

# Creating a Healthier Built Environment in British Columbia

*September 2007*



***Prepared for Dr. John Millar by:  
Dr. Lawrence D. Frank  
Bombardier Chair in Sustainable  
Transportation, School of Community  
and Regional Planning,  
University of British Columbia***

***Dr. Kim Raine  
Director and Professor  
Centre for Health Promotion Studies  
University of Alberta***

***This report is a project of the Provincial  
Health Services Authority's Prevention,  
Promotion and Protection Program.***

***The report is available online  
at [www.phsa.ca/HealthPro/  
PreventionPromoProtect/default.htm](http://www.phsa.ca/HealthPro/PreventionPromoProtect/default.htm)***

***Provincial Health Services Authority  
700-1380 Burrard St.  
Vancouver, BC  
V6Z 2H3 Canada  
[www.phsa.ca](http://www.phsa.ca)***

# Table of Contents

<b>Executive Summary</b> .....	<b>5</b>
Key Findings .....	5
Overview of Findings .....	6
Further Considerations .....	7
<b>Introduction</b> .....	<b>9</b>
Purpose .....	10
<b>The Built Environment &amp; Physical Activity</b> .....	<b>11</b>
Understanding the Relationships .....	11
State of the Knowledge .....	12
Density/Compactness .....	13
Mix of Land Uses .....	13
Network Connectivity .....	14
Transit Service and Facilities .....	16
Recreational Facilities and Open Space .....	16
Gaps in the Research .....	17
Key Points and Opportunities .....	18
Guiding Principles from the Evidence .....	19
<b>The Food Environment</b> .....	<b>20</b>
Understanding the Relationships .....	20
Food Retail Outlets .....	20
Fast Food Restaurants .....	20
Schools .....	21

State of the Knowledge . . . . .	21
The Physical Environment . . . . .	21
Schools . . . . .	21
Geographic Access/ Neighbourhood Design . . . . .	22
Restaurants/ Stores . . . . .	22
The Economic Environment . . . . .	23
Gaps in the Research . . . . .	23
Key Points and Opportunities . . . . .	24
<b>Other Links Between Land Use Planning &amp; Public Health . . . . .</b>	<b>25</b>
Air Quality & Respiratory Health . . . . .	25
Traffic Safety . . . . .	27
Affordable Housing . . . . .	29
Key Points and Opportunities . . . . .	29
<b>Decision Makers, Domains &amp; Opportunities . . . . .</b>	<b>30</b>
The Decision Makers . . . . .	30
<b>Multidisciplinary Decision-making for Better Population Health . . . . .</b>	<b>36</b>
The Research Supports Broad Changes to Our Built Environment . . . . .	36
A Collaborative Focus on Population Health is Crucial . . . . .	37
Protect Those Most at Risk . . . . .	38
<b>References . . . . .</b>	<b>40</b>
<b>Bibliography . . . . .</b>	<b>43</b>

## Executive Summary

Among the factors contributing to the rapid rise of obesity among Canadians, an increasingly large role is being attributed to man-made characteristics of our physical environment – the “built environment” – that influence our level of physical activity and our dietary choices. As the research evidence grows, policy-makers and practitioners have called for broad environmental interventions to address these “obesogenic” (obesity-promoting) factors of our built environment.

Based on a review of the best available research, the purpose of this report is to identify and assess a number of changes related to the built environment that can effectively address these obesogenic factors and promote healthy body weight at a population level through increased physical activity and improved nutrition.

## Key Findings

### **The health effects of the built environment are complex.**

The built environment can influence physical activity, nutrition and obesity, and can contribute to air pollution and increased rates of injury. Addressing this complex issue requires complex solutions involving many stakeholders and decision-makers.

### **There is sufficient evidence to take action now.**

Immediate action is warranted, and should be accompanied by evaluation and research to determine which measures are most and least effective.

### **The best available evidence supports the following interventions:**

- Increase urban residential density
- Increase land use mix
- Increase road and pathway connectivity to promote walking and cycling
- Increase public transit
- Increase availability of recreational facilities and parks including bike lanes and paths
- Enhance streetscape design to improve aesthetics and safety for pedestrians and cyclists
- Improve physical access to healthy foods and discourage junk foods through zoning and neighbourhood design where needed, to support grocery stores, farmers’ markets and restaurants

## **Overview of Findings**

### **The research supports making changes to our built environment**

The majority of research reviewed for this report finds a clear relationship between the built environment, physical activity and body weight. Based on existing evidence, the conclusion of this review is there is strong support for making changes to the built environment to help promote healthy body weight and improve population health.

### **Walkable neighbourhoods are associated with changes in travel behaviour**

Walkable neighbourhoods – neighbourhoods that are compact (high density), with an interconnected network of streets and a mix of land uses – are associated with statistically significant changes in travel behaviour, i.e. less driving and more walking, cycling and use of public transit.

### **Walkable neighbourhoods are associated with lower body weights**

Personal travel patterns influence a person's physical activity levels. The current evidence shows that people located in more walkable areas are less likely to be obese and more likely to meet recommended levels of daily physical activity.

### **Increased density is associated with less pollution**

People in compact, well-serviced neighbourhoods are less likely to drive, produce less greenhouse gases and consume less energy per capita. Such neighbourhoods are also accessible to a wider range of family types and household incomes. For low-income households, increased density offers an important economic benefit by making it possible to forego car ownership.

### **Pedestrian-friendly streetscapes encourage physical activity**

Areas that are safe and attractive for pedestrians encourage higher rates of physical activity. Furthermore, the visible presence of pedestrians and cyclists has been linked to promoting higher rates of physical activity, presumably because people notice the prevalence of such behaviour in the area and feel encouraged to participate.

### **Pedestrian-friendly streetscapes are associated with fewer traffic accidents and less crime**

Narrower streets and streets with marked pedestrian crossings help to slow traffic. Features such as landscaping, sidewalks, and parallel parking can further enhance pedestrian safety by increasing driver awareness. Such streets are also associated with lower rates of crime.

### **Public transit encourages physical activity**

As most public transit trips involve walking links, the existence of good public transit service helps promote physical activity. Furthermore, improved public transit service may achieve the greatest health benefits for low-income individuals.

### **The built environment influences nutrition**

The built environment can contribute to poor diet through the absence, in some communities, of local (within walking distance) food retailers and restaurants offering a good selection of nutritious food.

### **Improving the food environment can improve nutrition**

The local food environment can be improved through zoning to increase the number and quality of food retailers and restaurants in underserved areas. Food policy can improve nutrition by reducing or eliminating high-fat and high-sugar foods in institutional settings such as schools.

## ***Further Considerations***

### **Opportunities for changing the built environment**

These include increasing density in existing mixed-use centres, bringing other land uses into neighbourhoods that are currently residential-only, increasing the connectivity of street and trail networks, and improving the appearance and safety of streetscapes.

On the transportation side, research suggests that improved population health may be achieved through increased investments in bicycle, pedestrian and transit facilities and services.

To increase access to healthy food choices, vacant parcels of land, particularly in neighbourhoods that lack healthy food choices, could be purchased or temporarily used for community food gardens. In neighbourhoods lacking grocery stores, it may be expedient to have developers secure grocery stores or food markets as tenants as a condition for approval of new developments.

### **Changes to the built environment require significant time to show benefits**

Because land use development takes place parcel-by-parcel, it can take time to see new regulations implemented, especially in areas where compact, mixed-use neighbourhoods are a departure from the norm. Furthermore, there is an indirect relationship between land use and physical activity. Once land use patterns change it may take time for the corresponding change in people's behaviours and the desired outcomes – increased physical activity and reduced obesity – to occur.

### **A collaborative focus on population health is crucial**

Translating research into policy and action requires the commitment and cooperation of many players from a variety of areas to understand the issues, brainstorm policy solutions, and oversee the implementation of recommended changes. As new policies are implemented it is also essential to monitor their effects to assess whether the desired outcomes are achieved and, if not, what further changes are needed.

### **Public health representatives should be fully engaged in planning processes**

Given the significant health impacts related to land use, it is increasingly necessary for public health agencies to be engaged in the land use planning process. Explicit consideration of a population's health, safety and welfare should be included in the evaluation of land use planning alternatives and development proposals.

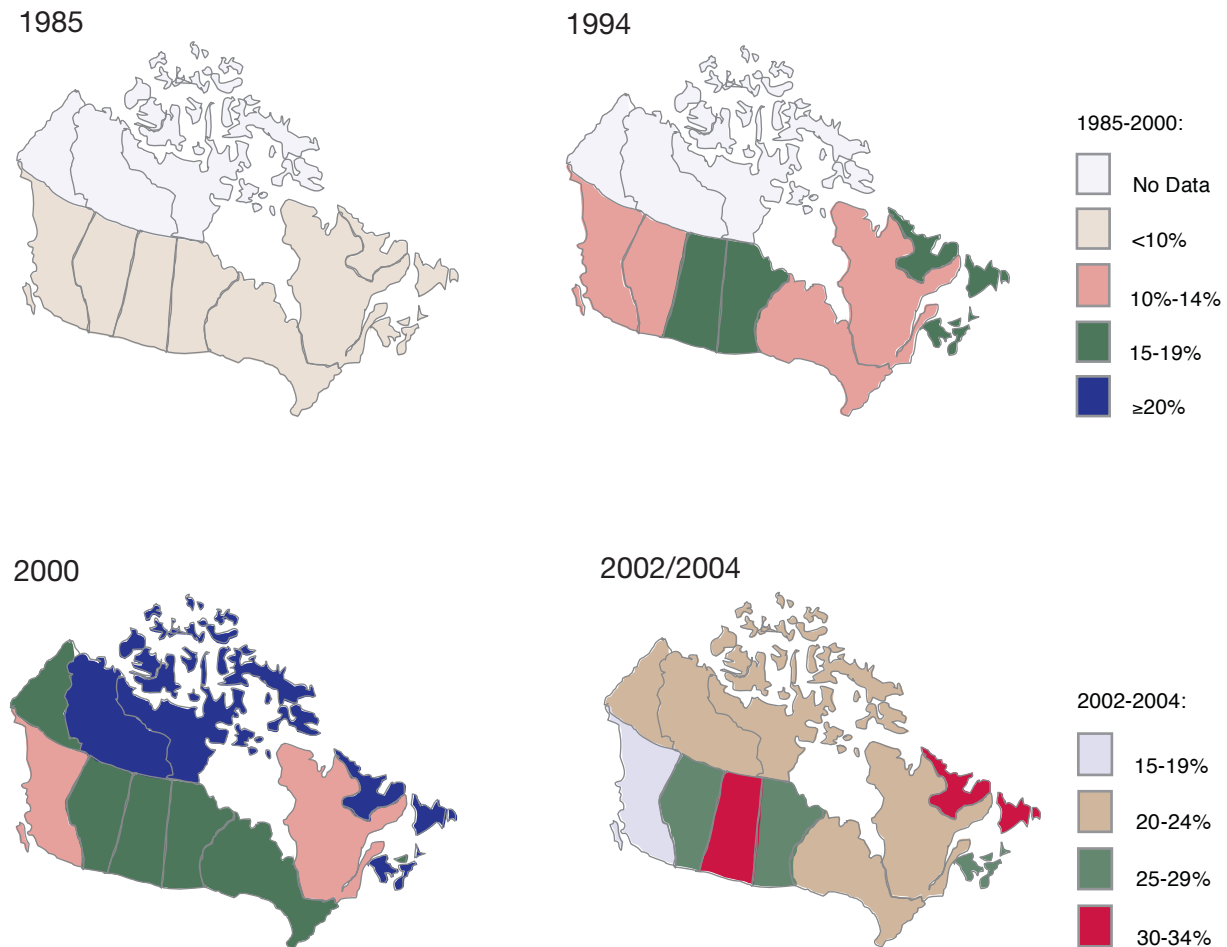


## Introduction

The rapid increase in overweight and obesity in Canada in the last 20 years has created a public health crisis of epidemic proportions. Every province in the country has experienced dramatic increases in overweight and obesity, as shown in the series of maps in Figure 1.

**Figure 1. Distribution and Percentage of Obesity in Canada, 1985-2004**

(from Katzmarzyk 2006)



As of 2003, based on self-reported data a full 59.3 percent of the population was classified as overweight or obese.<sup>1</sup> The number of obese Canadians has doubled since 1985 and now totals about 23 percent of the population. The increases in the most extreme forms of obesity, where body mass index (BMI)<sup>i</sup> exceeds 40 or more, are even more alarming – rising by 225 percent between 1990 and 2003.<sup>2</sup>

i The Body Mass Index is a ratio of weight to height, and is a common measure of obesity/overweight status. A BMI of over 25 is classified as overweight, and over 30 is considered obese. Obesity puts a person at risk for numerous health conditions and begins to seriously inhibit mobility.

Diseases associated with obesity are among the leading causes of disability and death. All of the diseases listed below have been linked to obesity and can be largely prevented or improved by maintaining a healthy body weight:

- Coronary heart disease
- Stroke
- Colon and breast cancer
- Osteoarthritis and osteoporosis
- Fall-related injuries
- Type 2 diabetes
- High blood pressure (hypertension)
- Depression and anxiety; low self-esteem

The impacts of obesity are not only felt by those directly affected; obesity also strains the resources of our health care system. One study has estimated the economic burden of obesity in Canada to be \$4.3 billion (2001 dollars).<sup>3</sup>

Increasingly, the rapid rise of obesity among Canadians is being attributed to changes in our physical environment that influence our physical activity behaviours and our diet. As evidence from the research grows, policy-makers and practitioners have called for broad environmental interventions to address the “obesogenic” (obesity-promoting) factors of our built environment.

## **Purpose**

The purpose of this report is to provide an assessment of interventions affecting the built environment that are most likely to promote healthy body weight for a population through increased physical activity and improved nutrition.

Toward this end, the report offers a summary of the best available evidence and includes discussion about the strength of existing research, as well as gaps in the research and where further study is required.

Based on available evidence, the report outlines the characteristics of built environments that promote or inhibit healthy body weight, assesses the effectiveness of environmental interventions to assist populations in achieving healthy weight, and provides evidence for the discussion that follows.

The report also includes evidence regarding other interactions between the built environment and health including air pollution and respiratory disease, the effects of streetscapes on reducing traffic injuries and the impact of affordable housing on homelessness.

Also considered are the various players – including land use planners, developers and public health officers – in a position to influence the built environment as it relates to public health, as well as the relationships between them and potential opportunities for collaboration and multidisciplinary action.

