PHYSICAL ACTIVITY AND TRANSPORTATION BENEFITS OF WALKABLE APPROACHES TO COMMUNITY DESIGN IN BRITISH COLUMBIA

Prepared for the

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EXECUTIVE SUMMARY

This report represents the first known effort to quantify relationships between a range of neighborhood scale walkability measures and travel behaviour in British Columbia, with a specific focus on Metro Vancouver. The primary aim was to understand how the planning, layout and design of neighbourhoods and communities throughout the region relates with the amount of driving, walking, and transit riding residents do on a daily basis. It also attempts to infer how these travel patterns may affect levels of physical activity region-wide and to evaluate the effectiveness of land use policies as a strategy for reducing automobile dependence and increasing the opportunity for active transportation.

Key Findings

Adults who live in more walkable neighbourhoods are more likely to engage in active transportation for home-based travel

When controlling for socio-economic and demographic factors, the odds of an adult taking any home-based walk trip were over 2.5 times higher in the most compact neighbourhoods; 2.5 times higher in the most well-connected neighbourhoods; 1.8 times higher in the most mixed-use neighbourhoods, and 3.8 times higher in neighbourhoods with the highest density of commercial uses.

Adults who live in more walkable neighbourhoods drive less

On average, adults in the least walkable neighbourhoods in the region drive approximately 12 km each day for home-based trips. Adults in the most walkable neighbourhoods drive approximately 58% less with the average reported daily travel distance for home-based trips around 7 km per day. With each quartile increase in measured neighbourhood walkability, vehicle kilometers traveled associated with home-based trips decreased by 1.34 km for adults in the sample.

Transit use and walking are highly synergistic

Transit use was observed to be the highest in locations where walking was the most prevalent. Neighbourhoods with a greater mix of land uses, better street connectivity, and higher densities provide the critical mass to support transit service and make it a viable option for regional trips such as going to school or work. The odds of an adult taking a home-based transit trip doubled in neighbourhoods located in the highest quartiles of net residential and commercial densities, street connectivity and land use mix compared to those in the lowest quartiles of the variables

Parks and open space are strong predictors of active transportation in the region

Adults residing in neighbourhoods with the highest number of parks and open space were between 1.5 and 2.5 times more likely to report a walk trip for a home-based discretionary trip, like shopping, recreation or dinning out. The study also found that the

number of parks and open space uses near one's home may be more important than the size of the park or open space itself in influencing whether or not people choose to walk for home-based trips.

Neighbourhood built environment, as measured in this study, does not significantly influence whether or not youth walk to school

The findings suggest that non-discretionary travel to school in youth is perhaps influenced more by variables not associated with built environment characteristics measured in this study. Travel to school in younger children is more likely the product of the travel patterns of their parents and the perception of neighborhood safety than the built environment where they live. In older youth, who are likely to be more mobile and independent, proximity to school from home may be a stronger predictor of walking to school.

Modest changes in the walkability of a neighbourhood can translate into important, health-enhancing increases in active transportation and physical activity

Many of the results in this study showed that significant increases in the odds that an adult will walk or take transit could be achieved not only in neighbourhoods with the highest densities or street connectivity but even in those areas considered to be even just slightly more pedestrian-friendly than the most sprawling and least walkable places in the region. For instance, the odds of an adult reporting a home-based walk trip doubled when the number of parks increased to 3 or more parks from no park or open space parcels residential densities were more than 15 units per acre compared to 6 units per acre. These trends suggest that municipalities and the region do not have to necessarily make dramatic policy and regulatory changes to make neighbourhoods throughout the region more walkable and pedestrian-friendly.

Recommendations

Taken collectively with a growing body of evidence from elsewhere in North America and globally, there is sufficient evidence to take action now toward developing more walkable neighbourhoods and communities throughout Metro Vancouver. The evidence in this study supports the following region-wide interventions:

1. Increase urban residential and commercial densities
2. Reduce distances to a variety of destinations by increasing land use mix
3. Increase road, pathway, and sidewalk connectivity and route choices
4. Give priority to non-motorized travel
5. Provide for parks and open spaces within new and existing communities
6. Increase the level of public transit service

Neighbourhood specific recommendations include developing local models for high density housing and increasing parks and open space corridors in urban areas, encourage the gradual redevelopment of shopping malls and big box retail to mixed use and support

location efficient development in suburban areas, and channeling new development into mixed-use settlements in rural areas.

In order to create more walkable and healthy places, local and regional policy-makers need to:

- Explore new planning and development directions such as more appropriate zoning regulations to allow mixing of uses and housing types.
- Complement well-designed communities with appropriate transit and pedestrian infrastructure investments to connect these places to the rest of the region.
- Create new partnerships to help improve the decision-making process.

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INTRODUCTION

Purpose

This report represents the first known effort to quantify the relationship between detailed measures of neighborhood walkability and travel behaviour in British Columbia, with a specific focus on Metro Vancouver. It seeks to understand how the planning, layout and design of neighbourhoods and communities throughout the region affects the amount of driving, walking, and transit riding residents do on a daily basis. It also attempts to infer how these travel patterns may affect levels of physical activity region-wide and to evaluate the effectiveness of land use policies as a strategy for reducing automobile dependence and increasing the opportunity for active transportation. The findings in this report help to establish and support existing local best practices that should be followed in order to achieve a healthier, more environmentally sustainable built environment in Metro Vancouver.

Background

The development of a healthier built environment in cities and towns throughout British Columbia has emerged as an important policy topic. In the past two years, two local reports have been released summarizing the research on physical activity and public health benefits of more walkable and pedestrian-friendly community design; one from Smart Growth BC, Promoting Public Health Through Smart Growth and another from the BC Provincial Health Service Authority entitled Creating a Healthier Built Environment in British Columbia. The findings presented in these documents are clear: more walkable community planning and design results in increased levels of active transportation and physical activity, and a decrease in driving and vehicle kilometers traveled (BCPHSA, 2007; Smart Growth BC, 2006).

These reports are quick to conclude, however, that the availability of local empirical evidence to either support or refute these claims is currently lacking. As efforts to promote infill, higher density and mixed use development are based on the assumptions that these types of development patterns will help reduce automobile dependence and increase the potential for active transportation alternatives like walking and cycling and transit, this situation makes it difficult for local agencies wanting to make a case for more walkable approaches to community planning and design in this region. However, each region is unique. Therefore, local evidence is needed to evaluate which approaches to community design are most likely to be effective agents at reducing auto dependence and promoting active transportation the Lower Mainland.

The results of this study support many local efforts underway in the region to promote transit, walking and to mitigate auto dependence. They also suggest the need for a broadening of the set of community design, land use, and transportation investment strategies to meet these same objectives.

Objectives

The current study seeks to establish an evidence base documenting the relationships between the built environment and travel behaviour in Metro Vancouver. Toward this end, this report strives to accomplish the following:

1. Summarize the general travel patterns in the region and how they vary across municipalities and between different urban forms.
2. Evaluate the degree to which changes in land use and transportation systems are associated with engagement in active transportation like walking and cycling, but also degree of transit use and driving.
3. Identify specific built environment characteristics which influence walking, cycling and transit use rather than vehicle use.
4. Quantify the potential effects of specific land use characteristics on general travel patterns and trip distances.

