.2	21.7	39.7		6.6
	Diabetes	11.7	6.5	7.7	19.1		2.9
	High blood pressure	21.4	14.5	17.9	29.2		8.0
	Chronic breathing condition	10.3	7.7	7.2	13.3		3.7
	Arthritis	9.5	11.6	13.1	27.6		4.6
	Mood or anxiety disorder	11.3	18.5	16.3	28.8		7.2
	Multiple chronic conditions	10.1	6.3	7.9	16.3		2.6
LIFESTYLE	Binge drinking (1+ times/month)	12.7	25.7	20.7	39.1		9.5
	Smoker (daily/occasional)	6.0	12.1	10.6	29.5		3.0
	Physical activity (150+ minutes/week)	35.6	45.9	44.1	26.9		62.1
	5+ servings of fruits and vegetables (/day)	24.1	28.0	24.9	12.9		40.8
	Stress (extremely/quite stressed)	18.4	17.1	17.8	29.1		9.0
	Screen time (2+ hours/day)	49.3	49.1	47.8	59.7		32.4
	High physical wellness score (10-16)	36.3	40.9	37.7	21.1		52.1
PRIMARY CARE ACCESS	Family doctor access	82.9	76.8	83.1	60.2		99.2
	Visited health care professional (past 12 months)	73.4	81.2	80.4	63.9		90.1
	Visited physician with appointment	73.7	69.6	75.0	60.8		91.6
	Visited walk-in clinic without appointment	17.6	19.4	16.5	30.7		4.5
BUILT ENVIRONMENT	Commute - car	38.6	32.7	55.1	92.0		10.7
	Commute - public transit	48.7	38.9	28.2	5.9		53.9
	Commute - walk or cycle	8.9	25.7	13.7	4.7		52.3
	Commute time (one way 30+ minutes)	58.8	52.6	56.0	81.3		38.8
	Primary mode to run errands - walk or cycle	10.0	38.1	19.8	4.2		77.4
	Second hand smoke exposure (public places)	33.7	32.0	26.6	43.7		7.9
	Sidewalks well maintained (strongly/somewhat agree)	74.9	79.8	75.5	4.9		90.9
	Amenities within walking/cycling distance (strongly/somewhat agree)	66.3	81.4	69.5	10.1		96.7
	Transit stop (less than 5 minute walk)	85.9	91.5	84.0	37.5		97.5
COMMUNITY RESILIENCY	Emergency supplies (3+ days)	26.0	24.1	26.7	16.6		46.6
	Food secure (enough to eat)	92.2	91.5	93.0	74.4		100.0
	Community belonging (strong/somewhat strong)	45.9	53.8	55.9	29.0		82.6
	4+ people to confide in/turn to for help	43.5	49.5	45.0	26.8		60.6

For indicator definitions, please refer to Technical Notes at www.myhealthmycommunity.org/Results/TechnicalNotes



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Appendix E Estimating the Relationship Between MUPOD and Individual Health and Social Well-Being Indicators

In order to explore the first research question *(Controlling for relevant personal characteristics, is there a significant association between the degree of neighborhood MUPOD and health and social well-being outcomes?*), Equation 3.1 of the relationship between MUPOD and health & social well-being index is estimated with individual health and social well-being indicators. The following sub-appendices present summaries of the estimation models.

E.1 Estimation model summary: MUPOD and mental health

Model Info				
Dependent Variable	*Ment.Health.Exc*			
Type	OLS linear regression			
Step 1				
Observations	100 (6 missing obs. deleted)			
	Est.	S.E.	t val.	p
(Intercept)	61.41	1.43	42.96	***
MUPOD15	-.08	.03	-3.07	**
Step 2				
Observations	68 (38 missing obs. deleted)			
Model Fit				
	F(6, 61)	6.68 p-value= 1.812e-05		
	R^2	0.40		
	Adj.R^2	0.34		
(Intercept)	40.89	17.66	2.31	*
MUPOD15	-.06	.04	-1.41	.16
Age.Over65	-.01	.12	-.06	.95
Gender.Male	-.42	.27	-1.55	.13
University	.09	.05	1.68	.
Marital.Married	.49	.14	3.56	***
Live.Alone	.37	.13	2.78	**
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

E.2 Estimation model summary: MUPOD and obesity

Model Info				
Dependent Variable	*Obese*			
Type	OLS linear regression			
Step 1				
Observations	97 (9 missing obs. deleted)			
	Est.	S.E.	t val.	p
(Intercept)	26.50	1.63	16.30	***
MUPOD15	-.08	.03	-2.77	**
Step 2				
Observations	66 (40 missing obs. deleted)			
Model Fit				
	F(6,59)	13.46 p- value=1.503e-09		
	R^2	0.58		
	Adj.R^2	0.53		
(Intercept)	-4.13	17.22	-.24	.81
MUPOD15	-.01	.04	-.22	.83
Age.Over65	.02	.12	.17	.87
Gender.Male	-.06	.26	-.21	.83
University	-.45	.06	-8.11	***
Marital.Married	.58	.13	4.36	***
Live.Alone	.50	.13	3.95	***
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

