

United Way senior vulnerability report – Nov 2011

Discussion paper #3: Transportation, community design and healthy aging

Seniors living well

United Way has been supporting services for seniors in the Metro Vancouver/Sea to Sky area for decades.

By focusing on issues faced by seniors, we can strengthen our community in a way that benefits us all. For example, with one in five seniors living in poverty – and with seniors soon to outnumber children in many of our communities – we face a growing risk of senior vulnerability and isolation. Ignoring their needs today means tough challenges tomorrow, as the impact of demographic change quickens and the implications of an aging society is felt by all of us. When older people are lonely and isolated, poor or homeless, we all lose.

United Way is helping seniors to age well – in their own homes and communities, surrounded by friends, families and caregivers. Our goal is independent and engaged seniors who contribute fully to society. By providing seniors with the support they need, United Way prevents isolation, loneliness, and related health problems. We can change the future by helping seniors live independently for as long as possible.

United Way brings together the resources needed to improve lives and strengthen communities. We work with others to research and act on the causes of problems that vulnerable people face. We bring together community leaders from all walks of life to identify solutions that work locally.

United Way of the Lower Mainland invests in preventive social services throughout 23 communities, from Pemberton to Langley. Together, with a network of community partners, we're building a healthy, caring and inclusive community.

Partnerships in research

This discussion paper was prepared for United Way of the Lower Mainland to support the November 2011 United Way senior vulnerability scan.

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United Way
of the Lower Mainland



Introduction

Many developed nations, including Canada, are in the midst of a significant demographic shift. The proportion of the global population aged 60 and above is expected to double from 11% in 2006 to 22% by 2050¹ and seniors now constitute our nation's most rapidly growing age group.² These demographic changes will not only have implications for the delivery of health care and other social services, but will also have a significant impact on transportation systems.³ Efforts to understand and respond to the transportation needs of older adults are being undertaken at both local and international levels as evidenced by the World Health Organization's Guide to Age Friendly Cities.⁴ To varying degrees, transportation policies in European and North American countries are beginning to reflect the context of aging societies and academic research is starting to generate evidence to inform policy decisions.

The first section of this paper provides an overview of the literature on transportation, travel behavior, and community design in relation to the health of older adults. The second section focuses specifically on the Lower Mainland, describing local projects related to seniors and identifying areas for future research. The final section offers policy and programmatic recommendations to support the creation of healthy environments in which seniors can age.

Context

Transportation has been described as “the glue that holds all of life's activities together.”⁵ Access to transportation, whether taking public transit or driving a car, enables older adults to carry out daily tasks such as working, shopping, or going to appointments. It also facilitates participation in social, cultural, and recreational activities. Transportation has been identified as a “determinant of health” by the World Health Organization because it is a means by which seniors access community resources.⁶ For many people, the ability to travel is linked to independence, personal freedom, personal image, and well-being,^{5,7,8} but access to transport can become problematic in older age. Dependence on a car for mobility is common amongst older adults. However, the ability to operate a car can change quickly leaving older adults in car dependent environments with a sudden loss of independence and isolation. A lack of affordable and appropriate transportation options increases the risk of social isolation, especially for older

adults.^{9,10} The consequences of inaccessibility may further increase the vulnerability of already disadvantaged populations, such as older adults living with economic insecurity, poor physical health or limited mobility.

Travel behaviour of older adults

Several recent studies focusing on the travel behavior of older adults suggest that it is considerably different than that of other age cohorts. Older adults take fewer trips and take them for different reasons, but their overall mobility appears to be facilitated by access to a private vehicle.^{11,12} Older non-drivers are reported to make only half the number of trips of older drivers.¹³ Furthermore, one study found that non-drivers were fifteen times more likely to report that they frequently missed activities as a result of lack of transportation,¹⁴ indicating that health and quality of life is impacted when adequate transportation options are not available. Another recent study found that older adults with a car in automobile dependent Atlanta were also more likely to meet daily physical activity requirements.¹⁵ Compared to twenty years ago, older adults in North America are making more daily trips and travelling greater distances in private vehicles.¹³ Similar trends have been identified in the Lower Mainland with TransLink's trip diary survey showing that older adults made more daily trips in 2004 relative to 1999.¹⁶ Older drivers tend to make the majority of their trips in a vehicle, while non-drivers rely more on others for rides or take public transit.

Through the aging process, older adults generally shift from driving cars to being car passengers, and then to taking public transit, particularly for women.¹⁷ However, there is often a reduced sense of independence and feelings of guilt and shame associated with having to rely on friends and family for rides to destinations.¹⁸ Access to quality public transit service appears to increase satisfaction with the ability to get to desired destinations. One study of older adults in Boston found that non-drivers living in the city with access to quality transit services reported greater satisfaction and more trips than suburban drivers and non-drivers.¹⁸ This result suggests that there may be a latent demand or desire to be more mobile for suburban seniors.

Transportation and community design

An individual's physical and social environment may have a considerable influence on his or her health.¹⁹ These influences may be especially important for older adults because they are likely to spend more time in and around their residence.^{19,20} As functional capacity declines with age,

the activities of everyday life for older people, including mobility, are more likely to be either impeded or enhanced by environmental characteristics.²¹ Therefore, the physical environment may play an increasingly important role in helping adults maintain health and independence as they age.

