The Impact of the Built Environment on the Health of the Population: A Review of the Review Literature

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1. INTRODUCTION

The built environment and health - An historical perspective
Between 1831 and 1854, a series of outbreaks of cholera in several major industrialized cities of Great Britain had killed tens of thousands of people. In 1853, in the city of London itself, more than 10,000 had died of the disease. But in September of that year, after what was to be a particularly lethal outbreak in the London neighbourhood of Soho, the deaths suddenly stopped. The halt of the outbreak was due to the action of Dr. John Snow, a local physician who had theorized that cholera was spread from person to person through contaminated water. Using what were to become the foundations for public health epidemiological methods, Snow conducted investigations to pinpoint the source of the outbreak to a contaminated water pump located on Broad Street in Soho. Once the location was identified, Snow convinced the authorities to remove the handle of the pump. It was then, after access to the pump was shut off, that the outbreak subsided.(1)

This event, known as the Broad Street Pump Outbreak, was a pivotal moment in history; not solely due to the scale of the extended cholera outbreak in London, but due to the recognition of the event as the advent of the modern practice of public health. That breakthrough moment illuminated the potential benefits of epidemiology as a modern tool of disease investigation. But it also highlighted the need for better protection of the public's health from infectious diseases and other risks and illnesses directly related to characteristics of, and factors influenced by, the physical environment in which the population lived. In this case it was the contamination of a major water source in an over-crowded, heavily populated area of London during the Industrial Revolution. But examples like this could commonly be found throughout the increasingly industrialized world.

The relationship between public health and the physical environment has existed for centuries. However, it wasn't until the Industrial Revolution of the early 19th century, when industrial growth in Europe and North America spawned an influx of rural residents into large urban areas where jobs and industry were flourishing, that its impacts became apparent. At that time, cities were unplanned. Most services were provided privately and land use decisions were dictated primarily by market forces. The result was the growth of large, disjointed urban areas where a majority of the population lived in crowded, unsafe and filthy conditions. In many areas sanitation systems and clean water supplies were non-existent. Smoke and odours from rubbish and manufacturing plants polluted the air. Little thought was given to health and safety features in the design and building of tightly packed dwellings. Large, polluting industrial sites were located in the same areas that people lived. Infectious diseases ran rampant. Quite simply, life in the 19th century urban centres of North America and Europe was dangerous to one's health.(2;3)

Move ahead to November 1st, 2007. The front page headline of the Toronto Star newspaper reads: "Diabetes Lurks in Urban Sprawl". The article accompanying this

headline features the results of a Toronto study that documents a series of associations between where people live and their risk of developing diabetes. Essentially, the research found that certain characteristics of the urban built environment (i.e. access to public transportation and grocery stores, presence of bicycle lanes) help to determine the lifestyle choices of residents (i.e. level of physical activity, food choices) that in turn impact on the high rate of diabetes in certain neighbourhoods in that city.(4)

Almost a quarter of a million adults in Toronto are diabetic. Of the city's 140 neighbourhoods, the highest rates of diabetes were found in its 13 poorest and most sprawled neighbourhoods. Interestingly, the researchers found that these neighbourhoods were low income, were under-serviced for health services, had high immigrant populations, had poor access to public transit, had less proximity to food outlets selling fresh fruits and vegetables; and had lower rates of resident walking and cycling trips per day.(5) These factors contribute to lower levels of physical activity and poorer nutritional habits among residents, which influence the higher rates of diabetes. The researchers noted that: "…many factors which influence health are not within our control; however, we are convinced that certain features of urban and suburban environments could be altered for the long-term health benefits of local residents."(p.ix)(5)

Over the past 150 years, clear connections have emerged between our health and the environment in which we live. But it has not been until the last several decades that research has been able to provide evidence of these connections. The evolution of the profession of public health in North America has in large part been all about the associations between health and the built and physical environment. Although many of the issues have remained constant since the 1800's, what is different is the nature of the ailments and health conditions. From an emphasis on infectious and communicable diseases in the early 19th century, the focus of health impacts associated with the built environment in the 21st century is on chronic disease. Cancer, diabetes, respiratory problems, obesity, cardiovascular disease - all of these highly prevalent diseases are linked, in part, to the environment in which we live.

In 2001, Dr. Richard Jackson, director of the Centers for Disease Control's National Center for Environmental Health, wrote: "(T)he built environment influences public health as much as vaccines or water quality."(p.15)(6) Over the years, enough evidence has been collected to support this statement to the extent that Frank and Engelke have concluded: "The ways in which cities are designed and constructed have public health consequences."(p.193)(7)

The links between the built environment, the way in which land use is planned and health are broad and varied and are related to environmental, behavioural, physical, economic and social factors within the environment that we live. The impacts of these factors include such negative health outcomes as asthma, respiratory problems, obesity, heart disease and stroke, some cancers, injuries, stress and social isolation. For instance, respiratory problems have been linked to living near high traffic areas

where air pollution is very concentrated. A rise in obesity has been linked in part to a lack of physical activity in sprawled communities where people drive rather than walk or bike. And an increase in aggressive driving and incidents of road rage is connected to driver stress induced by long commutes in heavy traffic that is the result of urban sprawl and low density developments.

Canada is not immune to these problems. Chronic disease and injuries are on the rise. A burgeoning rate of obesity is now labelled as an epidemic. Health care costs and hospital waiting times have ballooned. Concurrently, our cities are getting bigger and our population is growing. Roads are busier and traffic problems are worse. The way we conduct business is heavily dependent on the electronic flow of information. Changes in our economy have shifted the types of jobs that people seek. These factors and many others have resulted in changes to our lifestyles that today are generally more sedentary, and in some cases riskier, than they were several decades ago.

The Simcoe and Muskoka regions of Ontario are experiencing high growth rates. In addition the rates of hospitalizations for chronic disease and injury are higher than the rates for Ontario. With new research linking health and the built environment being released on a regular basis, it is clear that these issues need to be carefully examined in our region of the province.

Health and the built environment in Simcoe and Muskoka

Lying in the heart of “cottage country”, the Simcoe Muskoka District Health Unit encompasses a geographic area of 8,731 square kilometres. In 2006, the total population for Simcoe and Muskoka was 479,767; the majority of which (422,204) lived in Simcoe County, while the remaining (57,563) resided in Muskoka. By 2025, the population growth in these two regions is expected to rise by 40 per cent, to just under 700,000 people(8) with the bulk of the growth expected in Simcoe County.

Along with an increasing population comes a myriad of other growth issues, such as the creation of gainful employment opportunities, the need for social, health and other services, infrastructure enhancement, and transportation and land use planning that considers all aspects and types of development: residential, commercial, industrial, as well as planning for other types of land uses, including agriculture, recreation and open greenspace.

All of these issues impact on land use decisions for the region. The larger urban areas, which include Barrie and Orillia, are facing pressures to develop residential land for the influx of people into the area. According to City of Barrie estimates, there is a 3-5 year supply of dwelling units remaining in the city. Based on growth figures over the last three years, it is estimated that the city’s supply of land will be depleted within 4.75 years.(9)

A 2004 report prepared for Simcoe County identified that enough land has been set aside for long term growth in the County for the next 20 years (excluding the City of

Barrie).(10) Recently, Simcoe County and the cities of Barrie and Orillia were identified in Ontario's *Places to Grow* plan as one of several areas surrounding Toronto (an area known as the Greater Golden Horseshoe or GGH) that requires controlled and planned growth. According to *Places to Grow,* "…without properly managing growth, the negative aspects of rapid growth, such as, increased traffic congestion, risk of deteriorating air and water quality, and the consumption of agricultural lands and natural resources, will continue to be experienced (in these areas)."(p.4)(11)

It has also been identified that without proper infrastructure and transportation planning, development pressures will create a "leap-frog" effect around the provincially designated greenbelt area that runs through the GGH.(12) The implications of leap-frogging (which is when developers bypass vacant parcels of land located close to cities to buy less expensive land further away) include high costs for infrastructure such as roadways and sewers to service these areas, and isolated pockets of low density development that create automobile dependence.

Presently, Simcoe County is involved in a process to identify planning issues and to develop a comprehensive, integrated and collaborative approach to planning for the area up to the year 2031.(13) The process is being led by the County's Growth Process Steering Committee, which is working jointly with the provincial government and all Simcoe County municipalities (the City of Orillia and the City of Barrie are involved as observers to the process) to establish a future growth plan.

The District of Muskoka is also experiencing its share of growth and development, although it is not included in the *Places to Grow Act*. A projected population growth from just over 57,000 in 2006 to 75,040 residents by 2016 is expected to result in an increase of 12,000 permanent dwelling units in the district. Growth planning for the District of Muskoka, as outlined in its Official Plan, states that all growth must be managed and planned in a way that both supports settlement areas and protects the natural environment. Further, it states that urban centres will be the development focus "…as they can accommodate the mixed-use development necessary to provide the employment needed to support the projected population for Muskoka."(p.D1)(14)

Along with residential development, Simcoe and Muskoka are also faced with increased industrial and commercial development that must accommodate for a mix of employment and solidify a strong tax base. This growth creates pressure on the preservation of agricultural land, greenspace, wetlands, water systems and other natural features.(10) Development also needs to be weighed against the negative impacts created by growth, such as commuting, traffic, air pollution and sprawl.(11) Added to this are the needs and status of the population in relation to housing, education, income, health, social supports, transportation and leisure.

As the regions of Simcoe and Muskoka deal with their growth issues, planning decisions must be made that consider not just development to accommodate people, business, services and industry, but must also consider how communities are designed, how

buildings are built and how these decisions impact on the environment and the health and needs of the people who live and visit here.

The remainder of this literature review will examine the connections between land use planning, the built environment and health, and will present the evidence that supports these relationships.

1.1 Purpose

The purpose of this literature review is to provide the Simcoe Muskoka District Health Unit (SMDHU) with an overview of the evidence of the impacts of land use planning and the way in which the built environment is designed on the health of the population.

The vision of the SMDHU is that the residents of Simcoe and Muskoka lead healthy, fulfilling and productive lives. The health unit's mission, through its commitment to excellence in protecting and promoting health and preventing diseases and injury, is to work with individuals, families, communities and agencies to achieve optimal health. To help achieve its vision and mission, the SMDHU believes there is a need for stronger public health involvement in land use planning decisions as one way to effectively address social and environmental determinants of health and improve the health of our population. This belief is also reflected in the health unit's Strategic Plan 2007-2010. In this plan, the built environment is identified as an issue of emerging public health importance in which the health unit should have a role. In order to determine that role and to develop an evidence-based plan to work strategically in this area and to influence the environments that affect the health of the population, the health unit needs to better understand the evidence between land use planning and its impacts on the health of the population.

This literature review is one of three components of a *Building Healthy Communities (BHC) Study*. The two other components, a survey (key informant interviews) of the roles and practices of Ontario health units, community agencies and environmental organizations related to land use planning, and an internal survey of SMDHU management, are expected to be completed by the end of 2007. The learnings from the *BHC Study* will help the SMDHU to:

- inform its role in land use planning in Simcoe Muskoka;
- guide and define the development of an agency strategy for involvement in land use planning processes;
- define next steps to nurture existing and build new relationships and partnerships with key individuals, municipalities, professional organizations and other community stakeholders.

It is anticipated that the outcomes of these actions will have a positive impact on the built, natural, and social environments that affect the health of the population in Simcoe and Muskoka.

1.2 Methods

Information gathered for this study was limited to reviews and summaries of evidence that describe the impact of land use planning on the health of the population. These included:

- text books written by key authorities or experts;
- literature reviews or systematic reviews;
- grey literature that provided overviews of evidence (reports, government publications, technical documents, websites, agency/organizational reports, and on-line registries of effective evidence).

In some instances, specific scholarly articles were reviewed in order to provide a more in-depth analysis of a particular aspect of this topic area.

The search for literature was conducted with terms that were identified as being relevant to the topic of interest and by searching:

- relevant organization websites (i.e. government – including other health units websites - NGOs, PHAC, PHRED, etc.):
- website search engines (i.e. Google): and
- relevant literature databases (i.e. CINHAL, Ovid Medline).

This search also included materials identified by key contacts of other Ontario health units, such as unpublished literature, studies, reports and presentations that were deemed to be relevant. This information was helpful in providing localized data for different parts of the province, as well as some insight into the roles and practices of other Ontario health units in their work in this topic area.

Other primary literature was reviewed for an earlier iteration of this initiative. We would like to acknowledge and thank all those SMDHU staff who reviewed relevant studies and journal articles related to this project.

1.3 Definition of Terms

The focus of this literature review is on the evidence connecting land use planning and the built environment and their impacts on the health of the population. Due to the broad scope of this topic, it is essential to provide definitions of some of the key terms that are found in the literature and are used within the associated professions.

Active transport

Active transport comprises non-motorized, human powered modes of transportation, such as walking or cycling to work, to school or to carry out errands. Sufficient opportunities for public transport increase people's likelihood of walking and cycling in combination with using public transport.(15)

Body Mass Index (BMI) - Adults

For adults, body mass index (BMI) is a measure of an individual's weight in relation to his or her height. BMI is highly correlated with body fat and is widely used to indicate health risks (Health Canada as cited in Tjepkema, 2006). Overweight and obesity are based on body mass index. According to Canadian guidelines, which are in line with those of the World Health Organization, BMI for adults is classified into six categories, each representing a different level of health risk (Table 1).(16)

BMI is calculated as follows: BMI = weight (kg) / height (metres) ^{2}

Table 1 Body Mass Index Categories and Associated Health Risks – Adults

Body Mass Index (BMI)		
Category	**Range**	**Level of Health Risk**
Underweight	< 18.5	Increased
Normal weight	18.5 to 24.9	Least
Overweight	25.0 to 29.9	Increased
Obese Class I	30.0 to 34.9	High
Obese Class II	35.0 to 39.9	Very high
Obese Class III	> 40.0	Extremely high

Source: Tjepkema, M. Adult Obesity, 2006.

Body Mass Index (BMI) – Children and Adolescents

The definition and calculation for the BMI of children and adolescents are the same as adults. BMI is a measure of an individual's weight in relation to his or her height and is calculated by dividing the weight in kilograms by the square of the height in metres. However, the determination of the categories of overweight and obese is different for children and adolescents as it is not clear which BMI levels are associated with health risks at younger ages (Cole et al, as cited in Shields, 2006).

Two methods have been used to determine overweight and obese cut-points for children and adolescents. The first method used American growth curves and classified BMI values for age and sex specific categories. A BMI over the 85th percentile is categorized as overweight and a value over the 95th percentile is categorized as obese.(17) The second method, established by the International Obesity Task Force (IOTF), extrapolated the adult cut-points to create gender and age-specific values.(17) Values for these categories are lower for children and adolescents than the value of 25 and 30 for adults (World Health Organization and Health Canada, as cited in Shields, 2006) and rise incrementally with every year of age.(17) While the two methods generally produce similar results, the IOTF reference values tend to give lower estimates for young children and higher estimates for older children (Lobstein et al and Flegal et al, as cited in Shields, 2006).

Built environment

The built environment is defined by Health Canada as:

> *"…part of the overall ecosystem of our earth. It encompasses all buildings,*

spaces and products that are created, or at least significantly modified by people. It includes our homes, schools and workplaces, parks, business areas and roads. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains and across the country in the form of highways.

The built environment contains 'the basic services that are needed to keep a society running', otherwise known as infrastructure. Infrastructure is seen as essential to health and includes services delivered physically (roads, communications, provision of drinking water mains, sewage systems and so on), and utilities such as electricity and gas. Furthermore, the built environment can include broad features of urban layout, such as cityscapes (building heights, shapes and overall density) and streetscapes (width, tree cover, housing density, and the diversity of building uses). Provision of transport facilities for road, rail, tram, bicycle, pedestrian, air and sea traffic forms a key component of infrastructure." (Health Canada website, 1997, as cited in Victoria State Government Department of Human Services, 2001)(p.26)

Features of the built environment are numerous and include:

- land use - presence/type of building placed on land, designated use, density
- streets - design, grid, traffic calming features, crosswalks
- sidewalks - locations, width, connectivity
- bicycle/walking paths - location
- greenspace - gardens, recreation areas, playgrounds
- public spaces - gathering spots, meeting places
- amenities - street furniture, outdoor dining areas, public restrooms
- landscaping - trees, vegetation, lighting
- buildings - architecture, height, number, appearance
- safety - lighting, commercial establishments(18)

Land developments and transportation investments interact with each other and collectively have a tremendous influence in shaping the built environment. The location of transportation investments impacts where growth occurs. The type of transportation investment made, whether it is highways, public transit, sidewalks or bike ways, impacts the form of the growth that follows. Equally, the location of new land development impacts where the transportation investments are made. The nature of that land development, whether it is transit- and pedestrian-friendly versus auto-oriented, determines the feasibility of transportation scenarios. In order for alternative transportation to be possible, it needs to be supported by both land use and transportation infrastructure decisions.

Density

Within the context of land use planning, density is a measure of population, services or jobs per unit area. Although there are different approaches to measuring density and different purposes for measuring it, it is generally expressed as a ratio where the

numerator is a measure of population or built form (e.g. number of rooms, floor area, total population) and the denominator is a measure of land area (e.g. total land area or "gross density", usable land area or "net density").(19)

Different density calculations are useful for a variety of purposes. For example, Hess et al (2007) explain that calculating the ratio of floor space to land area can be useful for determining the intensity of a development over a parcel of land. Municipalities would find this calculation helpful when creating official plans. "Gross densities, on the other hand, give a bigger picture of land use as they express the amount of space a population consumes for all residential and non-residential uses." (Hitchcock, 1994, as cited in Hess et al, 2007, p.7)(19)

The calculation of density is complex as there is no standardized method of measuring it and measurement units are not always consistent. There are also limitations to that data used in measuring density that affect the calculations.(19)

In Ontario, the minimum gross density targets (residents and jobs) set for 2031 for the **urban centres** of the Greater Golden Horseshoe (GGH) area, as identified in the *Places to Grow Plan,* include:

- 400 residents and jobs (combined) per hectare in urban Toronto;
- 200 residents and jobs/hectare for downtown Brampton, Burlington, Cambridge, Hamilton, Milton, Markham, Mississauga, Newmarket, Oakville, Oshawa, Pickering, Richmond Hill/Langstaff, Vaughan, Kitchener and Waterloo;
- 150 residents and jobs/hectare for downtown Barrie, Brantford, Guelph, Peterborough and St. Catharines.(11)

In comparison, actual gross population plus employment density figures for some of these GGH designated areas are: Hamilton, 249 (population plus jobs/hectare); Kitchener, 148; Guelph, 121; Oshawa, 105; Waterloo, 92; Scarborough, 69; Barrie, 64; Mississauga, 58; Brampton, 51; and Markham, 58.(19)

Density affects many aspects of the built environment. Generally, the lower the density in an area the more land is needed to accommodate population growth.(19) Density is also a determinant of the viability of public transportation systems, as low density communities do not have the infrastructure or populations to support them.(19) As density increases, time and distances for travel between destinations tend to decline and people are more likely to walk or cycle (active transport) and to use public transport.(15) Residents of sprawling regions make more trips as well as making longer trips.(20) Almost all travel is done by car until the residential density reaches 13 persons per gross acre (Frank and Pivo, as cited in Frank, Kavage & Litman 2007). The same study also found that an employment density of 75 employees per gross acre was needed in order to see increases in work-related transit use and walking.

Determinants of health

The health status of individuals and populations is influenced by a number of

independent but inter-related factors.

> *"At every stage of life, health is determined by complex interactions between social and economic factors, the physical environment and individual behaviour. These factors are referred to as 'determinants of health'. They do not exist in isolation from each other. It is the combined influence of the determinants of health that determines health status."(21)*

The Public Health Agency of Canada has identified 12 key determinants of health, each of which plays an important role in determining health status (see Table 2). Improving or influencing the health status of a population requires that health determinants be considered within all strategies that address specific health conditions or risks.(22)

Table 2 Key Determinants of Health

Health Determinant	Influence on Health
Income and Social Status	Income and social status influence people's access to housing and food, and their sense of control over life decisions. Health status generally improves as people's income and social status improve.
Social Support Networks	Support from family, friends and the community contribute to better health.
Education and Literacy	People's level of education influences their opportunities for job selection and security, and a sufficient income.
Employment/ Working Conditions	People with a steady job that provides sufficient income and a safe workplace are generally healthier.
Social Environments	Social stability, recognition of diversity, good working relationships and cohesive communities contribute to healthy social environments.
Physical Environments	The natural environment, which includes air, water and soil, influences health. The human-built environment, which includes housing, workplaces and road design, also influences health.
Personal Health Practices and Coping Skills	People's knowledge, behaviours and abilities to handle outside influences and stressors affect health.
Healthy Child Development	Early child development influences health throughout the life span. Factors that influence child development include healthy birth weights, positive parenting and safe, friendly neighbourhoods.
Biology and Genetic Endowment	People's genetic endowment contributes to their predisposition to certain diseases. Biology influences their response to sources of stress, such as viruses or emotional strain.
Health Services	Health is influenced by having access to services that are structured to restore, maintain and promote health, and prevent disease.

Gender	Men and women do not always have equal roles, power and influence in society. Measures to address gender inequity and gender bias can improve health.
Culture	Language and beliefs influence people's health-related behaviours, access to health information, and the way people interact with the health system.

Source: Determinants of Health. Public Health Agency of Canada, 2003 (accessed 31 October 2007) http://www.phac-aspc.gc.ca/canada/regions/ab-nwt/pdf/resources/Determinants_colour_e.pdf

Health

Health, as defined by the World Health Organization (WHO, 1946) is: "…a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity."(23) This definition incorporates a broad view of health that elevates it from the traditional medical model (in which health is strictly associated with physical health) to a more holistic view that considers all aspects of a person's wellbeing, including mental health and social wellbeing. Within the WHO context health is viewed as an entity that is somewhat fluid and subjective in nature and is influenced by a number of interconnected determinants.(24)

Infill Developments

Infill development is defined as "…the economic use of vacant land, or restoration or rehabilitation of existing structures or infrastructure, in already urbanized areas where water, sewer and other public services are in place, that maintains the continuity of the original community fabric".(25)

Land use planning

The Canadian Institute of Planners offers a definition of planning that encompasses land use and differentiates it from social, cultural, and economic professional planning activity:

> *"'Planning' means the scientific, aesthetic, and orderly disposition of land, resources, facilities and services with a view to securing the physical, economic and social efficiency, health and wellbeing of urban and rural communities.*
>
> *Responsible planning has always been vital to the sustainability of safe, healthy, and secure urban environments. Canada's population is growing and, with more people migrating from rural to urban areas, the planning profession must increasingly deal with urbanization issues, such as:*
>
> - *conversion of land from natural habitats to urban built areas,*
> - *maintenance and use of natural resources and habitats,*
> - *development of transportation related infrastructure,*
> - *environmental protection.*

Not only do planners deal with land use, but also:

- *planning social and community services,*
- *managing cultural and heritage resources,*
- *creating economic capacity in local communities,*
- *addressing transportation and infrastructure,*
- *working internationally."(26)*

From a public health perspective it is recognized that the scope of public health action in planning, and in particular work to improve the social and economic determinants of health, is broader than land use planning.

Sprawl

Frumkin et al (2004) define sprawl and its components in this way:

> *"The rapid expansion of metropolitan areas…refer(s) to a complex pattern of land use, transportation, and social and economic development. As cities extend into rural areas, large tracts of land are developed in a 'leapfrog', low-density pattern. Different land uses – housing, retail stores, offices, industry, recreational facilities, and public spaces such as parks – are kept separate from each other… Extensive roads need to be constructed. With the expansion of suburbs, capital investment and economic opportunity shift from the centre to the periphery. Regional planning and coordination are relatively weak."(pg.201)(27)*

The Ontario Medical Association defines urban sprawl as "…low-density, car-dependent development on the outskirts of an urban area."(28)

Walkability

Walkability includes pedestrian movement to everyday destinations such as workplaces, shops, schools and community facilities. The World Health Organization defines walkability as "the degree to which a single route or a system of routes between points is relatively short, barrier-free, interesting, safe, well-lighted, comfortable and inviting to pedestrians".(15)

2. DISCUSSION

2.1 Physical Activity

2.1.1 Introduction

The effects of the built environment on physical activity levels operate through a complex set of relationships. The starting point is the individual. The amount of physical activity the individual engages in impacts her/his health. Her/his capacity and tendency to be physically active is influenced by demographic characteristics, genetics, lifestyle, attitudes and beliefs, and time constraints. The individual is surrounded by a built environment that includes land use patterns, the transportation system and design features.(29) Both the individual and the built environment fit into the larger social environment of economic, political and societal forces that shape the available opportunities and choices for physical activity.(29)

Faced with escalating chronic disease rates associated with physical inactivity, sedentary lifestyles, overweight and obesity that public health officials now describe as “epidemic”, the impetus is there to examine new ways to address these troubling trends. Health care costs are rising and the very nature of public provision of health care in Canada is threatened. While these conditions reflect a variety of root causes—from technological innovations to changing diets to increasingly sedentary jobs and leisure-time activities—evidence will be examined to determine whether a strong relationship exists among health, physical activity, and the way we plan and design our communities.

2.1.2 Types of Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that result in an expenditure of energy.(30) Physical activity can be reviewed many ways but three aspects will be examined more closely: recreational versus utilitarian physical activity, differences in physical activity levels among population sub-groups, and vigourous versus moderate physical activity.(31) Each of these aspects points to the concept of active living which is a way of life that encourages people to integrate regular physical activity into their daily lives.(15)

Physical activity can be categorized according to purpose – either recreational or utilitarian. Recreational (or leisure-time physical activity) is defined as exercise, sports, recreation or hobbies and occurs during one’s leisure or spare time and is not associated with activities as part of regular job duties, household or transportation.(30) Examples include jogging, playing tennis, or walking around the block with the baby in a stroller. Utilitarian physical activity (or active transportation) is self-powered human movement where the primary purpose is to get to the destination or accomplish the task

and the physical activity involved is secondary. Examples include walking, cycling and wheeling (for wheelchair users) or similar activities, to and from places such as work, school, one's place of worship and stores.(30) The distinction is important because the driving forces for recreational and utilitarian physical activity are different.(31) Recreational physical activity requires both motivation and time to initiate and sustain it whereas utilitarian physical activity is done as part of the tasks of the day that need to be accomplished. When a busy person is running out of time, it is usually the leisure-time physical activity that is sacrificed in order to get the other necessary items accomplished. But this same busy person needs to address the "must do's" on their list such as buy milk or go to the bank. If they can walk to the store or the bank, they accomplish their necessary tasks and are able to be physically active at the same time. Active transportation allows tasks to get accomplished with the added benefit of incorporating physical activity into one's routine.