The results presented in this report can help planners, politicians and other decision makers answer questions like:

1. What are the relative differences in travel patterns across the region and how do they vary based on level of walkability and regional location?
2. What kinds of policies are required to support the development of walkable communities throughout the urban, suburban and exurban areas of Metro Vancouver?

About this report

This report begins with a summary of the current state of physical activity and public health in British Columbia, highlighting the need to explore alternative means of encouraging physical activity. A brief review of the existing literature and study on the relationship between land use, travel behaviour and, more recently, physical activity and public health, which follows. This summary establishes a jumping off point and lays out the hypotheses of the study. A summary of the findings on the relationships between the built environment and travel behaviour in the region are then presented. A more detailed summary of the methodologies and results can be found in the technical appendices which accompany this report. The report concludes with guiding principles and best practices for encouraging more walkable community design and development in the region and highlight areas where future research and study are needed.

PHYSICAL ACTIVITY AND PUBLIC HEALTH IN BRITISH COLUMBIA

Current trends in physical activity and public health in the region and province warrant an exploration into how better community planning, and more specifically – increased levels of walkability and transit supportive land use planning, can aid in encouraging people to be more active.

Today, more and more British Columbians are leading sedentary lifestyles. According to the Canadian Fitness and Lifestyle Research Institute, 47% of British Columbians and 61% of Canadians in 1999 were too inactive to reap the health benefits of regular physical activity (Coleman and Walker, 2004). The number of British Columbians considered to lead physical active lifestyles is also decreasing. According to the 2000-2001 Canadian Community Health Survey, the share of physically active British Columbians dropped 1.1% from 27.2% in 1994 to 26.9% in 1999 (Coleman and Walker, 2004). The same survey found that 38% of the province's population was completely inactive or sedentary.

Low participation in health-enhancing physical activity substantially affects population health. Diseases associated with physical inactivity are among the leading causes of death and disability across Canada and include:

- Coronary heart disease
- Stroke
- Colon and breast cancer
- Obesity and being overweight
- Osteoarthritis and osteoporosis
- Fall-related injuries in seniors
- Type-2 diabetes
- High blood pressure; hypertension
- Depression and anxiety; low self-esteem

Maintaining a healthy and active lifestyle has been shown to largely prevent all of these diseases (Sallis et al., 2004).

The impacts of physical inactivity extend beyond those directly affected; physical inactivity also strains the resources of our health care system and economy. A recent study estimated that physical inactivity costs the British Columbia health care system approximately $211 million each year in direct costs and over $362 million each year in indirect costs associated with productivity losses due to premature death and disability (Coleman and Walker, 2004).

THE BUILT ENVIRONMENT AND ACTIVE TRANSPORTATION

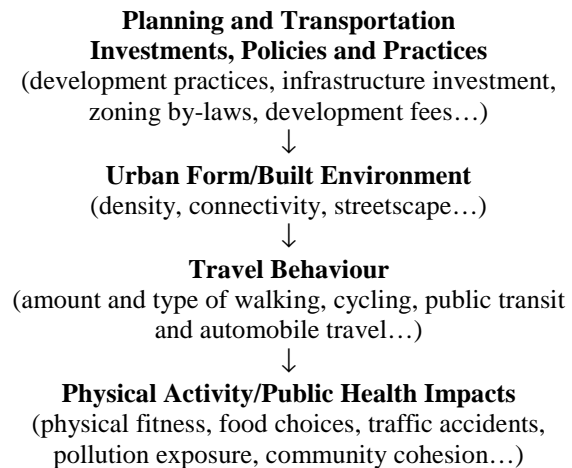## *Understanding the Relationship*

Reasons for the decline in physically active lifestyles include increasingly busy schedules and a lack of time to be active, lack of motivation, safety and risk concerns and perceived monetary costs of recreational facilities. More recently, evidence is pointing to the built environment. Our local neighbourhoods and communities are not designed to support active living and active transportation and many are not arguing this is having a major influence on daily physical activity levels.

The built environment can influence public health largely because of the transportation choices residents make that result from different approaches to community design (see Figure 1). Urban planning and transportation research has consistently shown that most often, compact, mixed use and well-connected neighbourhoods are associated higher levels of walking, cycling and transit use and a decrease in the amount of driving (Saelens et al., 2003). Conversely, suburban neighbourhoods characterized by sprawling, single use development have a tendency to foster more daily travel by vehicle and less active transportation

Planning and Transportation Investments, Policies and Practices
(development practices, infrastructure investment, zoning by-laws, development fees…)
↓
Urban Form/Built Environment
(density, connectivity, streetscape…)
↓
Travel Behaviour
(amount and type of walking, cycling, public transit and automobile travel…)
↓
Physical Activity/Public Health Impacts
(physical fitness, food choices, traffic accidents, pollution exposure, community cohesion…)

Figure 1: From Land Use to Travel Behaviour to Health

choices like walking and cycling (Boarnet and Crane, 2001; Bento et al., 2003). These results are highly intuitive. Live further away from work and non-work destinations where the car is the only viable option will result in more driving and less walking. Although causal evidence at this point is limited, significant associations have been found in many different locations and at many scales of measurement.

More recently, research in the public health and planning realm have measured associations with an area's walkability and health outcomes including physical activity and body weight, exposure to air pollution, traffic safety and others. This body of work has shown that residents of more walkable places report higher levels of physical fitness and lower levels of obesity than residents of more automobile-oriented communities (Humpel et al, 2002; Frank and Engelke, 2004; Ewing et al 2003).

Today, there is growing consensus among public health and urban planning experts that supporting more physically active modes of transportation and better access to parks and recreational opportunities through changes to the built environment offer the most effective ways to increase activity levels across the population (Frank et al., 2003). The

state of the knowledge regarding which elements of the built environment encourage or discourage active transportation is discussed below.

State of Knowledge

Urban form relates to travel patterns primarily by impacting the **proximity** between destinations and the **connectivity** or directness of travel between these destinations.

Proximity is defined by the **density or compactness** of uses or activities and the level of **land use mix** in a given area (Handy et al., 2002). The closer uses are to on another and the more uses and activities found in a given area, the easier and more convenient it may be to walk to a given destination (Ewing and Cervero, 2001). **Connectivity** is considered high when streets are laid out in a way to facilitate more direct travel and there are few barriers to like dead-ends, fencing or cul-de-sacs (Saelens et al., 2003).
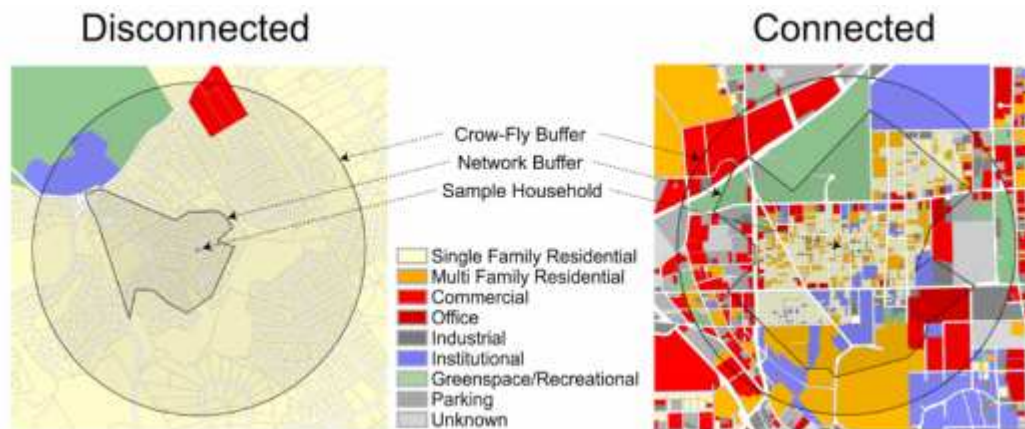
Figure 2: Comparing walkable community design and sprawl-type development
(Source: Frank et al., 2004).