# The Built Environment & Physical Activity

## Understanding the Relationships

In general, body weight results from a relationship between the number of calories consumed (what we eat) minus the number of calories expended (our physical activity). Half of the body weight equation, calories expended, depends on the amount of physical activity we get. Canadians today get less physical activity than in the past, spending more time than ever sitting behind desks, in front of computers or TVs, and in cars. A declining number of us are engaged in manual labour and relatively few of us walk or bicycle to work or school. And an increasing body of evidence is pointing to our built environment as having a major influence on the extent of our daily physical activity.

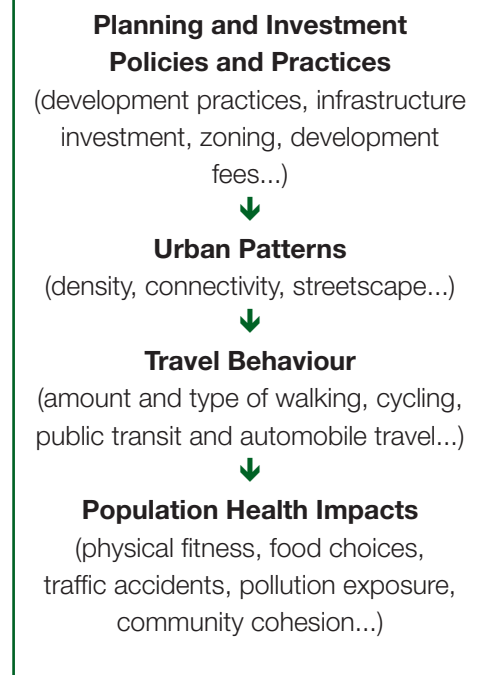
At the same time it is becoming clear that altering our built environment can support a reduction in our use of cars and an increase in physically active options available to get us where we need to go. The means of achieving this goal lies at the intersection of urban planning and public health. For years urban planning researchers have been studying the relationship between urban land use patterns and transportation outcomes – whether the layout and appearance of a city or neighbourhood makes a difference to how much people drive, walk, bicycle or take transit. From this research, a relatively strong link has been established between compact, mixed-use and pedestrian-oriented development patterns and higher levels of cycling, walking and transit use. Not surprisingly, low-density, car-oriented areas are associated with more driving and less transit, walking and bicycling.

Public health research has shown that even modest increases in physical activity tend to reduce mortality rates.<sup>4</sup> This has led to the realization that simple everyday activities – walking to and from the bus, to work, or to a nearby store, can help people achieve the Heart and Stroke Foundation of Canada’s recommendation of 30 minutes of moderate activity per day.<sup>5</sup>

There is also a growing consensus among public health experts that supporting more physically active modes of transportation and better access to recreational opportunities offer the most effective ways to increase activity levels across the population. Walking and cycling are among the most popular physical activities, particularly among people who are overweight and/or inactive, while programs to promote physical activity through gym memberships, school activities and other interventions have had only limited success.

With the emergence of obesity as a major health issue, researchers from the urban planning and public health fields have begun studying the connection between the built environment, transportation behaviour and overweight/obesity outcomes explicitly, as shown in Figure 2. Although this body of research is relatively new, it offers a strong argument for broad changes to policies and practices toward making our cities

**Figure 2. From Land Use to Travel Behaviour to Health**



and towns more supportive of physically active transportation options. Catering to the automobile has been the dominant paradigm for the last fifty years, and as we discover the extent of its impacts on our society (including environmental, social and economic, in addition to health impacts) the need for a different approach has become imperative.

## ***State of the Knowledge***

Research into health outcomes associated with the built environment offers evidence for key policy directions and actions. This report reviews current research on the relationship between land use and travel behaviour, which makes up the bulk of the evidence in this field, but which does not directly measure physical activity outcomes. The report also surveys the smaller but growing body of research that examines the connection between the built environment and obesity/physical activity variables directly.

The research finds five major characteristics of the built environment that are repeatedly related to physically active transportation behaviour, general physical activity, and obesity. These are: density/compactness; land use mix; network connectivity; streetscape design and safety; and access to recreational facilities and open space. Each of these is summarized in the sections that follow. Where applicable, specific aspects of the built environment that support other population health-related goals (such as air quality or traffic safety) are also noted.

In general, the consensus in the research is that there is a connection between the built environment and sedentary vs. physically active modes of transportation and the resulting physical activity and overweight/obesity levels.<sup>6</sup>

One study of 27 neighbourhoods in three provinces found that walking to work varied widely, from a high of over 40 percent to a low of under two percent.<sup>7</sup> The lowest walking rates (and the highest driving rates) were found in suburban (low-walkability) neighbourhoods. Similarly, a US study comparing high-walkability and low-walkability neighbourhoods found that people had significantly higher overall levels of moderate physical activity and significantly lower obesity rates in high-walkability neighbourhoods.<sup>8</sup>

The SMARTRAQ study, based in Atlanta, Georgia, used accelerometers to objectively measure total physical activity. The study found a measure of walkability that comprised mixed use, residential density, and street connectivity to be a significant factor in explaining the number of minutes per day of moderate physical activity.<sup>9</sup> Conversely, each additional hour spent in a car per day was associated with a six percent increase in the likelihood of obesity.<sup>10</sup> The Seattle-based Land Use, Transportation, Air Quality and Health (LUTAQH) study used the same index and found walkability to be correlated with lower rates of obesity and auto use, and higher rates of transit ridership, walking and overall physical activity<sup>11</sup>

Another US study conducted at the county level found a significant relationship between urban sprawl (as measured on an index) and physical activity, obesity, and hypertension.<sup>12</sup> Looking at 100 metro areas across the US, a further study correlated values from the same urban sprawl index with 16 different chronic diseases, including overweight-related conditions (e.g. hypertension), respiratory ailments (e.g. emphysema and asthma), and other conditions such as abdominal problems and severe headaches. The urban sprawl index was found to be a significant predictor of the number of chronic medical conditions in a population.<sup>13</sup>

## **Density/Compactness**

An area's population or employment density is one of the best-established determinants of transit use, walking and bicycling. Density can directly affect travel behaviour and can act as a proxy for other characteristics of the built environment – in many cases, more compact areas have better pedestrian facilities, a more connected street network and a greater mix of land uses. Denser land use patterns also generate lower levels of automobile emissions per capita.

Compact areas decrease the distances and the time needed for people to accomplish routine tasks on foot or bicycle, or to access transit. Urban density also enables a neighbourhood to support local shops and services (thereby increasing the mix of land uses, as discussed in the next section). Studies have consistently found density increases to be associated with lower per capita hours and miles of automobile travel, and higher rates of walking, bicycling and transit, all else being equal.<sup>14</sup> The Atlanta SMARTRAQ study found that as residential density increased from under two to over eight dwelling units per acre, the proportion of obese white males declined from 23 percent to 13 percent.<sup>15</sup>

Density is also thought to have a non-linear relationship with transportation behaviour – one study found that nearly all travel was done by car until residential density levels reached 13 persons per gross acre, and employment density levels greater than 75 employees per gross acre were necessary before there was a substantial increase in transit and pedestrian travel for work trips.<sup>16</sup>

In order to permit more compact development, zoning provisions not only need to be amended to allow higher-density housing and commercial development, but those provisions should be coupled with reductions in setback and parking requirements, both of which can effectively undermine the ability to build at higher densities.

Multi-family development, including accessory dwelling units (e.g. “mother-in-law” apartments), townhomes, apartments over shops, and condos should be expressly permitted. The development review process should also include design guidelines or a community-based design review board to ensure the style and aesthetics of any proposed development is appropriate and in keeping with the context of the neighbourhood.

## **Mix of Land Uses**

A high degree of land use mix – when a neighbourhood has housing, shops, services and employment within easy walking distance of each other (e.g. within half a kilometre) – is also highly correlated with increased physical activity. In a walkable neighbourhood, land use mix and density are almost inseparable – take away the density, and the neighbourhood is left with no one to support the local shops and services; take away the complementary land uses, and residents are left without convenient services and gathering places. In the research, neighbourhoods with a mix of land uses have been associated with more walking trips.<sup>17</sup> For vehicles, a mix of land uses has been associated with fewer vehicle miles traveled per capita, which results in lower emissions per capita.

A handful of much more detailed studies have looked at distances between objectively measured, specific land uses. Collectively, these studies found that the land use mix that generates the most walk trips is where

daily activities (home, work, school) are located near those that are used less regularly (movie theaters, shops, restaurants).<sup>18</sup>

The Seattle-based LUTAQH study found several specific land uses strongly linked to the percentage of household walking trips. These included educational facilities, commercial office buildings, restaurants and taverns, parks, neighbourhood-scale retail establishments, civic uses of land and grocery stores. The study also found that variety – the *number* of retail establishments – was more effective at generating walk trips for non-work purposes than was total square retail footage, as would be found in the case of a big box store. With each 25 percent increase in the total number of retail locations, walking for non-work trips increased 19 percent.<sup>19</sup>

A mixed land use pattern was directly correlated to lower obesity rates in the SMARTRAQ study. The study's participants were divided evenly into four groups (quartiles) based on the level of land use mix where they lived. Each 25 percent increase in land use mix was associated with a 12 percent reduction in the chance of a person from that area being obese.<sup>20, ii</sup>

Land use is, of course, governed by municipal zoning laws. The practice of zoning emerged during the industrial revolution to separate noxious smokestacks and the irritating byproducts of industry from areas where people lived. In the twenty-first century we are left with an unfortunate legacy of this practice – a segregated approach to land use planning which has resulted in the development of suburbs, where people live too far from school, work, shops and services to make walking a practical alternative to driving. Given the current state of light industrial development (with little or no pollution, noise or other undesirable byproducts), single-use zoning has become obsolete – and is being found to undermine public health objectives.<sup>21</sup> In order to increase land use mix in single-use neighbourhoods, zoning and other land use regulations need to allow, require or encourage mixed-use buildings as well as mixed-use neighbourhoods. Money lenders and developers, who may perceive mixed-use developments as risky, may require encouragement through density bonuses, tax breaks, parcel assembly assistance and infrastructure upgrades in selected areas.

## **Network Connectivity**

Network connectivity refers to the degree of interconnectedness between streets, paths, and sidewalks. Gridded street patterns typically provide more highly connected networks. Street patterns dominated by cul-de-sacs are less well connected. When street networks have a high degree of connectivity, more direct routes are created for pedestrians and cyclists. This makes up for the fact that traveling by foot or bicycle is slower than driving. Additionally, these street patterns also offer many route options, creating more variety and interest for the pedestrian or cyclist. Disconnected street networks create walking distances that are circuitous and too long to walk within a reasonable time, as shown in Figure 3. In one Canadian study, higher rates of walking to work were associated with neighbourhoods that had good route continuity (i.e. no interruptions) and multiple route choices, both of which are facilitated by a gridded or otherwise highly interconnected street system.<sup>22</sup>

---

ii The changes in obesity across levels of land use mix are also likely to be influenced by neighbourhood selection and access to healthy food choices.

**Figure 3. Walking Distances in Connected and Disconnected Networks**



The impact of a disconnected street network is conveyed in the above diagram. The straight line (crow-fly) distance between points A and B is the same in both diagrams, but the actual travel distance is only walkable in the connected network on the right. The disconnected network on the left has many dead-end streets and requires travel on arterials for most trips. (Source: Sallis et al., 2004. Transportation Research - Part A).

In the research, neighbourhood connectivity has been the topic of a great deal of study, much of it too limited in scope to be conclusive. Earlier studies found significant associations between connectivity variables and walking.<sup>23</sup>

Several newer studies have used GIS (geographic information system) mapping to support a much more precise analysis of connectivity variables. The LUTAQH study showed that the odds of someone reporting they walked for non-work purposes rose by 14 percent for each 25 percent increase in the level of street connectivity where they live.<sup>24</sup> These results are also supported by evidence from the SMARTRAQ project and by a Seattle-based study for the Washington State Department of Transportation<sup>25</sup> – both of which found higher intersection density to be associated with more walking and bicycling trips. Collectively, these studies suggest that intersection density needs to reach about 50 intersections per square kilometre before pedestrian travel becomes more commonplace.

From the regulatory perspective, different places have approached increasing connectivity differently. Some set a maximum block acreage, some set a maximum street segment length (the distance between intersections), some prohibit dead-end streets and fences surrounding development that prohibit through-movement. A combination of these strategies may be necessary for new development. For already developed areas, making new street connections requires a longer process. Planners and communities should identify the future street connections they want to see as part of the planning process and require

them as adjacent parcels redevelop. In the interim, new foot and bike pathways can be created within existing developments – between cul-de-sacs, or using sewer and water rights-of-way, which are too narrow for vehicular streets but can be used as footpaths. Barriers, such as fences, can be removed and more frequent maintenance can keep pathways more attractive and safe.

## **Transit Service and Facilities**

The research indicates that good public transit service can also encourage physical activity. Most public transit trips also involve a walking link. One analysis of US travel survey data found that 16 percent of all recorded walking trips were part of transit trips, and that transit-based walk trips tended to be longer than average.<sup>26</sup> Another US study based on travel survey data found that transit users spend a median of 19 minutes per day walking to transit. Twenty-nine percent of US transit users walked more than 30 minutes daily on their transit trip alone.<sup>27</sup>

A recent US study found that reduction in travel time was the most important variable in inducing a modal shift from driving to public transit and walking. Faster and more frequent transit service was associated with higher rates of transit use. Longer travel times for cars were also associated with a greater proportion of trips on foot and transit.<sup>28</sup> High-quality transit services may also leverage land use changes, reductions in per household automobile ownership, additional reductions in per-capita vehicle travel, and increased non-motorized travel.