As well, different types of built environment are needed to support recreational and utilitarian physical activity. Specific infrastructure is often required to support recreational physical activity. Baseball diamonds, tennis courts, skating arenas and recreation centres are needed for recreational or leisure-time physical activity. All these recreational activity supports are configured for specific sport requirements, often specific to only one activity, take up large areas of space, and require significant capital investment and maintenance so they are often not accessible to everyone. Utilitarian physical activity needs environments with connecting sidewalks and bicycle paths that support self-propelled movement like walking and biking. Additionally, utilitarian physical activity requires environments that locate destinations like shops, banks and restaurants within walking distance of home or work. However, there is significantly less capital and maintenance costs to invest in sidewalks, bike lanes or trails. Furthermore, these same environments support transit, since transit users are required to walk or cycle to the bus, subway or train stops. The built environment needed to support active transportation does not cost as much as recreational physical activity buildings or fields, can be used for more than one purpose, and is available for use by many people thereby reinforcing the concept of integrating physical activity into everyday life.

Another way physical activity can be considered is with respect to differences in levels and abilities among population sub-groups. Physical activity opportunities are most available to healthy, middle and upper class adults. Studies examining physical activity patterns according to demographic characteristics have found that inactivity is higher among women, lower socio-economic groups, and among members of minority ethnicities.(31) Other population sub-groups have known limitations which are often not considered. Young children are often restricted in their physical activity opportunities by their smaller size and limited experience and judgement(32) and depend on their parents or caregivers for transportation. When the child does not walk or walk as fast as everyone else, the parent or caregiver is reliant on a stroller to get the child one to areas that are safe to move around in. Additionally, as a person ages, reduced capabilities can prevent or reduce that ability and desire to be physically active.(32) The mobility of the elderly is enhanced by aids such as canes and walkers yet walking areas are often

not designed for the safe use of these aids. A wide range of barriers impact various population sub-groups including competing demands from job and family, being physically tired, insufficient money, lack of facilities, safety concerns and cultural perceptions of appropriateness. Unfortunately, little research has been done to identify environmental features that promote physical activity among groups who are least likely to engage in it. Opportunities for utilitarian physical activity are likely to impact the sub-groups of the population which are typically not easily reached through traditional programming. Most people need to conduct daily or weekly tasks in order to eat, pay bills and raise children and therefore would receive health benefits by being able to walk to work, school, a place of worship and stores.

The third way physical activity can be categorized is according to the intensity necessary to develop cardiorespiratory endurance (also known as aerobic endurance or aerobic fitness). “Cardiorespiratory endurance is the ability of the body's circulatory and respiratory systems to supply fuel and oxygen during sustained physical activity.”(30) Maximum capacity of the cardiorespiratory system is estimated by subtracting one’s age from 220. *Vigourous* physical activity, therefore, is defined as activity that raises the heart rate to at least 70 per cent of its maximum capacity.(31) M*oderate* physical activity is defined as activity that raises the heart rate to 50 to 69 per cent of its maximum capacity.(31) Cardiorespiratory endurance is one way of measuring the health benefits of vigourous physical activity. However, determining the intensity level necessary for other health benefits is an important endeavour, given that the types of activities done by the majority of people in the population most of the time are at a moderate level of intensity or less. The benefits of different intensities of physical activity on the participant will be discussed in the next section.

2.1.3 Physical Activity Impacts the Health of the Population

The published literature agrees that significant health benefits arise from regular physical activity. One of the landmark documents was the U.S. Surgeon General’s 1996 *Report on Physical Activity and Health,* which reviewed the existing literature on the role of physical activity in preventing disease and concluded that ***the evidence was sufficiently strong to draw a causal relationship between physical activity and health outcomes***, including:

- Lower mortality rates for both older and younger adults;
- Lower risk for heart disease and stroke;
- Prevention or delay of high blood pressure and among people with hypertension, lowering of blood pressure;
- Decrease risk for colon cancer;
- Lowered risk for type 2 diabetes (non-insulin dependent);
- Weight loss and redistribution of body fat;
- Increase in muscle mass;
- Improvement of mood and relief of the symptoms of depression and anxiety;
- Enhancement of psychological wellbeing and perceived health-related quality of life; and

- Improved physical functioning among people with poor health. (United States Department of Health and Human Services, as cited in Jackson and Kochtitzky, 2001)

The Surgeon General's 1996 *Report on Physical Activity and Health* broke new ground for public health in its approach to physical activity in two areas. First, it promoted the message that significant health benefits could be gained through moderately intense physical activity such as walking and bicycling.(32) The report highlighted that since the 1970's, the physical activity message to the public focused on doing vigourously intense exercise for at least 20 minutes at least three times per week in order to reduce the risk of chronic disease (Pate et al, as cited in Frank et al, 2003). In the mid 1990's, epidemiological work identified a dose-response relationship between moderate intensity physical activity and many chronic diseases (Pate et al. as cited in Sallis et al, 2006). The health benefits of physical activity were no longer attributed only to those who ran, jogged or did aerobics at a level vigourous enough to raise their heart rate to at least 70 per cent of its maximum. Meaningful health outcomes were achieved with *moderate* physical activity that raised the heart rate to 50 to 69 per cent of its maximum capacity provided. The efforts of those who walked, gardened and climbed stairs instead of riding elevators were acknowledged as benefiting their health. The Surgeon General concluded that "through a modest increase in daily activity, most Americans can improve their health and quality of life."(p.10) While it is important to note that additional health benefits can be gained by being physically active for longer periods of time or at a more vigourous intensity, both increased time commitments and increased perceived exertion can be barriers to physical activity.

Secondly, the Executive Summary of the Surgeon General's report identified that "physical activity programs and initiatives face the challenge of a highly technological society that makes it increasingly convenient to remain sedentary and that discourages physical activity in both obvious and subtle ways" (p.12). This remark points to the significant changes in both the lifestyles we lead, the communities we live in, the current reduced physical activity levels, and increased sedentary behaviour that characterize North American society.(6)

Canada's Physical Activity Guide advises that Canadians start slowly and progress gradually towards accumulating 30 to 60 minutes of activity a day which can be accumulated in 10 minute increments.(33) The effort expended in the activity determines the overall time needed to get the benefits. If the activity is of light effort, aim towards accumulating 60 minutes a day. If the activity is of moderate effort, aim towards accumulating 30 minutes a day.(34) People who move from small to moderate amounts of physical activity benefit the most. Frank et al (2003) identify that an additional benefit of moderate physical activity is its potential to increase levels of adherence because people can integrate it into their daily lives and therefore have a greater likelihood of maintaining the behaviour.(32) Recommendations from Canada's Physical Activity Guide include not only endurance activities that get the heart pumping for four to seven days per week, but also include flexibility activities for four to seven days per week and

strength activities from two to four days per week. Current population health recommendations are realistic and should be achievable by almost all Canadians. Unfortunately, many people in Canada are not physically active at a light or moderate level.

2.1.4 Physical Inactivity: Current Status and Health Impact

Data from the Canadian Community Health Survey, Cycle 3.1 which was conducted in 2005, indicate the following physical activity statistics for Simcoe Muskoka and Ontario and is contained in Table 3 below. Generally, the proportion of the population surveyed from Simcoe Muskoka indicated they were more active and less inactive as compared to Ontario as a whole. As the population gets older, there is a decrease in the proportion of people who identify themselves as active.(35;36)

Table 3 Proportion of Population (18+ years) with Reported Physical Activity Index, CCHS, 2005, Simcoe Muskoka and Ontario, 2005

Physical Activity Index	Simcoe Muskoka Proportion	95% Confidence Interval	Ontario Proportion	95% Confidence Interval
Active	31.2%	(28.1%-34.4%)	25.1 %	(24.5 %-25.8 %)
Moderate	22.6%	(20%-25.3%)	24.3 %	(23.6 %-25 %)
Inactive	44.4%	(41.1%-47.8%)	48.2 %	(47.4 %-49 %)
Not Stated	1.8%	(1.2%-2.8%)	2.3 %	(2.1 %-2.6 %)

Source: Canadian Community Health Survey, Cycle 3.1, 2005, Statistics Canada, Share File, Knowledge Management and Reporting Branch, Ontario Ministry of Health and Long-Term Care.

Among the age group 12 to 19 years, Simcoe Muskoka respondents were more active and less inactive as compared to Ontario as a whole(37;38). Data from the Canadian Community Health Survey, Cycle 3.1, which was conducted in 2005, indicate the following physical activity statistics for Simcoe Muskoka and Ontario (Table 4):

Table 4 Proportion of Population (12-19 years) with Reported Physical Activity Index, CCHS, 2005, Simcoe Muskoka and Ontario, 2005

Physical Activity Index	Simcoe Muskoka Proportion	95% confidence interval	Ontario Proportion	95% confidence interval
Active	58.1%	49%-66.6%	49%	47 % - 50.9 %
Moderate	19.9%	13.5%-28.4%	21.7%	20.1 %-23.3 %
Inactive	20.5%	14.3%-28.4%	27.5%	25.8 %-29.4 %
Not Stated	**	**	1.8%	1.5 %-2.3 %
**Not released				

Source: Canadian Community Health Survey, Cycle 3.1, 2005, Statistics Canada, Share File, Knowledge Management and Reporting Branch, Ontario Ministry of Health and Long-Term Care.

The decline in physical activity is seen as adolescents progress through high school. Findings from the 2001 Youth Risk Factor Behaviour Surveillance System (YRBSS)

conducted in the Unites States identified the increase of inactivity as grade level increases. In the ninth grade, 24.3 per cent of the high school students surveyed were inactive compared to 38.9 per cent of those in twelfth grade.(39) As well, the average amount of physical activity during school time has declined in the past 15 years. The percentage of students who attended Physical Education class daily decreased from 41.6 per cent in 1991 to 32.2 per cent in 2001.(39) Fewer students are taking the opportunity for physical activity and instruction during class time. The YRBSS defined inactivity as “did not participate in at least 20 minutes of vigorous physical activity on three or more of the past seven days and did not do at least 30 minutes of moderate physical activity on five or more of the past seven days”.

The public health burden of physical inactivity is seen in increased rates of premature death, reduction in quality of life due to chronic diseases and conditions, and the economic cost of treating these diseases.(40) Physical inactivity is a risk factor for several chronic diseases including coronary artery disease, stroke, colon cancer, breast cancer, type 2 diabetes mellitus and osteoporosis.(41) The prevalence of physical inactivity and chronic diseases and conditions in Canada pose a significant burden on the public health care system. In 1995, physical inactivity took about 21,000 lives prematurely in Canada.(41) If Canadians were to become more active, it is estimated that there would be: 26 per cent fewer deaths from type 2 diabetes; 20 per cent fewer deaths from colon cancer; and 22 per cent fewer deaths from cardiovascular disease.(40) Physical activity is also an important component of maintaining good mental health and dealing with the stress associated with day-to-day living. Physical inactivity contributes to a general sense of malaise and fatigue that many people experience. Physical activity is just as effective as the most commonly prescribed medications for treatment of relatively mild cases of anxiety and depression.(6)

While the health effects of smoking had been documented by the early 1960’s, the epidemiological evidence linking physical inactivity with a number of health problems became known much later - in the late 1970’s and early 1980’s.(42) It is estimated that obesity and its concomitant health problems rivals tobacco in its health impacts.(43) Sallis et al (2004) note that more than 70 per cent of American adults do not meet physical activity recommendations, whereas less than 20 per cent are smokers(42) and concluded that physical inactivity directly impacts more people than tobacco use does. The statement is true for Canada as well where approximately two-thirds of adults are inactive(41;44) and 21.8 per cent(45) of the population are smokers.

The price of wide-spread physical inactivity is seen in the ever increasing costs of health care in Canada. Katzmarcyk estimated the cost of physical inactivity in 1999 at about $2.1 billion, or 2.5 per cent of the total direct health care costs in Canada.(41) However, the most recent estimates put the cost at $5.3 billion.(40) Overall, Canadian health care spending in 2003 was estimated at $121.4 billion, which is 10 per cent of the gross domestic product of Canada.(40) Results from a study on health care costs by the Conference Board of Canada indicated that a 1 per cent increase in physical activity could save $10.2 million for heart disease, $877,000 for adult-onset diabetes and

$407,000 for colon cancer each year (in constant 1993 dollars).(46) While these figures are 15 years old, it demonstrates the significant cost savings that could be accrued to the health care system by small changes in behaviour at the population level. Physical activity is one of the most cost-effective ways to having a healthier population, both physically and mentally.(40)

Another important function of physical activity is to help maintain energy balance. Weight gain occurs when energy intake (calories consumed) exceeds energy expenditure (calories expended) for a prolonged period. Physical activity expends energy, which helps maintain energy balance. Lack of physical activity is also a risk factor for obesity. Relatively small changes in physical activity levels can play an important role in weight management and the reversal of obesity trends. For example, increasing physical activity levels by walking briskly for 1 to 1.5 miles a day (where brisk means walking a mile in 15 or 20 minutes) could counterbalance the estimated net daily caloric imbalance of 100 to 150 calories (Cutler et al, as cited in Committee on Physical Activity, Health, Transportation, and Land Use, 2005).

While both increased food intake and physical inactivity have contributed to the problem of obesity, physical inactivity has been proposed as the major contributing factor according to a study from the British Medical Journal and highlighted in the text book *Urban Sprawl and Public Health*.(31) The study compared proxy measures of food intake and physical inactivity to obesity trends from 1950 to 1990. Food intake was measured in proxy as energy intake and fat intake. Physical inactivity was measured in proxy by car ownership and television viewing. When compared to obesity trends, the food intake proxy measurement hit a peak around 1970 and declined subsequently. On the other hand, the physical inactivity proxy measurement increased along with obesity and has continued to increase. The data indicated that as the years progressed, the number of cars per household increased as did the number of hours spent viewing television per week although television viewing did hit a plateau.

The authors of the study suggested a causal relationship exists between physical inactivity and excess weight (Prentice and Jebb, 1995, as cited in Frumkin et al, 2004). A more precise way of stating the conclusion is that there is a causal relationship between obesity and the combination of increased car ownership and television viewing. Most studies show little relation between the amounts of time spent watching TV and physical activity (Sallis et al, 2000, as cited in Pratt et al, 2004). However, TV watching is associated with increased body mass index and other measures of adiposity (Andersen et al, 1998, as cited in Pratt et al, 2004).

Overweight and obesity are major public health problems in Canada and around the world. Obese individuals have a higher risk of developing coronary heart disease, diabetes, high blood pressure, osteoarthritis, joint problems, low back pain, fertility and hormone related problems(29;47), some cancers and gallbladder disease.(16) Being obese increases the risk of type 2 diabetes by forty-fold (Hu et al, in Frumkin et al, 2004) and diabetes is a major risk factor for amputations, blindness, kidney failure and

heart disease.(6) A recent type 2 diabetes study found that weight loss and physical activity were more effective in controlling the disease than medication.(6) It is estimated that obesity and its concomitant health problems rivals tobacco in its health impacts.(43)

The grouping of physical inactivity, unhealthy diet and excess body weight is a powerful determinant of cancer risk. One-quarter to one-third of cancers of the breast, colon, esophagus, kidney and uterus are attributed to excess body weight and physical inactivity (International Agency of Research on Cancer, as cited in Canadian Fitness and Lifestyle Research Institute, 2005). It is estimated that 30 to 40 per cent of all cancer cases could be prevented over time by a combination of following recommended diets and maintaining physical activity and appropriate body weight (American Cancer Research, as cited in Canadian Fitness and Lifestyle Research Institute, 2005).

According to the 2004 Canadian Community Health Survey (CCHS), 23.1 per cent of Canadians aged 18 or older were obese (with a BMI of 30 or more) and 36.1 per cent were overweight (with a BMI between 25.0 to 29.9).(16) These percentages translate into approximately 5.5 million obese Canadian adults and 8.6 million overweight Canadian adults.(16) The 2004 CCHS was different from other surveys in the previous 10 years as respondents' height and weight were measured. This is a sharp increase in obesity and overweight compared to the findings of the Canada Health Survey, which was conducted in 1978/79 with measured weights and heights, where the age-adjusted obesity estimate was 13.8 per cent.(16) Not only did the overall level of obesity rise in every age group except 65 to 74, but the proportion of obese adults in Class II (35.0 to 39.9) rose from 2.3 per cent to 5.1 per cent and in Class III (> 40.0) escalated from 0.9 per cent to 2.7 per cent.(16)

From a population health perspective, the entire BMI distribution has shifted towards the overweight and obese categories since 1970–1972(48), which indicates that the population as a whole has gotten heavier.(16) Indeed, the median BMI of adults rose from 24.4 in 1978/79 to 26.1 in 2004.(16)

When looking at the Body Mass Index (BMI) for adults over 18 years of age provincially (Table 5), the general trend is that the proportion of Simcoe Muskoka adults surveyed was heavier as compared to proportion of surveyed adults from Ontario as a whole.(49;50)

Table 5 Proportion of Adults (18+ years) with Reported Body Mass Index (BMI), CCHS, 2005, Simcoe Muskoka and Ontario, 2005

BMI	Simcoe Muskoka Proportion	95% confidence interval	Ontario Proportion	95% confidence interval
Under weight (< 18.5)	2.4 %	1.5%-3.8%	2.7 %	2.5%-3%
Normal weight (18.5 - 24.9)	39.2 %	36%-42.4%	46.2 %	45.4%-47%
Over Weight (25.0 - 29.9)	38.6 %	35.3%-42.1%	33.5 %	32.8%-34.3%

Obese (> =30.0)	18.1 %	15.6%20.9%	15.1 %	14.6%-15.7%
Not Stated	1.7 %	1%-2.7%	2.4 %	2.1%-2.6%

Source: Canadian Community Health Survey, Cycle 3.1, 2005, Statistics Canada, Share File, Knowledge Management and Reporting Branch, Ontario Ministry of Health and Long-Term Care.

Over the past 25 years, Canadian children and adolescents have become increasingly more overweight and obese. According to the 2004 CCHS, 18 per cent of Canadian children aged 2 to 17 were overweight and 8 per cent were obese, for a combined overweight/obesity rate of 26 per cent.(17) These percentages translate into 1.1 million overweight boys and girls and another half a million obese boys and girls.(17) Again this is a significant increase compared to the findings of the 1978/79 Canada Health Survey, where 12 per cent of 2 to 17 year olds were overweight and 3 per cent were obese, for a combined overweight/obesity rate of 15 per cent. Both boys and girls had similar increases in overweight and obesity.(17) The trends did differ among various age groups. The percentage of children aged 2 to 5 who were either overweight or obese was effectively unchanged.(17) However, among 12 to 17 year olds, the percentage of overweight adolescents more than doubled, from 14 per cent in 1978/79 to 29 per cent in 2004(17), and the percentage of obese adolescents tripled, from 3 per cent in 1978/79 to 9 per cent in 2004.(17) The BMI distribution has shifted towards heavier BMIs for adolescents

The Simcoe County Child Health Survey, conducted in 2003, found that 26 per cent of Grade 1 children (approximately six years of age) were at risk of overweight or were overweight, which was defined as a Body Mass Index for age greater than the 85th percentile.(51) This proportion of unhealthy weights in Grade 1 children in Simcoe County was significantly higher than the Centers for Disease Control and Prevention (CDC) reference for comparable age children.(51)

Children are affected by the same health problems related to obesity as adults. It has been estimated that more than one-third of all American children will develop type 2 diabetes, a condition associated with being overweight, at some point in their lives.(52) Among overweight American children from ages 5 to 10 years old, approximately 60 per cent will exhibit at least one physiological cardiovascular disease risk factor.(52)

The dramatic increase in the prevalence of obesity among both children and adults reflects a population shift toward a positive energy balance. As a society, we do not do sufficient activity to burn off the calories we eat. While excess weight has traditionally been seen solely as a personal problem which required personal control, the magnitude of this change would suggest that population-wide factors could be at work. The environment in which we live may be making it too easy to overeat and consume excessive calories and too difficult to be physically active and expend excessive calories. Given the evidence presented above, a population-wide decrease in physical activity is one plausible explanation for increased prevalence of excessive weight among the population. So what has changed in the environment that has resulted in the fattening of North America?

2.1.5 Changes in Society Influence the Amount of Physical Activity

Overall physical activity levels today have declined significantly as compared to levels from half a century ago.(6) Brownson et al (2005) reviewed current patterns and long-term trends over the past 50 years to identify the contributing factors.(39) Researchers observed an overall decline in physical activity associated with one's employment, the maintenance and running of a home, and for self-powered transportation. In other words, the amount of physical activity necessary for everyday life has decreased. Additionally, there has been an increase in sedentary behaviour. Only the physical activity exerted during leisure time has remained the same or slightly increased.

Today, most jobs do not involve significant physical exertion but rather considerable periods of sitting. Most of the changes in labour force participation occurred between 1950 and 1980, with only relatively minor change observed in the past 20 years.(39) In 1950, approximately 30 per cent more people were employed in high-activity occupations than low-activity occupations in the United States. In 2000, approximately twice as many people were employed in low-activity occupations than in high-activity occupations.(39) There has also been a substantial decline over the past 50 years in agricultural employment, which is usually correlated with high activity levels, from 12.2 per cent in 1950 to less than two per cent in 2000.(39)

Sitting is a sedentary behaviour that uses up a significant portion of time – both in and outside the workplace. On average, Americans who are 13 years and older spend 7.7 hours per day sitting and teens spend 9.5 hours a day sitting (Partnership to Promote Healthy Eating and Activity Living, 2003, as cited in Pratt et al, 2004).

The physical activity involved with maintaining a household had also declined. Most homes are equipped now with labour saving devices such as washing machine, dryer, lawn mower and snow blower. With less time being spent on chores, more time has been made available for leisure which potentially could include physical activity.(53)

However, the time that is saved is often used to engage in sedentary activities such as watching television or using the computer. In 1950, only about 10 per cent of American households had a television (Putnam, 1995, as cited in Brownson, 2005) as compared to the current figure of 98 per cent of households having at least one television.(39) As well, the average number of viewing hours spent has doubled since 1950. In fact, the average U.S. household increased its TV watching by 36 minutes every 10 years.(39) A Harris Interactive Poll (Partnership to Promote Healthy Eating and Activity Living as cited in Pratt et al, 2004) found that Americans 13 years and older spent four hours a day watching TV or playing computer or video games. In addition to the technological revolution that took the physical activity out of work, home and personal transportation, two additional dramatic changes have taken place in land use and transportation systems that have encouraged both sedentary living habits and physical inactivity.

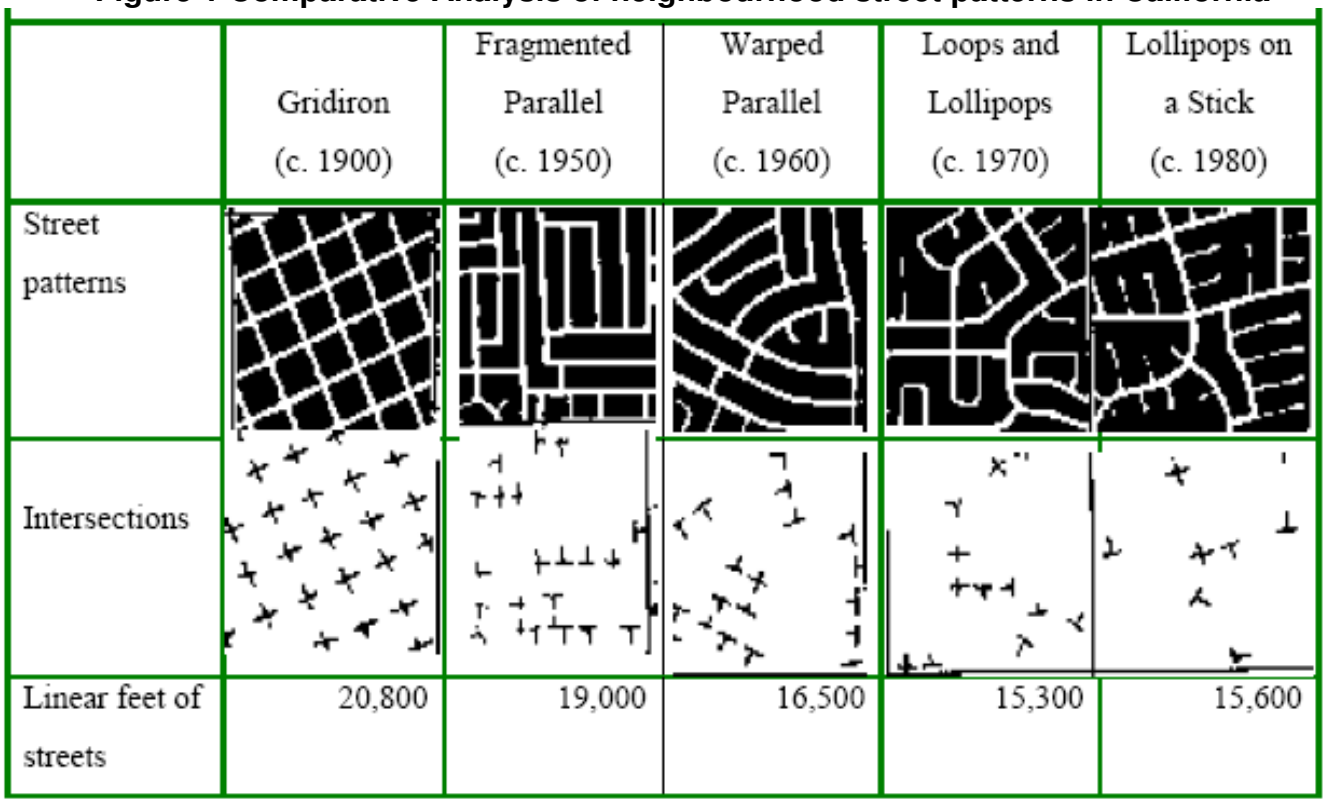
The second significant change has been in the design of towns and cities. Originally towns and cities were planned and built to serve the people who lived in them so that

stores and services were within walking distance of residences.(6) However, the grid pattern of the town and city was rejected with the post-war construction of single-family dwellings in the newly created suburbs of the 1950's and communities began to be designed around automobiles rather than people.

Since the late 1700's, town planning had been dominated by the classic grid pattern of two sets of parallel streets crossing at right angles to form square or rectangular blocks. Grid pattern design was geared to the pedestrian and allowed for variations in route. Criticism of the grid pattern began at the end of the nineteenth century as it was inappropriately associated with the social and economic problems in urban America, including the lack of open space, substandard housing, and the lack of light and fresh air in the city.(54) The early twentieth century marked the beginning of municipal zoning regulations where residential areas were separated from the perceived negative impact of mixed uses and decisions to separate different land uses was applied to the planning of suburbs in later decades.