Figure 2 illustrates how proximity and connectivity impact neighbourhood walkability and travel behaviour. The diagram contrasts a household located in a typical low-density, disconnected suburban neighbourhood with separated uses on the left, with a household located in a more compact, connected and mixed use neighbourhood on the right. The circle represents a 1-kilometer radius (the 'crow-fly' distance) from each household, while the asymmetrical 'network' inside the circle captures a 1-kilometer area considered to be walkable on the street network. This diagram shows not only how a disconnected street network pattern can impact walking and accessibility (directness), but also how a low-density, single use land pattern restricts the umber of accessible destinations within walking distance (proximity).

Density / Compactness of Development

Density relates with travel behaviour by affecting distances between destinations and the portion of destinations that can be reached by active transportation. Densely populated and compact neighbourhoods widen the range and diversity of services that can be supported in an area and make transit feasible and appropriate.

Studies have consistently found as neighbourhood density increases, time spent in cars and distances traveled in cars tend to decline while walk and bicycle trips are more prevalent (Ewing and Cervero, 2001; Hotzclaw, 1994; Frank et al., 2006).

Minor increases in density may not create an environment favourable for walking or cycling. A recent study in Seattle found that nearly all travel in the region was done by car until residential density levels reached approximately 13 persons per gross acre and employment density was greater than 75 employees per gross acre before there was a substantial increase in pedestrian and transit travel for work trips (Frank and Pivo, 1995). These findings suggest that only after certain density thresholds are reached will active transportation become a feasible travel alternative.

Many current zoning and planning policies limit density. Additional requirements like setbacks and parking standards corroborate to form a low-density environment that renders active transportation inconvenient.

Land Use Mix

A mixed-use neighbourhood includes not just homes but also offices, stores, parks and other land uses all within close proximity to one another. Like density, a good mix of functional land uses increases the proximity of destinations that people need on a daily basis, thereby making active transportation both appealing and appropriate.

A number of studies using detailed land use data have found greater land use mix to be highly correlated with increased active transportation and reduced automobile travel (Lee and Moudon, 2006; Moudon and Lee, 2003; Hess, 1999; Frank et al., 2006). Land use mix generates the most walk trips where daily activities like home, school and work are located nearer those that are important destinations of daily and weekly trips, particularly grocery stores, shops and restaurants. The number of uses rather than size or area is found to be more effective at generating more walking and cycling trips (King County ORTP, 2005). A mixed land use pattern was directly correlated to lower obesity rates in the Atlanta-based SMARTRAQ study. The study found that each 25% increase in measured

land use mix was associated with a 12% reduction in the chance of a person from that area being obese (Frank et al., 2004).

Traditional zoning and planning policy tends to produce mono-use neighbourhoods. Separating residential areas from shopping, work and recreational opportunities effectively makes active transportation no longer a viable travel option.

Connectivity

A more connected roadway, walkway and bikeway system reduces the distances that must be traveled to reach a destination. Studies have found significant positive associations between elements of connectivity and walking (Kitamura et al., 1997; Boarnet and Crane, 2001) The Seattle-based LUTAQH study found that the odds of someone reporting they walked for non-work purposes rose by 14% for each quartile increase in the level of street connectivity where they live (King County ORTP, 2005).

In recent years, many urban planning experts have begun advocating a return to more connected road and pathway networks. However, cul-de-sac designs are still very much the more common network design, especially in newer suburban developments where much of new growth in urban areas is being directed.

In many cases, the most walkable environments and neighbourhoods are those that contain high levels of density, land use mix and street connectivity. Current research supports this suggestion by demonstrating that these elements are often highly correlated with one another (Frank et al., 2004; Leslie et al., 2007). That is take away higher densities, and neighbourhoods are left without a population base to support a mix of shops and services – take away the shops and services and residents are left without a convenient and accessible place to shop and meet with family and friends. As a result, it can be difficult to disentangle the effects of each factor individually. The most recent research the relationships between the built environment, travel outcomes and physical activity have developed and utilized composite measures of walkability that integrate these variables into a single, more holistic picture of walkability. The SMARTRAQ study in Atlanta found that walking increased and vehicle miles traveled decreased as overall walkability increased (Frank et al., 2004).

Transit Service and Facilities

Transit trips are also associated with more active transportation. Many people who take transit choose to walk or cycle to the nearest transit stop and, often, complete their trip by walking or cycling as well. The LUTAQH study found highly correlated relationships between more walkable neighbourhoods and transit use (King County ORTP, 2005).

More compact, walkable neighbourhoods provide the critical mass to make transit service more viable and appropriate.

Competitive forms of transit and non-motorized facilities may facilitate one's ability to forgo car ownership and car use for many trips, especially work and school trips requires having a competitive form of transit and non-motorized opportunities. In the absence of such systems, people will be more inclined to utilize their car for many trips, thereby reducing the ability to gain physical activity benefits from active transportation.

<u>Parks and Open Space</u>

Parks and open space are common neighbourhood features that may provide opportunities to increase active transportation and levels of physical activity. Only recently has their influence on travel and physical activity been a focus of study. Accessible parks and open spaces with trails, pathways or playing fields may increase one's propensity to walk or cycle for both leisure and utilitarian purposes. This is especially true in children. A recent study found that access to parks and recreational space was the most important urban form variable related to walking for children and youth aged 5 through 20 (Kerr et al., 2007).

Key Points

Existing research suggests that:

- Travel behaviour is very much influenced by the built environment – however individual preferences and desire to travel by certain means and modes also helps mould our travel behaviour and choices.
- More walkable neighbourhoods, those characterized by high levels of density, connectivity and mixing of uses, are associated with more active transportation.
- Children, youth and adults may be influenced more by certain built environment elements than others.
- No research has been undertaken in the British Columbia context. Local evidence that demonstrates the increased active transportation benefits of more walkable community design is needed to support policy arguments for more compact and mixed-use development.

THE STUDY APPROACH

Existing research highlights the potential for more walkable community design to increase levels of active transportation. To date, no data or evidence exists in Metro Vancouver to either support or refute these claims. The current study explored the relationship between the built environment and reported travel behaviour in Metro Vancouver to determine the effectiveness of better land use planning as a strategy for reducing automobile dependence and increasing opportunities for active transportation. A detailed methodology on how this was completed in found in Appendix A.