The interaction between transportation and land use and its connection to the health of older adults is an important area of consideration. The degree of access provided through transportation infrastructure can influence land use and development. Alternatively, development density and location affect travel patterns in a region. Numerous studies have demonstrated that “land use affects travel by changing the distances between complementary (residential, retail, entertainment, service, and recreational) destinations.”^{22,23} Planning decisions related to such factors as street layout, density, and minimum parking requirements may encourage or discourage automobile dependence, as well as impact the feasibility of public transit or alternative modes of transportation, such as walking.

Travel patterns of older adults is related with community design. One study found that older adults living in higher density areas used transit at a much higher rate and accomplished approximately 20 percent of their trips by walking.²⁴ Another recent study found that older adults living in urban locations with mixed land uses and a complete pedestrian network (including sidewalks and crosswalks) took more trips each week and were more likely to use public transit or walk than residents in rural environments.²⁵ These findings have implications for the types of places in which older adults may age best. Aging in place is seen as a right and there is a major public policy thrust in this direction. However, some more walkable places may actually increase health risks for older adults. There are a substantial number of older adults choosing to age in place in suburban or rural communities that are car dependent.¹³ These individuals may experience limited access to amenities, community services and medical care when driving is no longer an option. Furthermore, there are financial implications for local governments and transit agencies in attempting to facilitate access to services in low-density, car dependent communities.¹⁵ Although services such as volunteer drivers and community shuttles exist in some locations to fill the transportation gap, they can be expensive and inefficient.⁵

Because community design and transportation are inextricably linked, it is critical to consider the built environment and its implications for physical activity, obesity, social isolation, safety and exposure to air pollution in the context of an aging population.

Physical activity & obesity

Mixed use, higher density neighbourhoods with well-connected streets have been found to encourage physical activity, mostly in the form of walking.²⁶ One study on the built environment, physical activity and obesity in older adults identified positive associations with mixed land use (i.e. having a variety of destinations within a close proximity) and meeting physical activity recommendations.²⁷ Furthermore, each unit increase (10%) in land-use mix was associated with a 25% reduction in the prevalence of overweight or obesity.²⁷ Another study found that residents of medium walkability neighbourhoods were 32% less likely to be overweight relative to those in low walkability neighbourhoods.^{15, i} Living in a purely residential area has also been associated with less time spent walking compared with a mixed use or commercial area.²¹ In general, older adults walk more when there are more destinations, such as drugstores, restaurants, grocery stores, and malls.^{28,29,30} Higher connectivity or more grid like street network has also been associated with increased walking in older adults, particularly walking to access destinations.^{27,28}

Neighbourhood environments that support active transportation may enable older adults to reap some of the numerous benefits of physical activity. Regular physical activity reduces the risk of many conditions and diseases, including cardiovascular disease, hypertension, type 2 diabetes, osteoporosis, obesity, colon cancer, and breast cancer.³¹ Physical activity may be beneficial in preventing osteoporosis, arthritic pain, depressive symptoms and heart disease in older women.³⁰ Evidence suggests that regular physical activity can improve appetite, sleep, energy levels and mood in older adults.³² Regular physical activity is thought to be a protective factor for cognitive decline and dementia in seniors.³³ Reduced depression and improved psychological well-being have been identified as additional benefits of physical activity.³⁴

Social isolation

It is estimated that the prevalence of depression in adults aged 65+ ranges from 8% to 27%.³⁵ The BC Ministry of Health states that “social isolation can contribute to poor nutrition, low physical and social activity, fatigue, anxiety and depression, higher levels of disability and

chronic disease, lower use of appropriate health services, premature institutionalization and earlier death.”³⁶ The 2003 Canadian Community Health Survey revealed that seniors with a strong sense of community were also more likely to be in good health relative to those who felt less connected. Limited access to private and public transport has been identified as an important contributing factor to social isolation and economic poverty that certain groups, including older adults, experience.³⁷ When driving is no longer an option, seniors in areas with fewer transportation alternatives may experience loss of independence and social isolation, which contributes to vulnerability. However, one study found that men living in more walkable neighbourhoods had a reduced prevalence depressive symptoms.³⁸ Another study confirmed that social capital can be encouraged by walkable, mixed use designs and those living in more walkable neighbourhoods were more likely to know their neighbours, trust others and be socially engaged.³⁹

Exposure to air pollution

While higher density, more walkable neighbourhoods have many potential benefits for healthy aging, there are some concerns about the health impacts of acute and chronic exposure to air pollution. Exposure to fine particulate air pollution has been causally linked with cardiopulmonary health in seniors.^{40,41} In a study based in the Lower Mainland, neighbourhoods with lower pollution and higher walkability were generally located near but not at the city center,⁴² and would be desirable locations for siting senior specific housing and care facilities. Additional policy options to address and mitigate air pollution exposure in central walkable areas include: strategies to reduce vehicle use on certain corridors, higher standards for vehicle emissions, and design for setback from the roadway edge. Suburban settings are not immune to air pollution either. Many outlying areas have the highest concentrations of ground level ozone during summer months which is also health adverse to older adults.

In summary, a walkable built environment can potentially support the health of older adults by providing a variety of transportation options and opportunities for physical activity, reducing social isolation, and enabling the maintenance of independence and quality of life. Accessible and affordable public transit and supportive community design could reduce the vulnerability of seniors and improve quality of life, particularly for those who may be at risk as a result of economic, health or mobility issues.

Lower Mainland analysis

A comprehensive understanding of the travel behavior, demographic characteristics and spatial distribution of older adults in the Lower Mainland would better enable local and regional governments, transportation and health authorities, and senior oriented service providers to respond to the needs of the most vulnerable older adults.