Rejection of the grid pattern and a new emphasis on street hierarchy, curvilinear design and disconnected networks had its roots in the early 1900's.(54) However these standards were widely adopted and implemented only ***after*** the end of the Second World War in suburban development (Wolfe, as cited in Frank and Engelke). This change in design was based on the assumption that people wanted to drive to more destinations.(6) Streets connecting houses, called neighborhood streets, were intended for use of the immediate residents and consequently were designed for lower traffic volumes and traveling at lower speeds. They contained fewer intersections in order to discourage through-traffic. Major arterials, designed to carry greater traffic volumes at higher speeds, were placed at the edges of neighborhoods in order to route through traffic around the neighborhood. Street networks became more curvilinear, which not only assisted in the goal of reducing connectivity on interior streets but also were seen as less monotonous and were more reflective of the natural contours of the land than the grid pattern allowed. These design principles were built upon further in following decades and resulted in even more disconnected neighbourhoods.(54) A pictorial representation of the changes in street patterns, the decrease in the number of intersections, and the reduction in length of road available for travel is presented in Figure 1.

Figure 1 Comparative Analysis of neighbourhood street patterns in California



Source: Frank and Engelke, 2006. How Land Use and Transportation Systems Impact Public Health: A literature review of the relationship between physical activity and built form (54)

The third significant change was the beginning of increased prosperity and a migration to the suburbs from both the cities and rural areas that occurred after the end of the Second World War. Both the United States and Canada had become significant manufacturing powers of both military and industrial exports during the war and had suffered comparatively little infrastructure damage as compared to the arenas of war in Europe and Asia. North America became the industrial powerhouse for the world and this economic engine benefited the returning soldiers who gained access to jobs and education. As a result, more people were able to buy newly-constructed, single-family dwellings outside the confines of the city. Additionally, they had the earning power to afford a family car. Significant migration to the suburbs occurred from 1950 to 1980 and the number of Americans living in the suburbs increased 5.3 per cent every 10 years.(39) While this trend has moderated since 1980, the percentage of U.S. residents living in the suburbs has more than doubled from 1950 to 2000.(39)

Notably, the increase in suburban growth was intimately tied to the increased use of automobiles for personal transportation.(43) Suburban living required at least one car as residential areas were separated from commercial and industrial areas due to stringent

zoning regulations. As the distance and barriers between working, shopping and living increased, people used their cars more to travel and were less likely to walk or bicycle to these destinations.(6) By placing major arterial roads at the edges of neighbourhoods, each area became walled off from the other and further isolated. Walking or cycling between these disconnected neighborhoods became dangerous (Untermann, as cited in Frank and Engelke) as cars became increasingly present on internal residential streets and few provisions were made for non-motorists (Wolfe, as cited in Frank and Engelke).

The concurrent increasing pervasiveness of the car and greater numbers of people scattered over greater distances resulted in more highways, roads, and increasing use of cars in order to connect people to residences, work, shopping and schools. While automobile mobility was increased, it came at the cost of spreading residential developments and severed communities(55), a decrease in self-powered mobility and more land being used to build roads and highways.(43) This self-perpetuating pattern of sprawling development or sprawl has continued to the present day.(43)

The dominance of the automobile for personal travel reduced the use of self-powered transportation for personal travel. The excessive reliance on the automobile for personal travel is illustrated by the statistic that 86 per cent of all person trips and 91 per cent of all person miles occurred in a private vehicle whereas walking accounted for only 5 per cent of trips and less than 1 per cent of miles.(54)

The current availability and convenience of a car obscures most opportunities to walk or bicycle to a destination. In fact, the probability of any self-powered transport is inversely related to the number of automobiles per household regardless of income level.(39) So the more vehicles a household has, the less likely anyone in it is going to walk. The 2001 National Household Transportation Survey (NHTS) (as cited in Brownson, 2005) found that American households have, on average, more vehicles than drivers. The NHTS estimated a mean of 1.9 personal vehicles per household while there were only a mean of 1.8 drivers who are 15 years and older per household.

With all these cars, there must be a lot of driving. And there is. Compared to baseline data from 1950, the number of Vehicle Miles Traveled (VMT) in 2000 increased by more than 200 per cent and the daily VMT per person increased by 0.4 miles per year over the past 50 years.(39) Adults drove an average of 55 minutes and 29 miles per day (approximately 47 kilometres) with men spending more time driving, 67 vs. 44 minutes, and driving further than women, 38 vs. 21 miles (approximately 61 kilometres vs. 34 kilometres).(39)

Changes in children's travel patterns illustrate the consequences of these transformations. As recently as the 1960s, roughly one in two children walked or biked to school.(56) In 1977, children aged 5 to 15 years made 15.8 per cent of their trips by walking or biking. By 1995, children within the same age group walked or biked for only 9.9 per cent of the trips - a 37 per cent decline.(6) Another study (Kouri, as cited in

Jackson and Kochtitzky, 2001) found that students were four times more likely to walk to schools built before 1983 than to those built more recently. Jackson and Kochtitzky identify that this difference points to a basic change in the ability to walk to newer built schools.(6) They postulated that these newer schools were not as geographically close to where the students live or that the school's property was designed to meet the needs of the automobiles used to drive there rather than the needs of students to walk and bike.

2.1.6 Built Environment Influences Physical Activity

The impact of the built environment on physical activity patterns will be examined in terms of land use patterns, transportation systems and design characteristics. Each area plays a distinct role in determining activity. Both land use patterns and transportation systems operate at the larger scale environment which would be the regional and neighbourhood level, whereas design characteristics operate on a smaller scale at the individual and family level and play a role in determining perceptions and decision-making. Quality design characteristics are pleasing, well-maintained, and capture people's attention and interest and can increase people's readiness and enjoyment to walk or cycle in an area.(15)

Land development patterns are the spatial arrangement of structures on the landscape for residential, commercial and industrial areas as well as community infrastructure. They include the number and proximity of buildings, the mixture of uses over a given area and the design of buildings and sites. Land development patterns determine the opportunities for physical activity.(31) Key land development pattern elements include density, land use mix and connectivity.

Density is the most important factor influencing physical activity or automobile usage. It is defined as the number of people or jobs per unit of area, such as the number of people per acre or jobs per square mile. Density affects distances between destinations and the number of destinations that can be reached by walking and cycling. A concentration of jobs or households makes active transportation and public transit more viable and provides the critical mass needed to support retail development.(57)

The amount of travel within large urban regions varies with density. Sprawl is characterized by low density and typically consists of fewer people living on large lots in large areas far from businesses, jobs, stores and restaurants. The more sprawl there is the more cars are likely to be used for two reasons. First is that when communities are spread out the distances that need to be traveled are too far for practicable access other than by motorized means.(20) Secondly, low densities in larger urban areas make mass transit alternatives financially difficult to sustain.

Residents of sprawling regions make more trips as well as making longer trips.(20) Almost all travel is done by car until the residential density reaches 13 persons per gross acre (Frank and Pivo, as cited in Frank, Kavage & Litman 2007). The same study

also found that an employment density of 75 employees per gross acre was needed in order to see increases in work-related transit use and walking.

Additionally, low-density development reinforces automobile use.(20) Low-density development is only possible when almost everyone has a car. Low-density areas are inaccessible and unappealing to those without automobile access. Once built, such development encourages car use that in turn reinforces the place of the car in society, making more low-density development feasible and likely. Without the car, travel within low-density areas is difficult. The second means of reinforcement arises from the way the car takes over the landscape. When most of the traffic consists of automobiles and trucks, other modes of transit, whether it is self-powered (active transportation or mass transit) can be made more difficult, less safe and less enjoyable. Therefore, car use is reinforced as the alternatives are not attractive and as a result, more cars are used. With more cars comes the need for more and wider roads and in turn the chance that people will travel by foot, bicycle or transit is reduced.(20)

In order to establish a more compact, easily-served community, more of the population growth must be accommodated within existing areas of development. Many people associate increased density with high-rise apartment buildings, but density can be increased using buildings not higher than five storeys. The choices available to increase the density of a development depend on their appropriateness for the area. The increased building density needs to fit into the existing neighbourhood. According to the Smart Choices Development Checklist, this development can be either small-scale or medium density residential which can be defined as:

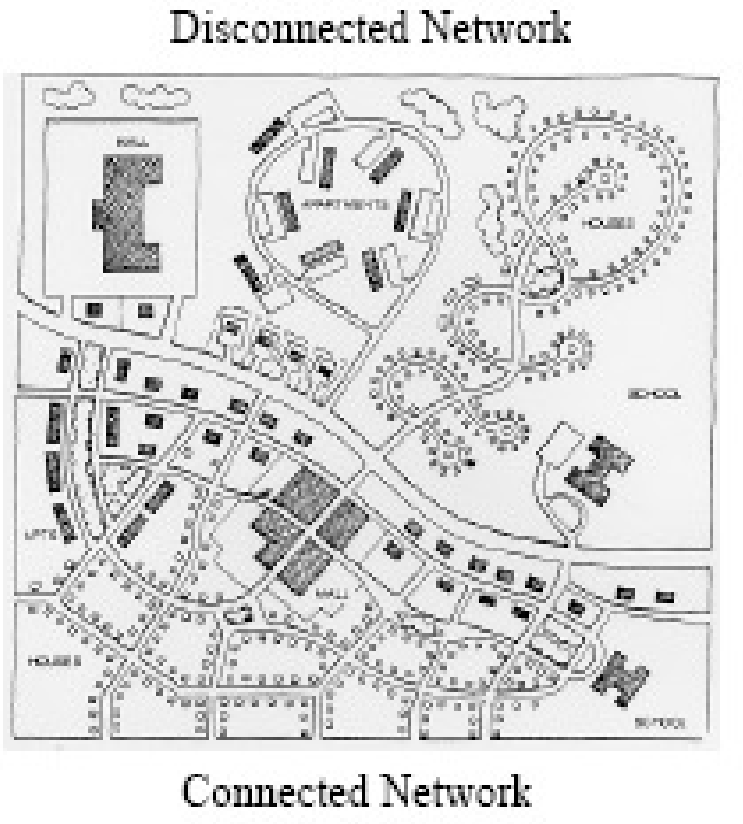
Small-scale residential infill includes the construction of single-detached houses on smaller subdivided lots, semidetached houses (duplexes), triplexes, four-plexes, and up to 6 units of row housing. Small-scale residential infill also includes secondary suites, coach houses, granny flats, and suites above garages. Medium density redevelopment refers to intensification on a moderate scale. It usually involves larger sites or sub-areas of a neighbourhood, and the construction of medium density housing types including linked or patio-homes (single-storey retirement complexes), rowhousing (more than six units), and apartment housing (up to 4½ storeys).(58)

Areas within Toronto provide examples where higher densities are created with and without the use of high-rises. The neighborhood near Don Mills Road north of Sheppard Avenue known as “The Peanut” has a gross density of 63 residents per hectare and has 55 per cent of its residential units in apartment buildings higher than five storeys. However, in the former Borough of East York, an area located between Coxwell Avenue and Victoria Park Avenue from east to west, and between the East Don River and Sunrise Avenue in the north and Danforth Avenue in the south, the same density was achieved with less than 12 per cent of its residential units in buildings higher than five storeys (Environmental Defence, as cited by Bray et al, 2005).

Land use mix is another factor that influences physical activity. It is defined as the

proximity of different land uses within a given area. The measurements for land-use mix include distance from each residence in a neighbourhood to the nearest store or the number of different land uses within a given area. Land use mix is a critical factor for achieving effective densities that promote physical activity and is correlated with increased walking and decreased automobile travel.(57) A mixed-use neighbourhood includes homes as well as offices, stores, restaurants and other services and amenities. Areas of high sprawl typically consist of low mixed-use land patterns with large residential areas without retail or businesses nearby. The LUTAQH (Land Use, Transportation, Air Quality and Health) study in Seattle found that land uses most strongly linked to household walking trips were to educational facilities, commercial office buildings, restaurants and taverns, parks and neighbourhood scale retail establishments, with civic uses and grocery stores following closely.(57) Situating schools, workplaces and stores near residences may result in more walking and bicycling. Even if the overall urban densities are low, transit may be feasible along connecting corridors when different services are clustered into nodes.

Figure 2 Comparison of Connected vs. Disconnected Networks



Source: (Diagram by Frank Spielberg) Frank and Engelke, 2006. How Land Use and Transportation Systems Impact Public Health: A literature review of the relationship between physical activity and built form.

Connectivity is the third factor that influences physical activity and is defined as the directness or connectedness from one point to another within a street network or the availability of alternative routes.(57) More connections among roads, sidewalks and bike lanes reduce the distance needed to travel to a destination. As seen in Figure 2, Comparison of Connected vs. Disconnected Networks, the traditional grid design provides more points of connection than the “loop and lollipop” design of hierarchical roads and cul-de-sacs. People living in the connected network can easily walk or cycle to the school and the local mall. The disconnected network area has distinct residential, commercial, school, and apartment areas and the distances between the areas necessitate use of an automobile. Walking trips are more affected by street network patterns than vehicle trips due to their lower travel speeds and shorter distances.(57) The LUTAQH study found that walking increased by 14 per cent for each quartile increase in street connectivity.(King County ORTP, as cited in Frank, Kavage & Litman, 2007) While connectivity is best determined when communities are first planned, retrofitting is possible by adding connecting links with sidewalks and diagonal paths, removing barriers and improving maintenance of streets and sidewalks and reducing traffic volume and speed.(57)

Land use planning does influence the amount of physical activity that a person can do. In order for an environment to support increased physical activity, the usual land use planning practices need to be changed to allow for increased density, more mixed land uses and better connectivity. The City Council of Edmonton, Alberta, approved a planning initiative called *Smart Choices* in 2004 which aims to accommodate growth while minimizing urban sprawl through intensified land development.(59) Woven within the focal areas identified for development is the concept of walkability, which is the degree to which walking is supported by the surrounding environment. The major elements that contribute to a Walkable City are higher population and building density, a mix of land uses, and an extensive interconnected pedestrian network that includes sidewalks, walkways and multi-use trails.(58)

Residential infill is a key component to increase both population and building density.(59) At its core, infill is about using what you have, which is existing development, and adding to it. Additional housing is provided where residential, infrastructure and services already exist. It involves incorporating more housing in older or more established neighbourhoods that is both compatible and complimentary to the existing development. Both small-scale and medium density residential redevelopment can occur depending on the area and its appropriateness. It does not mean that a 25-story apartment building is stuck in the middle of a development of single-detached houses. Residential infill development within a city is an alternative to the suburban sprawl that has been occurring outside the city limits.

More mixed land uses involves reinvestment in existing, older neighbourhoods and reviving deteriorated commercial and industrial areas along major transportation corridors(59) so that residential, commercial, office and industrial environments are

within a closer geographical area and result in shorter travel distances between places in daily life.(15) Active transportation is increased and automobile travel is reduced when people live closer to shopping and work. Older neighbourhoods with infill development need to be supported in order to meet the increased demands placed on them. Money needs to be spent on maintaining and upgrading hard infrastructure such as roads, storm and sanitary sewers, water mains, sidewalks and lighting, as well as soft infrastructure such as parks, boulevard trees and community facilities.(58) Neighbourhood reinvestment also includes renovation and new building construction to support the establishment of new businesses in older, under-utilized commercial and industrial areas along major streets.(59) The overall health of the public still needs to be considered and protected and encouraging increased proximity of work and home does not mean that industries that produce harmful or noxious by-products should be located near residential areas for the sake of more walking. Rather, the aim is to locate work environments which can safely coexist with residences closer to them.

Increasing the number of connections, or connectivity, among streets, bike lanes, trails and sidewalks will also increase physical activity. While upgrading and linking sidewalks are a component of walkability, “(s)idewalks by themselves will not induce walking” (Smart Choices, as cited in Walkable Edmonton Toolkit). Neighbourhoods need to relate to each other though expanded interconnected pedestrian and cyclist networks that include sidewalks, walkways, bike paths and multi-use trails. Increasing connectivity is supported by increasing the density and adding to the mix of development.

Transportation systems connect different land uses and determine the ease and convenience of usage by pedestrians, bicycles, cars and transit.(31) Transportation systems represent the cumulative result of investments in transportation infrastructure that carries traffic. They include the network of streets in a city, the design of individual streets and highways, rail lines and dedicated lanes for transit systems, and separated systems for non-motorized users.

The first way in which transportation systems influence physical activity is by street networks. Street networks influence the mode of travel and trip frequency through the ways in which trip origins and destinations are connected. Street networks are arranged using either a grid pattern or a transportation hierarchy pattern. The classic grid pattern consists of two sets of parallel streets crossing at right angles to form square or rectangular blocks. Grids are theoretically capable of increasing walking and biking trips in two ways. The grid pattern reduces trip distances as they have a large number of intersecting streets, thereby reducing the distance between trip origin and destination. Grid patterns also increase the number of route choices so that different routes can be made according to the desire for variety, safety and convenience.(54) Designing a city’s street network with a greater number of blocks, intersections, bicycle pathways and sidewalks allows residents to walk and cycle and interact with one another.(56)

Street networks can also be configured using a transportation hierarchy based on traffic

volume. This pattern is typical of most contemporary suburban development. At the top of the hierarchy are arterial roads, then collector streets and finally residential streets. Arterial roads are designed to carry high-speed, high volume traffic between major destination points. They are not designed to be used by non-motorists and therefore have no pedestrian or bicycle amenities. Collector streets are meant for moderate vehicle capacity and are a buffer between the arterial roadway and residential streets. Residential streets support low volume traffic and often loop back upon themselves or are laid out in a cul-de-sac fashion. With its winding arterials fed by cul-de-sac streets, this pattern has been described as “loops with lollipops”.(56) These areas are characterized by a low number of blocks and intersections per unit of area which reduces the degree of connectivity between trip origins and destinations. Therefore, both walking and biking are discouraged by increasing trip length and decreasing both route and modal choice.

The second way in which transportation systems influence physical activity is by street design, which refers to the design and look of individual streets themselves. Design characteristics refer to the aesthetic, physical, and functional qualities such as the look of streetscapes and buildings. They work on a smaller scale and give a sense of place(31) and determine if newly constructed buildings reinforce surrounding architectural periods and blend in or if a building looks out of place amid its surroundings. Within design characteristics are four categories that arrange the determinants of walking and bicycling and include the following factors: function, safety, aesthetics and destination.

As with street networks, street design can either encourage driving and discourage walking and biking or vice versa. Design characteristics determine whether a street has wide sidewalks, a canopy of trees, places and furniture for sitting and the presence of people, which encourages walking and cycling; or whether a street has no sidewalks, little vegetation, large billboards and few people, which supports driving.

The street environment is perceived differently by drivers as compared to pedestrians or cyclists. The key difference is the speed at which the information is processed.(32) These perceptions influence travel behaviour in subtle but important ways (Rapoport, as cited in Frank and Engelke, 2006). Since drivers travel at faster speeds than pedestrians, the ideal environment for the safe handling of vehicles is one that is simple and uncluttered with little visual information to process. Streets that are wide, with little visual detail and contain no abrupt corners, make driving easier.(32) However, pedestrians and cyclists travel at significantly slower speeds and can take the time to notice and enjoy more varied and complex environments. Streets that are more visually complex include those with shade trees, sidewalks, crosswalks and bike paths, and attract pedestrians and bicyclists. Rapoport’s research (as cited in Frank and Engelke, 2006) identified street design characteristics that appealed to drivers and those that appealed to pedestrians. Drivers preferred wide streets and spaces, simple buildings, gradual curves and long views, whereas pedestrians favoured narrower streets and spaces, sudden changes in direction, short views and complex buildings.

Street design in North America has catered to the needs of automobile traffic, resulting in design standards for streets that encourage driving and discourage transit, walking and biking. For example, most shopping areas provide large areas for parking cars around the store and sidewalks are on the perimeter of the shopping area. A driver is able to park as close as possible to access the store whereas the pedestrian has to walk from the sidewalk and through the parking lot to access the store.(6) However, street networks can be designed to increase the level of connectivity and increase the amount of public space thereby supporting transit, walking and biking and discouraging driving.(56) Placing buildings close to the sidewalk and positioning the parking either behind the building or underneath it encourages walking, cycling and public transit use.(57) The safety and appearance of the streetscape can be improved by increasing the presence of sidewalks, increasing the amount of on-street and surface (ground-level) parking, and enhancing transit accessibility as well as improving the perception of safety and walkability.(57) Walking, cycling and public transit use can also be encouraged through the use of traffic calming measures that are deliberately designed to slow vehicle speeds and hinder vehicle movement.

The third way in which transportation systems influence physical activity is through the creation of dedicated bicycle and pedestrian facilities that are physically separated from roads such as bike paths and walking trails. One popular example is the “Rails to Trails” system that converts abandoned railway lines into trails. Abandoned railway lines are primarily a North American phenomenon and reflect the dominance and accommodation of vehicle use that has characterized transportation systems thinking. North America used to use railways but in the last 40 years has relied on long-distance trucking, whereas European countries continue to use their railways for transportation and shipping. Most abandoned railway lines exist in rural areas and not urban areas, but nevertheless rail trails can serve as a linkage to connect rural communities. There are few examples of these separate systems so there is little literature on the physical activity impacts of such systems.

Transportation systems need to integrate human-powered movement as an integral component of overall transportation planning. The transportation system planning of most communities indicates that driving needs have been assigned a high priority and pedestrian needs have received a low priority. But ultimately, we are all pedestrians as every trip begins and ends on foot. Environments that support increased physical activity are characterized by increasing the connectivity of street networks, improving the design, attractiveness, and perceived safety of street, sidewalks and bike paths, and increasing the linkages between active transportation and mass public transit.

Neighbourhoods that are scaled to people are more pedestrian and cyclist friendly.(Smart Choices as cited in Walkable Edmonton Toolkit) Many older neighbourhoods were planned using a grid design and therefore have more existing connections and route variations, so any housing, stores or offices added to these neighbourhoods need to ensure that connectivity is maintained. Within the sprawling

developments planned with “loop and lollipop” road designs, connectivity can be increased through retrofitting. Adding sidewalks, linking cul-de-sacs and roads within subdivisions by paths, and removing barriers like fences between sub-divisions(57) will re-focus the existing infrastructure towards the needs of the pedestrian and cyclist. Linking existing parks with paths and trails opens new options for walking, biking, running and other forms of active transport.(59)

Public transit is another key component for local and regional transportation systems. But previous strategies used have not been successful in attracting people to use public transit nor in sustaining its use. The focus needs to be on making transit accessible where the people live and work. “Transit-oriented development encourages density close to key transit stations and puts transit where the people are to make it convenient to access, not where the roads are.”(59) As well, infrastructure supports must be in place so that people can walk or cycle to access it. For example, sidewalks and bike paths need to be maintained and snowplowed and secure areas for bicycle storage must exist in order to sustain usage.

2.1.7 Studies Linking Health and the Macro Built Environment

Recently, researchers have begun to study the relationship between urban sprawl, rates of obesity and physical activity. Their hypothesis is that living in sprawling suburbs with design features that discourage walking and bicycling and encourage residents to drive more may be a contributing factor to decreased physical activity and the obesity epidemic. The majority of published findings indicate that relationships do exist between the built environment and health outcomes including levels of physical activity and overweight and obesity status.

Regional differences in obesity have been identified based on actual measurements of height and weight from the 2004 Canadian Community Health Survey.(60) The study examined obesity and overweight individuals inside and outside census metropolitan areas (CMAs), which are defined as one or more adjacent municipalities centred on a large urban area.(60) Adults who lived in large Canadian cities in 2004 were far less likely to be obese than were their counterparts who lived outside such metropolitan areas. Overall, 20 per cent of CMA residents aged 18 years or older were obese in 2004, compared with 29 per cent of those who lived outside a CMA. The national average for obesity was 23 per cent.(60)

In addition, as the size of the city increased, the likelihood of being obese fell. Only 17 per cent of adults were obese in CMA’s with a population of at least 2 million (Toronto, Montréal and Vancouver). In CMAs with a population of 100,000 to 2 million, 24 per cent of adults were obese. In urban centres with populations of 10,000 to 100,000, 30 per cent of adults were obese.(60)

The report examined whether low obesity rates in the largest cities could be explained by the tendency of immigrants to settle in these areas, given that immigrants are less

likely than people born in Canada to be obese.(60) However, the relatively low prevalence of obesity in large cities persisted, even when immigrant status and the number of years since immigrating were both taken into account.(60)

Lopez (2004) compared different regions to determine if people living in areas of high sprawl had higher rates of obesity.(43) Even the extent of the sprawl differed vastly among the areas compared as the sprawl index values ranged from 6.72 to 100.00. Lopez found that the risk of being overweight or obese increased with the higher sprawl index, taking into account such variables as race, income, age, education and gender. In fact, residents had a 0.2 per cent increased risk of being overweight and a 0.5 per cent increased risk of being obese for every one-point increase in the sprawl index (as cited in Bray, 2005).