Research Design

Travel survey data

The study used self-reported travel data from the 1999 Regional Trip Diary Survey conducted by TransLink and the Greater Vancouver Regional District (now Metro Vancouver). A sub-sample of 3,821 individuals (3,155 adults age 18 and older; 666 youth age 5 through 17) was drawn from the full travel survey (N=7,063 persons, 2,990 households) for analysis. Individuals were selected based on having reported complete socio-economic, demographic and travel data. All participants reported on their travel patterns during a single weekday. Participants were assigned different weekdays to capture a complete set of weekdays (Monday-Friday) for the analysis. For the purposes of this study, only those trips originating from the home were analyzed. This was done to provide a more accurate account of the influence of the built environment where people live. These home-based trips were characterized as discretionary (shopping, recreation/social, eating/restaurant, personal business, pick up/drop off passengers, other) or non-discretionary (work and school) in order to observe how the built environment influences travel behaviour for different purposes. Only non-discretionary travel to school was studied in the youth population due to a small sample of reported discretionary travel.

Measuring urban form and walkability

The Metro Vancouver Walkability Surface Index was used to measure the characteristics of the built environment within the immediate areas where respondents live. The Walkability Index assess how walkable a particular streetscape or neighbourhood is based on the measures of four characteristics of the built environment known to relate with walking behaviour into a single, aggregate measure. These characteristics are: land use mix, density of commercial uses, net residential density and street connectivity (see Table 1).
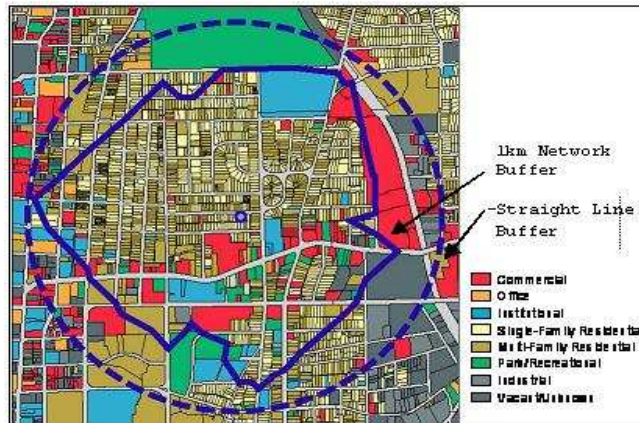
Table 1: Measures incorporated into the Metro Vancouver Walkability Surface Index

Built Environment Characteristic	Measure	Definition
Residential Density	Net residential density (NRD)	Number of residential units per acre designated 'Residential'
Commercial Density	Retail floor-area ratio (RFA)	Ratio of retail building floor area to area of retail parcel
Connectivity of Street Network	Intersection density (ID)	Number of intersections per square kilometer
Land Use Mix	An entropy index measure of land use mix (LUM)	Evenness of distribution of square footage of residential, commercial, entertainment and office development

Each of the four measures are calculated for each postal code using a 1-kilometer "network buffer" surrounding the centroid of the postal code. The network buffer is defined by the extent of all 1-kilometer paths along the road network emanating from the postal code centroid. This is conceptually illustrated in Figure 3. A detailed account of how the walkability index was constructed is provided in Appendix A.

Linking land use with reported travel behaviour

Household locations were spatially matched to their corresponding postal codes and the corresponding data on walkability around each household. This allowed us to evaluate relationships between the physical design of the environment where people live and their reported travel behaviour. The use of well-established and documented statistical analysis tools allowed the researchers to determine the specific influence of various built environment measures like residential density, street

Figure 3: Sample postal code centroid showing 1-km network buffer along roadways.

connectivity, degree of land use mix and the amount of nearby parks and open space on reported travel behaviour.

Controlling for other influential variables

Socio-economic and demographic variables like age, gender and household income were controlled for in all analyses. The study found that travel behaviour varied by age, gender and household income. As a result, it was important to isolate the effects of land use patterns from these demographic differences. Without controlling for such factors, we would not know if, for example, higher levels of driving were simply because of higher

incomes. Controlling for these variables allowed the researchers to convey a more accurate and objective relationship between neighbourhood form and travel behaviour.

Study Hypotheses

Previous research into the travel behaviour outcomes associated with the built environment offers evidence of the physical activity and active transportation benefits of more walkable approaches to community design and planning. This study predicts that the relationship between the built environment and reported travel behaviour in Metro Vancouver will be similar to the findings in the existing research and evidence. That is, it is expected that people who live in areas with higher densities, connectivity, land use mix and parks and open space will be more likely to choose active transportation means for daily home-based travel. People living in the least walkable neighbourhoods in the region will be more likely to drive and report higher vehicle kilometers traveled.

THE FINDINGS

The findings of the study establish the relationship between the built environment characteristics where people live and their reported travel behaviour in Metro Vancouver. A detailed account of these results can be found in Appendix B. The major findings are summarized in this section.

Most trips in the region are made by car

Figure 4 shows the transportation mode share by municipalities. More than half of the municipalities in Metro Vancouver reported around 80% or more of home-based travel in a private vehicle. Across the region, 15% of home-based trips were made on foot. Approximately 12% of home-based trips were made using transit. Residents in Vancouver, Burnaby, New Westminster and the City of North Vancouver reported the highest amount of walking and transit use for home-based trips. Individuals who live in these areas also reported, on average, the fewest vehicle kilometers traveled daily (see Figure 5).
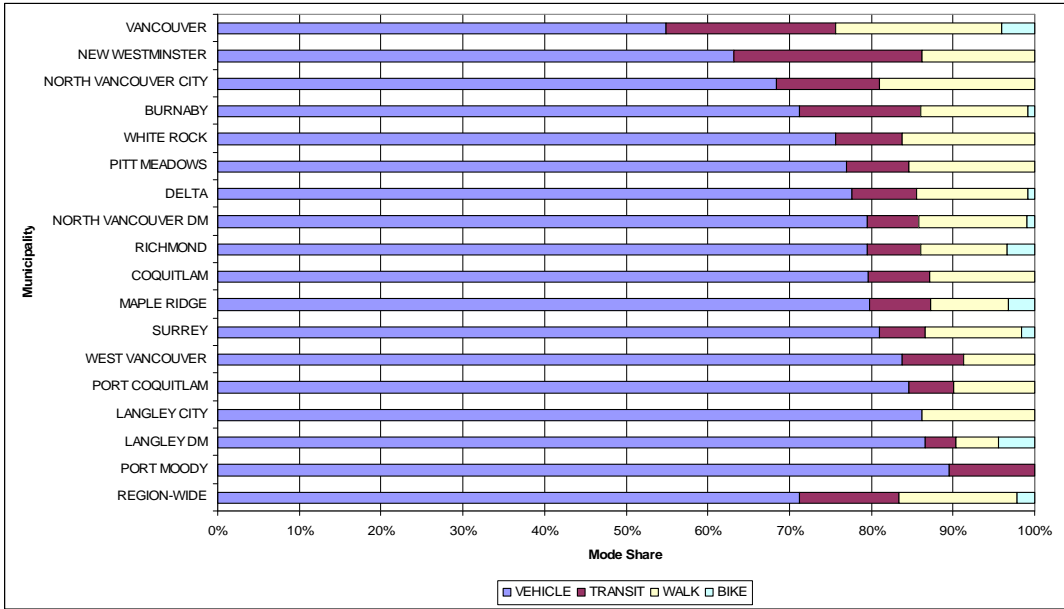
Figure 4: Mode share by municipality in Metro Vancouver.
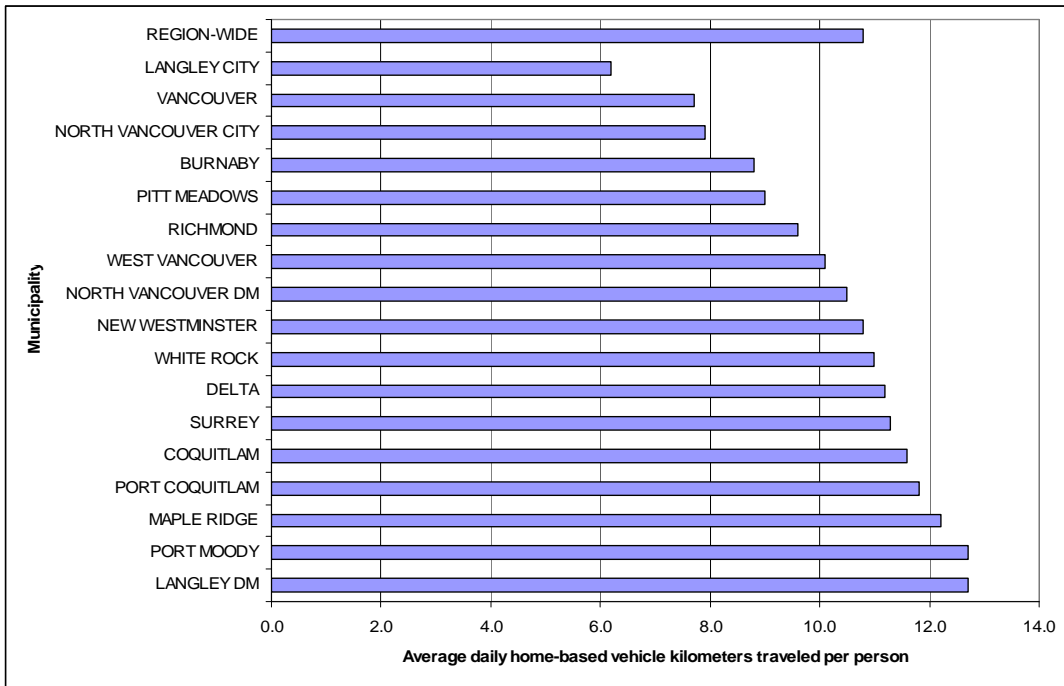
Figure 5: Average daily vehicle kilometers traveled per person by municipality in Metro Vancouver.