The Seattle-based LUTAQH study also found a highly synergistic relationship between public transit use and neighbourhood walkability. Urban form, at both the home and work ends of a trip, directly influences the time differential between public transit and auto travel, making transit more viable. Seattle-area neighbourhoods with a greater mix of land uses, better street connectivity, and high densities supported increased transit use for regional mobility and walking for nearby destinations. For every quarter-mile (half-kilometre) increase in distance from a transit stop to home, the odds of taking a transit trip to work decreased by 16 percent. A quarter-mile increase in distance from a transit stop to work reduced the likelihood of taking transit to work by 32 percent. Whereas the *number* of non-residential or commercial destinations did the most to influence walking rates, the *total square footage* of commercial destinations had the strongest relationship with public transit use. Land uses at the work end of a trip, rather than those surrounding the home end, were better predictors of work trip transit use.<sup>29</sup>

Facilitating pedestrian access to public transit may have the greatest health benefits for low-income individuals. Not only are they more likely to be transit users, low-income and minority groups are also more likely to walk to public transit, and more likely to spend more than 30 minutes on their trip to transit.<sup>30</sup>

## **Recreational Facilities and Open Space**

Research indicates that communities with parks, trails, playfields, and other recreational facilities within walking distance are associated with more physically active residents. One study showed respondents are more likely to meet physical activity recommendations if they live within a ten-minute walk of a park, trail or other place to walk.<sup>31</sup> Another survey found that trail use decreased by almost 50 percent with every quarter-mile (half-kilometre) distance increase in access.<sup>32</sup>



Recreational facilities play an especially important role in children's physical activity, and having good street or pathway connections to those facilities is just as important. If parks and recreation areas are within walking distance, kids can be more active on a regular basis. One study showed teens with access to a safe park were more active than those that did not have access to a safe park.<sup>33</sup> Another recent piece of research showed that the presence of at least one recreational space within a kilometre of where youths live was consistently associated with walking in youths of all age groups (between ages 5 and 20).<sup>34</sup>

Long-term planning and funding commitments will be necessary to substantially increase the density of parks and other recreational facilities, but in the interim cities can consider requirements for developers to build open space, trail connections or recreational facilities into their developments, as has been done in downtown Vancouver. In exchange for substantially higher density allowances, developers were required to set aside large portions of their downtown sites for open space. This preserved view corridors, light and air in what are now the densest areas of Vancouver. On a smaller scale, even well-designed pocket parks can allow city residents to get out, eat lunch, read and get some fresh air, and add interest and further variety to the streetscape. Cities can also allow communities to create community gardens out of vacant lots. Community gardens can provide a refuge for people and birds, a place to grow food, and enrich and empower neighbourhoods. Many examples of community gardens exist in cities across North America.

## Gaps in the Research

Even given the extent of existing research it is important to note the complications involved in quantifying or predicting physical activity behaviour changes associated with changes in land use patterns. In assessing the research, four important limitations must be acknowledged.

1. Because characteristics such as compactness, land-use mix, highly connected street networks, and high-quality pedestrian environments largely occur together, it can be difficult to disentangle the effects of each factor.
2. Many factors related to a person's choice to walk versus drive, such as level of visual interest, attractiveness, tidiness, visibility into buildings, and perceived safety and security from crime, can be difficult to quantify.
3. Changes in land use tend to be incremental, so it could take decades before the positive health effects related to a policy change are fully realized.
4. To date, the vast majority of research on these relationships is cross-sectional, drawing conclusions based on a statistical comparison of groups of individuals at a single point in time. These studies are different from longitudinal studies, which examine changes in the behaviour of a single group of individuals over time. Longitudinal studies can better assert *causation* between variables, whereas cross-sectional studies can only document *associations* between variables.

Of these four inherent difficulties, well-structured studies have compensated and accounted for the first three. However, because no multi-year longitudinal studies have been undertaken as yet, the question of association vs. causation remains problematic. It is likely that some of the differences in travel behaviour and physical activity reported in the studies to date may reflect self-selection rather than the pure effects of land use, insofar as transportation behaviour and physical activity levels partly reflect a person's attitudes and

preferences. In other words, people who prefer not to drive are more likely to live in walkable environments, and people who enjoy driving (or who are willing to tolerate the necessity of driving for a cheaper house, a better school, or a larger backyard) tend to choose more automobile-oriented locations.

A number of studies have attempted to answer the question of self-selection by incorporating people's attitudes about transportation and lifestyle as variables<sup>35</sup> or by using quasi-longitudinal research designs, which followed people who changed household locations.<sup>36</sup> The results from these studies are inconclusive – in some, people's preferences were found to be more influential in determining their mode of travel, and in others urban form factors were more influential. This suggests that both preferences and physical environment affect travel behaviour, and that disentangling the two will require a larger, long-term effort.

Although it may be impossible to prove causality without longitudinal studies, disentangling the effects of preferences from the effects of the built environment offers an important first step toward better understanding the relationship between variables. In a recent analysis of travel behaviour, obesity, and land use patterns, researchers controlled for neighbourhood preferences – which allowed them to separate the influence of the built environment from the influence of preferences. While both land use patterns and attitudes/preferences were found to be associated with travel patterns, physical activity, and obesity, walkable communities were associated with more walking and less driving independent of people's preferences.<sup>37</sup>

Regardless of the cause, the outcome is the same – in more walkable areas, people walk more. Although people who prefer a more walkable environment will be more active in walkable environments than those who prefer to drive, both groups will be more active than they would be in a non-walkable environment.<sup>38</sup> Further, research has also documented an unmet demand for more multi-modal, active environments – a sizable number of people currently living in non-walkable areas who would prefer to be in more walkable environments but because of work location, cost, or availability, are not able to do so.<sup>39</sup> Simply changing policies and practices in order to address this demand would enable these positive behavioural changes among people ready to make them.

## ***Key Points and Opportunities***

Based on the existing research it is possible to articulate several major points about the relationship between the built environment and public health. All of the discussion that follows is true when adjusting for socio-demographic factors, although some population groups may find certain aspects of the built environment more important than others.

### **Walkable neighbourhoods are associated with travel behaviour**

A large body of research has consistently associated walkable neighbourhoods – neighbourhoods that are compact, with an interconnected street network and a mix of land uses – with statistically significant changes in travel behaviour, i.e. less driving and more walking, bicycling and use of public transit. Transportation investments also make a difference. Safe streets with sidewalks, trails, and bicycle lanes, as well as frequent transit service will further encourage more physically active travel behaviour.

### **Walkable neighbourhoods are associated with lower body weights**

Because people's travel patterns influence their physical activity levels, the current evidence shows that people located in more walkable areas, with higher levels of land use mix, residential density, and street connectivity are less likely to be obese and more likely to meet recommended levels of daily physical activity.

### **Behaviour is associated with both built environment and lifestyle preferences**

Recent evidence shows that individual preferences for neighbourhood type and mode of travel, in addition to the built environment, have an affect on physical activity levels and how much people drive.

### **A need for more research**

To date, there is no clear evidence of a causal link between the built environment, healthy body weight, diet, and physical activity levels. While associations seem to be clear, there is limited evidence that a given change in the built environment will necessarily result in a given change in such health-related outcomes as activity patterns, food consumption and body weight. Research is now showing that the built environment is associated with travel behaviour regardless of preferences, but the direction of causation remains unclear. Longitudinal studies are needed to assess changes in health-related outcomes before and after exposure to changes in the built environment.

## ***Guiding Principles from the Evidence***

Based on the current evidence, a few guiding principles can be applied to various settings, including small villages, developing suburbs, old town centres and central cities. Each of these larger guidelines can be adapted for different geographic contexts and for the needs of different populations.

- Land uses – retail, office, residential, open space, and schools – should be integrated rather than separated from one another.
- More small shops and services near to where people live attract more walkers than do large shopping centres or a mall.
- Compact residential development puts more people within walking distance of parks, schools, transit, shops and services and provides the vital market for those services.
- Streets and buildings built from a pedestrian perspective create places that are safe, vibrant and interesting for walkers, bicyclists, and transit users.
- Street and trail networks that are highly interconnected reduce the time and distance needed for pedestrians and cyclists to get from one place to another and thereby encourage greater use.
- Recreational activities within easy walking or cycling distance create more convenient ways for kids and adults to be active.
- Good public transit service encourages physical activity as most public transit trips also involve a walking link.
- Facilitating access to public transit may have the greatest health benefits for low-income individuals.

# The Food Environment

## *Understanding the Relationships*

The other half of the body-weight equation is what we eat, and unfortunately, our declining rate of physical activity has been accompanied by an increased prevalence of high-fat, high-calorie, low-quality foods. Vending machines full of sugar-sweetened beverages and other sugary snacks are everywhere, from schools to workplaces to shopping areas. In the supermarket, snack food and convenience food dominate the aisles and are placed at the checkouts. And wherever one is in the city, there is almost certainly a fast food restaurant nearby.

In the same way the built environment influences physical activity, an increasing body of evidence suggests our built environment can also contribute to poor diet. Although the act of putting food into one's mouth is an individual act, the food available to us is dictated by market accessibility and the social environment that influences the appeal of food through advertising and marketing. According to the World Health Organization, "the fundamental causes of the obesity epidemic are societal, resulting from an environment that promotes sedentary lifestyles and the consumption of high-fat, energy-dense diets."

Some areas offering opportunities for policy-makers and planners to influence the food environment are zoning with respect to accessibility to food retailers and restaurants, and in institutional contexts such as schools. Unfortunately, there is little Canadian data on environmental determinants of food consumption patterns. This poses certain limitations to providing evidence-based policy options. Although it may be reasonable to assume that Canadian trends and influences in food consumption are parallel to global trends, caution is needed in generalizing data from different sociopolitical contexts.

## *Food Retail Outlets*

As the majority of food dollars in Canada (70 percent) are spent on food for consumption at home, access to food retail is likely to influence intake.<sup>40</sup> Availability of large supermarkets as opposed to small grocery stores in neighbourhoods may also have an influence on dietary intake. A local food environment with supermarkets was found to be positively associated with meeting dietary guidelines for fruits and vegetables, even when controlling for individuals' educational attainment and ability to afford healthy foods.<sup>41</sup> One possible interpretation of these data is that smaller groceries may not carry an assortment of produce, thereby limiting shoppers' choices. Considering that small Canadian studies have observed decreased access to supermarkets in lower-income areas<sup>42</sup> and in First Nations communities,<sup>43</sup> opportunities for policy to positively influence the environmental determinants of eating behaviour are evident.

## *Fast Food Restaurants*

The increase in consumption of foods away from home, particularly at fast food restaurants, is not surprising considering that in the US, the number of fast food restaurants grew 147 percent from 1972-1995, and the percentage of meals and snacks consumed at fast food restaurants doubled.<sup>44</sup> These trends have implications for dietary quality and quantity. Frequency of fast food restaurant use is associated with higher energy and fat intake, largely due to increases in high-fat, high-sugar food choices such as french fries and soft drinks, and decreases in consumption of fruits, vegetables and milk.<sup>45</sup>

## **Schools**

Although data are not readily available in Canada, observation suggests that school fundraising efforts regularly involve the sale of candy, chips and soft drinks to students. Food and beverage vending machines, the majority of which offer high-fat and high-sugar choices, are nearly universal in high schools. Recent media attention related to the voluntary withdrawal of carbonated soft drinks by major soft drink companies (but not branded juices, waters and sports drinks) from elementary schools, effective September 2004<sup>46</sup> has brought to the public's attention the proliferation of multi-year contracts that individual schools have entered into with major beverage companies, and the variability in policies regarding vending among school boards in Canada.<sup>47</sup> In the US, vending machines attract \$1 billion per year in student spending on snacks.<sup>48</sup>

As the food environment is becoming increasingly influenced by market forces, addressing the obesity epidemic through changes in the food environment will likely require controversial controls and market standards that may conflict with the interests of business. Decision-making will require the support of the best available evidence to stand up to the likely opposition. In the absence of direct evidence, parallel evidence from other health promotion campaigns may be helpful for suggesting possible policy options. Much can be learned from the experience of tobacco reduction initiatives for addressing the policy environment relevant to food access.

## **State of the Knowledge**

In assessing the current body of evidence concerning the food environment, this review includes research on the relationship between sociodemographic characteristics of neighbourhoods and food accessibility, which makes up the bulk of the research evidence but does not directly measure dietary behaviour outcomes. Also included is the smaller but growing body of research that examines more directly the connection between the food environment and obesity or dietary intake variables.

From the research, three general categories of environment have repeatedly been related to food accessibility, dietary behaviour, and obesity. These are the physical, economic, and political environments.

## **The Physical Environment**

The physical environment affects the nutrition of a population through the quality and type of food available from local food outlets. A systematic review,<sup>49</sup> of observational research shows a probable influence of the physical environment on food, nutrition and dietary variables. Existing studies of the physical environment with respect to food have focused predominantly on school environments, with geographic access/ neighbourhood design, and food availability in restaurants/stores comprising the remainder of the published research.

## **Schools**

Most studies of the school environment have focused on the influence of environmental interventions on food intake. All such studies reviewed for this report manipulated some aspect of the physical environment, such

as the availability of healthy choices in vending machines,<sup>50</sup> or point-of-purchase nutrition information.<sup>51</sup> All had at least some positive effects on food intake, either increasing healthy food choices or decreasing the consumption of unhealthy alternatives. Only a few studies and findings found no association between the intervention and change in dietary behaviour. In one study, family-style vs. cafeteria-style food service was found to have no effect on energy intake.<sup>52</sup>

The vast majority of studies dealing with the school environment found an association between school policy and food, nutrition and diet variables. Positive effects (increased consumption of healthier foods, i.e. lower fat or more fruit and vegetables) were associated with comprehensive policy or educational/promotional interventions,<sup>53</sup> and with promotion of healthy foods alone,<sup>54</sup> and in combination with price incentives.<sup>55</sup> Studies comparing the impact of school interventions on food, diet and nutrition found no effect in lower socioeconomic status (SES) school environments but positive effects in higher SES schools.<sup>56</sup>

## **Geographic Access/ Neighbourhood Design**

In examining geographic access to food in urban environments, only six studies were found. Five of these examined or reviewed relationships between local availability of food and socioeconomic status of residents.<sup>57</sup> Only one study connected neighbourhood environment with dietary intake/quality.<sup>58</sup> In all US studies, researchers observed greater access to high-energy density foods (e.g. fast food restaurants),<sup>59</sup> lower access to healthier food (e.g. supermarkets),<sup>60</sup> and lower availability of stores stocking healthy foods in less affluent or marginalized neighbourhoods.<sup>61</sup> Although relationships among geographic access to food outlets, purchase of food, and dietary intake were not established in most of these studies, the proximity of supermarket and other food retail outlets was shown to be associated with a positive influence (although no such association was found for grocery stores) on dietary quality in a single study of pregnant women.<sup>62</sup>

## **Restaurants/ Stores**

Inequitable geographic access to various food outlets does not necessarily mean that the food available at those outlets limits or promotes certain types of choices and predicts dietary quality. However, consistent with assumptions implied by inequitable geographic access, two US studies investigated the availability of food meeting nutrition recommendations in divergent neighbourhoods, and found lower availability of healthy foods in stores<sup>63</sup> and restaurants<sup>64</sup> in economically disadvantaged neighbourhoods. No such association was found in an Australian study.<sup>65</sup>

Two studies investigated the relationship between food availability in restaurants and food intake, and both found relationships. For children, the number of meals consumed in restaurants negatively affected diet quality.<sup>66</sup> Availability of fruit, juice and vegetables at restaurants positively influenced food intake.<sup>67</sup> In stores, however, no associations were found between food availability and consumption in two studies. Availability of fruit, juice and vegetables at local stores showed no association with their consumption.<sup>68</sup> Availability of low-fat foods at stores in disadvantaged communities was not associated with low-fat eating patterns.<sup>69</sup>

Only one study intervened in food outlets by using shelf labelling in stores to promote healthier choices, and the intervention positively influenced food purchase behaviour.<sup>70</sup>

## **The Economic Environment**

The economic environment concerns how indicators of SES influence food availability or accessibility and dietary intake. A systematic review of observational research shows the probable influence of the economic environment on food, nutrition and dietary variables;<sup>71</sup> the majority of research findings show associations between economic environments and dietary variables.