In a 2003 study, Ewing et al (as cited in Atlanta Regional Health Forum, Atlanta Regional Commission, 2006) found that people living in counties characterized by sprawling development were likely to walk less, weigh more and have a greater prevalence of hypertension than did people living in compact communities, controlling for age, education, gender, race and ethnicity.(56) The same researchers looked at the impact of sprawl on its residents another way. They found that regardless of whether the residents walked for exercise or not, people living in higher levels of sprawl were heavier.(56) The researchers postulated that this was a result of residents not being able to incorporate physical activity into their daily routine.(56)

In 2004, Frank and his colleagues identified additional connections among built environment, activity and obesity. Residents of counties characterised by sprawling development also spent more time driving, a sedentary activity. Research on more than 10,500 people in the Atlanta area indicated that the more time a person spent in a car, the more obese s/he tended to be.(56) For every hour spent driving in a car, the likelihood of being obese increased by 6 per cent (Frank et al, SMARTRAQ, 2004 as cited in Atlanta Regional Health Forum and Atlanta Regional Commission, 2006). The same study also found that there was a 4.8 per cent reduction in the likelihood of obesity with every kilometre walked per day and the more time people spent walking, the less likely they were to be obese.(61)

Frank's research found that areas with a mix of homes, shops and offices had fewer obese residents than areas containing only homes, controlling for age, income and education. Neighbourhoods with greater residential density and street plans that facilitated walking from place to place showed below-average rates of obesity.(61) The magnitude of the effect was not trivial. A typical white male living in a compact, mixed-use community weighs about 4.5 kilograms (10 pounds) less than a similar man in a subdivision containing nothing but homes.(61)

There has been criticism of the theory that urban sprawl is related to obesity. These critics argue that people who do not like to exercise choose to live in areas that do not encourage walking and cycling and where they need to drive to get anywhere or do

anything.(43) The critics contend that it is not necessarily the sprawling environment that brings about the obesity of this group but rather certain groups choose a neighbourhood which supported driving and inactivity and these groups happen to be overweight or obese. However, research done by Saelens et al in 2003 found that there were no differences in minutes walked when walking for recreational exercise between high and low-walkability neighbourhoods. They did find that rates of utilitarian exercises, such as walking trips for errands, were higher in neighbourhoods that were rated as highly walkable.(62) An analysis of studies in six communities found that on average, residents in highly-walkable neighbourhoods took twice as many walking trips as people in less walkable neighbourhoods and that most of the increase was due to walking for errands or to go to work.(62) This research indicated that people who did not walk for exercise were not a self-selected group who choose to live in urban sprawl areas. Rather, living in a neighbourhood not conducive to walking for errands was what was contributing to their obesity.(43)

In late 2006, a group of economists studied the relationship between urban sprawl and obesity. They argued that “we may observe more obesity in sprawling neighbourhoods because individuals who have a propensity to be obese choose to live in these neighbourhoods”.(63) In other words, people with tendencies to gain weight may sort themselves into different kinds of neighbourhoods, such as sprawling neighbourhoods, where they would not have to be physically active. One of their criticisms was that previous work had been done using cross-sectional studies and provided a snapshot of different people at a single time. They correctly stated that cross-sectional studies could not prove causation which, in this case, was that living amid sprawl led to inactivity. However, what they did differently from previous critics is that they conducted a longitudinal study and analyzed data collected over six years on more than 5000 young adults living across the United States who moved at least once during the study. They compared the weight of the participants before and after they moved between communities with different degrees of sprawl and found no significant difference.(63) They concluded that there was no effect of sprawl on weight. Rather, they postulated that obese people chose to live in areas where they did not have to be active and these areas happened to be low-density, car-dependent areas that were labelled as sprawl.

As this study was one of the first longitudinal studies conducted, more research is needed to test these findings. It could be the case that people who tend to be less active are inclined to live in neighbourhoods that do not encourage activity. One criticism of their study was that the use of young adults was not reflective of the age spectrum of people who typically lived in the suburbs. However, the bulk of the research conducted previously did indicate that regardless of inclination, people who lived in compact, walkable areas were more physically active. Indeed, recent research indicated just that – both preferences and the neighbourhood people lived in impact on their walking behaviour.

Findings presented in November 2006 by Dr. Lawrence Frank at the *Healthy Eating Active Living Conference* indicated that both preference and the built form impacted on

physical activity levels. While there was evidence that people who were less active tended to live in less walkable neighbourhoods he found that people who live in walkable environments were more likely to walk regardless of their preference to live in a walkable or less-walkable environment. Additionally, people who live in walkable environments were less likely to be obese. His results showed that among those people who preferred a walkable environment and lived in one, 51.2 per cent of them walked and 13.2 per cent of them were obese. Among those people who preferred a walkable environment but did not live in a walkable environment, 19 per cent walked and 17.5 per cent were obese. In the same way, he identified that people who live in less walkable environments were less likely to walk regardless of their preference. Among those people who preferred a less walkable environment and lived in a less walkable environment, only 3.4 per cent walked and 27.2 per cent were obese. But among those people who preferred a less walkable environment but nevertheless lived in a walkable environment, 7.5 per cent walked and 27.6 per cent were obese.(64)

Dr. Frank concluded that people walked more in areas that facilitated walking, regardless of their preference of walking-related environments. People walked less in areas that did not facilitate walking. He also found that people living in an environment that discouraged walking were more likely to be obese regardless of their preference of walking-related environments. With walking, the living environment had more impact than personal preference. The design of the environment people lived in did impact the amount of walking. As well, the design of the environment lived in did impact the amount of obesity.(64)

2.1.8 Conclusion

The evidence presented indicates a strong relationship among health, physical activity and the way we plan and design our communities. The findings of this section include that physical activity levels have declined sharply over the past 50 years and there are more sedentary activities that capture our attention. The built environment around us can either facilitate or constrain our ability to be physically active. Land use patterns, transportation systems and design features influence the health of the population by affecting the convenience, practicality and amount of any activity for both recreational and utilitarian purposes.

Unfortunately, a growing majority of the population is exhibiting the negative health impacts of living in residences built in sprawling patterns. The current indicators are increased physical inactivity and increase overweight and obesity among adults, children, and adolescents. The longer term impact will be seen in increasing chronic disease, decreased quality of life and a health care system over-taxed by illnesses that were preventable. The available empirical evidence shows an association between the built environment and physical activity but few studies have been conducted that demonstrate a causal relationship. One of the challenges is that most of the research has used cross-sectional studies correlating health indicators with land use design or transportation practices. Nevertheless, public health and local decision makers do not

need to wait for better research designs to provide evidence of causation. Enough research has been conducted to indicate that changes in the built environment are necessary and that action is necessary now.

2.2 Injury Prevention

2.2.1 Introduction

Research has found that the great majority of injuries are predictable and preventable. But when most people are asked for words associated with injury, a common response is the word “accident”. Traffic collisions and the resulting injuries and deaths are events that have become familiar and almost commonplace. Many people feel that accidents are part of the risk of driving and one has little control over whether or not they happen. However, people are less likely to take action to prevent injuries when they believe that injuries and deaths are caused by “accidents” and that “accidents” are uncontrollable and unavoidable.

When “accidents” are studied, many commonalities are identified in the interaction of pre-existing poor environmental conditions and high-risk behaviours that result in a specific outcome, inaccurately labelled an “accident”, which is actually a predictable event. A colloquial way of saying this truth is the phrase “it is an accident waiting to happen”. In fact, given a situation where the pre-existing poor conditions and high-risk behaviours exist together and intersect, the resulting event is foreseeable and avoidable. Therefore, strategies can be developed and used to prevent or reduce the environmental conditions and behaviours that cause the injuries.

This section will focus on how the built environment impacts fatal and non-fatal injuries sustained while on the road. The area of injury prevention examined will be on fatal and non-fatal injuries sustained by the driver and/or occupants of a vehicle, and pedestrians and bicyclists while in traffic. Examples will be given from other jurisdictions where the development and use of the land, transportation system and design elements have been integrated and has resulted in reduced rates of collisions, injuries and fatalities.

2.2.2 Injuries Influence Health

Traffic crashes are a major health risk and impose large economic costs on society (Wang et al, as cited in Frank, Kavage & Litman, 2007). In Ontario, unintentional injury ranks fourth among the leading causes of death after cancer, circulatory system diseases and respiratory diseases (Ministry of Health and Long-Term Care, as cited in Toronto Public Health Department, 2006).

Injuries kill people in the prime of their lives. For persons under the age of 45 years, injury is the leading cause of death and is a serious cause of disability (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta). Deaths

due to trauma are the leading cause of potential years of life lost for Canadians under the age of 45 years (CIHI 2001, as cited in Injury Control Facts for Canada and Alberta). The concept of potential years of life lost (PYLL) can be articulated as “dying before your time” or “dying prematurely”. Because collisions tend to injure and kill people at a relatively young age, the costs are larger still when measured by potential years of life lost, rather than just deaths (WHO, as cited in Frank, Kavage & Litman, 2007). In Simcoe Muskoka, motor vehicle collisions are the leading cause of death for 10 to 44 year olds, responsible for 19 per cent of all deaths in this age group (where the definition of motor vehicle collisions includes “occurring on a public thoroughfare resulting in the death of motor vehicle passengers, pedestrians, cyclists or motorcyclists”).(65)

Injuries cost all of us. At a national level, the economic burden of unintentional and intentional injuries as a whole is estimated to be $12.7 billion per year, which is eight per cent of the total cost of illness in Canada for direct and in-direct costs (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta). Injuries rank fourth in expenditure after cardiovascular diseases ($18.5 billion), musculoskeletal diseases ($16.4 billion) and cancer ($14.2 billion) (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta).

Deaths due to injuries in Canada cost $5.9 billion (17.7 per cent of all mortality costs) and rank third following cancer ($10.6 billion, 31.7 per cent of all mortality costs) and cardiovascular disease ($8.2 billion, 24.6 per cent of all mortality costs). Among injuries, the majority of mortality costs are accounted for by suicide ($2.2 billion, 36.6 per cent of all injury costs) and motor vehicle collisions ($1.6 billion, 26.3 per cent of all injury costs) (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta).

Based on 1996 data, it is estimated that these injuries result in Ontario spending nearly $3 billion in direct (health care) and indirect (social and economic productivity losses) provincial costs.(66) In 2003-4, about 11 per cent of injury-related hospitalizations and seven per cent of injury-related deaths in Ontario were due to vehicle collisions (Canadian Institute for Health Information, as cited in Toronto Public Health Department).

In a report examining the period 1997 to 1998, it was found that although fewer than 6 per cent of Americans take trips on foot, 13 per cent of all traffic fatalities occur among pedestrians - 10,696 people (Surface Transportation Policy Project, as cited by Jackson and Kochtitzky, 2001). Children account for approximately 1,500 of these deaths, about 14 per cent of all traffic fatalities. Even though only 13 per cent of the American population is elderly, 22 per cent of all traffic fatalities occur among pedestrians older than 65 years of age (Surface Transportation Policy Project, as cited by Jackson and Kochtitzky, 2001).

According to Ontario Ministry of Transportation’s 2004 Ontario Road Safety Annual

Report, there were 380,473 motor vehicle registrations in Simcoe Muskoka. During 2004, there were 9951 collisions, of which 41 were fatal, 46 people were killed and 2899 persons were injured.(67)

Given the significant increases in population size and vehicle kilometres traveled in Canada, there has been a decrease in traffic-related deaths and injuries. Over a 20 year period, deaths have declined by approximately one-third since a peak level in 1985.(43) The number of persons killed in motor vehicle collisions per 100,000 people in Ontario dropped from 10.4 in 1995(68) to 6.44 in 2004.(67) From 1995 to 2004, the number of serious injuries decreased by 36.1 per cent, and minor injuries by 12.9 per cent (Ministry of Transportation, as cited in Toronto Public Health Department 2006). A number of factors have contributed to the reduction in motor-vehicle-related fatality and injury rates including such measures as seatbelt use, airbags, more crashworthy vehicle design and improved road system design (limited access highways and improved traffic signals).(43)

The two most common measures of road safety in North America are the number of fatalities for every 10,000 licensed drivers in a jurisdiction (fatality rate per 10,000 licensed drivers), and the number of fatalities per 100 million kilometres travelled by motor vehicles (fatality rate per 100 million kilometres). In 2004, Ontario's rate of 0.92 fatalities per 10,000 licensed drivers was the lowest in North America and down from 0.97 in 2003.(67) Ontario's fatality rate per 100 million kilometres also declined to 0.66, down from 0.71 in 2003.(67) The total number of fatalities from motor vehicle collisions in Ontario fell below 800 for the first time since 1950, to 799.(67) The number of fatalities involving drinking and driving in Ontario also decreased, falling by more than 10 per cent from 217 in 2003 to 192 in 2004(67). The Ministry of Transportation of Ontario (MTO) and local road authorities determine the safety of Ontario’s roads and highways by examining the location of collisions. Comparing the number of collisions and injuries within specific municipalities over the years can help to highlight areas where trends in road safety change over time.(67) This information helps the MTO and local authorities to prioritize their infrastructure projects.

2.2.3 Vehicular Travel Influences Injuries

Any travel involves some risk of death or injury. However, the automobile is a relatively dangerous way to travel. A mile of motor vehicle travel has a higher likelihood of resulting in a traveler’s death than a mile of airplane, bus or train travel (Halperin, as cited in Frumkin et al, 2003). The National Safety Council has calculated the lifetime odds of dying for the following modes of travel: one in 242 as a driver or passenger in an automobile, one in 4,608 as a passenger on a plane, one in 170,003 as a bus passenger, and one in 119,335 as a train passenger (National Safety Council, as cited in Frumkin et al, 2003). The more driving or travel one does in a motor vehicle, the more one is exposed to increased risk of injury.

Research shows that there are three key factors that play causal roles in traffic

collisions, injuries and fatalities. They are traffic volume, vehicle speed and street environment. Traffic volume, defined as the number of vehicles on the roadway, is the most important causal factor in traffic collisions, injuries and fatalities. As a society, we are increasingly exposed to the risks of the road because there are more people and vehicles on the road and we are driving more kilometres. The number of motor vehicle kilometres Ontarians traveled increased from an estimated 78,167 million vehicle kilometres traveled in 1994(69) to an estimated 122,079 million vehicle kilometres in 2004(67), an increase of 56 per cent over just 10 years. The ever-increasing amount of time spent in a car and the escalating annual distance traveled means people are being exposed to the risks involved in travelling more often and for longer periods of time.(43) As well, there are more people in Ontario and more licensed drivers. According to the 1994 Ontario Road Safety Annual Report, the population of Ontarians has increased from an estimated 9,624,670 (based on 1991 statistics)(69) to an estimated 12,407,300 in 2004(67), an increase of 29 per cent. In 1994, the number of licensed drivers was 6,983,960(69) with 6,406,581(69) registered motor vehicles. By 2004, the number of licensed drivers increased to 8,655,597(67), a 24 per cent rise, with 7,698,416(67) registered motor vehicles, a growth of 20 per cent. While population growth, the number of licensed drivers, and the number of registered motor vehicles increased at percentage rates within the mid-twenties, the rate of kilometres travelled increased by more than 50 per cent. As a society, we are driving more kilometres than ever before and this could be influenced by the greater amount of sprawl that has occurred over the last 10 years.

Heavy traffic volume is a significant deterrent to walking and biking. In a study of San Francisco streets, Appleyard and Lintell (as cited in Frank and Engelke, 2006) assessed the feelings of residents regarding privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution to determine how traffic conditions affected the livability and quality of the street environment. Three streets were chosen with varying traffic volumes. One street, with a traffic volume of 15,750 vehicles per day was classified as heavy volume, a second street with 8,700 vehicles per day was classified as moderate, and the third street with 2,000 vehicles per day was as light. Using a five-point satisfaction rating scale, the heavy traffic volume street scored the worst and the light traffic volume street the best in all categories - privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution. The scores for the light street ranged between 1.2 and 2.6 (with 1 being most satisfied), while those for the heavy street ranged between 3.0 and 4.5 (with 5 being the most dissatisfied) with the scores for the moderate street always in-between those of the light and heavy streets.

Vehicular speed is the second causal factor of traffic collisions, injuries and fatalities. There are higher numbers of fatalities resulting from traffic crashes with the increased speed of the vehicle at the time of impact. Where **speed limits exceed 60 km/hr**, about **two-thirds** of the **collisions that occurred caused fatalities** (Transport Canada, as cited by Bray, 2005). In comparison, in areas with posted **speed limits below 60 km/hr**, **70 per cent** of the **collisions involved injuries** and not fatalities.(43) Speed at

impact determines whether the outcome is life, injury or death. Essentially, collisions at fast speed (exceeding 60 km/hr) usually result in death whereas collisions at slower speeds (below 60 km/hr) usually result in injuries.

Lower speeds allow drivers more time to react to unforeseen hazards and reduce the severity of impact when collisions occur. There is a non-linear relationship between the speeds a vehicle is traveling to the distance needed for the vehicle to stop. At 40 miles per hour (mph) (which is about 65 km/hr), a driver needs about 300 feet (which is just over 91 metres) to stop; at 30 mph (about 49 km/hr), the stopping distance is 197 feet (which is about 60 metres), and at 20 mph (about 32 km/hr), it is only 112 feet (which is just over 34 metres) (AASHTO, as cited by Ewing, Frank & Kreutzer, 2006).

Vehicle speed has an impact on the severity of injuries experienced by pedestrians in collisions as well. One study in the United Kingdom (Pilkington as cited in Toronto Public Health Department, 2006) found that a pedestrian has an 85 per cent chance of being killed if struck by a vehicle traveling 40 mph (which is about 65 km/hr). That risk drops significantly when the vehicle speed is reduced by 10 mph (which is about 16 km/hr). Pedestrians have a 45 per cent chance of being seriously injured or killed when struck by a car traveling 30 miles per hour (mph) (48 km/hr) and the risk drops substantially to only a five per cent chance of serious harm or death when struck by a car traveling at 20 mph (which is about 32 km/hr). The study also found that 20 mph zones reduced actual vehicle speeds by about 9 mph (5 km/hr), decreased all traffic collisions by 60 per cent, and reduced traffic collisions involving child pedestrians or cyclists by 67 per cent. An incremental reduction in speed significantly decreases the risk of injury or death.

An American study compared the outcome of crashes between a pedestrian aged under 20 years and vehicles traveling at different speeds. Compared to vehicle crash speeds of 16 to 31 kilometres/hour, the risk of serious injury or death a pedestrian aged under 20 years was 30.7 times higher at a speed of 64 kilometres per hour (km/h) or more, 7.2 times higher at a speed of 48 to 63 km/h, and 2.1 times higher at a speed of 32 km/h.(20)

Another study (Peterson et al, as cited by Ewing, Frank & Kreutzer, 2006) that looked at the risk of pedestrian injury found that injury increased by 7.6 times with an increase in the average speed of just 10 mph, from 20 to 30 mph. The authors concluded that measures that lower vehicle operating speeds should reduce the frequency and severity of traffic accidents. This study also found that the number of parked cars on the street was the second most influential factor in pedestrian injury.

A third causal factor is the street environment, which is defined as the built environment along the roadway and the activity it generates. Changes in engineering standards over the past 30 to 40 years have resulted in roads that generally have fewer curves, fewer roadside objects, and have wider and more travel lanes. While fatalities per mile traveled have declined substantially over the same period, this has led to the erroneous

belief that wide, straight and open roads improve traffic safety. But this belief ignores confounding factors such as increased seatbelt use, and also ignores behavioural changes on the part of drivers in response to road improvements (possibly driving farther, faster and less carefully). A study presented at the 2001 Annual Meeting of the Transportation Research Board (as cited by Ewing, Frank & Kreutzer, 2006) found that highway improvements over the past 14 years had actually had a negative effect on highway safety when demographic changes, increased seatbelt use, and improved medical technology were controlled (Noland, 2001; Noland, 2003, as cited by Ewing, Frank & Kreutzer, 2006).

Street design is another important factor in the safety of both motorists and pedestrians. Wide residential streets encourage increased speeds and thus are more dangerous; 55 per cent of the 6,000 vehicle-related pedestrian deaths each year occur on residential streets.(56) Roadways designed only for automobiles pose serious risks for pedestrians and cyclists.(56) The combination of fast-moving traffic and designs hostile to non-motorized transport create an environment that is unpleasant as well as unsafe. The most dangerous American metropolitan areas for walkers were newer, sprawling, southern and western communities where transportation systems are more focused on the automobile at the expense of other transportation options (Surface Transportation Policy Project, as cited by Jackson and Kochtitzky, 2001).

Some street environments encourage driver alertness and anticipation to exercise caution while other street environments are less engaging and discourage attentive driving. Crashes between motorists and pedestrians or bicyclists are less likely when there are more people walking or bicycling (Jacobsen, as cited by Ewing, Frank & Kreutzer, 2006). Several data sources show that in environments with many pedestrians or bicyclists, motorists come to expect them and adjust their behavior accordingly (Jacobson, 2003; Leden et al, 2000; Leden, 2002, as cited by Ewing, Frank & Kreutzer, 2006). However, as walking and bicycling decline, driver awareness declines as well, making the street environment conditions even more dangerous for pedestrians.(57)

Other causal factors that contribute to rates of collisions, injuries and fatalities on roads include driving while impaired due to alcohol or other substances and increased numbers of sports utility vehicles (SUV's) on the road. Motor vehicle collisions are responsible for nearly half of the severe trauma cases. In Canada, more than half of the severe trauma cases involved alcohol consumption during 2002-03 (Canadian Institute for Health Information 2005, as cited in Toronto Public Health Department, 2006). The number of severe trauma cases has increased by 9 per cent in Ontario over the three-year period from April 1999 to March 2003 (Canadian Institute for Health Information, as cited in Toronto Public Health Department, 2006).

The design of SUV's increases the severity of injuries for pedestrians. Since the front end of an SUV is higher than that of an automobile, the primary force of the SUV collision hits the pedestrian in the more vulnerable central body region whereas an automobile usually hits the pedestrian on the legs. Impact on the central body region

damages the organs and is more likely to end as a fatality. Comparing collisions in the United States found that at the same collision speed, pedestrians hit by SUV's are twice as likely to die as pedestrians struck by passenger cars.(66) Other studies have demonstrated higher rates (up to four times greater) of severe injury and death among pedestrians involved in collisions with SUV's.(66) The increased height of SUVs and light trucks also presents an increased risk of injury to children in driveways, as it is often more difficult for drivers to see things around the vehicle (Simms, as cited in Toronto Public Health Department, 2006).

2.2.4 Sprawl Influences Fatal and Non-fatal Injuries

The built environment does have an effect on vehicle-related collisions, injuries and deaths. Sprawl, automobile dependence and traffic safety influence each other in a number of ways. As people spend ever more time in cars, their risk of being in an accident increases.(57) The design of communities influences how reliant the residents are on the use of automobiles for transportation and, in turn, increased automobile use contributes to an increased likelihood of more motor vehicle crashes and pedestrian injuries. Additionally, roads connecting sprawling areas are designed to move vehicles as efficiently as possible – as many cars as possible and as fast as possible. The result is that when collisions occur they happen at higher speeds, and therefore are more severe.(57)

Most of the research regarding the effect of various factors on road accident rates, including the effects of urban sprawl, has come from the United States. In the United States., there are over 40,000 deaths per year with 3.4 million injuries (NHTSA 2000; AAPH 1999, as cited in Bray, 2005). Although accidents per mile driven have decreased over the years due to the physical improvements previously mentioned, the number of miles driven per person has increased due to both increasing affluence coupled with escalating low-density suburbanization.(43) The average distance driven varies remarkably depending on the degree of compactness or sprawl characterizing different American cites. In a sprawling city like Atlanta, the estimated driving distance is 35.1 miles/day on average (TTI, as cited by Bray, 2005) compared with more compact cities like Philadelphia, with 16.7 miles/day on average, Chicago with 19.7 miles/day on average and San Francisco with 21.1 miles/day on average.

Ewing et al (2003 as cited by Ewing, Frank & Kreutzer, 2006) developed Metropolitan Sprawl Indices to examine the impact of sprawl within cities and related the indices to various transportation outcomes. To develop the Metropolitan Sprawl Indices, Ewing et al took 22 land use and street network variables and reduced them to factors representing four dimensions of sprawl. The four were combined into an overall index where sprawl was defined as any environment characterized by:

- wide scattering of the population in low density residential developments which reflects varying density;
- rigid separation of homes, shops, and workplaces which reflects varying mix;
- a lack of distinct, thriving activity centers, such as strong downtowns or suburban

town centers which is known as centering; and
- a stretched-out network of roads marked by very large block size with limited access into and out of residential areas (low street accessibility) and poor access from one place to another which makes extensive vehicle use essential to access services.(Ewing, as cited by Bray 2005)
- The Metropolitan Sprawl Index was constructed so that the larger the sprawl index number, the more compact the metropolitan area. The smaller the sprawl index number, the more spread out (or sprawling) the metropolitan area.

What Ewing et al found was that three of the factors in metropolitan areas —density, mix, and centering — were significantly related to annual traffic fatalities per 100,000 residents when controlling for socio-demographic differences. Fewer fatalities per capita occurred in areas with higher density, a greater mix of homes, shops and workplaces, and a more centered the development pattern. This reduction in fatalities is due, in part, to fewer vehicle miles traveled per capita in compact metropolitan areas, and may also be due to lower average speeds. While this study was applicable to metropolitan areas, it may or may not be applicable to individual neighborhoods (Ewing et al, as cited by Ewing, Frank & Kreutzer, 2006).

Ewing et al (as cited by Ewing, Frank & Kreutzer, 2006) also developed a county sprawl index to measure the built environment at the individual county level. They used a linear combination of six variables that were available for counties - four that were related to residential density and two that were related to street accessibility from one place to another. Principal components analysis was used to extract the single factor that best represented the degree of sprawl. As with the Metropolitan Sprawl Index, the way the county sprawl index was constructed, the larger the value of the index, the more compact the county and the smaller the value, the more sprawling the county.

Ewing examined about 450 counties in detail, covering about two thirds of the United States population. At the county-level, the more sprawling the area, the higher the all-mode traffic fatality rate and the higher the rate of pedestrian fatalities, adjusted for exposure controlling for socio-economic differences across counties.(Ewing et al, as cited by Ewing, Frank & Kreutzer, 2006) The 10 most compact communities examined had an average sprawl index of 218 units and had a fatality rate of 5.6 per 100,000 and included some of the densest counties in American large cities such as New York, Philadelphia, Boston and San Francisco. On the other hand, for the 10 least dense areas in dispersed cities such as Cleveland, Atlanta and Minneapolis, the average sprawl index was 69 units and had a fatality rate of 26 per 100,000 (which was almost five times the fatality rate of the compact areas) (Ewing, as cited by Bray, 2005). Overall, the relationship indicates that a 1 per cent increase in the sprawl index function – i.e. increasing density – is associated with a 1.5 per cent decrease in the fatality rate (Ewing, as cited by Bray, 2005).

A study comparing low and higher densities neighbourhoods within the Puget Sound region found that per capita traffic casualties are about four times higher for residents in

low-density suburbs than for residents in higher density urban neighborhoods. The authors propose that this increased traffic casualty rate happens because on average suburban residents drive three times as much and twice as fast as urban dwellers (Durning, as cited by Ewing, Frank & Kreutzer, 2006). Residents in low-density suburbs face additional risks include the large number of separate trips taken for different activities, multiple access points and exits on both sides of the road, increased congestion on the road, increased speed capabilities of cars, and generally increased speed limits.(70)

2.2.5 Changes in the Built Environment Influence Fatal and Non-fatal Injuries

Traffic volume, vehicle speed and street environment all play causal roles in traffic collisions, injuries and fatalities and the built environment determines aspects of each, whether the measure is transportation or land-use related. In order to reduce the number of fatal and non-fatal traffic accidents, actions should be taken that:

- reduce traffic volumes and the vehicle miles traveled (VMT),
- decrease vehicle speeds and the amount of time spent in a vehicle or vehicle hours traveled (VHT), or
- change the street environment.