Adults who live in more walkable neighbourhoods are more likely to engage in active transportation for home-based trips

The study found that significantly more adults walk for home-based travel when they reside in more compact, mixed-use neighbourhoods with good street connectivity. The share of adults reporting a home-based walk trip was significantly higher in the third and fourth quartile of neighbourhood walkability. When controlling for socio-economic and demographic factors, the odds of an adult taking any home-based walk trip were:

- 2.5 times higher in the most compact neighbourhoods with residential densities over 15 unites per net acre
- 2.5 times higher in the most well-connected neighbourhoods with 55 or more intersection per square kilometer,
- 1.8 times higher in the most mixed-use neighbourhoods, and
- 3.8 times higher in neighbourhoods with the highest density of commercial uses.

Transit use is more common in more walkable places

Transit use was observed to be the highest in locations where walking was the most prevalent. The higher residential and commercial densities that also characterize walkable neighbourhoods provide the critical mass to support transit service and make it a viable option for regional trips such as going to school or work. When controlling for socio-economic and demographic factors, the odds of an adult taking a home-based transit trip effectively doubled in neighbourhoods located in the highest quartiles of net residential and commercial densities, street connectivity and land use mix compared to those in the lowest quartiles of the variables.

Adults who live in more walkable neighbourhoods drive less

Clearly, where more people report walking and transit use, they are driving less. Automobile dependency, as measured by home-based vehicle kilometers traveled, decreased with each quartile increase in neighbourhood walkability. The typical persons surveyed drove (or was driven) approximately 10.5 kilometers for home-based trips, but the variation between persons in different areas was quite large. On average, adults in the least walkable neighbourhoods in the region drive approximately 12 km each day for home-based trips. Adults in the most walkable neighbourhoods drive approximately 58% less with the average reported daily travel distance for home-based trips around 7 km per day, controlling for socio-economic and demographic factors. Higher net residential and commercial densities, land use mix and street connectivity were significant predictors of the amount of driving adults reported they did on a daily basis. Overall, with each quartile increase in measured neighbourhood walkability, vehicle kilometers traveled associated with home-based trips decreased by 1.34 km for adults in the sample.

Density is the most significant predictor of reported travel behaviour

Across all home-based trip types, both net residential density and commercial density (retail-floor area ratio) were found to consistently be the most significant and strongest predictor of reported travel. In neighbourhoods with the highest residential densities (15 residential units per acre or more), the odds of an adult walking to work or school were over 4 times higher than an individual living in a neighbourhood with the lowest density (0 to 6 units per acre). Adults were found to be about 3.5 times more likely to drive for home-based discretionary travel if they resided in an area with the lowest density of commercial uses (i.e. around sprawling suburban shopping malls and plazas) of the least compact areas in the region. These finding are not surprising. A concentration of jobs and people make transit more viable and provides the critical mass necessary for supporting local retail and service development nearby. Take away density and the distance between uses would be much too large for walking or public transit to be considered viable transportation options.

Parks and open spaces are strong predictors of active transportation in the region

Nearby public green space provides people with a destination to gather and socialize, eat and recreate. Parks and open space also provide pleasant environments to walk through on the way to nearby destinations. Significantly more people reported walking, especially for discretionary travel, where their neighbourhood contained more parks and open space. Adults residing in neighbourhoods with the highest number of parks and open space were between 1.5 and 2.5 times more likely to report walking for shopping, recreation, and eating/dinning out trips. However, the findings suggest that other built environment variables like density, street pattern and land use mix are stronger predictors of walking than parkland in adults and that parks only encourage walking when they are combined with other elements of urban form. Youth were between 2 and 3 times more likely to report walking for trips to school if they lived in areas with a high number of parks. Parkland provides youth with a relatively safer environment to walk to school compared to sidewalks beside busy roads. The study also found that the number of parks and open space parcels near one's home may be more important than the size of the use itself in influencing the whether or not people choose to walk for home-based trips. This is an important finding suggesting that a larger amount of smaller parks and open space interwoven into residential areas may be a good way to encourage walking and active transportation. A larger number of parks and open space closer to home makes these spaces much more accessible than a single large green space commonly found in many suburban areas.

Neighbourhood built environment, as measured in this study, does not significantly influence whether or not youth walk to school

The findings suggest that non-discretionary travel to school in youth is perhaps influenced more by variables not associated with built environment characteristics measured in this study. Younger children under the age of 14 are often completely reliant on parents or guardians for transportation to many destinations or they are limited to a

highly restricted spatial realm consisting of a small number of destinations that are readily and safely accessible by non-motorized means. The travel patterns of their parents, and likely the perception of neighborhood safety may be more influential then the built environment where they live. In older youth, who are likely to be more mobile and independent, proximity to school from home may be a stronger predictor of walking to school. Other studies have found that distance is a major predictor of youth walking or not to school (Frank et al., 2009).