With respect to the influence of the SES of populations (as indicated by income, education and employment) on food, nutrition and diet, studies that derived composite measures of SES and deprivation overwhelmingly supported the idea that lower SES and deprivation is associated with poor dietary quality.<sup>72</sup> Only one study found negative associations<sup>73</sup> and only three studies found no association.<sup>74</sup> When education was used as a proxy for SES, similar associations were found.<sup>75</sup> Weaker associations were found when income alone was used as an indicator of SES.<sup>76</sup>

At the neighbourhood or local level, the influence of the economic environment is less clear than at the population level. The largest share of the research at the local level deals with food costs. At this level, food costs have not been shown to be higher in disadvantaged neighbourhoods,<sup>77</sup> although lower incomes in such neighbourhoods may deter healthier choices. Most studies showed associations between price of food and consumption, with affordability having the most consistent influence.<sup>78</sup> Studies where the intervention was manipulation of food costs have inconsistent findings; some found price decreases of healthy foods increased consumption,<sup>79</sup> while a study in a worksite cafeteria found no effect of pricing on food choices.<sup>80</sup>

It is of interest that composite measures of SES/deprivation have been more frequently associated with food, diet and nutrition variables at the population level, while more specific measures of SES (education, employment) have been more frequently associated at the local level.

## **Gaps in the Research**

- Changes in the environment happen in parallel with changes in population food intake and obesity rates, but it is unknown how these changes are influenced by each other. Experimental studies that attempt to change the environment and monitor changes in dietary behaviour and weight status can provide a much stronger evidence base, but at this point there are few data available.
- Because characteristics such as physical location of food retail and the social and economic characteristics of environments largely occur together, it can be difficult to disentangle the effects of each factor.
- Many factors that relate to food choice, such as food preferences, quality, and cultural acceptability can be difficult to quantify and may have mediating influences on factors that are amenable to policy change, such as affordability of food and accessibility to food retail.
- To date, the vast majority of research on food environments is cross-sectional, drawing conclusions based on a statistical comparison of groups of individuals at a single point in time, as compared to longitudinal studies, which examine behavioural changes in a single group of individuals over time. Longitudinal studies can better assert causation between variables, whereas cross-sectional studies can only document associations between variables.

These gaps and problems with the evidence base create a dilemma for decision-makers: making policy changes requires evidence, yet the existing evidence base is limited, although evolving rapidly. Based on the strong observational evidence and the seriousness of the problem, the best approach may be to try the most plausible policy options, while including a strong evaluation component to gauge effectiveness and guide further policy decisions.

## ***Key Points and Opportunities***

From a review of the research, several major points emerge about the links between the food environment and public health. All of the discussion that follows is true when adjusting for socio-demographic factors, although some variables may be more important for certain subsets of the population.

The current available evidence suggests that policies that acknowledge the following points are likely to positively influence food consumption, dietary quality, and health status (including obesity rates). Many of the land use changes discussed in the previous section of this report can also result in more healthful food environments. Increased density, for example, can make well-serviced, walkable communities accessible to a wider range of families and household incomes. Increased density also helps reduce household expenses by making it possible for households to forego car ownership.

### **There are multiple influences on healthy food choices**

The economic, physical and policy environments have all been linked through the research to healthy food choices. To achieve the desired changes in population behaviour, each of these areas must be addressed, preferably in a coordinated fashion.

### **Use physical and economic levers to encourage better food choices**

Increasing access to nutritious, high quality foods while discouraging access to sources of high-energy, inexpensive foods can be an effective means of improving population health and nutrition. Research shows that both the physical surroundings (e.g. location, point-of-purchase signage) and price signals can impact food choices, so incentives can be designed from both angles.

### **Schools are an important venue for addressing healthy eating habits**

Some of the strongest research findings to date are from school-based studies. Schools help to establish healthy eating habits at an early age. And because they influence the behaviours and perceptions of large numbers of students, changes to school cafeteria and food policy offer an effective avenue for achieving desired health outcomes.

### **More research is needed**

Although there is some strong evidence linking economic, policy, and physical conditions to food choices, in the absence of longitudinal studies it is not possible to prove a causal link for these conditions. Approaches that acknowledge this uncertainty while still taking action are most likely to be effective.



## Other Links Between Land Use Planning & Public Health

### *Air Quality & Respiratory Health*

The relationships between air quality, vehicle travel, land use patterns and their health effects are complex. Air pollution is made up of a variety of substances, each with different sources, patterns of distribution, and health impacts (summarized in Figure 4). Each pollutant therefore has a different association with land use patterns and transport, making it difficult to determine how a particular land use policy will affect air pollution levels or exposure risks. It is even possible that a policy could reduce the health risks from some pollutants and increase the risk from others.

The elderly or young, people with asthma or other respiratory conditions, and people with heart disease are most vulnerable to air pollution. People who exercise outdoors, walk or bicycle may face additional air pollution health impacts due to their elevated breathing rates. However, a recent study showed that overall, motorists face higher exposure rates than walkers or cyclists.<sup>81</sup>

Localized air pollutants tend to concentrate near their source – near fixed locations such as factories and power plants, or along roadway corridors.<sup>82</sup> Therefore, health risks depend on both the total amount of these pollutants and on their location. A number of micro-environmental factors such as traffic conditions (vehicle mix, speed, congestion), the amount of time people spend walking, cycling or driving along roadways, and land use characteristics such as the proximity of buildings to high-traffic roadways, will determine level of exposure and how that exposure varies from one place and time to another.

Generally, actions that reduce per capita vehicle miles and the number of vehicle trips and that make vehicle traffic smoother, favour less polluting vehicles and increase the physical separation between vehicle traffic and people are likely to reduce human health risks from vehicle-related pollution. As population density increases, so do the benefits of these interventions.<sup>83</sup> Short motor vehicle trips in urban conditions tend to have relatively high per-kilometre pollution emission rates due to cold engine starts and traffic congestion, so reductions in the number of such trips tend to achieve relatively large emission reductions. These short trips also have the most potential for replacement by walking and cycling. Emissions per vehicle mile tend to be minimized at moderate traffic speeds (30-50 km per hour) with minimum stops. Although extreme traffic congestion increases emission rates, moderate congestion may reduce emission rates compared with higher free-flow speeds, depending on specific conditions.

High per capita vehicle miles of travel and number of vehicle trips are associated with higher levels of several air pollutants that have adverse respiratory health impacts: fine particulates, toxins, carbon monoxide, oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOC). By reducing the amount of per capita vehicle travel, walkable land use patterns can reduce pollution emissions and exposure. While there is no research directly testing the link between land use, pollutant exposure, and health impacts, there is clear evidence linking the built environment to travel behaviour and per capita air pollution, which can be linked to pollution exposure in a population.

Studies of the relationships between land use and exposure to air pollutants suggest that exposure to harmful ground-level ozone may be somewhat mitigated through increased walkability.<sup>84</sup> The LUTAQH study in the Seattle region also looked at the relationships between urban form and air quality. A 25 percent increase in the overall range of walkability within King County, Washington was associated with 6.5 percent fewer vehicle miles traveled, 5.6 percent fewer grams of NOx and 5.5 percent fewer grams of VOC per capita.<sup>85</sup>

A recent report for the BC Lung Association estimated that a ten percent reduction in airborne fine particulate matter (PM 2.5) and ozone emissions in the area of Vancouver would produce \$195 million (CAN) in health benefits (from decreases in mortality, emergency room visits, and in occurrences of asthma, bronchitis and cardiac incidents) in 2010.<sup>86</sup> The Border Air Quality Study is currently assessing the spatial variation in concentrations of fine particulates (PM 2.5) in more and less walkable areas of the Vancouver and Seattle regions.<sup>87</sup>

When looking at the tradeoffs between more walkable land use patterns and pollutant exposure, the walkable environments may be the same places where exposure to pollutants is greatest. This does not mean that we should forego more walkable environments. The cumulative benefits of such approaches to community design, including benefits concerning transportation, environment, and health, appear to be significant in the near term and even greater in the long term – especially in light of other, more global, long-range issues, such as energy supply and consumption and climate change. In conjunction with the promotion of more compact development, however, policymakers should also encourage the use of alternative fuels and clean engine technologies, especially in commercial fleets and transit vehicles. Core areas should be buffered from high-traffic corridors associated with the movement of goods. Housing facilities for at-risk populations, such as the elderly and people with respiratory illnesses, should be located in places where particulates are less concentrated.

**Figure 4. Characteristics of Major Air Pollutants**

Pollutant	Source	Health Impacts	Distribution
Carbon Monoxide (CO)	Vehicle exhaust, other combustion of fuels and wood	Aggravates coronary heart disease, impairs central nervous system, increased risk to fetuses	Local
Sulfur Oxides (SOx)	Combustion of fuels containing sulphur (esp. diesel), other industry	Wheezing and shortness of breath, particularly in those with asthma. Has been linked to cancer.	
Nitrogen Oxides (NOx) combine with VOCs to form ozone	Combustion of fossil fuels, other industry	Increases risk of acute respiratory illness, aggravates existing respiratory conditions	Regional
Particulate Matter (PM10 and PM2.5) – small particles that remain suspended, such as dust, diesel exhaust, and soot from fires	Burning fires, construction, fields/roads in a dry climate, diesel engines and other automotive sources	Aggravates existing respiratory disease, decreased lung function, increased respiratory infections, increased heart attack risk (Pope et al. 2000).	Local / regional
Ozone	Formed when NOx and VOCs combine in sunlight	Decreased lung function, inflammation, can trigger shortness of breath/asthma (Bell et al. 2004; Friedman et al. 1998, Gauderman et al., 2004, Hoek et al. 2002, Areskoug et al., 2000)	Regional
Lead	Lead gasoline, soil contamination, industrial processes	Central nervous system impairment	Local
Volatile Organic Compounds (VOCs)			
Airborne Toxics (e.g. benzene, formaldehyde, methanol, etc.)	Industrial processes	Have been linked to increased cancer risk	Local
Carbon Dioxide (CO2)	Burning of carbon – primarily wood (deforestation), fossil fuels (vehicles and power plants)	Impacts primarily indirect – increased risk to natural disasters, disease and dislocation due to global climate change	Global

## Traffic Safety

Land use patterns, automobile dependence and traffic safety affect each other in a number of ways. As people spend more time in cars, their risk of being in an accident increases. Additionally, roads that are designed to move vehicles as efficiently as possible mean accidents happen at higher speeds, and thus are more severe. Traffic accidents are currently one of the leading causes of death for people under 40. Because accidents tend to kill or disable people at a relatively young average age, the “potential years of life lost” is even greater.<sup>88</sup>

Recent research has found that per capita traffic fatality rates tend to be higher in sprawling communities than in compact, mixed use communities.<sup>89</sup> This is likely a result of increased per capita vehicle travel, higher travel speeds, and more driving by teenaged and elderly motorists due to poor travel options. Because compact, walkable communities have also been linked to lower per capita miles and hours of travel, they can lower exposure to traffic accidents.

For pedestrians and cyclists, the combination of fast-moving traffic and designs hostile to non-motorized transport create an environment that is unpleasant as well as unsafe. Further, as walking and bicycling decline, driver awareness of these modes declines, making conditions more dangerous for pedestrians and cyclists. The reverse is also possible – several studies have found that in areas with more people walking and cycling, traffic accidents are actually less likely. Researchers hypothesize that when drivers observe more walking and cycling they drive more cautiously.<sup>90</sup> Improvements that slow traffic, increase visibility of pedestrians and cyclists, and create safe crossing points can all encourage walking and cycling. This can even create a positive feedback loop, encouraging more physically active modes of transportation, as results from some research indicates that people seeing others in their neighbourhood exercising or being physically active are more likely to increase their level of physical activity.<sup>91</sup>

Well-designed streets are likely to encourage more physical activity by making bicyclists and pedestrians feel safe and welcome. Pleasant scenery and attractive neighbourhoods have both been associated with higher physical activity rates.<sup>92</sup> Especially in the case of women, children, the disabled, and the elderly, safety and security from crime and traffic is absolutely crucial, and has been linked to physical activity rates.<sup>93</sup> Parents need a safe environment for their children in order to feel safe letting them walk to school, the pool, or to sports practice, rather than being driven everywhere. Because they move more slowly and may be using a walker, cane, or wheelchair, the disabled and elderly are quite sensitive to the safety of their walking environment. Sidewalks are crucial in order to make pedestrians feel secure, and have been found to drastically reduce accidents.<sup>94</sup> A Canadian study also found sidewalks and crossing lights to be significantly associated with walking to work.<sup>95</sup>

Vehicle speed and volume are the two primary causes of traffic accidents, both vehicle/vehicle and vehicle/pedestrian. Traffic speeds have a large impact on the number and severity of accidents. The fatality rate for pedestrians struck by a vehicle travelling under 30 kph is only five percent. At 50 kph, the fatality rate increases to 45 percent and at 60 kph to 85 percent.<sup>96</sup>

Traffic speed is affected more by the “design speed” of a roadway than by the posted speed limit. The design speed is the maximum speed that feels safe to motorists, and can be lowered by reducing the number of lanes, narrowing the lane width, and by adding parallel parking, street trees and sidewalks. Wide travel lanes, which encourage higher speeds, are particularly inappropriate for urban traffic. A 1998 study found that out of a number of variables, street width was by far the strongest predictor of crash risk.<sup>97</sup> Several other studies have found fewer and less severe accidents on roadways with street trees, landscaping, on-street parking and other features that lower the design speed.<sup>98</sup>

Intersections are also common sites of vehicle/pedestrian conflict. A number of design features can improve pedestrian safety at intersections, including longer walk signal phases, tighter turn radiuses to slow turning vehicles, prominently marked crosswalks and refuge medians. Traffic circles, found in one study to reduce accidents by 82 percent, have been overwhelmingly successful at slowing traffic and reducing accidents at intersections.<sup>99</sup>

## ***Affordable Housing***

The built environment has an impact on the growing urban issue of homelessness. To help address this issue, dedicated land use planning is necessary for ensuring an adequate supply of affordable housing and emergency shelter-type accommodation for people on low incomes and the homeless. These housing solutions must be located in well-serviced areas, easily accessible to the populations for whom they are designed.