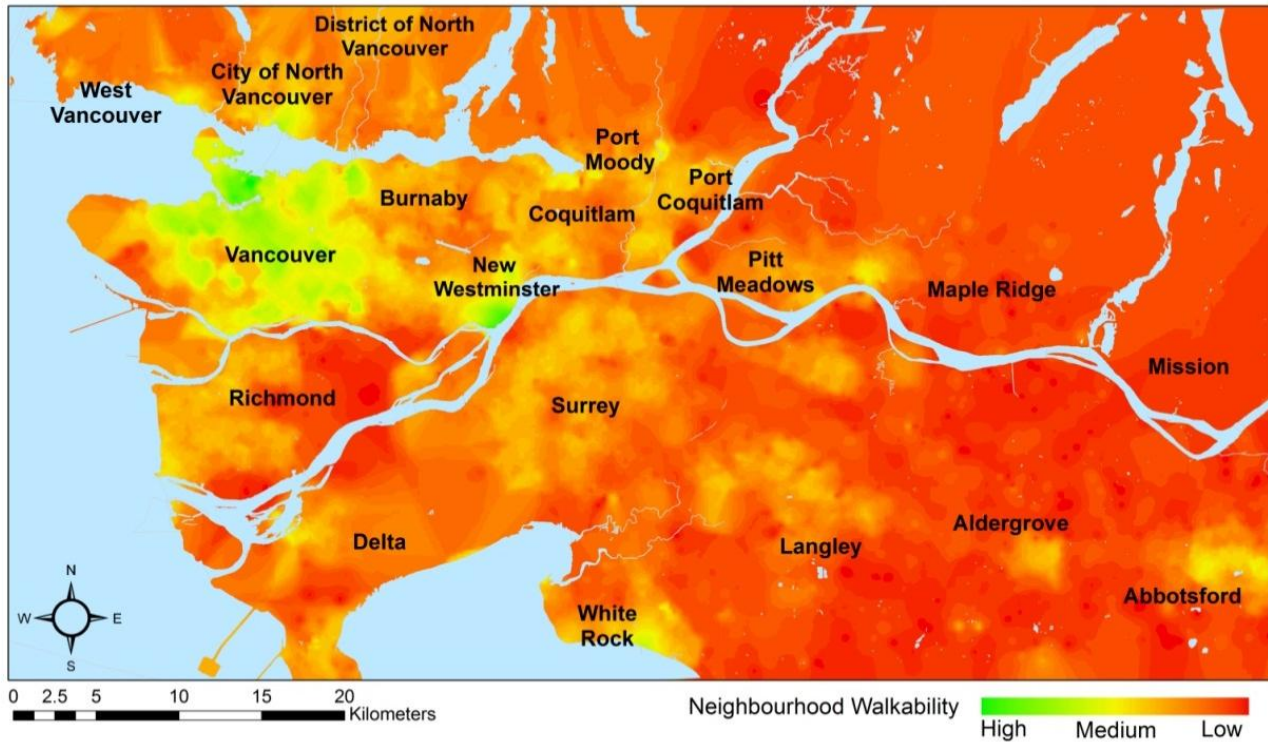
Some municipal governments and community organizations in the region have initiated projects to better understand the needs of seniors in their communities and support decisions with regard to service provision. For example, the *Seniors in Communities Mapping Project* used Geographic Information Systems (GIS) to map the locations of seniors and services in the North Shore.⁴³ These maps were used to facilitate discussion and create an overview of key issues for seniors living on the North Shore. The project identified several areas on the North Shore that are considered “remote” due to distance from commercial centres and health services and indicated that seniors in these areas may experience transportation challenges and require increased support from community services. However, several neighbourhood hubs, where the majority of senior activities are taking place, were also identified. These hubs may be considered desirable places to locate future senior oriented housing or care facilities.

Analysis at the neighbourhood scale was undertaken by the City of Burnaby and community partners in an area with a high concentration of older adults. Recognizing that accessible and safe pedestrian environments are essential for seniors to stay connected and physically active, a pedestrian audit of the Edmonds Town Centre was conducted.⁴⁴ Features such as the presence and quality of sidewalks, timing of lights, lighting, presence of benches and conditions of bus shelters were documented and recommendations were developed. Mapping and audits are just some of the tools available to obtain information about the needs and experiences of vulnerable seniors in our region.

The Metro Vancouver Walkability Index (VWI) is a comprehensive measure of community design features in small areas (postal codes) and has been shown to predict travel behaviour, health and environmental issues in our region. Based on data from the VWI developed at UBC’s

Health & Community Design Lab (formerly Active Transportation Collaboratory), Figure 1 illustrates the spatial distribution of walkability levels throughout the region.ⁱⁱ

Figure 1: Map showing results from the Metro Vancouver Walkability Index, 2005.



Highly walkable neighbourhoods appear in green, moderately walkable neighbourhoods in shades from yellow to orange, and the least walkable neighbourhoods are coloured red. High walkability levels emerge in many distinct but geographically separate areas, and there is considerable variation in walkability levels within each municipality. Areas of high walkability are characterized by higher densities of development, a mix of land uses and connected street networks. In the context of an aging population, it is expected that areas of higher walkability will offer older adults more transportation options, thereby enabling them to be less car dependent and to meet some of their transportation needs through walking or public transit.