Transit and vehicle use in older youth is more likely to be influenced by the built environment than younger children

Unlike their younger counterparts, older youth, especially those entering their high school years are much more mobile and independent. Many youth at this age get their first drivers license. Older youth are also more likely to attend a secondary school that is further from their home. The study found that this age cohort is usually able to make travel decisions themselves and are more likely to be significantly influenced by their neighbourhood built environment. Older youth living in the most walkable neighbourhoods in the region are almost 8 times more likely to make a home-based non-discretionary transit trip to school compared to older youth in the least walkable areas. Older youth in the least walkable neighbourhoods are between 4 and 5 times more likely to drive (or get driven) for home-based trips to school than those in the most walkable neighbourhoods in the region, all else being equal.

Modest changes in the walkability of a neighbourhood can translate into important, health-enhancing increases in active transportation and physical activity

Many of the results in this study showed that significant increases in the odds that an adult will walk or take transit could be achieved not only in neighbourhoods with the highest densities or street connectivity but even in those areas considered to be even just slightly more pedestrian-friendly than the most sprawling and least walkable places in the region. For instance, the odds of an adult reporting a home-based walk trip doubled when the number of parks increased to 3 or more parks from no park or open space parcels and residential densities were more than 15 units per acre compared to 6 units per acre. These trends suggest that municipalities and the region do not have to necessarily make dramatic policy and regulatory changes to make neighbourhoods throughout the region more walkable and pedestrian-friendly.

More walkable communities can help people become more physically active through their daily travel behaviour

More walkable neighbourhood types see a significantly larger share of people reporting walking and transit use and a decrease in vehicle use and vehicle kilometers traveled. A recent study of the Metro Vancouver region using the same walkability data used in the current study found that people residing in the most walkable neighbourhoods in the region are more likely to get the recommended amounts of daily physical activity (Frank et al., 2007).

DEFINING A WALKABLE NEIGHBOURHOOD IN METRO VANCOUVER

Using the Metro Vancouver Walkability Index, we are able to define what elements of the built environment characterize walkable streets and neighbourhoods and locate these places within the region. The Metro Vancouver Walkability Index measures walkability and built environment characteristics quantitatively. However, it is difficult to visualize urban form characteristics of a specific place based on numerical values and measurements. Aerial photos representing a cross-section of regional walkability values are included below to illustrate what different levels of walkability look like in terms of built form. Comparing these photos to the walkability index value allows an observer to understand what components lend themselves to more walkable areas and those that do not.

Characteristics of a Walkable Neighbourhood

Figure 7 illustrates four different neighbourhoods in the region. The images on the top are from two different neighbourhoods in Vancouver considered highly walkable. The bottom images are from different neighbourhoods in Surrey that are measured as very unwalkable. Each neighbourhood has a different walkability index value.

a) **Walkability ≈ 12**; Homer Street and Pender Street, Vancouver

b) **Walkability ≈ 6**; West Broadway and Macdonald Street, Vancouver

c) **Walkability ≈ 0**; 72 Avenue and 124 Street, Surrey

d) **Walkability ≈ -6**; 97 Avenue and 177A Street, Surrey

Figure 7: Visualizing and comparing neighbourhood walkability across Metro Vancouver

The aerial photos in Figure 7 illustrate that walkable neighbourhoods in the region have a more compact urban form characterized by medium to high residential densities, a concentration of nearby commercial uses, a functional mixing of land uses, a high degree of connectivity (i.e. small block sizes, higher number of intersections) and pedestrian friendly transportation options (i.e. well connected system of sidewalks, pathways, etc). It is apparent that these elements tend to occur together in these more walkable areas. This suggests that the overall walkability of a street or neighbourhood is the product of a collective effect of these factors. As measured neighbourhood walkability decreases, so to does the presence of higher residential densities, mixing of land uses and the more direct and connected grid street pattern. Least walkable areas tend to be those designed to be automobile-oriented with low residential density (predominantly single detached homes), a low degree of connectivity (large block sizes, cul-de-sacs, inconsistent street pattern), and a generally homogenous land use mix and pattern (i.e. residential areas are separated from commercial areas are separated from office areas are separated from recreational areas). These characteristics are comparable to other studies that have measured neighbourhood walkability in Seattle, Atlanta and in Australia.

Table 2: Values associated with each built environment quartile and neighbourhood examples

Built Environment Measure	Quartile	Value Range	Example
Net residential density	1	0.0 - 5.8	South Newton (Surrey)
(residential units per acre)	2	5.9 - 9.1	Kerridale (Vancouver)
	3	9.2 - 15.2	Marine Drive (North Vancouver)
	4	15.3 - 784.8	Commercial Drive (Vancouver)
Intersection density	1	0.0 - 36.3	Sunnyside Landing (Port Moody)
(number of intersections per	2	36.4 - 44.8	Strawberry Hill (Delta)
square kilometer)	3	44.9 - 55.4	Mallardville (Coquitlam)
	4	55.5 - 353.0	Downtown White Rock
Commercial floor-area ratio	1	0.0 - 0.06	Crescent Beach (Surrey)
(ratio of built floor area to	2	0.07 - 0.37	Fleetwood Town Centre (Surrey)
parcel size)	3	0.38 - 1.98	Marine Drive (West Vancouver)
	4	1.99 - 53.6	Main Street (Vancouver)
Mix of land uses	1	0.0 - 0.12	Brookswood (Langley)
(dimensions	2	0.13 - 0.34	Burquitlam (Coquitlam)
	3	0.35 - 0.53	West Point Grey (Vancouver)
	4	0.54 - 0.95	Downtown New Westminster
Number of parks and open	1	0 - 2	Downtown Burnaby
space	2	3 - 7	Quilchena (Vancouver)
	3	8 - 17	West End (Vancouver)
	4	18 - 491	North Kitsilano (Vancouver)
Area of parks and open spaces	1	0.0 - 0.77	Lansdowne Park Mall (Richmond)
(acres)	2	0.78 - 2.32	Hasting East (Vancouver)
	3	2.32 - 6.10	Royal Oak (Burnaby)
	4	6.11 - 146.76	West Hill Park (Port Moody)

The actual values and levels of residential and commercial density, street connectivity, land use mix, and amount of parks and open spaces that help make a street or neighbourhood more walkable vary from place to place. For example, downtown Vancouver and the Commercial Drive neighbourhood in Vancouver have different densities, degrees of land use mix, and street connectivity but are both considered highly walkable places. This suggests that there are threshold values of density, land use mix, street connectivity and number of parks and open spaces where walking and active transportation becomes more appropriate in the region. Table 2 shows the range of values associated with each quartile of the built environment measures in the walkability index.

From the findings in this report, we know that individuals who reside in the higher quartiles of residential density, intersection density, commercial density, land use mix and parks and open spaces are more likely to choose walking and transit for home-based trips and report reduced vehicle use than those that reside in the lower quartiles of these

variables. In general the characteristics that encourage significantly more active transportation in Metro Vancouver include:

- Net residential densities of over 15 units per acre,
- Over 44 intersections per square kilometer (smaller block sizes)
- A retail floor area ratio (commercial density) of over 0.5 (less space devoted to surface parking, building closer to road/sidewalk),
- Smaller, more scattered and interwoven parks and open spaces within 1-km of home (3 or more parks and open spaces with a total area of 1 to 6 acres)

These thresholds demonstrate that walkable communities are not necessarily characterized by extreme densities, land use mixing and connectivity.