2.2.5.1 Reduce traffic volumes or the vehicle miles traveled (VMT)

Reducing the overall vehicle miles traveled (VMT) will result in proportional declines in total crash costs. For each 1 per cent reduction in vehicle miles, total crash costs are reduced by 1.0 to 1.4 per cent (Litman, as cited by Ewing, Frank & Kreutzer 2006). When 10 street variables were tested, the second most significant determinant of accident rates was average daily traffic volume (Swift et al, as cited by Ewing, Frank & Kreutzer, 2006). A study published in the British Medical Journal found that the risk of injury to child pedestrians is strongly associated with traffic volume. Sites with the highest traffic volumes had 13 times greater risk of injury than that at the least busy sites (Roberts et al, as cited by Ewing, Frank & Kreutzer, 2006). More compact, walkable land use patterns will reduce per capita vehicle miles and increase the amount of active transport in an area(57) and further reduces traffic volumes and vehicle miles.

2.2.5.2. Decrease vehicle speeds

As streets get wider, vehicle speed gets faster. Among infrastructure variables, increases in lane widths accounted for over half of the total increase in fatalities and about one quarter of the increase in injuries. A study examining 20,000 crashes in the City of Longmont, Colorado, found that crash rates increased exponentially with an increase street width (Swift et al, as cited by Ewing, Frank & Kreutzer, 2006). When 10 street variables tested, the most significant determinant of accident rates was street width (Swift et al, as cited by Ewing, Frank & Kreutzer, 2006).

A number of studies have shown that vehicle operating speeds decline somewhat as individual lanes and street sections are narrowed (Farouki and Nixon, 1976; Heimbach et al, 1983; Clark, 1985; Harwood, 1990; Gattis and Watts, 1999; Fitzpatrick et al, 2001; and Gattis, 2001, as cited by Ewing, Frank & Kreutzer, 2006). Drivers seem to behave less aggressively on narrow streets and one indication of this is running fewer traffic signals (Untermann, as cited by Ewing, Frank & Kreutzer, 2006). Also, drivers may feel less safe and drive more cautiously on narrow streets (Mahalel and Szternfeld, 1986 as referenced in: Noland, R. B., 2003, as cited by Ewing, Frank & Kreutzer, 2006).

The number of road lanes available also impacts driving speed. As the number of lanes increases, more accidents occur. On two-lane roads, prudent drivers set the pace and others must follow but on multi-lane roads, aggressive drivers can pass slower drivers, and they tend to set the prevailing speed (Burden and Lagerwey, as cited by Ewing, Frank & Kreutzer, 2006). The conversion of an urban two-lane undivided road to four lanes typically produces a substantial increase in accident rates (Harwood, as cited by Ewing, Frank & Kreutzer, 2006). Studies finding that more lanes lead to more crashes include Milton and Mannering (1998, as cited by Ewing, Frank & Kreutzer, 2006), Sawalha and Sayed (2001), Vitaliano and Held (1991), and Noland and Oh (2004, as cited by Ewing, Frank & Kreutzer, 2006).

Conversely, safety improved when the number lanes was reduced. Converting driving lanes into turning lanes removes turning vehicles from through lanes, thereby reducing common rear-end collisions. A study presented at the 2001 Transportation Research Board Annual Meeting (as cited by Ewing, Frank & Kreutzer, 2006) determined that 23 “road diet” projects, involving the reduction in cross section from four lanes to three lanes (two through lanes plus a center turn lane), produced crash reductions of two to 42 per cent (Huang et al, as cited by Ewing, Frank & Kreutzer, 2006). In another study, conversions from undivided four-lane roads to three-lane roads with center turn lanes resulted in reductions in excessive speeds; and a reduction in total crashes by 17 to 62 per cent (Knaap and Giese, as cited by Ewing, Frank & Kreutzer, 2006).

Traffic calming also reduces traffic accidents by reducing traffic speeds and traffic volumes. In a report titled *Safety Benefits of Traffic Calming* (as cited by Ewing, Frank & Kreutzer, 2006) the Insurance Corporation of British Columbia summarized 43 international case studies. Among the case studies with traffic calming measures, collision frequencies declined by anywhere from eight to 100 per cent. Apparently in no case did collisions increase with traffic calming.

Traffic circles or roundabouts and chicanes (s-shaped curves) had the most favorable impacts on safety, reducing collision frequency by an average of 82 per cent (Insurance Corporation of British Columbia, as cited by Ewing, Frank & Kreutzer, 2006). Traffic circles are located at intersections, where a disproportionate number of traffic collisions occur. As vehicles approach the circles, they reduce their speed. The counter-clockwise circulation around the center island reduces the number of potential conflict points within the intersection from 21 to just eight(52) thereby eliminating certain types of

collisions such as right angle and left turn head-on crashes

Persuad et al (2002, as cited by Ewing, Frank & Kreutzer, 2006) evaluated the change in crash rates following the conversion of 24 intersections to modern roundabouts in the United States using a before-and-after study design. There was a significant overall reduction of 39 per cent in crash rates. For crashes involving injuries, reductions amounted to 76 per cent. Crashes involving deaths or incapacitating injuries fell by about 90 per cent. This same study addressed a common concern that older drivers may have difficulty adjusting to roundabouts. It found no increase in the average age of crash-involved drivers following the installation of roundabouts, indicating that roundabouts do not pose a problem for older drivers. Several other studies have concluded that roundabouts outperform other intersection control devices with respect to safety (Maycock and Hall, 1984; Ourston, 1993; Schoon and van Minnen, 1993; Flannery and Datta, 1996; Jacquemart, 1998; Robinson et al, 2000; Persuad et al, 2002, as cited by Ewing, Frank & Kreutzer, 2006). Even where crash frequencies are comparable to other intersections, crash severity is lessened (Brown, as cited by Ewing, Frank & Kreutzer 2006).

Humps were almost as effective as circles and chicanes, achieving an average collision reduction of 75 per cent (Insurance Corporation of British Columbia, as cited by Ewing, Frank & Kreutzer, 2006). This is counterintuitive. While humps slow traffic, they also create wide variations in speed within the traffic stream. Some vehicles slow down more than others, or slow down sooner than others. Variation in speed, as much as speed itself, is a cause of collisions

2.2.5.3 Change the road environment

According to Grava (1993, as cited in Frank and Engelke, 2006), specific street design techniques have traffic calming actions that minimize the undesirable impacts of motor vehicles on local human activities. Traffic calming schemes seek to transform neighbourhood roads in such a way as to eliminate or reduce the number of potential accident sites, minimize pollution and noise, recapture urban space for human use, and achieve harmony in neighborhood scale and appearance. Traffic calming strategies, such as narrower lanes, street trees and consolidating driveways (i.e. “access management”) can slow traffic while still maintaining efficient vehicle movement. Increasing the number of safe crossing points will make it easier for pedestrians to cross arterials safely and quickly.(57)

It is conventional engineering practice to keep large trees, utility poles, and other fixed objects away from the roadway edge. The rationale for doing so is safety related: given a wide clear zone, motorists leaving the roadway can safely recover before encountering a hazardous fixed object. Whether this practice actually enhances safety, however, is subject to debate. It ignores the possibility that having a wide open roadside may affect behaviour, causing drivers to go faster and exercise less care than they would in more defined and enclosed street space (Dumbaugh, as cited by Ewing, Frank

& Kreutzer, 2006).

Naderi (2003, as cited by Ewing, Frank & Kreutzer, 2006) examined the safety impacts of aesthetic streetscape enhancements placed along the roadside and medians of five arterial roadways in downtown Toronto. This study found that the inclusion of features such as trees and concrete planters resulted in statistically-significant reductions in the number of mid-block crashes along all five of the roadways, with the number of crashes decreasing from between five and 20 per cent as a result of the streetscape improvements. The author attributed this reduction to the presence of a well-defined roadside edge, leading drivers to exercise greater caution while driving.

Lee and Mannering (1999, as cited by Ewing, Frank & Kreutzer, 2006) investigated the effect of roadside trees. In rural areas, the presence of trees was associated with statistically-significant increases in the number of roadside crashes that occurred. However in urban areas, the presence of trees was associated with a decrease in the probability of a roadside crash. The number of sign supports was also associated with crash reductions, as were the presence of miscellaneous fixed objects, including mailboxes and telephone booths. Dumbaugh (2005, as cited by Ewing, Frank & Kreutzer, 2006) provides other examples of tree-lined street sections producing fewer accidents than control sections with wide clear zones. On balance, it would appear that having trees and other vertical elements close to a roadway in a low-speed urban setting may actually enhance safety, contrary to engineering theory and practice.

The literature suggests that on-street parking accounts for a significant proportion of urban crashes (Seburn, 1967; Humphreys et al, 1978; Texas Transportation Institute, 1982; Box, 2000, as cited by Ewing, Frank & Kreutzer, 2006). Parked cars act as a buffer between traffic and pedestrians and are a convenience to shoppers and residents. However, these benefits come at the expense of traffic safety. If parking is permitted, conflicts with parked cars produce about 40 per cent of total accidents on two-way major streets, 70 per cent on local streets, and a higher percentage on one-way streets (Box, as cited by Ewing, Frank & Kreutzer, 2006). The number of accidents increases with the parking turnover rate, meaning that land uses which generate high turnover will also generate more traffic accidents (Humphreys et al, as cited by Ewing, Frank & Kreutzer, 2006). Interestingly, there have been no study of accident rates on comparable roadway sections with and without curbside parking which would be the ultimate test of on-street parking's safety impact. It is possible that where parking is provided, parked cars account for a large proportion of accidents, and yet overall accident rates are about the same as on sections without parking. Particularly strong associations were found between the risk for pedestrian injuries and high traffic volume. The risk for injury to children living in neighbourhoods with the highest traffic volumes was 13 times that of children living in the least-busy areas.(6) Restricting curb parking at specific crossing points may be an effective approach to reducing children’s injuries in this arena.(6)

Access management is the control of the location, spacing and operation of driveways,

median openings and street connections to a roadway. The Transportation Research Board's *Impacts of Access Management Techniques* (Gluck et al, as cited by Ewing, Frank & Kreutzer, 2006) found that as the density of access points decreases, so do crash rates. Major roadways cluttered with a number of access points have more conflict areas where vehicles can join the main traffic flow without sufficient warning or space resulting in drivers on the main roads having less time to respond and more collisions occur. This same study found that also found that raised medians (non-traversable by vehicles) were successful in limiting access to main roads thereby reducing crash rates.

In most studies, roads with raised medians were safer than roads with center two-way left-turn lanes or undivided roads. A study of pedestrian-vehicle crash experience on arterial roadways in Atlanta, Phoenix, and Los Angeles found that crash rates were about the same for undivided roadways and roadways with center two-way left-turn lanes, but crash rates were about half as high on arterials with raised medians (Gluck et al, as cited by Ewing, Frank & Kreutzer, 2006). Raised medians also improved pedestrian safety by providing a refuge area for pedestrians crossing a roadway. Pedestrians could cross in two stages and was especially helpful for older pedestrians who walked at slower speeds (Gluck et al, as cited by Ewing, Frank & Kreutzer, 2006).

Safety benefits of medians appear to vary with median width. Research in Adelaide, South Australia, found that the wider the median, the lower the pedestrian accident rates on arterial roads. The narrowest medians (four feet) had four times the pedestrian crash rate of those with the widest median (10 feet) (Scriven, as cited by Ewing, Frank & Kreutzer, 2006). Replacing a 6-foot painted median with a wide raised median reduced pedestrian accidents by 23 per cent (Claessen and Jones, as cited by Ewing, Frank & Kreutzer, 2006).

Crash frequencies were also dependent on the form of traffic control at intersections. Where traffic volumes are enough to warrant traffic signals but not high enough to absolutely require them, all-way stop signs and roundabouts may be considered instead. All-way stop signs are not favored by traffic engineers but are well-liked by citizens who value their traffic calming effect and the minimal delays they cause under light traffic conditions. From a safety standpoint, all-way stops appear to outperform signals at moderate traffic volumes, say, up to 10,000 vehicles per day on the major street (Syrek, 1955; Ebbecke and Schuster, 1977; Bissell and Neudorff 1980, as cited by Ewing, Frank & Kreutzer 2006). One study found that pedestrian collisions declined by 25 per cent when traffic signals were converted to all-way stops at low-volume urban intersections (Persaud et al, 1997, as cited by Ewing, Frank & Kreutzer, 2006).

2.2.6 Protecting Pedestrians and Cyclists

The Federal Highway Administration (as cited in Frank and Engelke, 2006) summarizes the six design factors believed to have the greatest effect on bicycle use:

- Traffic volume. Higher motor vehicle traffic volumes represent greater potential risk for cyclists and contribute to their sense of fear.

- Average motor vehicle operating speed. The average operating speed is more important than the posted speed since the two frequently are not the same.
- Traffic mix. The regular presence of trucks and buses inhibits cycling.
- On-street parking. The presence of on-street parking increases the width needed in the adjacent travel or bike lane to accommodate bicycles.
- Sight distance. A lack of sight distance sufficient to allow motorists to slow or avoid bicyclists when passing causes safety problems.
- Number of intersections. Intersections create problems for cyclists and pedestrians, especially when bike lanes or separate paths are involved.

Trip distance, route safety and attractiveness are additional variables that influence the decision to walk or bike using public roads (Ewing, as cited in Frank and Engelke, 2006). Route safety is a function of both traffic speed and the presence or absence of bicycling and pedestrian facilities (Untermann, as cited in Frank and Engelke, 2006). Redesigning the road is critical and can be done by reducing the radius width of roads, driveways and intersections and by decreasing the amount of angled parking. Other ways to improve the route safety for pedestrians and bicyclists include the provision of sidewalks in residential areas, the creation of pedestrian islands to ease street crossings, and the more extensive use of pedestrian-friendly traffic signals (Federal Highway Administration, as cited in Frank and Engelke, 2006). Attractive settings are as important along the journey as they are in the destination. Pedestrian amenities or street furniture such as trees, telephones, bus stops and sculpture all contribute to the perception of a pleasant experience (Untermann, as cited in Frank and Engelke, 2006).

Engineering actions that improve the safety of roadways for pedestrians are known as pedestrian countermeasures. One study classified countermeasures into three broad categories: separation of pedestrians from vehicles by time and space; measures that increase the visibility and conspicuity of pedestrians; and reductions in vehicle speed (this already covered under traffic calming) (Retting et al, as cited by Ewing, Frank & Kreutzer, 2006). The Pedestrian Facilities Users Guide lists 47 such measures (Zegeer et al, as cited by Ewing, Frank & Kreutzer, 2006).

Most of the studies of pedestrian countermeasures have used proxies for traffic safety to document impacts. Travel speeds have been measured in some cases, conflict counts and yielding behaviour in others. Actual accident rates are seldom measured in such studies. This may not constitute as big a shortcoming as would at first appear, since conflict counts have been shown to provide an accurate estimate of multi-year crash rates (Hauer and Garder, as cited by Ewing, Frank & Kreutzer, 2006).

The use of mass transit results in pedestrians using both arterial roads and neighbourhood streets so pedestrian countermeasures are necessary along both types of roads. Auto-oriented arterials are often primary transit routes and many pedestrians need to cross the street to catch the bus and may take extra risks to do so.(57) A study by Hess et al (as cited in Frank, Kavage & Litman, 2007) for the Washington State Department of Transportation looked at pedestrian-vehicle collisions along state

highways in Washington and found them to have the strongest relationship to bus stop usage. Significant associations were also found with retail location and size, traffic volume and number of traffic lanes. Plans for public transit need to support the safety of the users of these systems.

Sidewalks are an absolute necessity along all through-streets serving developed areas. One study found that pedestrian collisions were two and one-half times more likely on street sections without sidewalks than those with them (Tobey et al, 1983; Knoblauch et al, 1988, as cited by Ewing, Frank & Kreutzer, 2006). Sidewalk clearances, vertical curbs, street trees between street and sidewalk, and parked cars all add to the sense of security of pedestrians.

A study of the impact of crosswalks at uncontrolled locations involved a comparison of five years of pedestrian crashes at 1,000 marked crosswalks and 1,000 matched unmarked comparison sites. All sites in this study lacked traffic signals or stop signs on the approaches (Zegeer et al, as cited by Ewing, Frank & Kreutzer, 2006). Study results revealed that on two-lane roads, the presence of a marked crosswalk alone at an uncontrolled location was associated with no difference in pedestrian crash rate, compared to an unmarked crossing. Further, on multi-lane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk alone (without other substantial improvements) was associated with higher pedestrian crash rates (after controlling for other site factors) compared to an unmarked crossing. However, raised medians provided significantly lower pedestrian crash rates on multi-lane roads, compared to roads with no raised median.

Pedestrian activated signals at uncontrolled crossing points (known as Pelican signals) have been highly effective in reducing crashes in Australia (Geoplan, as cited by Ewing, Frank & Kreutzer, 2006). The Pelican signal is similar to a standard mid-block pedestrian signal, except that during the pedestrian clearance phase the display facing motorists changes to a flashing yellow, indicating that vehicles may proceed cautiously through the crossing but are required to yield to pedestrians. These types of signals produce less delay for motorists than standard pedestrian activated signals. Compared to sites without pedestrian activated signals, the estimated reduction in pedestrian collisions was 87 per cent, which was statistically significant. Installing standard pedestrian-activated signals (i.e. those that were not Pelican signals) at mid-block locations also gave rise to a 49 per cent reduction in crashes, also statistically significant.

2.2.7 Conclusion

The incidence of fatal and non-fatal injuries as a result of traffic accidents is closely related to vehicle miles traveled, automobile speed and traffic volumes. These characteristics of travel have been linked in the research to the design of the roadway and street network and the distribution of land uses. In particular, development patterns that increase the number of miles traveled in a vehicle, vehicle speed and traffic volume

increase accident rates.

Traffic safety can be improved by reducing per capita motor vehicle mileage, slowing traffic, increasing the number of bicyclists and pedestrians, and reducing the exposure of pedestrians and cyclists to unsafe conditions (Litman and Fitzroy, 2005, as cited in Frank, Kavage & Litman, 2007).

Traffic calming and other facility design strategies can reduce crash frequency and severity. Well-designed walking and cycling facilities can reduce pedestrian and cyclist risks.(57)

Significant work needs to be done to reduce conflicts between pedestrians, cyclists and vehicles. Many intersections and street environments are hostile to walking and biking. Resulting exposure to risk from cars makes it possible to assert that one should walk and bike less to be safer – or even healthier. However, less walking and biking equals less physical activity, and increased odds of obesity, increased air pollution, and so on. Therefore, a holistic model of community design that maximizes population health benefits would make active transportation and public transit both desirable and safe.(57)

2.3 Air Quality

2.3.1 Introduction

Since the early 19th century, air quality has been linked to the built environment. From the extensive use of fossil fuels that powered the industrial revolution 200 years ago, to the dependence on fossil fuels to power motorized vehicles in the 21st century, air pollution has been the result. In the 1700 and 1800's, poor air quality was generally associated with the spread of disease. As Frumkin et al (2004) note in their history of urban health, early concerns were related to foul air caused by gases and smells resulting from rotting garbage and undrained areas where water collected and became swamps. In 1874, one public health physician described the results of foul air in the following way: "It is this odour which indicates the commencement of that condition known as crowd-poisoned atmosphere, and which, if allowed to increase, furnishes the specific germs which develop typhus, ship or jail fever." (Dr. Edward H. Janes, 1874, as cited in Frumkin et al, 2004, p.52)

From foul smells two centuries ago to much worse today, the polluting of our air is a global problem. Although it can be the result of natural environmental events, it is predominantly a man-made phenomenon; the outcome of a world obsessively dependent on vehicle use and the consumption of fossil fuels to drive industry and to sustain business and economies. The contamination of our air negatively impacts on human health, which results in increased demands on our health care system, thus supporting its associated billowing costs. Worse yet, air pollution is a key factor of global warming that has brought us to the brink of irreversible climate change, which if not reversed could present catastrophic challenges to life as we know it.

Air pollution is in large part caused by vehicle emissions, which is determined by the amount of driving done and the number of miles driven. These factors relate directly back to the design of the environment in which we live. In recent years, research has established a definite link between the built environment, air quality and health. This section examines those connections and the evidence that binds them together.

2.3.2 Air pollution - Causes and Results

Air pollution is a complex blend of chemicals and other pollutants. Its source can be classified into two basic groups: anthropogenic (man-made) and biogenic (natural) pollutants. Anthropogenic pollutants come from a variety of sources of power generation (e.g. lawnmowers, automobiles, airplanes, boats, factories, power plants). Biogenic are natural pollutants such as gases and chemicals that are emitted from trees, forest fires, volcanoes and other such sources. Both anthropogenic and biogenic sources contribute to poor air quality, either as chemical pollutants, particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_x), ozone or other volatile organic compounds (VOCs). These compounds, in turn, are what affect health, influencing adverse

outcomes such as respiratory diseases, asthma, cancer and premature mortality.(31)

It is now accepted that exhaust from vehicles (such as cars, trucks and airplanes) is the greatest contributor to air pollution in North America. Statistics from the United States show that vehicles account for more than three quarters of carbon monoxide pollution in that country and about half of volatile organic compounds and nitrogen oxide emissions.(52) In Ontario, 37 per cent of VOC emissions and 62 per cent of NO_x emissions were contributed by the transportation sector in 2005. Vehicles and the transportation sector were also responsible for 18 per cent of particulate matter emissions, and 86 per cent of carbon monoxide emissions.(71) Therefore, urban areas that experience greater vehicular use and heavier traffic patterns generally have poorer air quality than rural areas.

Vehicle emissions are caused by two processes: combustion and evaporation. During combustion, the burning fuel in a vehicle and the air around it experience oxidation. This process produces carbon monoxide, carbon dioxide, and in some cases sulphur oxides (SO_x) and nitrogen oxides. Particulate matter is also the result of combustion. Visually, PM is the smoke that comes out of tailpipes and smokestacks. It is composed of small particles that vary in size and that contain such elements as organic chemicals, ammonium, sulfates, nitrates, carbon and other metals. The smaller the particles, the easier they are to enter into human lungs and compromise health.

Evaporation occurs when certain components of vehicle fuel, such as hydrocarbons and air toxins, evaporate due to handling or storage. The components that easily evaporate are volatile organic compounds (VOCs), or hydrocarbons. The release of these compounds and gases into the air contribute to pollution levels.

Several primary pollutants are known to be precursors of secondary pollutants, which are produced when precursor pollutants mix with other compounds in the atmosphere and undergo chemical reactions. For example, carbon monoxide is an important precursor of smog, the brownish, thick haze that can be seen hovering over large urban areas on warm days. Smog (smoke and fog) is normally produced in the summer as a result of particulates and pollutants (NO_x and VOCs) that mix in the atmosphere and react to heat. One of the by-products of smog is ozone, also a secondary pollutant. Ozone forms in the air when precursor chemicals such as hydrocarbons, VOCs and NO_x mix. Smog and ozone are extremely hazardous to both human health and the environment. According to the Ontario College of Family Physicians, “there is no safe level of exposure to ground-level ozone.”(p 4)(28) Health Canada states that ozone and particulate matter are particularly bad for health. Studies have linked long-term exposure to PM with premature death and lung cancer. Studies looking at the health impacts of ozone suggest that once it is in a person’s lungs, ozone continues to irritate and cause damage, even if a person is not experiencing physical symptoms.(72)

Carbon dioxide, along with other atmospheric gases like methane and water vapour, absorb heat. These gases act like a heat sponge around the earth, thereby reducing the

amount of heat that can leave the earth's atmosphere. This phenomenon is known as the "greenhouse effect", and these gases are often referred to as greenhouse gases. The trapped heat leads to an overall increase of temperatures, which in turn contributes to global warming and climate change.

Greenhouse gases have several sources, one of the most significant being vehicle emissions. Another significant source is the CO_2 produced when fossil fuels, such as coal or oil, are burned. Thus, the activities of millions of people around the world, including such daily rituals as cooking, heating, cooling, driving and using electricity, all produce gases that contribute to the greenhouse effect. According to the Worldwatch Institute:

> *"Such activities have significantly increased the quantity of several heat-trapping gases in the atmosphere over the past few centuries. For example, carbon dioxide concentrations in the Earth's atmosphere are 34 per cent higher today than they were at the onset of the industrial revolution in 1750—higher than at any time in the last 400,000 years."(73)*

Scientists agree that: "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."(p.10)(74) Although it cannot be predicted with comlete certainty what the results of global warming will be, consensus among scientists is that the consequences of this phenomenon will pose serious risks to both the environment and human health. Environmental impacts could include more frequent and intense storms, extreme temperatures, flooding, droughts, and rising ocean levels. These climatic events, should they occur, will flood populated coastal areas, kill coral reefs, and increase the number and range of mosquitoes (a significant vector of disease), other insects, pests, and weeds. "Such events, in turn, will influence our food supply, our access to clean water, our health, and the economic and social conditions of families and communities around the world."(73)

2.3.3 Air Quality and Health

Research over many years has shown that air quality impacts on health.

> *"… long-term exposure to air pollution causes lung cancer, may cause asthma (as opposed to aggravating pre-existing asthma), and, most importantly, may affect normal development and growth of the lungs in children."(p.16)(43)*

Poor air quality contributes to mortality, cancer, cardiovascular disease and birth defects.(31) Frumkin et al (2004) cite several studies that provide evidence for this statement. In one study, Pope (2002) found that exposure to PM was linked to cardiopulmonary mortality, and that an increase of PM increased the risk of death due to lung cancer. A study by Pekkanen et al (2002) found an increased level of ischemic changes took place in patients who had coronary artery disease and who were exposed

to PM. Additionally, a report from Toronto Public Health on the burden of illness caused by air pollution cites further studies by Brook et al, (2002), Pope and Dockery, (1999), Burnett et al, (1999), and Lin et al, (2003) that support this conclusion.(75)

The biggest impact of air pollution, however, is on respiratory health. Resulting health outcomes include bronchitis, asthma, reduced lung function and cardiac-related respiratory problems.(75) Numerous studies have found that exposure to high levels of ozone (>80 parts per billion) over a period exceeding eight hours results in adverse affects, including severe asthma, a reduction in lung capacity and airflow, and a negative impact on life expectancy (U.S. EPA 2003; Hoek et al, 2002; Friedman et al, 1998, as cited in Ewing et al, 2006 and McConnell et al, 2002; Korrick et al, 1998, as cited in Frumkin et al, 2004). Bray et al, (2006) cite research that found the onset of a viral respiratory infection combined with exposure to NO_2 is associated with increased severity in asthma (Pathmanathan, 2003, and Chauhan, 2003).