When the VWI is overlaid with socio-economic and demographic information it provides a mechanism to assess disparities across specific mobility and health outcomes for vulnerable

populations. The figures below illustrate applications of the walkability index when considering the older adult population in the Lower Mainland.

Figure 2 reveals that concentrations of older adults (age 65+) residing in the least walkable areas of the region are clustered primarily in West Vancouver, Port Coquitlam, South Surrey and Langley. However, there are several neighbourhoods in White Rock, New Westminster, Vancouver and North Vancouver that are classified as highly walkable and have high concentrations of older adults. The ability to identify such areas could aid decision makers and service providers to strategically target programs, services and interventions in order to foster a high level of mobility, independence, and health in the most vulnerable populations.

Figure 2: Map showing Census Dissemination Areas with high concentrations of older adults in either high or low walkability areas.

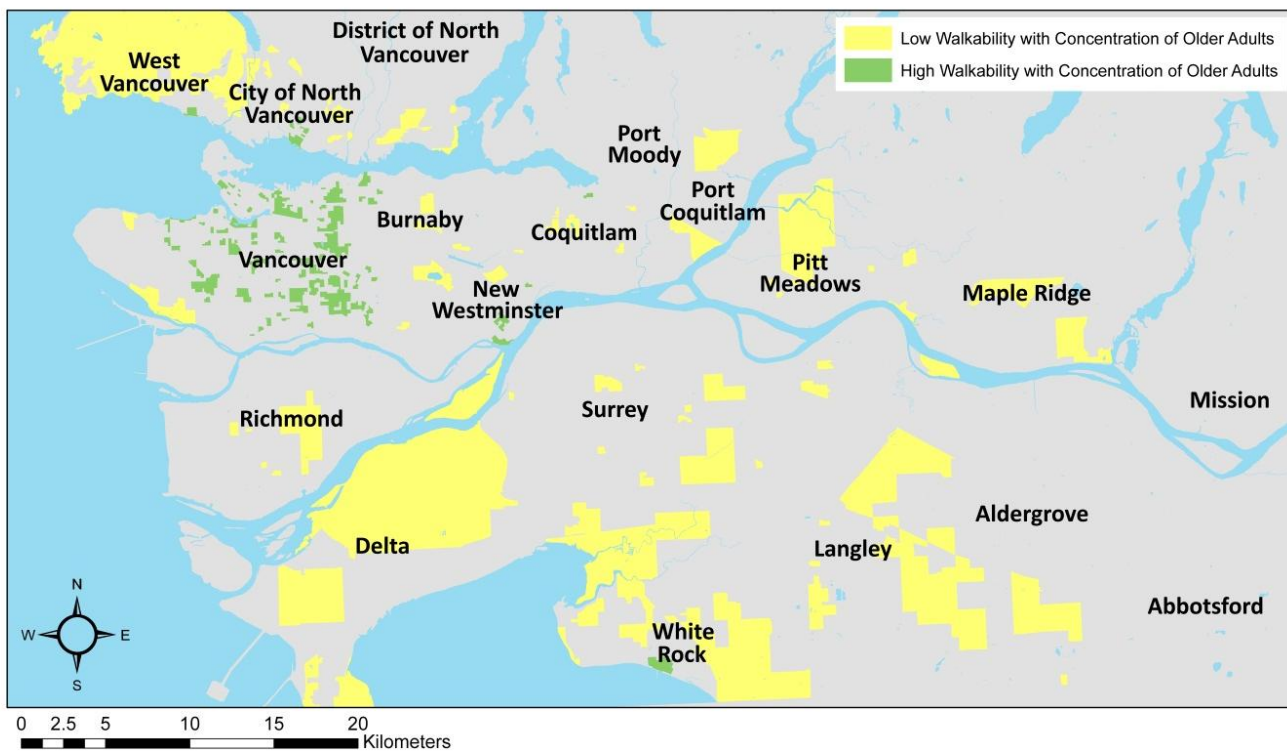


Figure 3 depicts areas with high concentrations of older adults and both high and low transit access. A Transit Accessibility Index (TAI) was created using 3 measures: service coverage, frequency, and capacity.ⁱⁱⁱ Those living in areas with lower transit access and without the means or ability to drive may experience challenges accessing goods, services and activities. A lack of accessible public transit may impede seniors from socializing or participating in their communities. Without adequate transportation options some seniors remain isolated for long periods, which can negatively affect health. Similar to Figure 2, this map reveals that areas with high concentrations of older adults (age 65+) with limited access to transit services can be found in South Surrey, Delta, Maple Ridge, Pitt Meadows and West Vancouver. These parts of the region tend to have lower populations densities and greater distances to city centres, making it more costly to service with public transit. The areas shaded in purple represent approximately 25,000 older adults. Older adults living in these neighbourhoods may require additional community services, such as meal or grocery transportation programs, in order to maintain their independence.