Location of Walkable Neighbourhoods
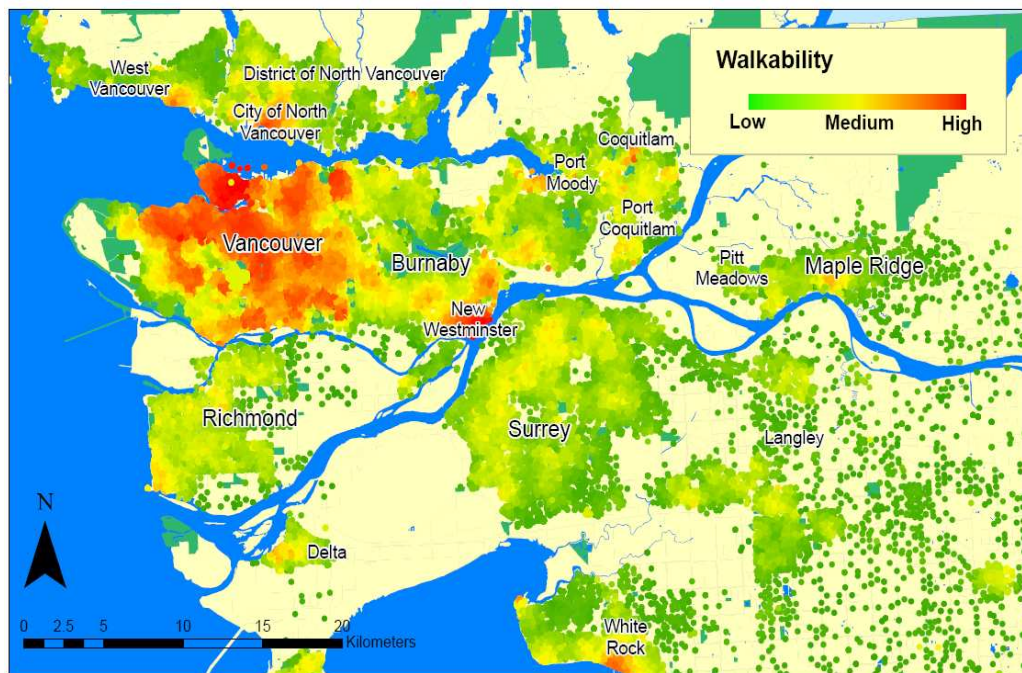
Figure 8: Neighbourhood walkability across Metro Vancouver

Figure 8 illustrates the measured walkability for each neighbourhood (at the postal code level) in Metro Vancouver. The most evident trend in examining the Walkability Surface for the region is the strong gradient of decreasing walkability extending out from the regional core centred on the City of Vancouver. The City of Vancouver and surrounding municipalities have the largest number of walkable areas (see Figure 9). This is not surprising. Vancouver is an older city that was originally developed around horse and trolley travel. Traditionally, the city has had progressive land use and transportation policies to maintain high levels of density, connectivity and land use mixing throughout the city. Outlying areas like Surrey, Delta and Langley have the least number of walkable areas. These areas have developed in relatively recent times and focused growth and

development around the automobile. The large amount of space required for the automobile has resulted in mono-use neighbourhoods, irregular road patterns and largely inaccessible green and open space.
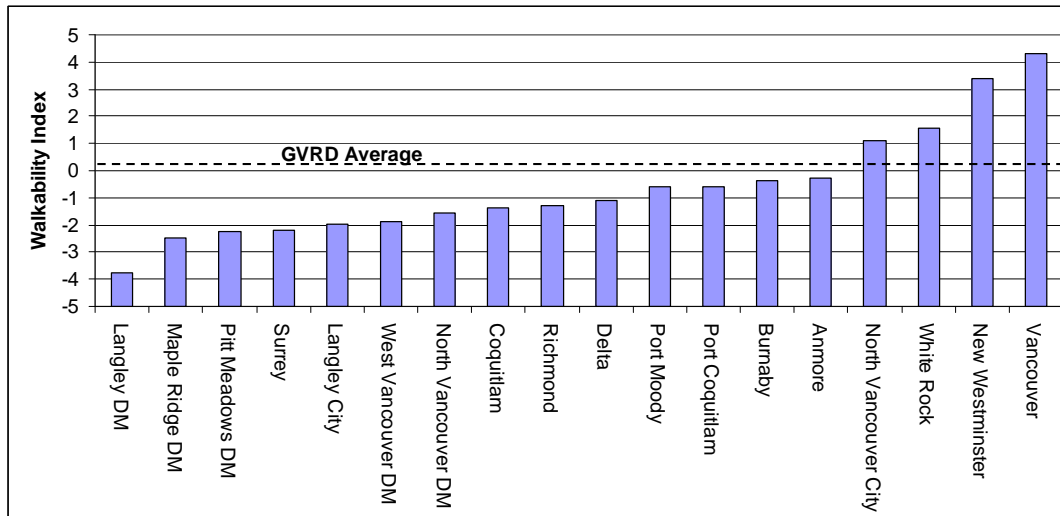
Figure 9: Average Walkability Indices across Metro Vancouver

RECOMMENDATIONS

The findings of this report extend and support the results of previous research on the relationship between the built environment, where people live, and their daily travel behaviour. The physical characteristics of the built environment was found to be significantly related with the choice to walk, take transit, and drive. The results show that encouraging compact, mixed-use development will help Metro Vancouver develop healthier and more active neighbourhoods and communities. Beyond this, the study found that the inclusion of parks and open space in neighbourhoods also helps people to choose active transportation.

The study found that neighbourhoods and communities already exhibiting some of these attributes are delivering benefits to their residents in the form of less automobile dependence and more opportunities to be physically active on a daily basis. These neighbourhoods exist because, in the past, people were more reliant on their feet and transit to get around. Cities had to be designed in ways that this was possible and reasonably efficient. Therefore, investments were made in compact development serviced by well-connected streets and an abundance of accessible shops and services close by.

There are certain built environment characteristics which planners can encourage through effective land use policies and regulations making transit and active transportation choices like walking and cycling more attractive. These policies may not mean a total switch to transit and active transportation, or the elimination of private vehicles. Rather it would result in the ability to choose between driving and transit for longer trips (work or major shopping), and walking or biking within an area to shops, dinner, services, etc.

Region-wide Recommendations

1. <u>Increase urban residential and employment densities</u>. More compact development supports a diversity of shops, services and transit options and gets people close enough to these privately and publicly provided services to make them economically viable.

2. <u>Reduce distances to a variety of destination by increasing land use mix</u>. Land uses need to be functionally mixed (live, work, play) in neighbourhoods to ensure shops and service people need on a daily or weekly basis are close by.

3. <u>Increase road, pathway and sidewalk connectivity and route choices</u>. Most residential streets in outlying suburban areas in the region end in cul-de-sacs and thwart direct connections for both motorists and pedestrians. Providing for a more complete street network, wider sidewalk systems, and dedicated pathways in these areas, coupled with traffic calming measures, may help promote walking and cycling. Smaller block sizes offer alternative and shorter routes to a destination.

4. <u>Give priority to non-motorized travel</u>: Walking and cycling should be considered as functional transportation modes on par with the automobile. Planning for complete streets that are designed and operated to enable safe and efficient access for all modes can help accomplish this.

5. <u>Provide open space within communities</u>. A larger number of smaller, more accessible parks and recreational activities within easy walking distance create opportunities for people to be more active.