Studies have also shown that children are particularly vulnerable to health impacts from air pollution. Frumkin et al (2004) suggest that this is due to the following factors:

- Physical development – small lungs, narrow airways and rapid breathing mean that children inhale a greater amount of air than adults.
- Play – outdoor play and recreation activities place children in areas where pollution levels are highest, and exposure to ozone is most likely.
- Asthma – asthma rates are high among children. In Canada, the prevalence of physician-diagnosed asthma among children aged 4-11 years was 15.2 per cent in 1999(76). Asthma is affected by pollutants, particularly ozone and particulate matter. It has been known for some time that air pollution makes asthma symptoms worse; however, recent studies suggest that exposure to air pollution may lead to the development of asthma.(72)

Studies done in Los Angeles found that children experience reduced lung growth when exposed to increasing levels of NO_x, acid vapour and PM (Gauderman et al 2000 and 2002, as cited in Frumkin et al, 2004). Studies have also shown that children living in communities with higher levels of traffic-related pollution had lung function growth that was approximately 10 per cent slower than that of children in lower air pollution communities. The rate of lung function growth improved in children who moved to lower pollution areas.(43) Research has also been done into the affect of air quality on newborns, and has found that poor air quality can affect newborns through increased cancer risks, premature birth, and low birth weights.(52)

2.3.4 The Costs of Poor Air Quality

In 2005, the Ontario Medical Association (OMA) released its report, *The Illness Costs of Air Pollution*, which presented the estimated health and associated economic impacts of air pollution in Ontario. Using specially designed software, the OMA was able to estimate health impacts of air pollution on four outcomes: premature death, hospital admissions (with respiratory and cardiovascular illnesses), emergency room visits (with

less severe respiratory and cardiovascular illnesses), and minor illnesses. Table 6 shows a summary of the four endpoints for Ontario in 2005, with projected figures for 2015 and 2026.

Table 6 Health Damage from Air Pollution, Ontario, 2005, 2015, 2026

Health Damage	Example Years		
	2005	**2015**	**2026**
Premature Deaths	5,829	7,436	10,061
Hospital Admissions	16,807	20,067	24,587
Emergency Room Visits	59,696	71,548	87,963
Minor Illnesses	29,292,100	31,962,200	38,549,300

Source: Ontario Medical Association. The Illness Costs of Air Pollution, 2005

In the area covered by the SMDHU, OMA estimates indicate that Simcoe Muskoka experienced 211 premature deaths, 550 hospital admissions and 2,052 hospital emergency visits as a result of air pollution in 2005. The estimated health care cost resulting from air pollution for Simcoe Muskoka totalled $15.86 million, while the cost of lost productivity due to pollution was estimated at $11.87 million. The OMA predicts that by 2026, the health impacts from air pollution will result in 366 premature deaths, 819 hospital admissions and 3,066 emergency visits in Simcoe Muskoka.(77)

Other air pollution studies conducted in Ontario reveal similar patterns. In a 2004 report produced by Toronto Public Health, it was estimated that 1,700 premature deaths and 6,000 hospitalizations in Toronto could be attributed annually to air pollution in that city. These estimates were based on burden of illness studies on the risks of acute exposure to ozone, carbon monoxide, nitrogen dioxide, sulphur dioxide and chronic exposure to fine particles. These studies also noted that thousands of people in Toronto are affected every year by less serious health impacts of poor air quality including: asthma, bronchitis and emergency room visits for pre-existing heart and breathing problems that are aggravated by air pollution. The report presents evidence that air pollution can be particularly devastating for people with asthma, congestive heart failure and diabetes. It also cites research that shows a relationship between increased adverse affects of breathing air pollution with increased physical activity levels, and that these effects “tend to be most pronounced in people with underlying health conditions such as asthma.”(p.1)(75)

The OMA estimates of the health care costs of air pollution-related illness in Toronto in 2005 was $118.16 million, and $80.9 million in lost productivity costs. It predicts that by 2026, premature deaths in Toronto due to air pollution will rise to 2,500, with 5,860 hospital admissions and more than 21,000 emergency visits.(77)

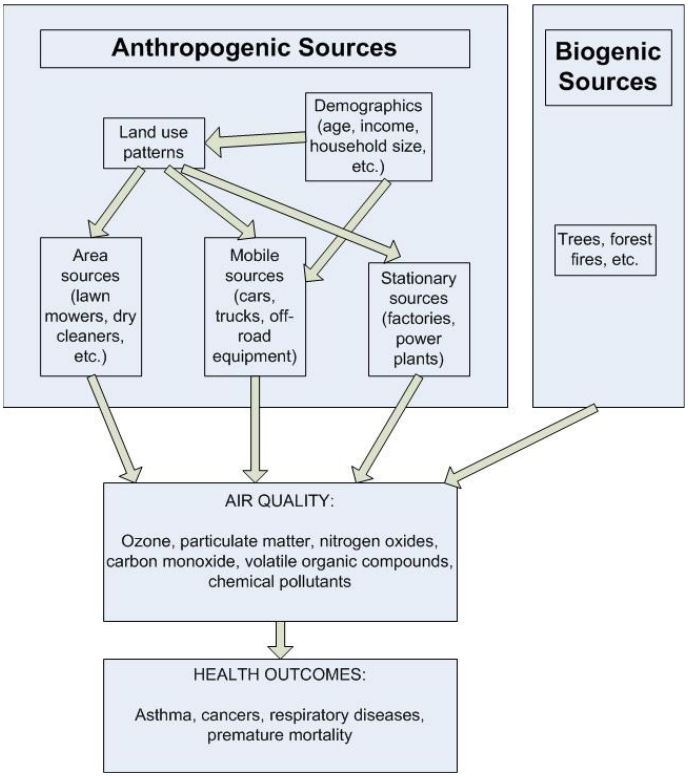
2.3.5 Air Quality and the Built Environment

As mentioned earlier, researchers have established that connections exist between the built environment, air quality and health. In fact, much of the research previously cited

demonstrates that the built environment is a factor in air quality and its subsequent affects on health. Frank et al (2005) state that: “While there is no research directly testing the link between land use, pollutant exposure, and health impacts, there is a clear evidence base that links the built environment to travel behaviour and per capita air pollution, which can be linked to pollution exposure in a population.”(p.28)(57) The authors emphasize that direct relationships are hard to establish due to the complexity and dynamism of the relationship between these different variables.

Frumkin et al (2004) developed a conceptual model (see Figure 3) to help illustrate the relationship between air pollution, the built environment and health. The model shows how land use decisions and demographics impact on different sources of anthropogenic air pollution, particularly mobile sources, and how these in turn affect air quality and inevitably health outcomes.

Figure 3 Model Linking Sprawl, Travel, Air Pollution and Health



Source: Frumkin, Frank and Jackson. Urban Sprawl and Public Health – Designing, Planning and Building for Healthy Communities, 2004, p. 66

Essentially, the relationships are established in the following way: Land use patterns and zoning regulations determine the location of residential areas, lot sizes and where other types of development are located (i.e. commercial or industrial areas). Residential developments may be located in proximity to a stationary source of pollution (such as a power plant or an airport) which can result in residents being exposed to high levels of vehicular and static emissions. Larger lot sizes require the use of lawnmowers, which produce pollution. Land use planning also determines transportation routes and systems. Low density developments result in large distances between home, work, school and services, which require greater amounts of driving. This results in more vehicles on the road and higher levels of emissions. Demographics also play a role here. Age, gender, income and household size help to determine number and type of vehicles per household, number of miles traveled and number of trips taken. This combination of variables and series of events clearly demonstrates the link between air quality, the built environment, vehicle use and health.(31)

Other factors also play a role in how air pollution affects health. For instance, in the scenario above, proximity is not always the key factor in pollution exposure. Pollutants

can also affect people living across a very large area due to wind patterns and other climatic conditions that carry pollutants over long distances. Similarly, how much pollution a vehicle produces and what the pollution is made up of are due in part to weather conditions and the type of pollutants already existing in the air. The most important factors that determine how much vehicles pollute are the type of vehicle, the length of time it is driven, and the type of trip. Three specific functions of a vehicle account for the highest emissions rates: turning the engine off and on, accelerating and climbing a hill. Of these, turning an engine on after it has cooled down for at least one hour (also known as a "cold start") is the most polluting function of all.

2.3.6 The Evidence

The conceptual model developed by Frumkin et al (2004) is supported by evidence. Numerous studies have linked poor air quality caused by vehicle emissions to adverse respiratory outcomes. "Breathing higher concentrations of CO, VOC, fine particulate matter (< 2.5 microns) and other emissions released from tail pipes has consistently been shown to induce detrimental health outcomes."(p.4)(52)

In their 2001 report, *Creating a Healthy Environment: Impact of the Built Environment on Public Health,* Jackson and Kochtitzky(6) cite two major U.S. studies that make the connection between pollution and asthma. The first study, conducted by Freidman et al (2001), looked at the relationship between decreased traffic volume in Atlanta, Georgia, during the 1996 Olympic Games, and air pollution and asthma emergencies. The study found that lower levels of vehicular traffic during the Games resulted in a decrease of daily ozone concentrations by 27.9 per cent. This coincided with a drop of asthma-related emergency medical visits by 41.6 per cent, in particular, with a reduced rate of asthma attacks in children. The second study, by ABT Associates (as cited in Jackson and Kochtitzky, 2001), was able to attribute large numbers of asthma attacks in three major cities in the United States to excessive ozone pollution.

A report prepared for the Office of Energy Efficiency, Natural Resources Canada, cites a number of studies that link vehicle emissions with respiratory health.(78) A few of these studies looked at vehicular traffic at schools and its affect on children. Study results showed an association between vehicle exhaust, both inside and outside of schools, and asthma, coughing, wheezing and overall decreased lung function in children (van Vliet, 1997; Guo, 1999; Hirsch, 1999; Brunekreef, 1997). A long-term study by McConnell (2002) found that children may develop asthma from exposure to air pollution.

Urban areas generally have a higher volume of traffic than rural areas, thus they present a greater health risk for people from exposure to vehicular emissions. A report by the Ontario College of Family Physicians(43) cites several studies that show a direct relationship between pollution levels and traffic volume. A study by Zhu (2002) found that pollutants exist at higher levels near roadways containing large amounts of traffic. Other studies show that particulate matter can be at levels up to 30 per cent higher near

busy roads, and that NO_x and CO display the same type of patterns (Brook, 2002 and Zhu, 2002, as cited in Bray et al, 2005).

Living close to a busy traffic route also poses adverse health affects. Roemer et al, (2000, as cited in Ewing et al, 2006) conducted two studies in Amsterdam that looked at the levels of exposure to vehicle emissions for people living next to a street that carried more than 10,000 vehicles per day. They found that people who lived near a busy street such as this experienced two to three times the exposure rate to CO, NO_x, VOCs and PM compared to those living near streets with less traffic. The Amsterdam studies found that exposure effects were not just confined to the outside of buildings, but in fact were also present within buildings. A study by Buckeridge (2002, as cited in Bray et al, 2005) showed an association between hospital admissions for respiratory problems, including pneumonia, bronchitis and asthma, and being exposed to vehicle emissions from living in close proximity to a high traffic volume route. Finkelstein et al (2004) found an association between higher mortality risks for people living in close proximity to a major traffic route. The advancement period for this mortality risk was 2.5 years.(79)

Two other studies are of note here. In a study by Lin et al (2002, as cited in McKeown, 2006) of hospitalized children in New York State, the researchers found that those children who were in the hospital for asthma, compared to those who were in for reasons other than respiratory-related illness, were more likely to live less than one-quarter of a kilometre away from busy roadways that carried truck traffic and other vehicles with high amounts of miles travelled. Another American study, conducted by Wilhelm (2003, as cited in McKeown, 2006), determined that pregnant women living in Los Angeles who were exposed to air pollution from traffic emissions due to traffic volume and proximity of where they lived to busy roadways, had a higher rate of having a low birth weight baby (risk ratio 1.08).(80)

2.3.7 Vehicle Emissions

Several variables play a role in determining the impact of vehicle emissions on air quality and the amount of emissions that go into the air. First is the number of vehicles on the road. Urban roadways and transportation systems are designed with wide roads and large highway capacities, both of which accommodate an increasing number of vehicles. Other variables include the type of vehicle, the characteristics of the trip (speed, duration, length, acceleration, etc.), the type of pollutant produced, weather conditions and patterns, and the activity scale of different pollutants, including their formation, the length of time they remain in the air and how quickly they scatter.(31)

One of the key determinants of poor air quality is known as VMT, or vehicle miles travelled. VMT has increased over the years, due to the increased number of cars on the road and to community design and land use development. A 2001 study by the U.S. Environmental Protection Agency found that the biggest determinant of the length of a trip in miles (VMT), as well as the duration of a trip in hours (VHT), is the built environment. Interestingly, socioeconomic status is the key factor influencing the

number of vehicular trips taken.(52) One characteristic of the built environment in particular – sprawl – has resulted in increased distances between places, which encourages more driving, including commuting. And Canadians, it seems, do their share of commuting. According to the *National Active Transportation Survey 2004*, 62 per cent of Canadians travel to work regularly by car.(81) Statistics Canada reports that in 2005 the average Canadian driver spent 12 full days commuting to and from work. This breaks down to 275 commuting hours per year (based on 260 working days), or an average of just over one hour (63 minutes) of round-trip commuting each day.(82)

More detailed data from University of Toronto's *2001 and 1996 Transportation Tomorrow Surveys*(83) provide a regional portrait of travel behaviour by residents of Toronto and regions in the surrounding GTA. Statistics for the City of Barrie, City of Orillia, Simcoe County and the City of Toronto, as displayed in Table 7, show the number and mode of trips made by residents of each of those regions in a 24-hour period and the median trip length by mode. For comparison purposes, two study years have been shown.

Table 7 Trips Made by Residents of City/Region in 24-Hour Period, by Mode and Median Trip Length, 1996 and 2001

TRIPS MADE BY RESIDENTS IN 24-HOURS	CITY/REGION							
	CITY OF BARRIE		CITY OF ORILLIA		SIMCOE COUNTY		CITY OF TORONTO	
	1996	2001	1996	2001	1996	2001	1996	2001
Number of Trips	168,100	230,000	n/a	68,500	n/a	526,100	4,522,800	4,763,900
Auto Driver	71%	71%	n/a	70%	n/a	74%	53%	54%
Auto Passenger	18%	17%	n/a	20%	n/a	16%	15%	14%
Local Transit	3%	2%	n/a	1%	n/a	0%	22%	22%
GO Train	n/a	0%	n/a	n/a	n/a	0%	0%	0%
Walk & Cycle	6%	6%	n/a	7%	n/a	4%	8%	8%
Other	2%	3%	n/a	3%	n/a	6%	1%	1%
MEDIAN TRIP LENGTH (KM) BY MODE	**CITY OF BARRIE**		**CITY OF ORILLIA**		**SIMCOE COUNTY**		**CITY OF TORONTO**	
	1996	**2001**	**1996**	**2001**	**1996**	**2001**	**1996**	**2001**
Auto Driver	2.8	3.3	n/a	1.9	n/a	9.6	5.0	5.0
Auto Passenger	2.5	2.6	n/a	1.7	n/a	8.3	3.8	3.9
Local Transit	3.0	3.3	n/a	2.3	n/a	48.6	5.4	5.6
GO Train	n/a	80.8	n/a	n/a	n/a	57.2	17.5	18.2

Source: 2001 and 1996 Transportation Tomorrow Surveys, University of Toronto, 2003

As illustrated by these numbers, the vast majority of trips (almost three-quarters) made by Simcoe area residents are by private vehicle, while very few (<10%) are by active forms of transportation (walking or cycling) or public transit. The average length of a trip is between two and three kilometres, which according to *Go For Green* is a distance that a majority of Canadians are willing to walk or cycle.(84) These statistics show a dependency on private vehicles that has remained fairly consistent over the five year period covered by the survey. This dependence, and the fact that very few trips are taken by means of active transportation or public transport, results in high levels of emissions that contribute to air pollution. A 2004 report by *Go For Green* states:

"Walking and bicycling produces virtually no air pollution. Per kilometre air pollution reductions are large because bicycling usually replaces short, cold start trips for which internal combustion engines have high emission rates, so each 1 per cent of automobile travel replaced by active transportation decreases motor vehicle air pollution emissions by 2 per cent to 4 per cent."(p.20)(84)

Different variables of the built environment, such as density, public transit systems, location of housing and jobs, and pedestrian amenities, affect people's travel behaviour. Therefore, it is helpful to look more closely at some of these specific factors to see how they affect driving choices and travel behaviour, which directly influence the amount of vehicle emissions going into the air.

2.3.8 Density

According to research, the compactness (or density) of a neighbourhood plays a key role in determining the vehicular use and driving behaviour of individuals.

In a major American study that looked at density as a variable of the built environment, Holtzclaw (1994, as cited in Ewing et al, 2006) found that compared to low density communities, high density neighbourhoods with mixed land use, pedestrian access and public transit services produced about 30 per cent fewer VMTs. In a 2000 follow-up to the 1994 study, Holtzclaw et al (2002, as cited in Ewing et al, 2006) found that a doubling in the density of an area resulted in reduced VMT by as much as 43 per cent, and that higher density was correlated with less vehicle ownership. This study concluded that four variables play a key role in the number of vehicles that people own and the total amount of miles that people drive: density, access to transit, household income and household size.

Other research has also made the link between density and driving. Frank et al (2000, as cited in Ewing et al, 2006) looked at several variables, including mixed land use, density, street connectivity and commute length, and their relationship to vehicle emissions. Results of their study showed a substantial decrease in emissions as both household and workplace densities increased. In a similar vein, land use planning simulations done in cities in the United States have shown that limiting growth to existing urban or developed areas (that is, increasing the density of already developed land) results in decreased VMT. According to the 1994 *Metro 2040 Growth Concept Report* (as cited in Ewing et al, 2006) for Portland, Oregon, this type of growth restriction would produce 16.7 per cent lower VMT in that city. Results of other studies and planning simulations conclude that, when taking into account a variety of land use and other transportation variables: "Building more compactly changes the distance of trips and mode share distributions."(p.18)(52)

Increasing density, however, could also produce some negative effects. As some of the literature suggests, a more compact community can result in a small area with a high volume of traffic and congestion. This can result in negative health impacts to residents

who are exposed to traffic emissions due to living in close proximity to busy roadways.(52)

2.3.9 Transportation Issues

In the report, *Understanding the Relationship Between Public Health and the Built Environment*, Ewing et al (2006) discuss two aspects of transportation that directly influence the frequency of vehicular use and the number of miles that a vehicle travels. One aspect is accessibility to public transportation systems; the second is how streets are connected.

Having access to a public transportation system may be the most obvious reason that a person may choose to take public transit instead of taking a car to a specific destination. However, access is not the only factor. The distance to public transit is also an important determinant in making this choice.

What is a reasonable distance for convenient access to public transit? Studies in the U.S. have shown that although 70 per cent of people will walk 500 feet for a normal daily trip, 40 per cent will walk 1,000 feet and 10 per cent will walk half a mile (Unterman 1990, as cited in Ewing et al, 2006), this distance increases for people who walk to a public transit stop (a quarter mile for a bus and up to half a mile for a train) (Frank, Stone and Bachman, as cited in Ewing et al, 2006). In Canada, only 11 per cent of Canadians travel to work by public transportation most of the time or always. Of those, 41 per cent walked to public transit some of the time. Only 8 per cent of Canadians who owned a bicycle and who lived within 8 kilometres of a public transit stop had biked to a public transit stop at some time.(81)

The importance of accessibility to public transit cannot be underestimated. How this achieved is a combination of two planning features: the building of a public transit system or the expansion of an existing system; and planning residential and employment developments near the public transit system. As Ewing et al (2006) point out: "…the potential benefits of these combined investments indicate that increasing transit access helps reduce air pollution by shifting travel from vehicle to transit trips and by reducing rate of vehicle ownership."(p.26)

In a study that looked at a traffic impact model for Portland, Oregon, it was concluded that public transit trips to work would almost double if the transit system in that city was expanded (1000 Friends of Oregon, 1997, as cited in Ewing et al, 2006). These results were replicated in another modeling study in Montgomery County, Maryland. There it was found that with expanded transit infrastructure, along with development that was centred around the transit system, the County could double over 30 years the number of employment opportunities and households within the acceptable traffic congestion levels, inferring that public transit would be a highly used mode of transportation (Replogle, 1993, as cited in Ewing et al, 2006).

Several other strategies have been found effective in increasing public transit use, thereby reducing private vehicle use. One such example is the tolls imposed on vehicles entering the central area of London, England (an area of about 20 kilometres in size) in 2003. During the weekday, vehicles going into the city centre were charged a flat fee. The result of this fee was a 20 per cent increase of kilometres traveled by buses within the fee zone, as well as 25 per cent increase in bus use and a 29 per cent decrease in vehicle kilometres traveled. Overall, these changes resulted in a reduction of NO_x and PM emissions by 12 per cent, and CO_2 by 19 per cent. (Beevers 2004, as cited in McKeown, 2006).

The other strategy widely cited in the literature is the one used during the Atlanta Olympic Games in 1996. This strategy, which saw the implementation of an alternative transportation strategy, including an increase in the use of public transit, saw astonishing results: reduced weekday traffic counts (up to 22 per cent), and a 28 per cent reduction in peak daily ozone concentrations (Friedman, 2001, as cited in McKeown, 2006).

2.3.10 Land Planning Issues

Research has found that two elements of land use planning can influence the number of vehicle trips and miles travelled: location of development and land use mix. Ewing et al (2006) expand on these two elements in detail in their report, *Understanding the Relationship Between Public Health and the Built Environment*. They cite several studies that have shown how, with proper planning, both of these factors can reduce vehicle use, thereby reducing air pollution.

In terms of location, studies have found that development taking place on an infill site, as compared to a new or greenfield site, generates fewer vehicle miles and emissions. Allen et al (1999, as cited in Ewing et al, 2006) studied three metropolitan areas in the United States to compare the potential environmental and transportation impacts of developing an infill and a greenfield site. In each modelling case, they found significantly lower emissions of CO, NO_x, SO_x, PM and CO_2 (ranging from 47-110 per cent lower) with the infill development. The results were the same for a similar study conducted by the U.S. Environmental Protection Agency (EPA) in another city in the U.S. that found emission savings from 15-316 per cent (EPA 1999, as cited in Ewing et al, 2006).

In a study looking at the location of two existing and similar communities near Nashville, Tennessee, it was found that the community that was closer to downtown Nashville, and that had a street grid pattern and a higher density, had emission rates 30 per cent lower than the low density neighbourhood located closer to the suburbs (Allen, 2003, as cited in Ewing et al, 2006).

As discussed in earlier sections of this review, the way in which neighbourhoods are designed impacts on several aspects of health and behaviour, including air quality and vehicle use. Particular design features that have an impact include street grids, transportation systems and land use mix (residential, commercial, employment). Land

use mix is a factor because "…mixing land uses is associated with shorter trips and a shift in mode from automobiles to pedestrian, bicycle and transit travel... This, then, reduces the total number of trips taken by automobile and thus reduces emissions."(p.20)(52)

Several studies make the case for this conclusion, although Ewing et al (2006) state that very few have shown a direct connection between mixed land use and lower emissions. However, there is enough evidence to show that neighbourhoods that have a blend of homes, workplaces, services and shops results in shorter traveling distances for people, more combined trips, and more travel by bike, foot and public transit. Study highlights include:

- One U.S. study found that the residents of a mixed use neighbourhood drove half the distance per trip than residents of a single use neighbourhood. As well, the mixed use residents made more trips using non-motorized means of transport than the single use residents (12.2 per cent vs 3.9 per cent). (Rutherford et al, 1996, as cited in Ewing et al, 2006)
- Mixing employment areas with housing can decrease vehicle use, particularly with commuting. One study that looked at how the balance of employment and housing areas affects commuting rates found that those living in a balanced area commuted less (by one third) than those who lived in an area dominated by housing (Ewing, 1994, as cited in Ewing et al, 2006)
- Mixing employment areas with retail can also decrease vehicle use, as found in a study that looked at transit use by workers whose workplace was located near retail stores and services. Transit use went from 3.4 to 7.1 per cent in these areas. (U.S. Dept. of Transportation, 1994, as cited in Ewing et al, 2006)

2.3.11 Conclusion

Evidence has existed for a number of years that concludes that poor air quality, caused by air pollution, negatively affects health. It is also clear that fossil fuel-based vehicle emissions are one of the prime sources of air pollution. What has become evident more recently is the impact of the built environment on air quality and health. Much of the literature used in this review agrees that this relationship is based on a series of connections that starts with community design, which influences vehicle use, which impacts on vehicle emissions, which contributes to air pollution, thus affecting health. Low density, sprawled communities that provide poor public transit or little opportunity for active modes of transportation will continue to contribute to increased levels of air pollution through land use patterns that emphasize vehicle use.

Some experts suggest that improving air quality is contingent on primary prevention; that is, to control air pollution at the outset. Suggestions to tackle this problem include (but are not limited to):

- Incorporate smart growth principles into land use planning policies, such as: designing communities that favour walking; increase neighbourhood density; allow for mixed-use zoning; encourage infill development.

- Encourage alternative forms of transportation, including active transportation and public transit.
- Invest in public transit system infrastructure.
- Adopt policies to increase the use of alternative fuels in all vehicles – private, public and commercial.(31;43;57;75;85)

2.4 Water Quality

2.4.1 Introduction

The availability of clean, accessible water is an important one for humans. Without it we cannot survive. Fresh water found in rivers, lakes, underground aquifers, snow and ice, accounts for only 2.5 per cent of the earth's water supply. Of that, more than two-thirds (69 per cent) is frozen in polar ice caps and glaciers. The total amount of replenishable fresh water directly available for human consumption from ground water sources (lakes, rivers, reservoirs) and shallow underground sources is less than 1 per cent of the overall freshwater supply.(86) The relative scarcity of fresh water highlights the importance of careful stewardship of our water and the need to ensure that the existing supply is clean and sustainable.

In the natural environment water sources are replenished by rainfall. Rainfall can take two courses of action. It either seeps into the soil where it is filtered by vegetation before it reaches groundwater (below the surface), or it runs along the surface and flows into streams, rivers and lakes (known as surface water).

After the United States, Canada is (per capita) the highest user of water in the world. Based on 1998 statistics, Canadians used an average of 343 litres of water per day, compared to 382 litres for the U.S. and 150 litres for France.(87)

Water quality is affected by pollutants and other contaminants. Contaminants are either microbial or chemical in origin. Biological contaminants include:

- bacteria – e.g. E.coli, Cmpylobacter sp., vibrio cholera (causes cholera), Salmonella typhi (causes typhus) and Shigella
- parasites – e.g. Giardia sp. and Cryptosporidium sp.
- viruses – e.g. Norwalk, rotovirus and norovirus

Chemical contaminants can come from a variety of sources. Point sources are contaminants that come from a single location, such as from the drainpipe of a factory or manufacturing plant. Nonpoint source contamination is runoff from large expanses of land, such as golf courses, farms, landfills and parking lots. Examples of chemical pollutants that run off from these areas are nitrates, metals, pesticides, solvents, and organic chemicals. Both sources of contamination therefore are often connected directly

to land use decisions; decisions that can have huge implications for the quality and availability of our water.