Figure 3: Map showing Census Dissemination Areas with high concentrations of older adults and high and low transit accessibility

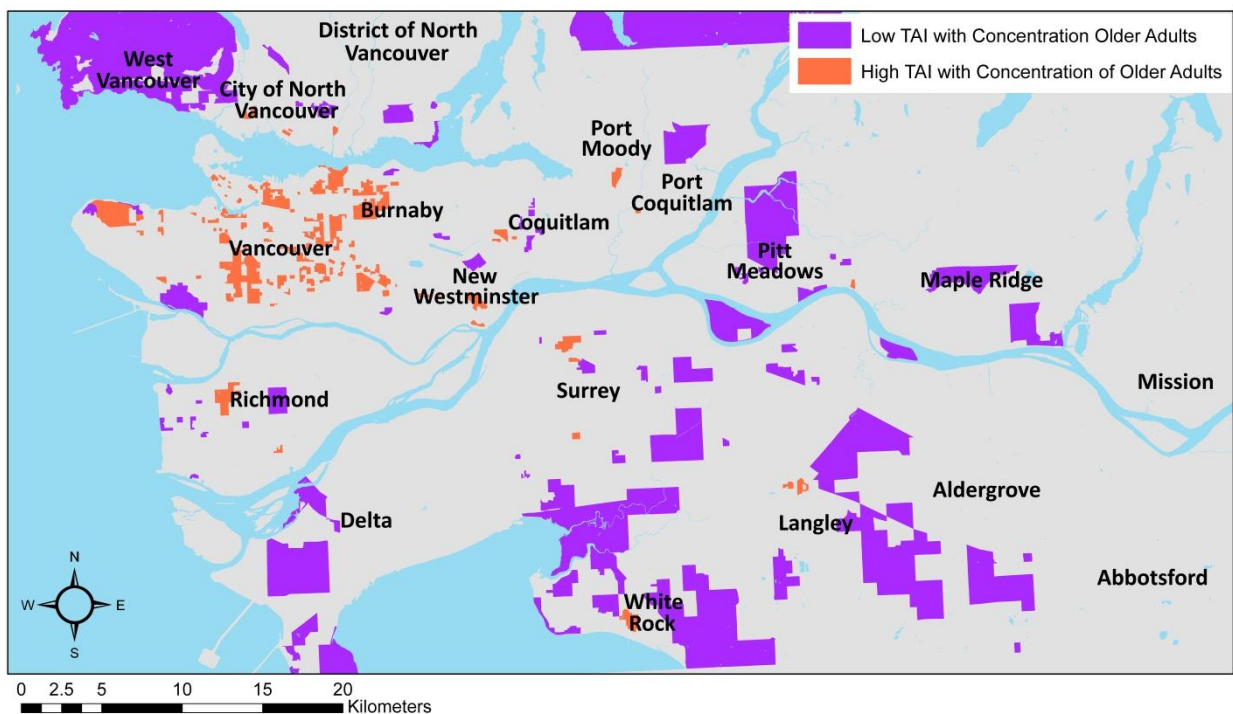
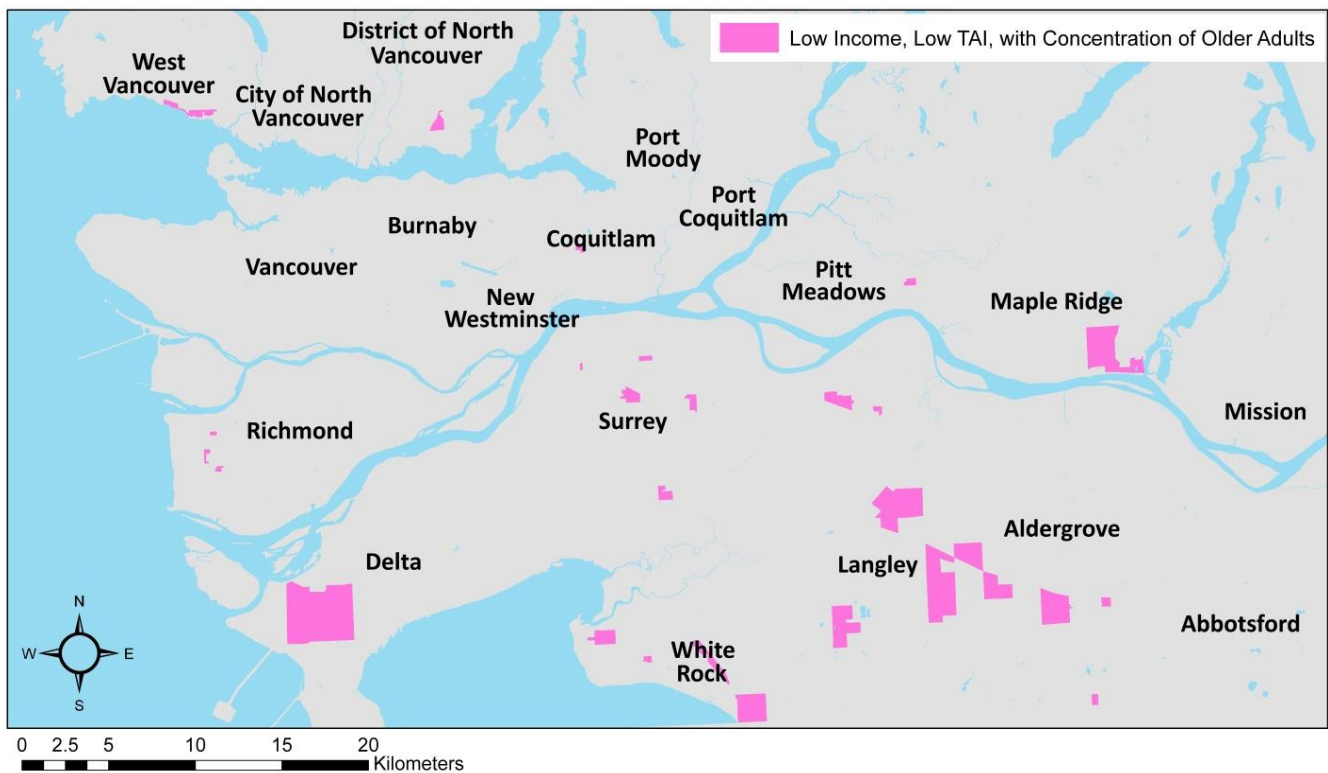