6. <u>Increase the level of public transit service</u>. This means reduce the distances to transit and the travel time on transit. The majority of trips to and from transit are walking and cycling. Well-connected transit that is time competitive and can serve large areas also encourages walking outside the neighbourhood and throughout a region.

Specific Recommendations for Different Neighbourhood Types

One of the challenges of smarter growth and development patterns is that broader solutions must be tailored to specific neighbourhood and community types in order to be successful. What might work to encourage more active transportation in downtown Vancouver may be less successful in the rural areas of Langley or the suburban communities in southern Surrey. Below are policy suggestions for specific community typologies (urban, suburban, and exurban) found throughout Metro Vancouver that may help to encourage a reduction in private vehicle use and an increase in walking and transit use.

Urban neighbourhoods like downtown New Westminster and Vancouver's West End:

- Develop local models for higher density urban housing. Vancouver's EcoDensity policy is a good example of such an initiative.
- Permit the development of non-traditional forms of housing forms, such as live-work-play spaces.
- Maintain and, where possible, increase the presence of parks and open space corridors.
- Implement traffic calming measures, including curb extensions, traffic circles and diagonal or right-in-right-out diverters that will divert or slow traffic while maintaining pedestrian and non-motorized connectivity.

Auto-oriented suburban neighbourhoods like Cloverdale in Surrey or Lynn Creek in North Vancouver:

- Encourage the gradual redevelopment of shopping malls and big box retail to mixed use.
- Discourage superfluous surface parking though appropriate design guidelines.
- Support location efficient development of new housing close to efficient public transit, shops and services, characterized by good waling and cycling conditions.
- Consider rezoning targeted single-family areas to allow infill duplexes and triplexes to increase residential density

Exurban (rural) areas like Brookswood in Langley:

- Channel development and public services into accessible, mixed-use settlements rather than dispersed, poorly connected patterns.
- Increase transportation options through community trail development for local trips and bike/transit integration for longer, regional travel.

Implications for Policy and Decision-Makers

Both regional and local policies have put Metro Vancouver in a good position to act on these recommendations. The policies in the Livable Region Strategic Plan support complete and compact communities characterized by mixed-use development, non-motorized modes and the reduction of single occupancy vehicle use. However, as this report has demonstrated the vast majority of the region is extremely auto dependent. Changing entrenched patterns of decision making that create our built environment will require an integrated set of strategies that traverse land use, transportation, health, and the environment. Towards this end, key implications for local policy and decision-makers include:

New planning and development approaches from local government

Consistency is required between broader goals and policies and "on the ground" regulations. Conventional zoning prevents the development of more walkable, mixed-use neighbourhoods by separating uses so that they must be connected by car trips. Easing these restrictions to allow for more appropriate, community-scaled growth will be important. In many local markets where well-located land may be more expensive, making pedestrian-friendly living choices affordable to people of a wide range of incomes may require additional government incentives.

Complementing well-designed communities with appropriate transportation investment

Metro Vancouver's population is expected to grow by about 800,000 residents to approach a total of 3 million people over the next 25 years. The region will need to make appropriate infrastructure improvements such as transit and pedestrian/bicycle network upgrades to serve these growing areas and connect them with the rest of the region in a sustainable and efficient manner.

Creating new partnerships to help improve decision-making process

Planning for a more walkable and healthy built environment will require a holistic viewpoints to assess the inter-relationships between future regional growth and development patterns and the overall quality of life and health implications on Metro Vancouver's population. There are a number of groups and agencies in the region, including the BC Recreation and Parks Association, who are dedicated to building healthier and more sustainable communities through funding support, programs and other services. Incorporating agencies like the BC Recreation and Parks Association in local planning and assessment processes can help re-orient policies and regulation to ensure they promote public health and physical activity across the population, support community engagement and increase transparency and accountability.

In order to be successful, these initiatives will require both consistency and cooperation in policy, regulation and action across municipalities in the region and between the region itself and the provincial government.

STUDY SHORTCOMMINGS AND FUTURE RESEARCH NEEDS

This study establishes a positive relationship between active transportation, transit use, and more walkable neighbourhood design in Metro Vancouver. It further clarifies some of the strengths of these relationships and the odds that someone will walk, take transit, or drive based on the type of neighborhood in which they live. While these findings are important to support calls for better land use and transportation planning, they fall short of establishing a causal link between the between environment and active transportation.

The current study was conducted cross-sectionally. This means that travel and activity patterns were compared between individuals in different built environments at a single point in time. A more rigorous study design would experimentally isolate built environment effects from pre-disposition and attitudinal factors and also provide an ordered stimulus (change in neighborhood exposure) and follow on response (travel patterns). There are two ways to do this, either through examining changes in travel behaviour among individuals moving from one type of built environment to another or for individuals that live in places that change dramatically; like around a transit station before and after it opens.

The travel data used in this study was for one day only. Longer periods and more complete assessment of walking and cycling (i.e. duration) are necessary to establish a more reliable estimate of representative travel patterns, especially for youth. In addition, objectively measured travel patterns would be ideal whereby GPS is used to document where people actually go and when they get there. These advancements will provide a better link to the public health and physical activity impacts of the built environment.

The models used to determine the significance of built environment characteristics in influencing travel behaviour may be considered incomplete. They accounted for only a modest proportion of variance explained in walking, transit and car use. These behaviours and outcomes have been shown to be very multi-dimensional and require consideration of many influential factors not accounted for in this report. Understanding the myriad of factors and their relationships will better allow for the determination of the independent effects of the built environment on travel behaviour. For example, detailed data on sidewalks and regional accessibility to destinations would advance the study considerably.

More travel data is required on children and youth. This study did not have enough complete travel data on these demographic groups to draw out whether the built environment is consistently a significant predictor of travel patterns in youth. Given the increased focus on obesity and overall health of our youth, this data collection is a priority. Overall, this study constitutes a creative use of comparatively limited existing data to evaluate the relationships between travel choice and neighborhood design in Metro Vancouver.

CONCLUSIONS: WHERE TO FROM HERE?

Creating more walkable and healthier communities in Metro Vancouver and throughout British Columbia will be a complex endeavor; but it is inevitable. There is a critical convergence between improved population health and reducing greenhouse gas emissions; both policy objectives point to the increased use of human power and transit for moving about within urban settings. The design and arrangement of land uses and the transportation connections provided between destinations largely determine how people will get around. Changing entrenched patterns of decision making that create our built environment will require an integrated set of strategies that traverse land use,

transportation, health, and the environment. Moreover, vertical consistency (between municipal, regional, provincial bodies) and horizontal consistency (between adjacent municipalities) is required to effectively change how decisions are made impacting the built environment on a regional scale. Cooperation is needed between all levels of government and other agencies to properly invest and allocate resources and services effectively.

A confluence of geographic barriers, cultural values favoring parks and open space, and a former resistance to highway investment helped to create some very walkable areas in the region. These more central urbanized parts of the region are what most people see when they visit. As a result, Metro Vancouver is often heralded as among, if not, the most walkable or livable region in North America. However, the vast majority of the region is extremely auto dependent. Most of what is currently being planned and developing in the areas south of the Fraser River, where growth is being focused, is built around the car. There is an emerging policy discussion regarding the need to create healthier communities and local residents are demanding a more cohesive, coordinated and sustainable approach to planning for new growth and development. The findings in this report support a push for more walkable community design and planning in Metro Vancouver and throughout the province

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