## ***Key Points and Opportunities***

The research indicates that, in general, the same walkable land use patterns associated with more physical activity and lower obesity levels are also associated with lower traffic accident rates and lower rates of pollution exposure. However, it is important to consider how increasing population density and activity in an area can potentially conflict with goals of reduced pollutant exposure and traffic safety. Streetscape improvements and traffic calming measures should take place in conjunction with increases in density at the neighbourhood level to slow and sensitize vehicles to pedestrian activity. Care should also be taken to insure that sensitive uses and populations (seniors, schools, hospitals) are located away or buffered from high-traffic locations.

### **Walkable neighbourhoods are associated with less pollution**

People in walkable neighbourhoods are less likely to drive, produce less greenhouse gases and consume less energy per capita. However, because local emission concentrations are primarily related to vehicle volume in an area, it is not possible to say specifically how per capita reductions in emissions translate into respiratory health, even though, in general, impacts on air quality are positive. At the regional and global levels, reduced per capita vehicle miles and hours of travel can have a definite positive impact.

### **Pedestrian-friendly streetscapes encourage physical activity**

Areas that are attractive and safe from traffic and crime have been linked to higher rates of physical activity. Further, the presence of pedestrians and cyclists has been linked to higher physical activity rates and safer traffic conditions, presumably as people notice the prevalence of physically active behaviour in the area.

### **Pedestrian-friendly streetscapes are associated with lower and less serious accident rates**

Streets that are narrower and easier to cross slow traffic. Other features, such as landscaping, sidewalks, and parallel parking can further enhance pedestrian safety and increase driver awareness.

### **Land use planning is required to address housing issues**

Dedicated land use planning is necessary for ensuring an adequate supply of affordable housing and emergency shelter-type accommodation for people on low incomes and the homeless.

# Decision Makers, Domains & Opportunities

## *The Decision Makers*

### Elected Officials

Elected officials can help promote population health and reduce obesity by passing supportive legislation and directing funds toward improving the built environment. Public leadership from the elected bodies of municipal and provincial government also provides direction and spurs action at the staff level and in the private sector. However, the reverse is also true. For elected officials to feel comfortable taking action they must believe those actions are warranted, supported by their constituents, and implementable by their staff.

At the provincial level, designating funding that supports physically active modes of transportation and access to healthy food – and taxing actions that undermine these goals – may be the most supportive action elected leaders can take. A strategic funding plan for investments supporting more physically active modes of transportation can direct funding in the geographic areas where it is most likely to have an impact – urban areas, redeveloping suburban centres, key transport corridors, areas around schools, etc. Funds for environmental cleanup, infrastructure upgrades, and transit improvements in those target areas can all support more healthy communities. Impact fee reductions or tax breaks can encourage developers to build in in-city areas, to clean up and reclaim brown fields, and to otherwise invest in areas that are supportive of more physically active transportation alternatives. At the municipal level, where individual land use changes happen, elected officials can also revise zoning regulations, development requirements and parking standards to be more supportive of physically active modes of transportation, in cooperation with land use and transportation planners.

### Land Use Planners

Decisions about land use typically take place in the context of two overarching processes, the longer-term, regional planning process, and the local process of influencing the appearance and location of proposed development within a city's borders.

The regional planning process influences or dictates where population growth is directed and where development is restricted at the regional scale. It also influences plans for other larger infrastructure needs such as power generation, water treatment, airports, landfills, etc. In BC, these decisions are made by provincial ministries, Translink, and municipalities.

Most decisions about specific land use projects are made at the local level, with the exception of large infrastructure projects, such as waste treatment, intercity river crossings, etc. Land use planners typically use long-range, comprehensive plans to establish policy priorities and goals, and short-term, strategic or action plans to take an in-depth look at a sub-area, neighbourhood, or corridor.

Long-range comprehensive plans tend to be more general and direction-setting than shorter-term action plans, and are updated infrequently. They also tend to go through a lengthy development period with an

impact review, not more frequently than once every five years. The long range planning process offers the best opportunity to incorporate health-related policy priorities into the city's overall vision.

The goals, policies and priorities in the various plans are eventually translated into zoning and development regulations. Zoning regulations control site design, density, mass or bulk of buildings, the land uses permitted within a given area, parking requirements, street width, and any other requirements for building design, amenities, affordable housing, or streetscape design. This also includes internal building requirements, such as structural requirements, earthquake and fire protection, and "healthy building" requirements.

Although zoning regulations should align with the policies contained in the comprehensive and short-term development plans, this does not always happen. Zoning regulations are technical and complex, and are typically revised piecemeal rather than through comprehensive overhauls. Additionally, policies laid out in the long-range plans may conflict, especially since they tend to be broadly written and subject to interpretation. Decisions on specific development proposals and zoning are generally difficult to track and are technical in nature unless a project of large significance is proposed. However, with the potential for ambiguity between plan/policy and implementation, feedback from a public health perspective at this level of detail could be warranted and valuable.

Municipal land use planners also control the review process, meaning they can also choose to expedite reviews or waive certain regulations in exchange for other features – for instance, allowing a developer to build at a higher density in exchange for building affordable housing, or granting an expedited review for projects in a target area. These regulations, fees and practices are set by city elected officials and land use planners, and changes in these processes can be just as important, if not more so, than the regulations themselves.

Although land use plans and zoning control what types of land uses apply and where, the specifics of location for, say, a single grocery store are generally left to the private sector. However, local land use planners, community development departments, and public health officials could take a more active role in increasing ease of access to sources of healthy food. They can, for example, establish financial incentives or disincentives, repurpose vacant land, or facilitate the creation of farmers' markets to increase healthy food environments, especially in lower-income neighbourhoods. Zoning regulations that discourage drive-through fast food restaurants are becoming more common to help promote walkability, but can also have a positive influence on the food environment.

## Transportation Planners and Engineers

As with land use planning, decisions on transport range from the large-scale, high-budget provincial/regional infrastructure planning to extremely small-scale decisions about streetscape function, amenities and appearance at the local level.

### The Regional/Provincial Level

The federal budget typically allocates funding for large infrastructure projects, including transportation projects. Whether this funding gives priority to road building, transit, or to bicycle and pedestrian projects

depends on the politics of the time, but road building has been prioritized since the mid-1900s. Only recently has this trend started to shift towards more public transit and trails funding.

The regional planning process also influences transportation investment priorities. Policies concerning favoured modes of transportation and geographic priorities for a region are generally determined during the long-range, comprehensive planning process. The regional planning process goes through an environmental impact assessment to determine which general growth and transportation alternatives should be formally adopted by the regional plan. Including public health impacts in the scope of outcomes for consideration will help determine which plan alternatives should be selected. Public health officials may want to monitor this process and make sure that public health goals are considered at each step. Large-scale planning processes will often have advisory or steering committees, and public health interests should be represented on these groups.

Specific regional or provincial scale roadway or transit projects will also typically require some level of environmental review – the scope of the review depending on the size of the project and whether it is likely to have significant impacts. Again, public health officials should monitor this process and encourage the inclusion of public health goals in the scope, mission statements, outcomes, and alternatives of the analysis and final decisions.

### **The Municipal Level**

Decisions about pedestrian and bicycle amenities are largely made at the local level. During the long-range planning process, certain streets or neighbourhoods may be targeted for street improvements, or improvements may take place ad-hoc in conjunction with development. These decisions are made by elected officials, land use planners, transport planners and communities, and may be influenced by regional or federal planning and funding processes.

Implementation – the actual design of the street on the ground – is largely the domain of transport engineers. Standards for street width, turning radii, parking, and other roadway design elements may be determined by transport engineers at the local level, but are frequently adopted wholesale from national transportation engineering associations such as the Institute for Transportation Engineers, resulting in solutions that are not necessarily appropriate for a specific location or for promoting physical activity. Sometimes provincial or federal transportation departments have restrictions on what can be done on various classifications of roadway, even within a city's borders.

Transportation or public works departments could review and adjust local roadway standards to encourage traffic calming and narrower, more pedestrian-friendly streets. Allowing flexibility and creativity in design practices will go a long way toward making streets that fit within the context of a walkable, active neighbourhood. Wide, 11-foot lanes are inappropriate for urban areas in most cases. Converting a four-lane street into a three-lane street – one lane in each direction with a centre turn lane – can actually improve traffic movement by reducing slowing (and accidents) caused by left turning traffic. To slow right-turning traffic, a common cause of pedestrian-vehicle conflict, discourage or eliminate free right-turn lanes or channels, and reduce turning radii at intersections.

Other safety enhancements require even less infrastructure investment and construction, and can enhance safety in targeted locations. To make crossing easier (or even possible) for the elderly and the disabled,



“walk” phases of traffic signals should be timed for people moving at slower than average speeds (closer to 2.5 ft/second rather than four ft/second, which is the average speed of an able-bodied adult). Intersections in high-traffic locations, near hospitals and other specific facilities will benefit from audible pedestrian signals, which let visually impaired people know when it is safe to cross.

Public funding is generally required for pedestrian and bicycle amenities, although some cities do require developers to make improvements as a condition of development approval. Although some local governments have their own designated funding sources, these instances are rare and it is more typical for bicycle and pedestrian programs to have to jostle for position in the local budgeting process or to compete for federal or provincial grants. Roadway expansion or repaving offers opportunities for bicycle and pedestrian improvements to be added on – often this is required and incremental costs are minimal if the work is coordinated. Other streetscape improvements such as trees, bicycle racks, and community gardens may be implemented by the city, neighbourhood associations, individuals or businesses – and most likely by a combination of all four.

Public transit-related decisions such as service frequency and the location of stops and waiting areas are made by the transit agency planners. Typically, transit agencies operate separately from the local municipality, although a great deal of coordination with the local land use and transport planners is obviously necessary. In some cases, transit agencies and local jurisdictions will put agreements in place to increase transit service in conjunction with density increases or neighbourhood redevelopment. Large transit infrastructure investments, such as a new rail line, will usually go through a more formal environmental impact assessment.

### **The Private Sector, Developers and Lenders**

Changes through the private, as well as the public sector are important to help counter obesity trends and promote population health. It needs to be profitable, expedient and cost-effective for private developers to build quality developments that support physically active transportation alternatives. Lenders should be supported in policy and practice to make it possible for them to finance such projects. Taxing policy, which currently favours new construction and greenfield development, should be changed to support development in previously built areas. If tax incentives favoured infill development and refurbished housing, this would encourage developers, homeowners and businesses to build and locate in already-developed areas instead of greenfields.

Regulations impact the bottom line for developers in two primary ways: through the project's design (the number of units that can be accommodated on a particular parcel, parking requirements, required amenities) and the time it takes to develop (obtaining permits and community review/approval). Delays are costly. It is common to hear developers state that having a predictable process is the most important factor in a project's financial success.

Banks, through lending and financing requirements, are another major player in land use development. Banks are generally risk averse, which means they may avoid projects that might otherwise serve the public good. A mixed-use project at a time when the real estate market is soft, or the first mixed-use project in an otherwise single-use neighbourhood, may represent greater risk and therefore be more challenging to finance. Having tax breaks or other cost-reduction measures in place can make the difference to whether or not projects like these happen.

Although on the surface, requirements for higher density allow builders to build (and therefore sell) more units, a number of other factors play into whether compact development is actually profitable. Typically, requirements such as structured parking, elevators, infrastructure upgrading and steel construction kick in at higher densities, increasing a building's cost. Additionally, fewer developers have sufficient experience building at higher densities, and the extra profit may not be worth tackling the learning curve. Although city land use planners may not be able to foresee the financial ramifications of every possible development scenario, new regulatory requirements should be carefully considered in the context of financial feasibility.

In urban areas, parcels are frequently too small for modern construction equipment, and may need environmental remediation or upgraded infrastructure and telecommunications. A collaborative approach between land use and economic development departments in conjunction with private developers can bring improvements to a targeted area. By helping to assemble several parcels into one larger site, or upgrading infrastructure – sewer and water lines, sidewalks, transit service, lighting, etc. – in urban areas, a city can vastly improve the odds of mixed use or infill development being successful. One successful development will often spur further development, as other lenders and developers take notice.

## School Officials and School Boards

In the schools, policy decisions are made by the school board for each district and the administrators for each individual school. School boards make decisions about facilities and construction, which affect the physical activity environment. Often, district budgets are skewed towards construction of new schools rather than the remodelling of older, in-city schools. Additionally, adherence to national guidelines for school and playfield size can result in effectively eliminating in-city schools – as the only parcels that are large enough and/or affordable are in outlying areas. Local land use regulations can compound this problem by requiring large amounts of parking, especially for high schools, when in fact, high school students are good potential candidates for city bus pass programs and other programs that encourage more physically active modes of transportation to school.

## Public Health Officials

Public health encompasses a broad range of activities focused on improving the health of the population and is well positioned to represent the health sector at the built environment decision-making table. The public health function of surveillance, including chronic disease epidemiology, provides information that can be useful to the planning and decision-making processes. Surveillance and reporting on the health of a population includes detailed analysis of the profile and health issues within a geographical area. The analysis goes beyond disease and considers such determinants of health as the distribution of behavioural risk factors. The built environment also aligns well with the environmental health area within public health. Environmental health officers have responsibilities for regulatory functions that relate directly to land use. Although not traditionally focused on the built environment, many environmental health officers are beginning to develop a new role in healthy community planning and are participating in discussions with their colleagues at the municipal and regional levels.

At present, there is limited formal collaboration among other sectors involved in community planning. The emerging evidence on the impacts of the built environment on health provides the opportunity for more

interdisciplinary, inter-sectoral collaboration to more effectively design communities for health. It is hoped this will result in more comprehensive plans that include a health component. It could also result in agreement on minimum standards for healthy cities and communities in the areas of land use and transportation.

Health assessments, advocacy and advising are potential roles and activities for public health. Surveillance and epidemiological activities contribute directly to health assessments and demonstrate the real and potential impacts of the built environment on health as well as the interventions known to promote positive health outcomes. Public health also has a unique function through the legislated responsibilities of the medical health officer, and advocacy is a key role when actions are needed to improve health. This role can enhance decision-making outcomes. Environmental health officers could participate in advisory and steering committees and collaborate with municipal planners on environmental impact assessments for long-range planning and transportation projects.

### **NGOs, Research Institutions and Advocacy Groups**

Although research institutions, NGOs (non-governmental organizations) and advocacy groups have very different perspectives and approaches to problem solving, they add an important dimension to the public and private sector perspectives. This “third sector” is well-suited to prompting interdisciplinary thinking and bridging the gaps between the public and private sectors.

NGOs and research institutions are often best poised to increase the comfort level of elected officials, planners and the private sector. They bring sectors together to articulate and define problems, research causes and develop potential policy solutions. And because they are outside the traditional business/government dichotomy they can build political support and knowledge within the general public.