Other threats to our water sources include: algal toxins, aquatic acidification, genetically modified organisms, wastewater effluents, industrial discharges, dams, climate change, agricultural and forestry land use, and natural trace element contaminants.

2.4.2 Effects of Water Contamination on Human Health

Death and illness from water contamination occurs around the world. Global estimates from the World Health Organization in 2000 (as cited in Neumann et al, 2005) are that four billion people suffer from waterborne diseases each year, and that two million people will die annually due to the ingestion of contaminated drinking water.(88) Waterborne-related contamination can have negative health effects on healthy people, but particularly can affect the fetus, children, the elderly and those who are immuno-compromised. Waterborne bacteria can cause gastrointestinal illness, as well as more severe illnesses such as: Guillain-Barre paralysis, kidney failure, pneumonia, dysentery and cholera. Waterborne viruses can also cause gastroenteritis, as well as other illness like meningitis, fever, eye infections and respiratory disease.

Compiling estimates on the number of illnesses and deaths related directly to waterborne-related causes is difficult. According to Peterson there are several reasons for this:

> *Some waterborne diseases, such as salmonellosis, campylobacteriosis and giardiasis, can exhibit clinically mild symptoms with patients not seeking medical help. The frequency of reporting is also affected by awareness of specific diseases, interest and the availability of resources in different areas. The portion of a specific disease that can be attributed to water is also typically not known.(p.162)(89)*

Identifying waterborne-related outbreaks within a population, particularly small outbreaks, can also be difficult due to a lack of active disease surveillance and in some cases, lack of recognition of it being an outbreak due to the small number of people affected. The result is that the actual number of reported cases of waterborne illness in Canada is most likely just a fraction of the actual number of cases.(89) To provide a general overview, Table 8 shows the total number of cases of five reportable waterborne-related illnesses in Canada in 1998.

Table 8 Total Cases of Five Reportable Waterborne-Related Diseases in Canada - 1998

	Giardiasis	Campylo-bacteriosis	E. coli 0157:H7	Shigellosis	Hepatitis A
Total cases in Canada	5519	14236	1484	1593	1090

Source: Peterson, HG, Rural Drinking Water and Waterborne Illness

Several large waterborne outbreaks have occurred in Canada recently. Two of the most notorious are the E.coli outbreak in the municipal water system in Walkerton, Ontario, in 2000, which killed seven people and caused 2300 people, half the town's population, to become ill. The other was the 2001 outbreak in North Battleford, Saskatchewan, which resulted in 7000 cryptosporidium infections. In the United States, waterborne illnesses in both public and private water systems affected more than 430,000 Americans. Almost 700 of those people were hospitalized; 58 of them died (Barwick et al, 2000; Lee et al, 2002, as cited in Frumkin et al, 2004).

Heavy rainfall runoff and outbreaks of waterborne diseases have been shown to be closely linked. Frumkin et al (2004) state that this is largely due to pet and wildlife waste, chemicals and other nutrients from fertilizers that flow unfiltered into streams and storm sewers after a rainfall. It is suspected that the 2001 E.coli outbreak in Walkerton was the result of cow manure from neighbouring farms that had infiltrated the municipal water treatment plant as runoff after local heavy rainfalls and flooding. Research by Johns Hopkins University has shown extreme rainfall preceded more than 50 per cent of waterborne disease outbreaks in the United States between 1948 and 1994. Outbreaks due to surface water contamination were most strongly and immediately related while outbreaks due to groundwater contamination were most often delayed by a month or two.

Runoff also creates sediment in waterways, which can affect the ability of water treatment systems to do their job properly. This is because soil particles (often compounded by sediment) provide protection for some types of microbial organisms, such as cryptosporidium and giardia. The soil prevents the organism from coming into contact with chlorine, which is used in water purification to kill it. Organisms that are not killed by chlorine can be detrimental to humans if ingested.(31)

2.4.3 Water Quality and Land Use

Land use decisions can influence the quality of our water. Deciding where to locate a commercial development, or how many buildings a piece of land will accommodate, are all factors that impact on water quality. For instance, an impervious surface (such as a concrete rooftop, an asphalt parking lot or a road) will constrict the amount of water that gets absorbed into the ground. The water that pools on these surfaces becomes unfiltered storm water runoff that enters surface water sources, like lakes and streams, with pollutants, chemicals and other contaminants that have accumulated in it.

There are other implications to high levels of runoff and greater areas of impervious surfaces. First, as development increases, less rainfall falls in the natural environment, thus less water is absorbed directly into the earth's groundwater system. Less rainwater soaking into the water table can be detrimental to the earth's water supply. Second, storm water runoff can have negative impacts on the natural stability of water courses. For instance, large runoff surges can lead to stream and riverbank erosion and can alter the foundations of riverbeds. Erosion causes other problems, as the soil and dirt that is swept from river banks into water bodies can actually change the ecology of the water, thus affecting aquatic vegetation, life and water quality.(31)

Undisturbed forested lands have the highest capacity to absorb water and the lowest rates of storm water runoff. In contrast, impervious surfaces have the highest runoff rates. A study by Zheng et al (1999, as cited in Bray et al, 2005) found that 15 per cent of rainfall on land covered by an artificial hard surface became runoff, as compared with only 4 per cent of rain that fell on undeveloped land. In urban areas, runoff from wide roads and parking lots was found to be the largest source of water pollution (USGS 1999; Bannerman et al, 1993, as cited in Frank et al, 2005). The problems associated with runoff become exacerbated when it mixes with chemicals from the urban environment, such as those used in lawn care in suburban areas. (Van Metre et al, 2000; Callendar and Rice, 2000; Dierberg, 1991; as cited in Frank et al 2005)

Further, it seems that high density areas fare better than low density ones when it comes to amount of runoff produced. Schmidt (1998, as cited in Bray et al, 2005) found that suburban sprawl areas produced 43 per cent more runoff as compared to higher density areas. And Goonetilleke et al (2005, as cited in Frank et al, 2005) found that low density areas contributed most negatively to water quality due to two factors: more paved roads (thus creating more impervious surfaces) and more large lawns (contributing to water pollution from lawncare chemicals).

Development of green space also poses a potential negative impact on water supply and quality, due to its effects on watersheds. Based on the results of studies that have looked at the effects of development on watersheds, Frank et al (2005) conclude that: "Any disruption to a watershed, even at very minor levels, has relatively large impacts – construction sediment, loss of trees, topsoil and ground cover, increased impervious surfaces and disruption of the natural water flows – all of which degrade water quality."(p.31)

Studies have also shown a link to a negative effect on water quality by pollutants attributed to gasoline and more directly to driving. In urban areas, increased roadways and vehicles contribute to water pollution through contaminants and chemicals that collect onto impervious surfaces and are then washed away as runoff and enter a water source either through groundwater or through streams and rivers. These contaminants include antifreeze, oil, gasoline, lead particles and other household chemicals. Vehicles cause water contamination in other ways, particularly from the air pollutants they create,

such as nitrogen, that negatively affect surface water. Also, thousands of gas stations that supply fuel for vehicles have been known to leak gasoline additives, such as MTBE, from their underground storage tanks. This additive directly contaminates groundwater.(31)

Groundwater contamination can also occur due to the overuse of septic systems in low-density suburban and rural residential developments. In Florida alone, due to the increase in onsite sewage treatment and disposal systems, 450 million gallons of partially treated, non-disinfected wastewater is released every day. Development that destroys and builds on natural wetlands can lead to flooding in these areas, as wetlands are like sponges that absorb water and can prevent flooding. They also help to filter runoff water.(6) Greenberg (2003) states that: "Uncontrolled development has already threatened potable water supplies across the United States." In fact Heisig (1999) found that some major reservoirs in the United States are "…now threatened by the sprawl-related runoff of street salts, nutrients, and hazardous contaminants."(as cited in Greenberg et al, 2003, p.1522).

2.4.4 Conclusion

The impact of the built environment on water quality is significant. Sprawled communities, lack of greenspace and paved surfaces are all contributors to contaminated run-off and degradation of watersheds and water sources.

Development must be regulated in such a way as to preserve water supplies and watersheds, and to ensure that there is enough greenspace within the built environment that will allow for a natural and safe hydrological system. The literature suggests several strategies that will help to ensure an adequate supply of water, including: establishing urban growth boundaries; regulating buffers around watersheds; decreasing the size of impervious surfaces (such as roadways, driveways and parking lots); offering incentives for retrofitting old buildings with green roofs, and adding green roofs to new building regulations; and putting systems in place that will help to filter and reduce storm run-off.(31;57)

2.5 Mental Health

2.5.1 Introduction

The World Health Organization (WHO) describes health as: "…a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity."(23;52) This description clearly places mental health as an essential component of overall health. Mental health, as described by WHO, is: "…a state of wellbeing in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a

contribution to his or her community."(52;90) Echoing this definition is one offered by the Public Health Agency of Canada, which provides a holistic approach to defining mental health:

> *"[Mental health is] the capacity of each and all of us to feel, think and act in ways that enhance our ability to enjoy life and deal with the challenges we face. It is a positive sense of emotional and spiritual wellbeing that respects the importance of culture, equity, social justice, interconnections, and personal dignity."(p.3)(91)*

As with physical health, mental health is the result of many factors and determinants that interconnect with each other to produce an individual's mental health status. Risk and protective factors influencing mental health are found at many levels, beginning with the individual and extending to the family, community and society. Determinants are broad and include such factors as housing, education, employment, gender, culture and social equality. In a 2006 report, *The Human Face of Mental Health and Mental Illness in Canada*, the Public Health Agency of Canada identified the physical environment as another prime determinant of mental health.

Although there are factors about the built environment that provide a benefit to mental health, there are others that adversely affect it. This section will examine findings from the review literature that establish connections between the built environment and mental health.

2.5.2 Impacts of the Physical Environment on Mental Health

The physical environment is made up of the natural environment (air, water, land, etc.) and the built environment (buildings, streets, playgrounds, etc.). Both of these environments influence mental health in different ways.

The natural environment

There is no doubt that exposure to the natural environment impacts on the wellbeing of individuals. In research by Kaplan and Kaplan (1989, as cited in Maller et al, 2005) it was concluded that: "People with access to nearby natural settings have been found to be healthier overall than other individuals."(p.47)(92) Overall health impacts in this research were not just physical. They included such mental health indicators as increased levels of job and homelife satisfaction and satisfaction with "life in general".(p.47) Further, Maller et al (2005) cite several studies conducted between 1987 and 2001 that indicate the human connection to the natural environment is not only vital for good physical health in terms of meeting basic needs (such as food, air, shelter and water), but that it is also essential for human mental health by fulfilling a plethora of emotional, spiritual and psychological needs (Wilson, 1984; Katcher & Beck, 1987; Friedmann & Thomas, 1995; Roszack, et al 1995; Frumkin, 2001; Wilson, 2001). More specifically, Rohde and Kendle (1994, as cited in Maller et al 2005) concluded in their review of the literature that: "…the psychological response to nature involves feelings of pleasure, sustained attention or interest, 'relaxed wakefulness', and diminution of

negative emotions, such as anger and anxiety.)(p.48)(92)

Research has found important correlations between positive mental health outcomes and access to the natural environment from within the built environment. Ulrich (1984, as cited in Frumkin et al, 2004) found that hospital patients who could view the outside from their hospital room had quicker healing times after surgery. Diette et al (2003, as cited in Frumkin et al, 2004) concluded that having a view of the natural environment allowed patients who had invasive medical procedures to better control their pain. And studies by Moore (1981-82, as cited in Frank et al, 2005) also confirmed this link with their findings that having a view of the outdoors can result in fewer visits to the infirmary.

Findings from the workplace are similar. Kaplan and Kaplan (1989, as cited in Maller et al, 2005), conducted studies that looked at the impact of access to nature by employees on their feelings of job satisfaction and personal wellbeing. They found that access to nature was correlated to greater job satisfaction, less job stress, and fewer headaches and other illnesses.(92)

The built environment

According to the review literature little evidence exists that directly connects the built environment to mental health outcomes.(52) Despite the paucity of evidence, several recent studies have been able to establish some associations between the two.

In a 2002 study by Weich et al (as cited in Ewing et al, 2006) the authors looked at several design features of the built environment, including the number of apartment units in a building, specific features of the building, the age and cleanliness of the building, and access to recreational space. The research was conducted to determine if any of these factors had an impact on the mental health of the residents living in that complex. Results indicated that several of these measures were associated with depression in some of the residents.

Ross (2000, as cited in Ewing et al 2006) looked at the social and economic characteristics of neighbourhoods in Illinois to determine the mental health status of residents. Ross found that symptoms of depression were more commonly reported in neighbourhoods that were socially and economically disadvantaged than in neighbourhoods that were less disadvantaged. In another study, Ross et al (2002, as cited in Ewing et al 2006) looked at poverty levels and neighbourhood stability (i.e. residential turnover) to examine the impact these factors had on mental health. The researchers found that residents who lived in neighbourhoods with a constant turnover rate had higher levels of anxiety and depression than those who lived in more stable neighbourhoods, where both neighbourhoods experienced the same low poverty level.(52)

Frumkin et al (2004) hypothesize that certain aspects of urban sprawl are beneficial to mental health while others are not. In the past, cities were unsanitary, overcrowded places where people often lived in squalid and cramped conditions that bred disease

and stress. Over time conditions improved, but as cities and their populations grew, so too did traffic, crime and other urban and social problems. Cities became places to get away from, and so for many the suburbs became a desired place to settle. Suburbs were regarded as places of "sanctuary", where people could live in close proximity to nature and have easier access to the natural environment. The suburbs offered distance from the stress and bustle of the city, and were less impacted by traffic, noise and crowds. Although the reality of living in the suburbs did not always fulfill those expectations, Frumkin et al state that the benefits of these aspects of suburban living, whether perceived or real, do indeed contribute to a person's wellbeing.(31)

Research into the impact of urban sprawl on mental health is neither extensive nor conclusive. According to the 2006 *Leadership in Energy and Environmental Design for Neighbourhood Development (LEED-ND) Report*, there are no studies that show a direct association between mental health and urban sprawl. In fact, it cites one study that shows there is no link. This study, by Sturm and Cohen (2004), used a sprawl index to look at connections between sprawl and physical and mental health. The researchers found significant relationships between several chronic medical conditions (such as asthma and hypertension) and sprawl. For mental health ailments such as anxiety and depression, no direct relationships were found.(52)

However, research has shown that certain characteristics of sprawl can lead to feelings of depression, isolation, anxiety, and stress – all of which can impact negatively on the mental wellbeing of a person. These characteristics will be examined more closely in the sections below.

2.5.3 Isolation and Loss of Community

Suburbs are characterized by neighbourhoods that are spread out, in which people drive more often than they walk; stores and services that are boxy and impersonal; and large residential lots that separate neighbours and create vast distances between homes, schools, shops and services. These characteristics of a neighbourhood can often lead to a person experiencing feelings of isolation and alienation. Many sprawl areas have little or poorly serviced public transit systems, making jobs and services hard to get to without access to a car. This can lead to further feelings of isolation.

For some, these factors can also contribute to a lack of cohesion and connectivity to the community. Their sense of "community" or "belonging" is lost when they do not know their neighbours, can't shop at local stores, or must spend most of their day in a car commuting to work, robbing them of time at home and in their neighbourhood. As Frank et al (2005) state: "A connected and supportive community can both prevent and mitigate the impact of mental health disorders."(p.34)(57)

Bray et al (2005) note that one of the results of sprawl is a lack of diversity which "…forces people to be transient because they cannot grow old in these communities, due to the isolating and restrictive layout."(p.34)(43). Staying in the same house or

community as one ages – being familiar with the area, the neighbours, the services – is an important component of feeling secure and being part of a community. Not having a sense of continuity and belonging can affect a person's overall sense of wellbeing.

Isolation is not just a phenomenon of the suburbs. Research looking at the affect of crowding in cities has shown that crowding can lead to feelings of loss of control and can result in self-induced isolation.(93) This will be discussed in greater depth in Section 2.7 - Social Capital.

The Public Health Agency of Canada states that: "Good mental health and positive self-esteem enable an individual to connect with and embrace a community of people."(p.12)(91) In a 2002 survey, only 18.5 per cent of Canadians 15 years and over reported having a very strong sense of being part of their community, while almost 40 per cent reported a somewhat strong feeling of belonging.

2.5.4 Safety, Fear and Crime

Fear caused by certain characteristics of community design, and the perceived threat to one's safety while engaging in daily activities, can impact on mental health. The literature points out that fearing for one's safety due to his or her surroundings can impede the amount of physical activity that a person engages in. Regular physical activity can reduce anxiety and depression, and it can help to increase emotional stability. Therefore, a lack of physical activity can negatively affect both physical and mental health.(31) This is confirmed by findings of the Canadian 2002 Mental Health and Wellbeing Survey that reported Canadians who were physically inactive were more likely to perceive their level of mental health to be fair or poor, compared to those who were active.(91) In regards to physical activity and its relationship to safety, Frumkin et al (2004) discuss several studies that report a correlation between feelings of being safe in one's community to increased levels of physical activity. In one study, Australian researchers found that walking nearly doubled amongst people who perceived the walking paths to be safe (Booth et al, 2000, as cited in Frumkin, et al 2004).

Bray et al (2005) conclude from the research that "…the greatest perceived barrier to physical exercise in sprawl communities [is] lack of a safe place in which to do so."(p.33)(43). Since physical activity is often used as a way to treat some forms of depression, anxiety and stress, the fear for one's safety in poorly designed communities means that physical activity may not occur, which can be worse for mental health. The most common fears in communities include crime, traffic, lack of lighting or streetlights, roads built for speed, roads fronted by large apartments and/or commercial and industrial space, few crosswalks, and lack of sidewalks (Hancock, 2000 and Hanzlick, 1999, as cited in Bray et al, 2005).

The way that communities are designed and the types of structures that are built can influence the level of crime that occurs there. Crime levels impact the amount of fear that people feel and their perceived sense of safety. For example, spread out

commercial and industrial areas that are commonly associated with sprawl are usually abandoned at night. The result is few or no 'eyes on the street', making the area more vulnerable to crime. This is also true of low density residential areas. Areas with abandoned or derelict buildings can be a target of vandalism and can be an attractive setting for other types of crime.(94)

A crime prevention strategy designed to improve public safety through housing layout designs has been shown to reduce crime. Implemented in the U.S. in the 1970s, the Crime Prevention Through Environmental Design (CPTED) program works with communities to implement design elements in housing, land use and property maintenance that are known to reduce crime. Evaluators of the program concluded that: "Implementation of CPTED recommendations may have consequences on the health of a community beyond crime prevention, such as improvements in physical activity, mental health, and social capital."(p.1504)(94) Fear also contributes to a decline in social capital, which will be discussed in Section 2.7.

2.5.5 Driving and Commuting

Driving is one element of the built environment, particularly related to urban sprawl, that has clearly been shown to impact on mental health. As has already been established, sprawl results in large distances between homes, services, schools and jobs, which translates into increased driving.

In *Urban Sprawl and Public Health*, Frumkin et al (2004) devote almost a whole chapter to the impact of driving on mental health by highlighting the effect driving has on stress levels. They cite several studies that acknowledge a relationship between driving and an increased level of stress. White (1998, as cited in Frumkin et al, 2004) found that individuals who drove their car across a city for 45 minutes experienced high heart rates and blood pressure, as well as high levels of frustration. In another study by Hennessy and Wiesenthal (1997, as cited in Frumkin et al, 2004), drivers reported feelings of frustration, unease, distress and loss of temper when they drove in the city.

Bray et al (2005) cite more recent studies that show traffic stress to be associated with depression and lower overall health status (Gee and Takeuchi, 2003 & 2004). Curbow (1999) found that several traffic-related factors, such as exposure to vehicle fumes, traffic volume, visual distractions on the road, and the anxiety and stress that results from driving in heavy traffic, can lead to increased blood pressure and headaches, and in some cases, incidents of road rage. Frumkin (2002, as cited in Bray et al, 2005) reported that driving can even impact negatively on relations with family, friends and coworkers who can be the ones to feel the effects of a frustrated and anxious driver. He hypothesizes that drivers who come home from long commutes feeling angry and disgruntled do not just restrict their negative feelings to their cars, but bring home their frustration and let it out on their loved ones. Social and family relationships may be compromised as the result.

The evidence shows that commuting can also cause significant stress to a person. In a study of commuters in Washington, DC, Schaeffer et al (1988, as cited in Frumkin et al, 2004) found that those who constantly travelled in regular traffic congestion reported lower work performance levels and higher blood pressure than those who did not travel in these conditions.

Bray et al (2005) point out several studies that indicate negative mental and physical health effects of commuting, including increased cardiovascular disease, back pain (Koslowsky et al, 1995), headaches, asthma, arthritis (Sturm and Cohen, 2004), and lower feelings of overall life satisfaction and a perception that work performance was impaired (Novaco, 1990).

Commuting stress, however, is not just specific to those who drive. Several studies have shown that stress and anxiety are also found amongst people who use other forms of transportation to commute to work, such as by train or bus.(57)

Although these studies implicate driving, and in particular commuting, as a stressful form of travel for most people(57), there have been a handful of studies that show the other side of this equation. Kluger (1998 as cited in Frank et al, 2005) found that for some people, driving was actually a beneficial activity. Reported benefits of time spent behind the wheel include time to unwind from work, time for oneself, and in some circumstances, time to relax and enjoy the scenery.

2.5.6 Aggressive Driving and Road Rage

The stress of driving can often manifest into aggressive driving behaviour by some, often involving incidents of road rage. The U.S. National Highways Traffic Safety Administration (NHTSA) defines aggressive driving as: “The operation of a motor vehicle in a manner which endangers or is likely to endanger persons or property.” Acts of aggression can include tailgating, speeding, unsafe lane changes, and failure to obey traffic lights and signs. These acts can sometimes move beyond mere traffic violations into the realm of criminal activity.(95)

NHTSA lists some of the reasons for aggressive driving as: traffic and congestion especially in urban and suburban areas where commuting is common; being in a rush to get somewhere; feelings of losing valuable time when having to drive long distances to work or leisure activities; and community design and road patterns that have created a greater need for automobile use, thus putting more vehicles on the already congested roadways.(96)

A *2003 Nerves of Steel Survey* conducted for the Canada Safety Council reported that a high level of aggressive driving exists in Canada. In a telephone survey, 84 per cent of Canadians surveyed admitted to engaging in at least one act of aggressive driving in

the last year; despite the majority of those interviewed believing that aggressive driving was a safety concern. The most common forms of aggressive driving reported were running yellow lights (61 per cent) and driving at least 20 km per hour over the posted speed limit (55 per cent). Demographically, slightly more men than women (86 per cent vs. 81 per cent) reported driving aggressively, while young drivers 18-29 years (95 per cent) reported more aggressive driving than older drivers 50+ years (75 per cent). Almost three-quarters of Canadians surveyed (75 per cent of females and 69 per cent of males) believed that aggressive driving is getting worse and is on the rise. The report concluded that the results of this survey had broad public health implications due to the fact that there are more than 20 million licensed drivers in Canada.(97)

According to the Surface Transportation Policy Partnership (STPP) in the United States, aggressive driving is very closely linked to the way communities are designed. In its 1999 report, *Aggressive Driving: Where You Live Matters*, the partnership found that:

> *"Compact communities with connecting neighborhood streets and local businesses are easier to serve with transit, more convenient for residents, and are safer for automobile users because they require lower travel speeds. Sprawling subdivisions and office parks that can only be reached by high-speed arterials are more dangerous for drivers and provoke more frustration among residents, resulting in more aggressive driving."*

The STPP looked at the rate of aggressive driving in relation to road patterns, transit systems and the presence of sidewalks in several large metropolitan areas in the United States. They found:

> *"The majority of the metropolitan areas with lower aggressive driving deaths are older and have grid street patterns, sidewalks and more developed transit systems. The ten metropolitan areas with the lowest aggressive driving death rates include Boston, with two deaths per 100,000 people due to aggressive driving, followed by New York City, Minneapolis, Pittsburgh, Virginia Beach-Norfolk-Newport News, Cleveland, Milwaukee, Cincinnati, New Orleans, and Seattle. When people in these regions go out to lunch, run to the drugstore or go to the office, many of them have the choice to leave their cars behind and walk, bike, take the bus or ride the train."*

The partnership was also able to make some statistical connections between aggressive driving death rates at the state level and the use of transportation forms other than the automobile. They found that for states where a higher proportion of commuters used bus or train transportation there was a 34 per cent lower risk of a commuter dying as the result of an aggressive driving crash. Further, they concluded that: "States with fewer aggressive driving deaths had a significantly higher percentage of residents walking to work."(95)

The extreme result of aggressive driving is road rage. Road rage, as described by

Smart and Mann (2002), is when "…a driver or passenger attempts to kill, injure or intimidate a pedestrian or another driver or passenger or to damage their vehicle in a traffic incident."(p.761)(98). Research has found that incidents of road rage most often happen during times of high traffic and travel periods, usually in the summer and often on Friday afternoons. Other risk factors include delays, traffic volume and travel distance(43), as well as the personal characteristics of drivers, such as gender, age, and stress levels.(31)

Over the last two decades, road rage has been increasing in countries such as the United States, Britain and Australia. In the U.S., the AAA Foundation for Traffic Safety reports that from 1990 to 1996 the number of road rage incidents rose 51 per cent, from 1,129 to 1,800 incidents per year, resulting in 218 fatalities and more than 12,500 injuries during that time period. (Mizell, 1997, as cited in Ewing et al, 2006).(52) In Canada, a 2001 study conducted by Canadian Press/Leger Marketing, reported that almost five million Canadians (or 20.4 per cent of Canadian adults) were victims of road rage. Of those, 4.2 per cent (or 202,500) adults had been injured as a result of the incident, and 5.3 per cent of those incidents had involved the deliberate colliding of the aggressor's vehicle with the victim's vehicle. Other incidents involved rude gestures, threats, vulgar language, or dangerous driving.(99)

Other Canadian research on road rage is sporadic. However, in a review by Smart and Mann (2002) of reports about road rage in Canadian newspapers between 1998 and 2000, the researchers found that most incidents of road rage (96.6 per cent) were perpetrated by males and most victims were also males, with an average age of 33.5 years. Of the reported cases, almost 73 per cent involved nonfatal injuries, while almost 7 per cent involved fatalities. The authors state that: "Newspaper reports cannot be used to estimate the total number of cases but can give us a first, cursory look at road rage, and it appears that road rage does result in deaths and serious injuries in Canada."(p.761)(98).