Figure 4 highlights areas of low average income, low transit access and high concentration of older adults. The pink regions represent approximately 9000 older adults who may be particularly vulnerable due to an inability to afford alternative transportation options, such as a personal vehicle or taxis. Community service providers could focus their efforts in these neighbourhoods to support the independence and quality of life of lower income seniors in areas not well serviced by transit. Given the housing affordability issues in the Metro Vancouver Region, older adults with low incomes may not have the option to move to more walkable, transit oriented neighbourhood as they age.

Figure 4: Map showing Census Dissemination Areas with low average income, low transit access and high concentrations of older adults



As exemplified by these figures, the Vancouver Walkability Index could serve as a useful tool for identifying areas with higher concentrations of vulnerable seniors. It could also aid decision makers in considering where best to allocate resources for interventions to alleviate poor mobility conditions and support the healthy aging of the region's population.

Future research directions

Given that older adults will comprise a significant proportion of the region's population in the years to come, further investigation into the travel patterns of older adults and the built environment connection to various health outcomes is warranted. Future research could provide valuable information to elected officials, decision makers, and community organizations in support of policies, programs, and investments that address the transportation and accessibility needs of seniors in the Lower Mainland.

Descriptive visual assessment of older adults and neighborhood environment

Building on the analyses shown in Figures 2-4 above - it would be possible to evaluate the spatial distribution of older adults in the Lower Mainland relative to a variety of services including transit, medical facilities, social services, parks and open space, and food outlets. It would also be possible to evaluate proximity to adverse features such as high speed traffic, air pollution, noise, and congestion.

Evaluating seniors travel patterns and urban form

A high quality and affordable public transit system has been identified by researchers as a means by which older adults can maintain their independence and access community services, shopping and recreational activities, especially when driving is not an option. An analysis of TransLink's 2008 travel survey data with a focus on seniors and spatially matched to the walkability surface would provide a comprehensive overview of the variations in travel behavior of older adults across levels of walkability and socio-demographic contexts.

Evaluating health status and health care utilization and urban form relationships

The Canadian Community Health Survey (CCHS) is a cross-sectional survey that collects information related to health status, health care utilization and health determinants for the Canadian population. Spatially matching the walkability surface with CCHS data for older adult participants would enable the evaluation of relationships between older adults' physical activity levels, dietary patterns, social interaction, perceptions of the built environment, health characteristics, and the environments in which they live.

Pre-post infrastructure intervention study

Infrastructure investments in new public transit or pedestrian infrastructure offer opportunities for natural experiments in the region. A pre-post infrastructure intervention project would examine travel behavior, physical activity, and health in older adults before and after the proposed intervention. This type of study could enable the evaluation of micro-scale features (e.g. benches, street trees, sidewalks) that are thought to create more pedestrian friendly environments, especially for older adults.

Policy and Program Recommendations

Transportation choice is a critical component of policies for aging populations. In light of the discussion on transportation, community design and the health of seniors, there are several recommendations that could support healthy aging in the region:

- Increase land use mix to facilitate better access to goods and services close to home (e.g. form-based zoning). Older adults in sprawling residential areas may encounter more difficulty travelling, which may reduce functional independence (e.g. ability to purchase food for meals, picking up prescriptions, managing finances at the bank).
- Improve the connectivity of street networks in order to reduce trip length to transit, shops and services for older adults.
- Increase residential densities. Higher density neighbourhoods are essential to provide the critical mass of people necessary to support a diversity of shops, services and transit options.
- Encourage transit oriented development.

- Investments in public transit. Access to safe and reliable public transit is important for seniors to maintain independence and access recreational facilities.
- Municipal investments in micro-scale features to enhance safety and comfort for seniors. Dense, connected, mixed use communities aren't enough in themselves. Older adults require benches for rest, quality sidewalks, and clearly marked curbs.
- Modify pedestrian design guidelines to reflect the safety needs of older adults. Traffic lights and appropriately timed cross-walks would improve the safety of older pedestrians crossing arterial roads and busy streets.
- Identification of appropriate locations to site facilities for seniors. For example, mapping areas of high levels of particulate matter and excessive noise could support better decisions about facility location.
- Site new nursing homes, subsidized senior's housing and other senior's facilities in more walkable neighbourhoods.
- Encourage retail and services to locate in community-oriented centres as opposed to development along arterial roadways⁴⁵

Conclusion

Some have argued that older adults are an “indicator species” when it comes to community design. This is because of increased sensitivity to the conditions that would support or prevent their ability to access destinations on foot or by transit. For an older adult, shops and services may need to be closer than for the general population and, ideally, housing may need to be located further away from congested traffic where air pollution is worst. Signal timing may need to be increased to allow safe passage across busy streets and buildings may need to be built close to the curb and sidewalk rather than set behind a sea of parking.

Considerable opportunities exist to evaluate how the design of communities relates to the health of vulnerable seniors in our region. Given the rate of increase in the numbers of older adults, it is essential that a coherent set of actions are taken to proactively address and minimize potentially adverse health impacts of community design. Moreover, it is important that opportunities are maximized to create environments that foster health and a good quality of life for the region's seniors.