Research institutions can lend specific, high-level knowledge and technical expertise to any goal-setting or monitoring task. They also comprise the most thorough and credible sector to take on additional research required for better understanding a problem, its causes and possible solutions. Such knowledge is especially valuable in the case of obesity, which is a serious and worsening problem with many interconnected causes. Moreover, the system of scientific research, which relies on published, peer-reviewed research to draw conclusions and inform further research, is less subject to bias and political viewpoints. NGOs, on the other hand, exist largely because they have a particular point of view. For this reason, they can function well in a watchdog or monitoring role or to facilitate and brainstorm solutions for a particular issue.

## Multidisciplinary Decision-making for Better Population Health

The recommendations presented below are intentionally far-reaching, ambitious and in some cases could entail large changes to the status quo. However, the complex health impacts of the built environment are unlikely to be solved by small, piecemeal solutions.

Although there are numerous hurdles to achieving changes in policies and practices governing the built environment, and potentially long time lags between those changes and their eventual positive health outcomes, it is crucially important to address this area. Parcel-by-parcel changes in the urban fabric may seem modest, but our cities and suburbs are full of opportunities for changes to the built environment that promote health. Policymakers, planners, public health officials and others all have important roles in the enterprise of creating communities that encourage and enable citizens to be more active and healthy.

### *The Research Supports Broad Changes to Our Built Environment*

**The bulk of research consistently finds a relationship between the built environment, physical activity and body weight.**

Although longitudinal studies are necessary to definitively confirm causality, given the severity of the obesity epidemic, adopting an approach that takes action now, incorporates flexibility, and continues research into the problem may be the best course.

With such an approach, evaluation is key. Building in evaluative components to policy changes can help ensure decisions are made based on the best and most current information, and that public resources are used accountably. ‘Natural experiments’ such as this offer an opportunity to effectively assess the impact of changes to the built environment on physical activity. This approach also offers a first step toward addressing causation, the major gap in the existing built environment research.

In order to share the positive results of this approach with other jurisdictions and interested parties, the research agenda must include an effective knowledge synthesis, transfer & exchange program.

### **Creating walkable land use patterns can have multiple benefits**

The same actions that are linked to more physical activity and lower obesity rates are also linked to lower per capita air pollution and lower fatal traffic accident rates, making the potential benefits of action even greater. Over the long term, creating change in the built environment can have a considerable impact on our overall health – not just obesity. Whether the built environment encourages driving or more physically active modes of transportation has implications for respiratory health, the number and severity of traffic accidents, mental conditions such as stress and depression, a neighbourhood’s social capital and community engagement, and even water quality.<sup>100</sup>

### **There are numerous opportunities to change the built environment**

These include increasing density in existing mixed use centres, bringing other uses into neighbourhoods that are currently residential-only, increasing the connectivity of the street and trail network, and improving the appearance and safety of the streetscape. Open space and recreational opportunities are also linked to greater physical activity levels. These changes may be achieved through a number of mechanisms, including funded programs and seed investments to encourage development, changes in regulatory requirements and processes, and long-range plan changes.

On the transportation side, research suggests that health objectives may be better achieved through investments in bicycle, pedestrian and transit facilities and services. This is a strong argument for increasing funding for transit, bicycle and pedestrian investments. Funding criteria and project prioritization processes for all transportation modes (roadway, non-motorized and transit) should support public health objectives. Evaluation of the economic impacts of any transportation plan or project should include consideration of the associated health care costs.

In order to increase access to healthy food choices, vacant parcels of land – particularly in neighbourhoods that lack healthy food choices – could be purchased or used temporarily for community food gardens. In neighbourhoods lacking grocery stores, finding a grocery store or market as a tenant could conceivably be a requirement of new development. Alternatively, tax abatements, density bonuses, or other financial incentives could be offered to encourage developers to include supermarkets as tenants. Weekly farmers' markets – on a closed-off street, in schoolyards, or parking lots – could fill the gap and bring neighbourhood residents and local producers closer together.

### **Changes to the built environment will require significant time to show benefits**

Because land use development takes place parcel by parcel, it can take time to see new regulations implemented – especially in areas where compact, mixed use neighbourhoods are a departure from the norm. Additionally, the relationship between land use and physical activity is indirect, meaning that once the land use patterns change, it may take time for people's behaviours to change in response, and for the desired outcomes – increased physical activity and reduced obesity – to occur. This time lag supports yet another argument for early action to change built environments.

## ***A Collaborative Focus on Population Health is Crucial***

### **Commitment and cooperation from many players is necessary to understand the issues, inspire actions and evaluate/continue research.**

Making the leap from concept to research to action will require ongoing dialogue and cooperation between disciplines. The current research base was made possible through researchers from planning and medical fields coming together to examine the varied, interlocking issues, devise research approaches, and share data. The result has been a broader, more robust and more policy-relevant understanding of the multifaceted relationships between urban planning and public health. Likewise, as research is translated into policy and action, the commitment and cooperation of many players is necessary to understand the issues, brainstorm policy solutions, and create a knowledge base.

## **Public health representatives should be fully engaged in a wide range of planning processes**

Given the health impacts of land use planning decisions, it is becoming imperative for public health agencies to have a seat at the table during the planning process. Changes in a population's health, safety and welfare should be explicitly considered in the evaluation of various planning alternatives and development proposals.

Multi-disciplinary teams of researchers, land use planners, health policy officials, and transport planners, should work collaboratively to develop sets of indicators that can be used for:

- Transportation funding prioritization (at the federal, provincial, and local levels)
- Local level development proposals
- Regional long-range planning
- Environmental impact reviews (at the federal, provincial, and local levels) for long-range plans and transportation projects
- School policy reviews (at the district and individual school level)

These reviews can have the effect of encouraging healthy food environments, in addition to changing the built environment. They should employ an appropriate level of detail for each particular context in which they are used. For example, a long-range regional plan should be subjected to a much more rigorous review process than a decision affecting a local development.

## **Changes to development through both the private and public sector are important for countering adverse trends in physical activity, nutrition, obesity, air pollution and injuries.**

It should be profitable, expedient and cost-effective for private developers to build quality developments that support physically active transportation. Lenders should be encouraged in policy and practice to finance such projects. Taxing policy, which currently favours new construction and greenfield development, should be changed to support the opposite. If tax incentives favoured infill development and refurbished housing, this would encourage developers, homeowners and businesses to build and locate in already-developed areas instead of greenfields.

## ***Protect Those Most at Risk***

### **Children and youth.**

For children and youth, open space and parks and being able to walk or bicycle to school are crucial for maintaining a minimum level of physical activity and creating healthy habits that last a lifetime. Unfortunately, school district policies often discourage school renovation, instead favouring large suburban sites and large parking lots. If such policies were reversed there is a likelihood that better use could be made of existing in-city schools and reduce capital requirements for new construction. Not only are more places needed for kids to play, but access to those destinations needs to be made safe from traffic so that kids are able to access them on foot or bicycle. Once at school, kids need healthy food choices, and need to be protected from environments that encourage over-consumption of low-nutrient 'junk food.' The BC government has made

a number of strides in healthy schools initiatives and early successes indicate that further actions would be both well-received and effective.

### **Elderly and the disabled.**

For the elderly and disabled, the micro-walking environment is most important – such small things as uneven sidewalks, too many curb cuts, or short walk signals can create problems. Open space destinations and grocery stores should be located within a short distance of seniors' housing (i.e. within a quarter-kilometre or less). Because it facilitates physical activity, a walkable built environment can play a role in preventing declines in health and mobility. The large population of aging “baby boomers” creates a huge unmet demand for places to live that encourage physical activity and offer convenient access to services without the need for a car. The consequences of not addressing this demand will be even more expensive for our health care, emergency response, and transportation systems.

### **The poor.**

Affordable housing and good access to public transit is crucial for economically disadvantaged citizens. Currently, high demand for many walkable in-city neighbourhoods has pushed the price of these neighbourhoods beyond normally affordable levels. When people move to the suburbs they are forced to either buy a car or endure inadequate transit service. These lose-lose situations affect not just the poor, but even those at mid-level incomes, such as teachers and firefighters. In order to improve quality of life for all economic sectors of the community, the affordability of in-city housing should be increased, in tandem with improvements in the quality of suburban transit service. As noted above, community gardens and farmers' markets can be a key interim strategy for low-income neighbourhoods that lack access to healthy food in grocery stores or supermarkets.

Altogether, in addition to helping create more active communities, the reforms recommended above can help promote the overall health of communities by making them more environmentally sustainable, economically robust and equitable. More specifically, the benefits include:

- Reducing the costs of providing public services and infrastructure, such as schools, fire stations, water and sewer service, and transportation
- Reducing per capita air pollution and greenhouse gases
- Increasing equity and access to jobs and services for disadvantaged groups, such as the poor, disabled, youth and elderly
- Reducing cost of providing medical assistance to the disabled and elderly
- Lowering per capita energy costs
- Stimulating economic development in cities
- Creating more vibrant, attractive neighbourhoods

## References

- 1 Vanasse et al. 2005
- 2 Katzmarzyk and Mason 2006
- 3 Katzmarzyk and Jenssen (2004)
- 4 Sallis et al. 2004
- 5 Blair et al 1996
- 6 Lopez 2004
- 7 Craig et al. (2002
- 8 Saelens et al. 2003
- 9 Frank et al. 2005
- 10 Frank et al. 2004
- 11 King County ORTP 2005
- 12 Ewing et al. 2003
- 13 Sturm and Cohen 2004
- 14 Ewing and Cervero, 2001; Holtzclaw 1994; Frank et al 2006, King County ORTP, 2005.
- 15 Frank et al. 2003.
- 16 Frank and Pivo 1995.
- 17 Cervero and Kockelman 1997; Frank and Pivo 1995; Handy 1996; Moudon et al 1997
- 18 Lee and Moudon 2004; Moudon and Lee 2003; Hess 2001; Frank et al. 2006, King County ORTP 2005
- 19 King County ORTP, 2005
- 20 Frank 2004
- 21 Frumkin et al. 2004
- 22 Craig et al. 2002,
- 23 Kitamura et al. (1997) Greenwald and Boarnet (2001)
- 24 King County ORTP 2005
- 25 WSDOT, 2005
- 26 Weinstein and Schimek 2005
- 27 Besser and Dannenberg 2005
- 28 WSDOT, 2005
- 29 King County ORTP 2005
- 30 Besser and Dannenberg (2005)
- 31 Powell et al. 2003
- 32 Troped et al. 2001
- 33 Babey et al. 2005
- 34 Frank et al 2007, forthcoming
- 35 Kitamura et al. 1997, Boarnet and Sarmiento 1998, Bagley and Mokhtarian 2002, Giles-Corti and Donovan 2002, Greenwald and Boarnet 2001, Schwanen and Mokhtarian 2005
- 36 Krizek 2003, Handy et al. 2005
- 37 Lawrence Frank et al (forthcoming 2007)
- 38 Rodriguez and Frank 2005
- 39 Levine 1999, Belden Russenello & Stewart 2004, Frank, Chapman, and Levine 2004, Levine and Frank 2006
- 40 Food Bureau, 2001
- 41 Morland, Wing, Diez Roux, 2002
- 42 Travers, 1996
- 43 Travers, 1995
- 44 French, Story & Jeffery, 2001
- 45 French, Story, Neumark-Sztainer et al., 2001
- 46 Refreshments Canada, 2004
- 47 Heyman & Markusoff, 2004
- 48 Story, Neumark-Sztainer & French, 2002
- 49 Raine et al, in progress
- 50 Hoerr & Loudon 1993, Crawford 1977



- 51 French, Jeffery et al 2001, Buscher, Martin et al 2001
- 52 Cain 1987
- 53 Dietz, Bland, Gortmaker, Malloy & Schmid, 2002; Horne, Tapper, Lowe et al., 2004; Kelder, Perry, Lytle & Klepp, 1995; Lytle, 1998
- 54 Whitaker, Wright, Koepsell, Finch & Psaty, 1994
- 55 French, Story, Fulkerson & Hannan, 2004; Fulkerson, French, Story, Nelson & Hannan, 2004
- 56 Walter, Hofman, Vaughan & Wynder, 1988; Walter, 1989
- 57 Lewis, Sloane et al. 2005; Block, Scribner et al. 2004; Sloane, Diamant et al. 2003; Horowitz, Colson et al. 2004; Diez Roux, 2003
- 58 Laraia, Siega-Riz et al. 2004
- 59 Lewis, Sloane, Nascimento et al., 2005; Block, Scribner & Desalvo, 2004
- 60 Lewis, Sloane, Nascimento et al., 2005; Sloane, Diamant, Lewis et al., 2003
- 61 Horowitz, Colson et al. 2004
- 62 Laraia, Siega-Riz, Kaufman & Jones, 2004
- 63 Horowicz, Colson, Hebert & Lancaster, 2004
- 64 Lewis, Sloane et al. 2005
- 65 Turrell 1996
- 66 Cullen, Bishop & deMoor, 2002
- 67 Edmonds, Baranowski, Baranowski et al., 2001
- 68 Edmonds, Baranowski, Baranowski et al., 2001
- 69 Eyler, Haire-Joshu, Brownson & Nanney, 2004
- 70 Hunt, Lefebvre et al. 1990
- 71 Raine et al, in progress
- 72 Osler 1993; Donkin, Johnson et al. 1998; Cade 1992; Evans, Booth et al. 2000; Eyler, Haire-Joshu et al. 2004; Ruxton & Kirk 1996; Ruxton, Osullivan et al. 1996; Vaandrager, Colomer et al. 1992; Macario & Sorensen 1998; Evers & Hooper 1995
- 73 Hackett, Kirby et al. 1997
- 74 Cade, Barker et al. 1988; Evans, Booth et al. 2000; Laroche, Kim et al. 1997
- 75 Osler 1993; Harnack, Sherwood et al. 1999; Drake, Roach et al. 1958; Devine, Wolfe et al. 1999; Hupkens, Knibbe et al. 1998; Vaandrager, Colomer et al. 1992; Bediako, Kwate et al. 2004
- 76 Bediako, Kwate et al. 2004; Campbell & Horton 1991; Drake, Roach et al. 1958; Frenn, Malin et al. 2005; Vaandrager, Colomer et al. 1992
- 77 Horowicz, Colson, Hebert & Lancaster, 2004
- 78 Donkin, Johnson et al 1998; Horowitz, Colson et al 2004
- 79 French, Story, Neumark-Sztainer et al 2001; Horgen & Brownell 2002
- 80 Perlmutter, Canter & Gregoire, 1997
- 81 Chertok et al. 2004
- 82 Brauer 2001
- 83 Friedman et al 2001; Frank and Engelke 2005
- 84 Frank and Engelke 2005
- 85 Frank et al. 2006
- 86 RWDI Air 2005
- 87 BAQS, Dr. Michael Brauer, PI, UBC
- 88 WHO 2004
- 89 Ewing et al. 2003, Lucy et al. 2003, Durning 1996
- 90 Jacobson, 2003; Leden et al., 2000; Leden, 2002
- 91 Booth et al. 2000; King et al. 2000
- 92 Wilcox et al., 2000; King et al., 2000; Ball et al., 2001
- 93 Weinstein et al. 1996; Booth et al. 2000
- 94 Tobey et al., 1983; Knoblauch et al., 1988
- 95 Craig et al. (2002)
- 96 U.K. Department of Transport 1997; Zegeer et al. 2002
- 97 Swift and Associates 1998