E.3 Estimation model summary: MUPOD and sense of belonging

Model Info				
Dependent Variable	*SOB.Strong*			
Type	OLS linear regression			
Step 1				
Observations	100 (6 missing obs. deleted)			
	Est.	S.E.	t val.	p
(Intercept)	60.48	1.98	30.61	***
MUPOD15	-.08	.03	-2.38	*
Step 2				
Observations	68 (38 missing obs. deleted)			
Model Fit				
	F(6, 61)	8.74 p-value= 7.08e-07		
	R^2	0.46		
	Adj.R^2	0.41		
(Intercept)	-36.47	24.56	-1.48	0.14

Model Info				
MUPOD15	-0.03	0.06	-0.54	0.59
Age.Over65	0.65	0.17	3.94	0.00***
Gender.Male	0.49	0.38	1.28	0.20
University	0.03	0.07	0.38	0.71
Marital.Married	0.88	0.19	4.56	0.00***
Live.Alone	0.53	0.19	2.86	0.01**

Standard errors: OLS
Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Appendix F **Estimating the Relationship Between MUPOD and Rent Value by Bedroom**

In order to explore the second research question (*Controlling for Relevant Neighborhood Characteristics, Is There A Significant Association Between the Degree of Neighborhood MUPOD and Housing Costs?*), Equation 3.2 of the relationship between MUPOD and house value is estimated by number of bedrooms. The following sub-appendices present summaries of the estimation models.

F.1 Estimation model summary: MUPOD and bachelor unit median rent

Model Info				
Observations	94 (12 missing obs. deleted)			
Dependent Variable	*CMHC_bachelor_2014MedRent*			
Type	OLS linear regression			
Step 1				
	Est.	S.E.	t val.	p
(Intercept)	690.74	29.37	23.52	***
MUPOD15	1.65	.51	3.22	**
Step 2				
Model Fit				
	F(2, 91)	34.56	p-value: 6.826e-12	
	R^2	0.43		
	Adj.R^2	0.42		
(Intercept)	936.43	41.14	22.76	***
MUPOD15	-.25	.49	-.51	.61
Dist.VanDT	-.01	.00	-7.27	***
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

F.2 Estimation model summary: MUPOD and one-bedroom unit median rent

Model Info				
Observations	96 (10 missing obs. deleted)			
Dependent Variable	*CMHC_onebed_2014MedRent*			
Type	OLS linear regression			
Step 1				
	Est.	S.E.	t val.	p
(Intercept)	806.31	17.05	47.28	***
MUPOD15	.60	.31	1.92	.
Step 2				
Model Fit				
	F(2, 93)	32.26	p-value: 2.287e-11	
	R^2	0.41		
	Adj.R^2	0.40		
(Intercept)	962.62	24.45	39.38	***
MUPOD15	-.54	.29	-1.86	.
Dist.VanDT	-.01	.00	-7.65	***
Standard errors: OLS Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

F.3 Estimation model summary: MUPOD and two-bedroom unit median rent

Model Info				
Observations	106			
Dependent Variable	*CMHC_twobed_2014MedRent*			
Type	OLS linear regression			
Step 1				
	Est.	S.E.	t val.	p
(Intercept)	1085.61	57.76	18.80	***
MUPOD15	2.13	1.04	2.05	*
Step 2				
Model Fit				
	F(2, 103)	33.36	p-value: 6.749e-12	
	R^2	.39		
	Adj.R^2	.38		
(Intercept)	1,619.33	82.86	19.54	***
MUPOD15	-1.96	.98	-2.00	*
Dist.VanDT	-.02	.00	-7.75	***

Standard errors: OLS
Significance. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

F.4 Estimation model summary: MUPOD and three-bedroom unit median rent

Model Info				
Observations	95 (11 missing obs. deleted)			
Dependent Variable	*CMHC_threebed_2014MedRent*			
Type	OLS linear regression			
Step 1				
	Est.	S.E.	t val.	p
(Intercept)	1412.47	79.68	17.73	***
MUPOD15	.88	1.40	.63	.53
Step 2				
Model Fit				
	F(2, 92)	13.44	p-value: 7.583e-06	
	R^2	0.23		
	Adj.R^2	0.21		
(Intercept)	1,979.74	131.11	15.10	***
MUPOD15	-3.75	1.54	-2.44	*
Dist.VanDT	-.02	.00	-5.14	***
Standard errors: OLS Significance. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				