References

- ¹ World Health Organization - http://www.who.int/ageing/age_friendly_cities/en/index.html Accessed August, 2011.
- ² Health Canada. (2002). Canada's Aging Population. <http://dsp.spsd.pwgsc.gc.ca/Collection/H39-608-2002E.pdf> Accessed April, 2010.
- ³ Pisarski, A.E., 2003. Prescriptions for research: reviewing the history of TRB's critical issues in transportation. TR News, 226, 30–35.
- ⁴ World Health Organization. (2007.) Global Age Friendly Cities: A Guide. WHO Press, World Health Organization, Geneva, Switzerland http://www.who.int/ageing/publications/Global_age_friendly_cities_Guide_English.pdf
- ⁵ Cobb, R. & Coughlin, J. (2004). Transport Policy for an ageing society: Keeping older Americans on the move in Transportation in an Aging Society: A Decade of Experience. Transport Research Conference Proceedings, 27, 272-292.
- ⁶ British Columbia Psychogeriatric Association. Seniors Policy Lens Toolkit. <http://www.seniorspolicylens.ca/Root/AccessibilityTransport.html> Accessed August, 2011.
- ⁷ Coughlin, J. (2000). Transportation and older persons: Needs, preferences and activities. Public Policy Institute, American Association of Retired Persons, Washington, D.C.
- ⁸ Harrison, A. & Ragland, D.R. (2003). Consequences of driving reduction or cessation for older adults. Transportation Research Record, 1843, 96–104.
- ⁹ Cvitkovich, Y. & Wister, A. (2001). The importance of transportation and prioritization of environmental needs to sustain well-being among older adults, Environment and Behavior, 33(6), 809–829.
- ¹⁰ Hine, J. & Mitchell, F. (2003). Better for everyone? Travel experiences and transport exclusion. Urban Studies, 38 (2), 319-322.
- ¹¹ Newbold, K.B., Scott, D., Spinney, J., Kanaroglou, P., & Paez, A. (2005). Travel behavior within Canada's older population: A cohort analysis. Journal of Transport Geography, 13(4), 340-351.
- ¹² Paez, A., Scott, D., Potoglou, D., Kanaroglou, P., & Newbold, K. (2007). Elderly mobility: Demographic and spatial analysis of trip making in the Hamilton CMA, Canada. Urban Studies, 44(1), 123-146.
- ¹³ Rosenbloom, S. & Herbel, S. (2009). The safety and mobility patterns of older women: Do current patterns foretell the future? Public Works Management Policy, 13, 338-354.
- ¹⁴ AARP. (2005). Understanding senior transportation; Report and analysis of a survey of consumers 50+ (by D. R. Ragland, W. A. Satariano, & K. E. MacLeod). Washington, DC: AARP Public Policy Institute.
- ¹⁵ Frank, L., Kerr, J., Rosenberg, D., & King, A. (2010). Healthy aging and where you live: Community design relationships with physical activity and body weight in older Americans. Journal of Physical Activity and Health, 7(Suppl 1), S82-S90.

- ¹⁶ TransLink & Ministry of Transportation. (2004). Great Vancouver Trip Diary Survey. http://www.th.gov.bc.ca/gateway/reports/pdr-supp/Trip_Diary_Summary-TransLink.pdf
- ¹⁷ Golob, T., & Hensher, A. (2007). The trip chaining activity of Sydney residents: A cross-section assessment by age group with a focus on seniors. *Journal of Transport Geography*, 15: 298-312.
- ¹⁸ Coughlin, J. (2001). *Transportation and older persons: Perceptions and preferences*. Washington, DC:AARP.
- ¹⁹ Beard, J.R., Blaney, S., Cerda, M., Frye, V., Lovasi, G.S., Ompad, D., Rundle, A., & Vlahov, D. (2009). Neighborhood characteristics and disability in older adults. *Journal of Gerontology: Social Sciences*, 64B(2), 252–257.
- ²⁰ Yen, I.H., Michael, Y.L., & Perdue, L. (2009). Neighborhood environment in studies of health of older adults: A systematic review. *American Journal of Preventative Medicine*, 37(5), 455-463.
- ²¹ Satariano, W.A., Ivey, S.L., Kurtovich, E., Kealey, M., Hubbard, A.E., Bayles, C.M., Bryant, L.L., Hunter, R.H., & Prohaska, T.R. (2010). Lower-Body Function, Neighborhoods, and Walking in an Older Population. *American Journal of Preventive Medicine*, 38(4), 419-428.
- ²² Frank, L.D. (2000). Land use and transportation interaction: Implications on public health and quality of life. *Journal of Planning Education and Research*, 20, 6-22.
- ²³ Ewing, R. & Cervero, R. (2001). *Travel and the built environment: A synthesis*. Transportation Research Record, 1780, 87-114.
- ²⁴ Giuliano, G. 2004. Land use and travel patterns among the elderly. In *Transportation in an aging society: A decade of experience*, 192-212. Washington, DC. National Academy of Sciences, Transportation Research Board.
- ²⁵ Lynott, J., McAuley, W., & McCutcheon, M. (2009). Getting out and about: The relationship between urban form and senior travel patterns. *Journal of Housing for the Elderly*, 23(4), 390-402.
- ²⁶ Frank, L.D., Engelke, P.O., & Schmid, T. (2003). *Health and community design: The impact of the built environment on physical activity*. Island Press, Washington, DC.
- ²⁷ Li, F., Harmer, P., Cardinal, B.J., Bosworth, M., Acock, A., Johnson-Shelton, D., & Moore, J.M. (2008). Built environment, adiposity, and physical activity in adults aged 50–75. *Am J Prev Med*, 35(1), 38-46.
- ²⁸ Wang, Z, & Lee, C. (2010). Site and neighborhood environments for walking among older adults. *Health and Place*, 16(6), 1268-1279.
- ²⁹ Michael, Y., Beard, T., Choi, D., Farquhar, S., & Carlson, N. (2006). Measuring the influence of built neighborhood environments on walking in older adults. *Journal of Aging and Physical Activity*, 14(3), 302–312.
- ³⁰ King, C.W., Brach, S.J., Belle, S., Killingsworth, R., Fenton, M., & Kriska, A.M. (2003). The relationship between convenience of destinations and walking levels in older women. *American Journal of Health Promotion*, 18(1), 74–82.
- ³¹ Kesaniemi, Y.K., Danforth, E., Jr, Jensen, M.D., Kopelman, P.G., Lefebvre, P., & Reeder, B.A. (2001). Dose-response issues concerning physical activity and health: An evidence-based symposium. *Medicine and Science in Sports and Exercise*, 33(6 Suppl), S351-8.