98 Dumbaugh 2005, Lee and Mannering 1999, Naderi 2003

99 Geddes et al 1996

100 Frumkin et al, 2004

## Bibliography

- Areskoug H, Camner P, Dahlén S-E, Låstbom L, Nyberg F, Pershagen G, Sydbom A (2000). "Particles in ambient air — a health risk assessment" *Scandinavian Journal of Work, Environment and Health*. 26 suppl 1:1-96
- Babey, Susan H., E. Richard Brown and Theresa A. Hastert. "Access to Safe Parks Helps Increase Physical Activity Among Teenagers." *UCLA Health Policy Research Brief*, December 2005.
- Bagley MN, and Mokhtarian PL (2002). The Impact of Residential Neighborhood Type on Travel Behavior: A Structural Equations Modeling Approach. *Annals of Regional Science*, Vol. 36, No. 2, pp. 279–297.
- Ball K, Bauman A, Leslie E, Owen N. Perceived environmental and social influences on walking for exercise in Australian adults. *Preventive Medicine* 2001;33:434-40.
- Bediako, S. M., Kwate, N. O. A., & Rucker, R. (2004). Dietary behavior among African Americans: Assessing cultural identity and health consciousness. *Ethnicity & Disease*, 14, 527-532.
- Belden Russonello & Stewart (2004). "American Community Survey National Survey on Communities." For Smart Growth America and National Association of Realtors.
- Bell ML, McDermott A, Zeger SL, Samet JM, Dominici F (2004). "Ozone and Short-term Mortality in 95 US Urban Communities, 1987-2000 ." *JAMA*, 292: 2372-2378.
- Bento, Antonio M, Cropper ML, Mobarak AM and Vinha K (2003), The Impact of Urban Spatial Structure on Travel Demand in the United States, World Bank Group Working Paper 2007, World Bank ([http://econ.worldbank.org/files/24989\\_wps3007.pdf](http://econ.worldbank.org/files/24989_wps3007.pdf)).
- Blair SN, Connelly JC (1996). How much physical activity should we do? The case for moderate amounts and intensities of physical activity. *Res Q Exerc Sport*. 67(2): 193-205.
- Block, J. P., Scribner, R. A., & DeSalvo, K. B. (2004). Fast food, race/ethnicity, and income: A geographic analysis. *American Journal of Preventive Medicine*, 27, 211-217.
- Boarnet M and Sarmiento S (1998). Can Land Use Policy Really Affect Travel Behavior? A Study of the Link Between Non-work Travel and Land Use Characteristics. *Urban Studies* Vol. 35 No. 7, pp. 1155-69.
- Boarnet, Marlon and Crane R (2001). "The Influence of Land Use on Travel Behavior: A Specification and Estimation Strategies," *Transportation Research A*, Vol. 35, No. 9 ([www.elsevier.com/locate/tra](http://www.elsevier.com/locate/tra)), November 2001, pp. 823-845.
- Booth MN, Owen A, Bauman A, Clavisi O, Leslie E. Social-cognitive and perceived environmental influences associated with physical activity in older Australians. *Prev Med* 2000;31:15-22. Cervero R and Kockelman K (1997). "Travel demand and the 3Ds: density, diversity, and Design." *Transportation Research Part D* 2(3), 199-219.
- Buscher, L. A., Martin, K. A., & Crocker, S. (2001). Point-of-purchase messages framed in terms of cost, convenience, taste, and energy improve healthful snack selection in a college foodservice setting. *Journal of the American Dietetic Association*, 101, 909-913.
- Cade, J. (1992). Diet of adults living in houses in multiple occupation. *European Journal of Clinical Nutrition*, 46,795-801.
- Cade, J. E., Barker, D. J., Margetts, B. M., & Morris, J. A. (1988). Diet and inequalities in health in three English towns. *British Medical Journal*, 296, 1359-1362.
- Cade J, Lambert H. (1991). Evaluation of the effect of the removal of the family income supplement (FIS) free school meal on the food intake of secondary schoolchildren. *Journal of Public Health Medicine*; 13:295-306.
- Cain, L. B., Newell, G. K., Dayton, A. D., Vaden, A. G., & Greig, S. (1987). Effect of family- versus cafeteria-style service on students' food preferences and nutrient intakes. *School Food Service Research Review*, 11, 40-47.
- Campbell, C. C., & Horton, S. E. (1991). Apparent nutrient intakes of Canadians: Continuing nutritional challenges for public health professionals. *Canadian Journal of Public Health*, 82, 374-380.
- Chertok, Michael, Voukelatos A, Sheppard V and Rissel C (2004). "Comparison of Air Pollution Exposure for Five Commuting Modes in Sydney – Car, Train, Bus, Bicycle and Walking," *Health Promotion Journal of Australia*, Vol. 15, No. 1, pp. 63-67.
- Craig CL, Brownson RC, Cragg SE, Dunn AL. Exploring the effect of the environment on physical activity: A study examining walking to work. *Am J Prev Med* 2002;23(2S):36-43.
- Crawford, L. (1977). Junk food in our schools? A look at student spending in school vending machines and concessions. *Journal of the Canadian Dietetic Association*, 38, 193-197.
- Cullen KW, Bishop RG, de Moor C. (2002). Fat practices and consumption among African-American adolescent Boy Scouts: the impact of meal source. *Ethnicity & Disease*; 12(2):193-8.
- Devine, C. M., Wolfe, W. S., Frongillo, E. A. Jr , & Bisogni, C. A. (1999). Life-course events and experiences: Association with fruit and vegetable consumption in 3 ethnic groups. *Journal of the American Dietetic Association*, 99, 309-314.
- Dietz WH, Bland MG, Gortmaker SL, Molloy M, Schmid TL. (2002). Policy tools for the childhood obesity epidemic. *Journal of Law, Medicine and Ethics*; 30(3 Suppl):83-7.

- Diez Roux, A. V. (2003). Residential environments and cardiovascular risk. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, 80, 569-589.
- Donkin, A. J., Johnson, A. E., Morgan, K., Neale, R. J., Page, R. M., & Silburn, R. L. (1998). Gender and living alone as determinants of fruit and vegetable consumption among the elderly living at home in urban Nottingham. *Appetite*, 30, 39-51.
- Donkin, A. J., Johnson, A. E., Morgan, K., Neale, R. J., Page, R. M., & Silburn, R. L. (1998). Gender and living alone as determinants of fruit and vegetable consumption among the elderly living at home in urban Nottingham. *Appetite*, 30, 39-51.
- Drake, P. E., Roach, F. E., & Mitchell, J. H. Jr. (1958). Use of fruits and vegetables by urban and rural families in South Carolina. (Report No. DNAL 100-So8-1-no.465). Clemson, S.C.: South Carolina Agricultural Experiment Station.
- Dubbert PM, Wilson GT. (1984). Goal-setting and spouse involvement in the treatment of obesity. *Behaviour Research and Therapy*; 22:227-42.
- Dumbaugh, Eric (2005). "Safe Streets, Liveable Streets." *Journal of the American Planning Association*, Vol. 71, No. 3.
- Durning, A.T, 1996, *The Car and the City: 24Steps to Safe Streets and Healthy Communities*, Northwest Environmental Watch, Seattle, WA.
- Edmonds J, Baranowski T, Baranowski J, Cullen KW, Myres D. (2001). Ecological and socioeconomic correlates of fruit, juice, and vegetable consumption among African-American boys. *Preventive Medicine*; 32:476-81.
- Evans, A., Booth, H., & Cashel, K. (2000). Sociodemographic determinants of energy, fat and dietary fibre intake in Australian adults. *Public Health Nutrition*, 3(1), 67-75.
- Evans, A., Booth, H., & Cashel, K. (2000). Sociodemographic determinants of energy, fat and dietary fibre intake in Australian adults. *Public Health Nutrition*, 3(1), 67-75.
- Evers, S. E., & Hooper, M. D. (1995). Dietary intake and anthropometric status of 7 to 9 year old children in economically disadvantaged communities in Ontario. *Journal of the American College of Nutrition*, 14, 595-603.
- Ewing, Reid and Cervero R (2002). "Travel and the Built Environment – A Synthesis," *Transportation Research Record* 1780 (www.trb.org).
- Ewing, R., R. Schieber and C. Zegeer, "Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities," *American Journal of Public Health*, Vol. 93, September 2003, pages 1541-1545.
- Eyler, A. A., Haire-Joshu, D., Brownson, R. C., & Nanney, M. S. (2004). Correlates of fat intake among urban, low income African Americans. *American Journal of Health Behavior*, 28, 410-417.
- Farris RP, Nicklas TA, Webber LS, Berenson GS. (1992). Nutrient contribution of the school lunch program: Implications for healthy people 2000. *Journal of School Health*; 62:180-4.
- Food Bureau. (2001). 1996 Consumer spending - Overview. Retrieved 2003, from [http://www.agr.gc.ca/food/consumer/mrkreports/reports\\_e.html](http://www.agr.gc.ca/food/consumer/mrkreports/reports_e.html)
- Frank LD, Engelke PE, Schmid TL. *Health and Community Design: The Impacts of the Built Environment on Physical Activity*. Washington: Island Press, 2003.
- Frank, L.D., Engelke, P., "The Impacts of the Built Environment on Physical Activity: ACES Working Paper #1." 1999.
- Frank, Lawrence and Engelke, Peter (2005). "Multiple Impacts Of The Built Environment On Public Health: Walkable Places And the Exposure To Air Pollution." *International Regional Science Review*.
- Frank, Lawrence and Pivo, Gary (1995). "Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: SOV, Transit and Walking," *Transportation Research Record* 1466, pp. 44-55.
- Frank, Lawrence, Andresen, Martin and Schmid, Tom (2004). Obesity Relationships With Community Design, Physical Activity, and Time Spent in Cars. *American Journal of Preventive Medicine* Vol 27. No 2. June, 2004, pp. 87-97.
- Frank, Lawrence, Levine, Jonathan, Chapman, James D, McMillan S, Carpenter A (2004). *Transportation and Land Use Preferences and Atlanta's Neighborhood Choices*. Report for Georgia Regional Transportation Authority.
- Frank, Lawrence, Sallis JF, Conway T, Chapman J, Saelens B, Bachman W (2006). "Multiple Pathways from Land Use to Health: Walkability Associations With Active Transportation, Body Mass Index, and Air Quality." *Journal of the American Planning Association* Vol. 72 No. 1.
- French, S. A., Jeffery, R. W., Story, M., Breitlow, K. K., Baxter, J. S., Hannan, P., & Snyder, M. P. (2001). Pricing and promotion effects on low-fat vending snack purchases: The CHIPS Study. *American Journal of Public Health*, 91, 112-117.
- French SA, Story M, Jeffery RW. (2001). Environmental influences on eating and physical activity. *Annual Review of Public Health*; 22:309-35.
- French SA, Story M, Neumark-Sztainer D, Fulkerson JA, Hannan P. (2001). Fast food restaurant use among adolescents: Associations with nutrient intake, food choices and behavioral and psychosocial variables. *International Journal of Obesity & Related Metabolic Disorders*; 25(12):1823-33.

- French SA, Story M, Fulkerson JA, Hannan P. (2004). An environmental intervention to promote lower-fat food choices in secondary schools: Outcomes of the TACOS Study. *American Journal of Public Health*; 94:1507-12.
- Frenn, M., Malin, S., Villarruel, A. M., Slaikeu, K., Mccarthy, S., Freeman, J., & Nee, E. (2005). Determinants of physical activity and low-fat diet among low income African American and Hispanic middle school students. *Public Health Nursing*, 22, 89-97.
- Friedman M, Powell K, Hutwagner L, Graham L and Teague W (1998). "Impact of changes in transportation and commuting behaviors during the 1996 Summer Olympic Games in Atlanta on air quality and childhood asthma." *Journal of the American Medical Association* 285(7): 897-905.
- Frumkin H, Frank L and Jackson R (2004). *The Public Health Impacts of Sprawl*. Washington, DC: Island Press.
- Fulkerson JA, French SA, Story M, Nelson H, Hannan PJ. (2004) Promotions to increase lower-fat food choices among students in secondary schools: description and outcomes of TACOS (Trying Alternative Cafeteria Options in Schools). *Public Health Nutrition*; 7:665-74.
- Gauderman W J, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, Margolis H, Bates D, Peters J (2004). "The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age." *New England Journal of Medicine*, 351, 1057-1067, Sep 9, 2004.
- Geddes, E. et al., *Safety Benefits of Traffic Calming*, Insurance Corporation of British Columbia, Vancouver, British Columbia, 1996.
- Giles-Corti B and Donovan RJ (2002). The Relative Influence of Individual, Social, and Environmental Determinants of Physical Activity. *Social Science and Medicine*, Vol. 54, pp. 1793–1812.
- Greenwald M and Boarnet M (2001). "Built Environment as Determinant of Walking Behavior: Analyzing Nonwork Pedestrian Travel in Portland, Oregon." In *Transportation Research Record* 1780. TRB, National Research Council, Washington D.C., pp. 33-41
- Hackett, A. F., Kirby, S., & Howie, M. (1997). A national survey of the diet of children aged 13-14 years living in urban areas of the United Kingdom. *Journal of Human Nutrition & Dietetics*, 10(1), 37-51.
- Handy SL (1996). "Understanding the link between urban form and nonwork travel behavior." *Journal of Planning Education and Research* 15, 183-98.
- Handy, Susan, Cao X, and Mokhtarian P (2005). "Correlation or causality between the built environment and travel behavior? Evidence from Northern California." *Transportation Research Part D* 10, 427–444.
- Harnack, L., Sherwood, N., & Story, M. (1999). Diet and physical activity patterns of urban American Indian women. *American Journal of Health Promotion*, 13, 233-236.
- Hess, Paul M (2001). *Pedestrians, networks, and neighborhoods : a study of walking and mixed-use, medium-density development patterns in the Puget Sound region*, PhD dissertation, University of Washington.
- David Heyman and Jason Markusoff (2004). Coke, Pepsi pulling pop out of Canada's schools. *Edmonton Journal*. 6 January 2004: A.1.
- Hoek G, Brunekreef B, Goldbohm S, Fischer P and van den Brandt P (2002). "Association between mortality and indicators of traffic-related air pollution in the Netherlands: A cohort study." *Lancet* 360: 1203-9.
- Hoerr, S. M., & Loudon, V. A. (1993). Can nutrition information increase sales of healthful vended snacks? *Journal of School Health*, 63, 386-390.
- Hoerr, S. M., & Loudon, V. A. (1993). Can nutrition information increase sales of healthful vended snacks? *Journal of School Health*, 63, 386-390.
- Holtzclaw, John (1994), *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*. National Resources Defense Council.
- Horgen, K. B., & Brownell, K. D. (2002). Comparison of price change and health message interventions in promoting healthy food choices. *Health Psychology*, 21, 505-512.
- Horne PJ, Tapper K, Lowe CF, Hardman CA, Jackson MC, Woolner J. (2004). Increasing children's fruit and vegetable consumption: A peer-modelling and rewards-based intervention. *European Journal of Clinical Nutrition*; 58:1649-60.
- Horowitz, C. R., Colson, K. A., Hebert, P. L., & Lancaster, K. (2004). Barriers to buying healthy foods for people with diabetes: Evidence of environmental disparities. *American Journal of Public Health*, 94, 1549-1554.
- Horowitz, C. R., Colson, K. A., Hebert, P. L., & Lancaster, K. (2004). Barriers to buying healthy foods for people with diabetes: Evidence of environmental disparities. *American Journal of Public Health*, 94, 1549-1554.
- Hunt, M. K., Lefebvre, R. C., Hixson, M. L., Banspach, S. W., Assaf, A. R., & Carleton, R. A. (1990). Pawtucket Heart Health Program point-of-purchase nutrition education program in supermarkets. *American Journal of Public Health*, 80, 730-732.
- Hupkens, C. L., Knibbe, R. A., Van Otterloo, A. H., & Drop, M. J. (1998). Class differences in the food rules mothers impose on their children: A cross-national study. *Social Science & Medicine*, 47, 1331-1339.