- ³² Myers, A.M., Malott, O.W., Gray, E., Tudor-Locke, C., Ecclestone, N.A., Cousins, S.O., et al. (1999). Measuring accumulated health-related benefits of exercise participation for older adults: The vitality plus scale. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 54(9), M456-66.
- ³³ Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001). Physical activity and risk of cognitive impairment and dementia in elderly persons. *Arch Neurol.*, 58, 498-504.
- ³⁴ Kaplan, M.S., Newson, J.T., McFarland, B.H., & Lu, L. (2001). Demographic and psychosocial correlates of physical activity in late life. *American Journal of Preventive Medicine*, 21(4), 306-312.
- ³⁵ Blazer, D.G. (2003). Depression in late life: Review and commentary. *J Gerontol A Biol Sci Med Sci*, 58A, M249-M265.
- ³⁶ BC Ministry of Health Services. <http://www.health.gov.bc.ca/seniors/index.html>
Accessed April 10, 2010.
- ³⁷ Engels, B., & Liu, G. (2011). Social exclusion, location and transport disadvantage amongst non-driving seniors in a Melbourne municipality, Australia. *Journal of Transport Geography*, 19, 984-996.
- ³⁸ Berke, E.M., Gottlieb, L.M., Moudon, A.V., & Larson, E.B. (2007). Protective association between neighborhood walkability and depression in older men. *J Am Geriatr Soc*, 55(4), 526-533.
- ³⁹ Leyden, K. (2003). Social capital and the built environment: The importance of walkable neighbourhoods. *American Journal of Public Health*, 93(9), 1546-1551.
- ⁴⁰ Pope, C. (2000). Epidemiology of fine particulate air pollution and human health: Biologic mechanisms and who's at risk? *Environmental Health Perspectives*, 108(4), 713-723.
- ⁴¹ Dominici, F., Peng, R., Bell, M., Pham, L., McDermott, A., Zeger, S., & Samet, J. (2006). Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases. *Journal of the American Medical Association*, 295(10), 1127-1134.
- ⁴² Marshall, J.D., Brauer, M., & Frank, L.D. (2009). Healthy neighborhoods: Walkability and air pollution. *Environmental Health Perspectives*, 117(11), 1752-1759.
- ⁴³ North Shore Community Resources. Seniors in Community Mapping Project. <http://www.nscr.bc.ca/senior/maps/Final%20Report.PDF>
- ⁴⁴ Voices of Burnaby Seniors. <http://burnabyseniors.ca/voices.shtml>
- ⁴⁵ Dumbaugh, E. (2008). Designing communities to enhance the safety and mobility of older adults: A universal approach. *Journal of Planning Literature*, 23(1), 17-36.

End notes

ⁱ Measures of three urban form characteristics (land use mix, residential density and street connectivity) were used to calculate a walkability index, which was tertiled into low, medium and high walkability.

ⁱⁱ The Metro Vancouver Walkability Index (VWI) is a high-resolution spatial database used to quantify physical urban environment features across the region. Using Geographic Information Systems, neighbourhoods are spatially defined by drawing a 1-kilometer street network buffer (representing a 10- to 15-minute walking distance) from each postal code centroid in the region. The 1-kilometer network buffer represents the area that people can access around their homes along the existing street network, and is considered an accurate approach to measuring the physical environment unique to each place of residence. The VWI combines parcel-level land use data from the British Columbia Assessment Authority, street network data from CanMap, and census data to measure four urban form elements known to shape the design of neighbourhoods within each neighbourhood buffer. These four key components are residential density, commercial density, land use mix, and street connectivity, and are shown in the literature to be significant predictors of physical activity. Data on the four components are combined into a composite value of overall walkability to measure the physical aspects of the environment that Metro Vancouver residents encounter every day, in their immediate neighbourhoods.

ⁱⁱⁱ The Transit Accessibility Index was modeled after the Local Index of Transit Availability (LITA), developed by Rood (1998) for the Sacramento-based Local Government Commission http://www.utexas.edu/research/ctr/pdf_reports/0_5178_P3.pdf