- Jacobsen, PL (2003). "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling". *Injury Prevention*, Vol. 9 No. 3
- Katzmarzyk PT, Janssen I (2004). The economic costs associated with physical inactivity and obesity in Canada: An update." *Canadian Journal of Applied Physiology* 29: 90–115.
- Katzmarzyk, Peter T. and Mason C (2006). "Prevalence of class I, II and III obesity in Canada." *Canadian Medical Association Journal* January 17 174(2) | 156-157.
- Kelder SH, Perry CL, Lytle LA, Klepp KI. (1995). Community-wide youth nutrition education: Long-term outcomes of the Minnesota Heart Health Program. *Health Education Research*; 10:119-31.
- King AC, Castro C, Wilcox S, Eyler AA, Sallis JF, Brownson RC. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of US middle-aged and older aged adults. *Health Psychol* 2000;19:354-64. Kitamura R, Mokhtarian PL, and Laidet, L (1997). "A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area." *Transportation*, Vol. 24, No. 2, pp. 125–158.
- King County Office of Regional Transportation Planning (2005). *A Study of Land Use, Transportation, Air Quality and Health in King County, WA*. Prepared by Lawrence Frank and Company, Inc., Dr. James Sallis, Dr. Brian Saelens, McCann Consulting, GeoStats LLC, and Kevin Washbrook.
- Knoblauch, R.L. et al., Investigation of Exposure Based Pedestrian Accident Areas: Crosswalks, Sidewalks, Local Streets and Major Arterials, Federal Highway Administration, Washington, D.C., 1988, pages 126-133.
- Krizek, KJ (2003). "Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter?" *Journal of the American Planning Association*, Vol. 69, No. 3, pp. 265–279.
- Kubik MY, Lytle LA, Hannan PJ, Perry CL, Story M. (2003). The association of the school food environment with dietary behaviors of young adolescents. *American Journal of Public Health*; 93:1168-73.
- Kuzmyak, Richard J and Pratt, Richard H (2003), *Land Use and Site Design: Traveler Response to Transport System Changes*. Chapter 15, Transit Cooperative Research Program Report 95, Transportation Research Board ([www.trb.org](http://www.trb.org)).
- Laraia, B. A., Siega-Riz, A. M., Kaufman, J. S., & Jones, S. J. (2004). Proximity of supermarkets is positively associated with diet quality index for pregnancy. *Preventive Medicine*, 39, 869-875.
- Laroche, M., Kim, C., Hui, M. K., & Tomiuk, M. A. (1997). A multidimensional perspective on acculturation and its relative impact on consumption of convenience foods. *Journal of International Consumer Marketing*, 10(1-2), 33-56.
- Leden, L., 2002, "Pedestrian Risk Decrease with Pedestrian Flow. A Case Study Based on Data from Signalised Intersections in Hamilton, Ontario." *Accident Analysis and Preventio*. Volume 34, pages 457–64.
- Leden, L, Gärdner, P, Pulkkinen, U, 2000, "An Expert Judgment Mode Applied to Estimating the Safety Effect of a Bicycle Facility," *Accident Analysis and Prevention*. Volume 32, pages 589–99.
- Lee, J. and F. Mannering, Analysis of Roadside Accident Frequency and Severity and Roadside Safety Management. Washington State Department of Transportation. December, 1999.
- Lee C and Moudon AV (2004). "Physical activity and environment research in the health field: Implications for urban and transportation planning practice and research." *Journal of Planning Literature*, 19(2), 147-181.
- Legislative Assembly of British Columbia (2006). "A Strategy for Combatting Childhood Obesity and Physical Inactivity in British Columbia." British Columbia Legislative Assembly, Select Standing Committee on Health.
- Levine, Jonathan (1999). "Access to choice." *Access s(magazine of the University of California Transportation Center)* 14:16–19.
- Levine, Jonathan and Frank, LD (under review). "Transportation and Land-Use Preferences and Residents' Neighborhood Choices: The Sufficiency of "Smart Growth" in the Atlanta Region." *Growth and Change*.
- Levine, Jonathan. "Zoned Out: Regulation, Markets, and Choices in Transportation and Metropolitan Land Use." Baltimore, MD: The Johns Hopkins University Press, 2005.
- Lewis, L. B., Sloane, D. C., Nascimento, L. M., Diamant, A. L., Guinyard, J. J., Yancey, A. K., Flynn, G., & REACH Coalition of the African Americans' access to healthy food options in south Los Angeles restaurants. *American Journal of Public Health*, 95, 668-673. African Americans Building a Legacy of Health Project. (2005). African
- Lopez, Russ (2004). "Urban Sprawl and Risk for Being Overweight or Obese." *American Journal of Public Health*, Volume 94 Issue 9, pp. 1574-1579.
- Lucy, William H (2003). "Mortality Risk Associated With Leaving Home: Recognizing the Relevance of the Built Environment" *American Journal of Public Health*; v.93,n.9; pp.1564-1569.
- Lytle LA. (1998). Lessons from the child and adolescent trial for cardiovascular health (CATCH): Interventions with children. *Current Opinion in Lipidology*; 9:29-33.
- Macario, E., & Sorensen, G. (1998). Spousal similarities in fruit and vegetable consumption. *American Journal of Health Promotion*, 12, 369-377.

- Morland K, Wing S, Diez Roux A. (2002). The contextual effect of the local food environment on residents' diets: The atherosclerosis risk in communities study. *Am J Public Health*; 92(11):1761-7.
- Moudon AV and Lee C (2003). Walking and biking: An evaluation of environmental audit instruments. *American Journal of Health Promotion*, 18(1), 21-37
- Moudon, AV, Hess PM, Stanilov K and Snyder, MC (1997). Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments. In *Transportation Research Record 1578*, TRB, National Research Council, Washington, D.C., pp. 48–55.
- Naderi, J.R. Landscape Design in Clear Zone: Effect of Landscape Variables on Pedestrian Health and Driver Safety. *Transportation Research* 1851, 2003, pages 119-130.
- Osler, M. (1993). Social class and health behaviour in Danish adults: A longitudinal study. *Public Health*, 107, 251-260.
- Perlmutter CA, Canter DD, Gregoire MB. (1997). Profitability and acceptability of fat- and sodium-modified hot entrees in a worksite cafeteria. *Journal of the American Dietetic Association*; 97:391-5.
- Peter Swift, Residential Street Typology and Injury Accident Frequency, Swift and Associates, 1998.
- Pope C (2000). Epidemiology of fine particulate air pollution and human health: Biologic mechanisms and who's at risk. *Environmental Health Perspectives* 108 (suppl. 4): 713-23.
- Powell KE, Martin LM, Chowdhury PP. Places to walk: Convenience and regular physical activity. *Am J Public Health* 2003;93(9):1519-21.
- Raines et al. (2006, in progress).
- Refreshments Canada. (2004). Canadian beverage manufacturers will offer only non-carbonated beverages for sale in vending machines in elementary schools. Retrieved 2004, from [http://refcan.collideoscope.ca/en/press/pr\\_template1.asp?ID=402](http://refcan.collideoscope.ca/en/press/pr_template1.asp?ID=402)
- Rodriguez D and Frank LD (2005). "The Built Environment Indices and Creation of the Environmental Index." Presentation at the Active Living Research Conference, February 24-26, 2005, Coronado, California.
- Ruxton, C. H. S., & Kirk, T. R. (1996). Relationships between social class, nutrient intake and dietary patterns in Edinburgh schoolchildren. *International Journal of Food Sciences and Nutrition*, 47, 341-349.
- Ruxton, C. H. S., Osullivan, K. R., Kirk, T. R., & Belton, N. R. (1996). The contribution of breakfast to the diets of a sample of 136 primary-schoolchildren in Edinburgh. *British Journal of Nutrition*, 75, 419-431.
- RWDI Air, Inc. for BC Lung Association (2005). "Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed - Final Report."
- Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health*. 2003;93(9):1552-8
- Sahota, P., Rudolf, M. C., Dixey, R., Hill, A. J., Barth, J. H., & Cade, J. (2001). Randomised controlled trial of primary school based intervention to reduce risk factors for obesity. *British Medical Journal*, 323, 1029-1032.
- Sallis, J.F. et al. "Active Transportation and Physical Activity: Opportunities for Collaboration on Transportation and Public Health Research", *Transportation Research Part A* 38, 2004.
- Schilling, Joseph and Linton LS (2005). "The Public Health Roots of Zoning: In Search of Active Living's Legal Genealogy." *American Journal of Preventive Medicine* v.28, n.2, Supplement 2; pp.96-104.
- Schwanen T and Mokhtarian PL (2005). "What affects commute mode choice: neighborhood physical structure or preferences toward neighborhoods?" *Journal of Transport Geography* 13, 83-99.
- Sloane, D. C., Diamant, A. L., Lewis, L. B., Yancey, A. K., Flynn, G., Nascimento, L. M., McCarthy, W. J., Guinyard, J. J., & Cousineau, M. R. (2003). Improving the nutritional resource environment for healthy living through community-based participatory research. *Journal of General Internal Medicine*, 18, 568-575.
- Story M, Neumark-Sztainer D, French S. (2002). Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association*; 102(3 (Pippah Supplement)):40-51.
- Swift, Peter. Residential Street Typology and Injury Accident Frequency. Unpublished report by Swift and Associates, 1998.
- Tobey, H.N., Shunamen, E.M., and Knoblauch, R.L., Pedestrian Trip Making Characteristics and Exposure Measures, Federal Highway Administration, Washington, D.C., 1983, pages 74-75.
- Travers KD. (1996). The social organization of nutritional inequities. *Soc Sci Med* 43(4):543-53.
- Travers KD. (1995). Using qualitative research to understand the socio-cultural origins of diabetes among Cape Breton Mi'kmaq. *Chronic Diseases in Canada*; 16(4):140-3.
- TRB/IOM Committee on Physical Activity, Health, Transportation, and Land Use, Does the Built Environment Influence Physical Activity? Examining the Evidence. TRB Special Report 282, Transportation Research Board/Institute of Medicine 2005.
- Troped PJ, Saunders RP, Pate RR, Reininger B, Ureda JR, Thompson SJ. Associations between self-reported and objective physical environmental factors and use of a community rail-trail. *Prev Med* 2001;32:191-200.

Turrell, G. (1996). Structural, material and economic influences on the food-purchasing choices of socioeconomic groups. *Australian and New Zealand Journal of Public Health*, 20, 611-617.

U.K. Department of Transport, *Killing Speed and Saving Lives*, London, 1997.

USEPA (2001), *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation and Environmental Quality*, US Environmental Protection Agency.

Vaandrager, H. W., Colomer, C., & Ashton, J. (1992). Inequalities in nutritional choice: A baseline study from Valencia. *Health Promotion International*, 7(2), 109-118.

Vaandrager, H. W., Colomer, C., & Ashton, J. (1992). Inequalities in nutritional choice: A baseline study from Valencia. *Health Promotion International*, 7(2), 109-118.

Vanasse, Demers M, Hemiami A and Courteau J(2005). "Obesity in Canada: where and how many?" *International Journal of Obesity*: 1–7

Walter HJ. (1989). Primary prevention of chronic disease among children: the school-based "Know Your Body" intervention trials. *Health Education Quarterly*; 16(2):201-14.

Walter HJ, Hofman A, Vaughan RD, Wynder EL. (1988). Modification of risk factors for coronary heart disease. Five-year results of a school-based intervention trial. *New England Journal of Medicine*; 318(17):1093-100.

Washington State Department of Transportation (2005). *Travel Behavior, Emissions, & Land Use Correlation Analysis in the Central Puget Sound*. Prepared by Lawrence Frank and Company, Inc., Mark Bradley, and Keith Lawton Associates. Report no. WA-RD 625.1.

Weinstein A, Feigley P, Pullen P, Mann L, Redman L. Neighborhood safety and the prevalence of physical inactivity -- Selected states, 1996. *MMWR* 1999;48(07):143-46.

Whitaker RC, Wright JA, Koepsell TD, Finch AJ, Psaty BM.(1994). Randomized intervention to increase children's selection of low-fat foods in school lunches. *Journal of Pediatrics*; 125(4 ):535-40.

Wilcox S, Castro C, King AC, Housemann R, Brownson RC. Determinants of leisure time physical activity in rural compared with urban older and ethnically diverse women in the United States. *J Epidemiol Community Health* 2000;54:667-72.

World Health Organization. WHO Technical Report Series No 894. *Obesity: Preventing and managing the global epidemic*. Geneva: Author, 2000.

WHO, *World Report on Road Traffic Injury Prevention: Special Report for World Health Day on Road Safety*, World Health Organization, April 2004.

Zegeer, C.V., J.R. Stewert, H.H. Huang, and P.A. Lagerwey, *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines*, Report No. FHWA-RD-01-075, Federal Highway Administration, Washington, D.C., 2002.