2.5.7 Conclusion

This section has provided a summary of research that highlights the impacts of the natural and built environment on mental health. Although the scientific evidence is not robust, the literature has shown how certain characteristics of the environment, such as aesthetics, design and sprawl can affect an individual's mental health, particularly affecting feelings of safety, fear, isolation, stress, depression and sense of belonging.

Riediker and Koren (2003) suggest that, due to these associations, consideration of mental health issues should be an integral part of land use and urban planning.

> *"Aspects of physical health are well-accepted components in policy making concerning the protection and development of the environment (e.g. clean air act and drinking water act). In future it might be advisable to include the dimensions of mental and social wellbeing as equally important components in the decision*

making for environmental and urban planning projects."(p.199)(100)

It is possible to design communities and make land use decisions that will enhance, rather than hinder, overall population mental health. Based on what is written on this topic in the literature actions to achieve this can include:

- Provide open space and park areas within the urban environment that are easily accessible to all residents and visitors of a community, but particularly located near schools, workplaces and housing developments.(92)
- Ensure that communities Include meeting places and common areas that address all stages of the life cycle.(101)
- Increase community safety features and initiatives to induce more social interaction among neighbours and increase physical activity.(101)

2.6 Social Capital

2.6.1 Introduction

The ways in which people interact with one another, the relationships they form within the community, and the amount of time they spend engaged in civic endeavours, volunteer work or other activities are all important elements of a healthy and functional community. It is these often intangible but vital interactions that help to define a community. It is these interactions that establish connectedness and cohesion between residents, and that promote good will and harmony in a community. These elements are known collectively as social capital. The creation of social capital in a community is achieved by the contributions that people bring to their community, as well as the involvement and the amount of participation they have in it. These contributions, participation and involvement are dependent on a number of factors, such as the extent to which a person feels a sense of belonging, security and connectedness to their community, how well one integrates into their environment, how much influence one has over it, and how well their needs are met within the community they live.

The term "social capital" was coined in 1916 by a United States school official who used it to refer to the regular social exchanges that take place between people, their families and the broader community. Although named almost a century ago, its meaning has not changed. Putman (2000, as cited in Frumkin et al, 2004) defines social capital as: "…connections among people – social networks and the norms of reciprocity and trustworthiness that arise from them."(p.163) At a more practical level, social capital is, "the degree of citizen involvement in a community, the degree to which people know and trust their neighbours, and the numerous social interactions and transactions that people have as we go about our daily business."(p.34)(57)

Social capital is built upon relationships and networks, which are generally established through both formal and informal channels. Formal channels include organizations and

groups, such as volunteer groups, clubs or political associations, that represent a special interest or activity and that involve two or more people. Informal channels are random and unstructured settings where social capital is often built unexpectedly, such as when one talks to a stranger at the local bank, or chats with a neighbour while out cutting the grass. Social capital is also built through the participation of individuals and groups in civic activities, such as voting or running for public office.(52)

Social capital has been described as transformative – as a phenomenon that changes individuals from being egocentric and self-serving into individuals who see themselves as members of a community who pool collective wisdom and deeds toward a common purpose aimed at improving the lives of all members of that community (Newton 2001, as cited in Frumkin et al, 2004). Transformation can also occur at the community level, where it has been found that communities with a high level of social capital are better able to function, and have been found to experience increased prosperity, lower levels of crime, a greater sense of overall community cohesion, and governments that are able to better meet the needs of the community and its members.(31)

Social capital is clearly good for society, but to discern the extent to which it exists is a challenging undertaking. Due to the subjective nature of social capital and many of its associated variables (such as the differences in cohesion that exist between neighbourhoods and communities, the degree to which interactions take place there, and the attitudes, perceptions and practices that people have towards it) it can be difficult to measure. However, researchers have been able to gauge levels of social capital within a community by using a variety of quantitative and qualitative indicators. These include: individual perceptions (e.g. level of satisfaction and feelings of inclusion in a community; personal levels of social support systems and networks where a person lives); individual participation (e.g. level of participation in groups and activities in a community); and level of involvement in civic politics and community activity.(57)

2.6.2 Social Capital and Health

If social capital is good for the health of a community, by implication is it also good for human health? The impact of social capital on health has been an area of interest to researchers for several years. In many cases it is research that has extended from existing knowledge about the social needs of human beings; that is, that people crave social interactions and bonding, and that forming relationships is better for a person's wellbeing than is isolation and loneliness. But social bonding is not the same as social capital. However, because one of the essential elements of social capital is social networking, which functions at a community level much the same that bonding does at an individual level, then some of the learnings of applied social research can be applied here.(31)

In fact, research does show that social capital is linked with health. Frumkin et al (2004) refers to several long-term studies that were conducted in the United States in the late 1990's that looked at the association between mortality rates and social

networks/relationships. These studies revealed a number of interesting results, including that "people with strong social networks live longer." (p.166), that men, more-so than women, seem to benefit from strong social networks, and that the leading causes of mortality in those with few or no social contacts are suicide, strokes, cardiovascular disease and injuries.

Kawachi et al (1997, as cited in Frumkin et al, 2004) conducted a cross-sectional study that looked at 39 states and compared each state's mortality rate with its level of social capital. The researchers concluded that age-adjusted mortality decreased as the state's level of social capital increased. Similar results were found in a 2002 study conducted by Veestra (as cited in Frumkin et al, 2004) in Saskatchewan that used an index to compare social capital in each health district in the province with mortality rates. Veestra also found that age-adjusted mortality decreased with increased levels of social capital. As an interesting sidebar to this study, when he compared improved overall health status and social capital, Veestra did not find a relationship between these two. What he did find was that overall health was predicted by higher education and income, but not by social capital. Conversely, Kawachi et al were able to find a positive relationship between social capital and overall health status in their studies.

Despite some contradictions in the research findings, many other health effects have been linked to social capital, including:

- A lower level of social support is linked to the development of coronary artery disease. This was the conclusion of a 1993 Swedish study, in which researchers found that men who have lower levels of social and family support, attachment and social integration were more likely to develop the disease. (Orth-Gomer, 1993, as cited in Frumkin et al, 2004)
- The intellectual and emotional development of children is more advanced in communities that are walkable and that combine a mix of land uses. This, say the researchers, is attributable to a child's opportunity to experience independence and engage in physical activity in a community that is more cohesive and close-knit; generally a community that has a higher level of social capital. (Gilbert and Obrien, 2005; Hertzman, 2002; as cited in Frank et al, 2005)
- The LEED-ND Report cites several studies that link social capital to a person's ability to recover faster from illness, such as colds. Studies have also shown that social capital is connected to lower incidence of death for people who have had heart attacks, cancer, heart disease and stroke.(52)
- Mental health is improved with higher levels of social capital. Since social capital is created through social networking and bonding, it follows that in communities with more social capital, human connections and relationships are more likely to occur. Therefore, communities that have lower levels of social capital may have a larger proportion of the population that experience isolation and loneliness, which can lead to depression, poor mental health, and poor overall health status. Putman (as cited in Ewing et al 2006) states: "The single most common finding from a half century's research on the correlates of life satisfaction, [from] around the world, is that happiness is best predicted by the breadth and depth of one's

social connections." (p.92)

Lastly, social capital has been found to be connected with a variety of other social issues that impact on overall health status. Lindstrom et al (2001, as cited in Frumkin et al, 2004) found a connection between social capital and people taking more leisure physical activity time. Kennedy et al (1998, as cited in Frumkin et al, 2004) found social capital to be associated with a decrease in the rate of crime. Other studies have shown social capital to be linked with lower levels of teenage pregnancy and binge drinking rates.

2.6.3 Social Capital and Urban Sprawl

Many experts speculate that social capital in North America has been on the decline over the last few decades. One of the factors implicated in this decline is the design of the built environment, particularly sprawl and the suburbanization of cities.

During the early 1950s, as North Americans headed out of the cities and into the booming suburbs, social capital thrived. Organizations, clubs and associations formed. Social activity and community involvement were high. An overall sense of personal happiness was reported by people who lived in low density neighbourhoods located outside of the urban centre (Wilson and Baldassare, 1996, as cited in Frumkin et al, 2004). However, as suburbia grew and distances between work and home became greater, so too did the distances between people. Lack of time for involvement in community activities resulted in feelings of isolation and detachment. The sense of community that many people moved to the suburbs for was diminishing, due in part to what Mumford (1938, as cited in Frumkin et al, 2004) described as a "collective effort to lead a private life". (p.172)(31)

In his article Urban Sprawl and Public Health, Frumkin (2002) hypothesizes that there are several components of suburban development that affect the level of social capital in a community. The first is the distance factor that is created by sprawl development. Sprawl, by its very nature, results in large distances between where people live and where they work and play. This results in people spending a great deal of time commuting to work and driving to a variety of other destinations. Driving takes precious time away from individuals who could be spending it with family, friends, or engaged in other social and civic related activities. In a statistic that is often quoted from his book Bowling Alone, Robert Putman (2000, as cited in Ewing et al, 2006) found that one of the strongest predictors of community involvement is the time spent behind the wheel of a car, especially time spent commuting. His conclusion was that, "for each additional ten minutes spent in daily commuting time cuts involvement in community affairs by 10 per cent".(p93) Commuting caused by land use planning decisions clearly has an impact on people's ability to be engaged in their community.

Second, Frumkin (2002) states that sprawl creates economic stratification due to residential development patterns that segregates housing into different price ranges.

For instance, houses priced over $500,000 are generally built in different sections of a community from houses priced under $150,000. This segregation results in neighbourhood homogeneity that can negatively affect cohesion and connectedness, and tends to highlight income inequality within a community.

The third factor is associated with the length of time an individual lives in one place, and the features of a community that are conducive to an individual staying in that place throughout their lifespan. According to Frumkin (2002), suburbs offer little appeal for older people to stay in the family home. Large, low-density residences and lots make it difficult for older adults to maintain their home and property, especially once their children have left home. Often feelings of isolation grow. Poorly planned communities may not have the health, long-term care, recreational and social service facilities that some older adults require. All of these factors can detract from social capital when it fosters isolation and results in an exodus of long-time residents to another community that has these facilities.

Lastly, Frumkin cites polling data from the U.S. that show residents of suburban areas tend to be less collaborative than residents in urban, rural or small town settings in their approach to problem-solving around community issues. Based on these factors Frumkin concludes that:

> *…to the extent that sprawl is associated with social stratification and loss of social capital and these phenomena are in turn associated with increased morbidity and mortality, sprawl may have a negative health impact on this broad scale."(pg.209)(27)*

However, not all researchers agree that urban sprawl, particularly its mixed use and density characteristics, is the sole detractor of social capital. In fact, research is both mixed and inconclusive. Freeman (2001) argues that although studies have found that sprawl negatively affects social capital, there are also studies that show high density urban neighbourhoods can also have the same affect. In a 1996 study, Wilson and Baldassare (as cited in Freeman, 2001) concluded that sense of community was diminished by higher density. Michelson (1977, as cited in Freeman 2001) found that making or keeping friends was no different for those who lived in an urban area than for those who lived in a suburban area.

Recently, attention has been given to the theory that crowding – as found in high density urban areas – affects social capital. The hypothesis is that crowding can generate feelings of lack of control that a person has over their interactions with other people. This overwhelming surge of humanity can cause people to withdraw and isolate themselves in their own space, which impedes the build up of social capital in a community. Freeman concludes that:

> *…whereas very low densities may undermine neighbourhood social ties, as we move up the density scale, at some point higher densities start to have the same*

effect. The point at which increasing density switches from having a positive to a negative effect on neighbourhood social ties is not suggested by the literature."(p. 71)(93)

2.6.4 Social Capital and the Built Environment

The review literature cites multiple studies that confirm that land use decisions and the design of the built environment does impact on social capital. These studies examine specific characteristics of the built environment, such as density, walkability, automobile dependency, traffic volume, mixed land use, and greenspace to determine how they affect social capital within a community.

In a 2003 study of residents of different neighbourhoods in Galway, Ireland, Leyden investigated the relationship between levels of individual social capital and the type of neighbourhood residents lived in. The study found that people who lived in mixed-use walkable neighbourhoods had an increased level of social capital compared with those who lived in sprawled car-dominated suburbs. Those people living in a walkable community were more likely to report knowing their neighbours and to trust others, as well as to be politically and socially engaged.(102) In an earlier U.S. study, Nasar and Julian (1995) also found that residents of a mixed-use neighbourhood felt a significantly higher sense of community as compared to residents of a single-use neighbourhood.(103)

In 1981 study, Appleyard (as cited in Frank et al, 2005) found that knowing one's neighbour was more likely to occur on streets that had less traffic than residents of streets that had more traffic. Lund (2002, as cited in Frumkin et al, 2004) compared a low density suburban neighbourhood with one that was more traditional (high density, mixed land use) to see how walkability affects social capital. This was assessed through a survey of residents' perceptions about social capital and walking. Study results indicated that sense of community was most likely predicted by the walking environment (safety and aesthetic features), positive attitudes towards walking and an opportunity for interaction during walking episodes.

As referred to earlier, vehicle use is a factor that can undermine social capital. Putman determined that time spent driving takes away from time that could be spent on other social activities. Additionally, driving inhibits a person's ability to have face-to-face contact with others. A 2001 study by Freeman of this relationship arrived at the same conclusion: that automobile dependency is not conducive to the creation of social capital. In fact, Freeman found that "every 1 per cent increase in the proportion of individuals driving to work [in a neighbourhood] is associated with a 73 per cent decrease in the odds of an individual having a neighbourhood social tie… [and a] 71 per cent decrease in the odds of a respondent having relatively more neighbourhood social ties."(p.74)(93).

Greenspace is another feature of community design that has been found to impact on social capital. Greenspace not only helps to stimulate social capital but also provides

further health and environmental benefits, such as increased opportunity for physical activity, and exposure to the natural environment that can result in an increase in mental wellbeing. Parks, recreational fields and walking/biking trails often become a focal point of many communities. They provide a meeting place for people – a place to congregate, to meet neighbours, to engage in communal activities – and are an important venue at which social interaction between residents takes place.

In 1992, Skjaeveland and Garling (1997, as cited in Frumkin et al, 2004) examined various aspects of community design and the impact these variables had on "neighbouring" in the city of Bergen, Norway. Their results indicated that neighbouring was strongly predicted by lower density dwelling, as well as the availability of greenspaces, such as parks and gardens, located near people's homes. The authors concluded that public greenspaces provide an opportunity for people to spend time outside, which increases the chance for interaction amongst neighbours.

A study by Sullivan and Kuo (1996, as cited in Jackson and Kochititzky, 2001) looked at violence and conflict in public housing complexes in Chicago, and found that people who lived in buildings with greenspace around them reported better relationships with their neighbours, were able to handle domestic conflicts in less violent ways, and had a greater sense of community cohesion.

One final feature of the built environment and its impact on social capital is the size of a community. In an analysis of the results of a large social survey in the United States, Putman (as cited in Ewing et al, 2006) was able to find a relationship between the size of a community and the social connectedness and community participation of its residents. Results indicated that the largest cities in the United States reported lower levels of participation in groups, organizations and civic engagement.

2.6.5 Conclusion

The review literature highlights a multitude of studies that shows the connections between overall health and mortality status and social capital. Generally, the evidence indicates that increased levels of social capital are associated with improved overall health status and lower mortality rates. Therefore, social capital is good for health.

The evidence also indicates that different features of the built environment can impact on social capital, which in turn impacts on health. Characteristics such as density, mixed land use, walkability, greenspace, and community size can either serve to create, foster or detract from social capital. Despite some conflicting study results, some of the experts who have studied the connection between social capital and the built environment agree that designing neighbourhoods to be mixed-use and walkable are key to building and maintaining social capital in a community.

Frank et al (2005) state that walking in a neighbourhood can increase contact with neighbours, provide more eyes on the street, and thus prevent crime, and can instil a greater sense of community pride and cohesion. "Practices that decrease time spent

driving and increase pedestrian activity, social interactions and commercial activity in a neighbourhood can probably also increase social capital."(p.35)(57)

Freeman (2001) adds that if social capital is to increase then communities must be designed to be less car-oriented and more walkable, which is dependent on good public transportation system planning. "Developing more transit-oriented neighbourhoods would likely enhance neighbourhood social ties, either by attracting individuals who are inclined to form such ties or by causing individuals already residing there to form them."(p.74)(93)

3.0 CONCLUSION

"Communities can be shaped by choice, or they can be shaped by chance.
We can keep on accepting the kind of communities we get, or we can start creating the kind of communities we want."(104)

Richard Moe, President of the National Trust for
Historic Preservation, United States of America

This literature review has examined a large body of evidence and concludes that the built environment profoundly impacts the health of the population. Sprawling and fragmented communities have fostered car dependency, inactivity, obesity, loneliness, fossil fuel and resource consumption, and environmental pollution.(105) Addressing these health impacts of the built environment will be one of the most significant challenges of the 21st century as it encompasses chronic disease, environmental degradation and global warming. We are presented with an epidemic of our own making. How do we move forward?

Before we move forward, it is prudent to look back for "(t)hose who cannot learn from history are doomed to repeat it" (George Santayana). In the introduction to this literature review, the story of Dr. John Snow was told. In 1854, a cholera epidemic hit London. By talking to local residents Dr. Snow realized that the victims of the disease got their water from the same pump in the middle of the city. He disabled the pump and the epidemic quickly waned. At that time, Snow's insight was revolutionary on a number of counts: the health of the public was directly related to the environment in which they lived; the problem had to be addressed at the source; and connections among disparate components eventually solved the problem.

The learnings from this experience in the 19th century connected the health of the environment with the health of the public and ignited action from health professionals and scientists, business people, planners, engineers, politicians, architects, lawyers and many others outside the realm of health and science.(105) The outcomes of their work together were manifested in improved sanitation and infrastructure.

Over the last half century, the science and practice of public health, planning and environmental stewardship has become more specialized and fragmented.(105) We are now experiencing the impacts of this separation and the challenges we face need to be addressed by everyone working together. Health professionals, scientists, business people, planners, engineers, politicians, architects, lawyers, citizens and many others need to choose our communities' future and act upon what we know(106).

In simple words, our main goal is to achieve a good place to live that supports the health and aspirations of the current generation and is sustainable to support those of future generations. This goal works at a local, national and global level.

The four fundamental qualities of a good place to live are viability, vitality, options and accessibility.(107) These ideas were distilled by the City of Edmonton in their *Smart Choices Catalogue of Ideas*. These four fundamentals acknowledge that the health of the community is directly related to the environment in which we live, addresses solutions to the sources of the problems, and connects a number of components to work towards a successful solution.

A good place to live is viable. It means being capable of living and growing.(108) A good place to live is capable of existence and development as an independent unit. A viable community has valuable assets and requires ongoing work.(108) Viability involves efficient use of all the resources – built, natural, economic and social. It requires investment and reinvestment, needs affordable and sustainable infrastructure and services, and supports social cohesion among its citizens who are working towards the shared goal of contributing and benefiting from a good place to live.(107)

A good place to live is vital. It is fundamentally concerned with living beings and renewing or refreshing the living.(109) It is a vibrant community that is interesting to live in and attractive to other people.(107) “Vitality requires a mix of activities and uses, community interaction, heritage, culture and beauty, diversity, interest and excitement, active democracy, and a strong downtown and commercial area.”(107)

A good place to live has options. There are a variety of choices regarding location, housing, work and transportation.(107) Community elected officials, municipal staff, other key decision-makers and the private sector work to provide options by offering different neighbourhoods, housing types, business and work locations, and transportation modes.(107)

A good place to live is accessible. Access is defined as, “permission, liberty, or ability to enter, approach, or pass to and from a place or to approach or communicate with a person or thing”.(110) “A community provides access to a variety of amenities and destinations. The need for access influences individual decisions about locating near places of work and learning, community facilities and services, recreation and entertainment, health and emergency services, open space and natural areas and shopping.”(107)

Application of these four fundamentals of a good place to live is required to guide our communities’ future, to offer direction for action and to provide indicators for success. Leadership and collaboration are necessary to respond to the challenges presented by our current built environment(105) and to create communities that promote the health and aspirations of the current generation and are sustainable to support those of future generations.

The following section outlines a number of recommendations found in the literature to guide future specific actions.

4.0 RECOMMENDATIONS

BUILDING HEALTHY COMMUNITIES: RECOMMENDATIONS RELATED TO HEALTH IMPACTS

The following chart outlines 36 negative health impacts resulting from the existing built environment, and recommendations for public health agencies, municipalities, planners and communities to consider in addressing those impacts through changes to the built environment.

Overall Recommendations

1. Health considerations should be an integral component of the land use, transportation and community design planning process and health outcomes should be used as indicators within that process.(6)
2. All official and/or growth plans should incorporate healthy community principles that include explicit health-related goals and objectives addressing the multiple impacts of the built environment.(57)
3. Health promotion strategies, such as social marketing campaigns, advocacy and community interventions, should be used to educate the public and other targeted audiences about issues related to healthy communities, including:
    a. Smart growth principles;
    b. What makes a healthy community;
    c. How to be part of the process for creating and sustaining a healthy community.(57;101)
4. Research and development related to health, the built environment, community design and land use planning, should be on-going in order to maintain knowledge and understanding of the issues, and results of findings should be disseminated widely.(6)

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
PHYSICAL & MENTAL HEALTH IMPACTS		

1. Physical Inactivity	• 86 per cent of all person trips and 91 per cent of all person miles occurred in a the private vehicle whereas walking accounted for only five per cent of trips and less than one per cent of miles.(54)
	• Between the years 1977 and 1995, there was a 37 per cent decline among children aged 5 to 15 years in the number of trips they made by walking or biking.(6)
	• Walking trips are more affected by street network patterns than vehicle trips due to their lower travel speeds and shorter distances.(57)
	• Research shows a relationship between increased adverse affects of breathing air pollution with increased physical activity levels, and that these effects "tend to be most pronounced in people with underlying health conditions such as asthma."(p. 1)(75)
	• Walking distance increases for people who walk to a public transit stop (a quarter mile for a bus and up to half a mile for a train) (Frank, Stone and Bachman, as cited in Ewing et al, 2006)
	• Lack of physical activity can negatively affect both physical and mental health. This is confirmed by findings of the Canadian 2002 Mental Health and Wellbeing Survey that reported Canadians who were physically inactive were more likely to perceive their level of mental health to be fair or poor, compared to those who were active.(91)
	• Frumkin et al (2004) discuss several studies that report a correlation between feelings of being safe in one's community to increased levels of physical activity. In one study it was found that walking nearly doubled amongst people who perceived the walking paths to be safe (Booth et al, 2000, as cited in Frumkin et al, 2004)
	• Lindstrom et al (2001, as cited in Frumkin et al, 2004) found a connection between social capital and people taking more leisure physical activity time.
	• Study results indicate that sense of community was most likely
		Increase physical activity through the following changes to the built environment:
		• Create landscapes and streetscapes for all ages and abilities.
		  ○ Design landscapes and streetscapes to accommodate strollers, wheelchairs, walkers, and canes.(31;32;101)
		  ○ Maintain walkways and bikeways and keep them clear of debris and snow.(31;32;101)
		• Incorporate pedestrian, cycling and public transit opportunities, infrastructure, development and maintenance in Master Transportation Plans.(59;101)
		• Design communities so people can walk and cycle more.(57)
		  ○ Engage citizens of all ages, backgrounds and abilities in design of neighbourhoods through consultation.(32)
		  ○ Conduct neighbourhood walkability assessments.(32;58)
		  ○ Use grid design over lollipop design in new developments to increase walkability. (King County ORTP, as cited in Frank, Kavage & Litman, 2007).(57)

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
	predicted by the walking environment (safety and aesthetic features), positive attitudes towards walking and an opportunity for interaction during walking episodes. (Lund, 2002, as cited in Frumkin et al, 2004)	○ Improve streetscape aesthetics and design (trees, benches, wider sidewalks, etc.) (Rapoport, as cited in Frank and Engelke, 2006). ○ Increase and improve quality of sidewalks, paths and trails for walking, biking and other forms of active transportation.(32)(p.105) ○ Locate schools, services, and retail within walkable distance of residential neighbourhoods (8 kilometres for biking and 2.5 kilometres for walking).(101;111) ○ Support walk-to-school programs.(32)(p.80) ○ Plan development within transit routes in order to increase public transit use and accessibility.(32) (p.140) ○ Provide secure bicycle storage at strategic destinations such as schools, transit stations, shopping malls, public buildings, public housing and apartments.(4;32) (p. 135) • Retrofit sprawling communities. ○ Create pedestrian cut-throughs for increased access.(112) ○ Redevelop shopping malls to include residential developments.(112)

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
		○ Redevelop edges of large parking lots for streetscape developments.(112) • Revitalize older neighbourhoods that are walkable. ○ Create new housing for a mix of income levels.(4;112) ○ Incorporate more housing in older or more established neighbourhoods that is both compatible and complimentary to the existing development. (4;59;112) ○ Revive deteriorated commercial areas with investment and incentives.(59;112) ○ Upgrade hard and soft infrastructure.(59;112) • Design communities that reduce automobile dependency. ○ Provide mixed use development (housing, services, retail, community spaces, etc.).(57;101) ○ Increase density to levels that will support public transportation system.(57;101) ○ Locate employment close to residential areas.(101;111) ○ Build transit-oriented development.(112) ○ Connect public transit routes to businesses and other areas of

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
		employment.(112) • Design communities so children can play more. o Place play areas in safe areas away from high traffic areas to decrease exposure to air pollution.(101;111) • Design communities so people feel and are safe. o Plan for mixed use neighbourhoods (housing, shops, services, etc.) that provide opportunities for socialization and activity.(57;101) o Calm traffic by narrowing streets, installing traffic circles, s-shaped curves, speed bumps and using pedestrian-assisted or raised crosswalks to reduce pedestrian-vehicle collisions.(52;112) o Provide bike lanes on all streets, bridges and tunnels to reduce bicycle-vehicle collisions.(52;112) o Provide and maintain trees, greenery and planters to reduce traffic-related crashes and to increase people's sense of wellbeing through aesthetic appeal.(57;112) o Include features such as streetlights and increased number of crosswalks on streets.(15)

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT

		• Design “complete” or “integrated” communities that provide for the daily needs of life, including jobs, schools, services, retail, etc. so that people can stay within their community.
		  ○ Increase density to eliminate sprawl.(57;101)
		  ○ Ensure mixed-use development in new neighbourhoods.(57;101)
		• Enhance public transit to decrease dependence on cars.(4)
		  ○ Provide funding to provide faster, more convenient transit services operating on more frequent schedules.(4)
		  ○ Support employee opportunities to walk, bike, use mass transit or carpool to work.(111)
		  ○ Provide showers, change areas and bike racks.(111)
		  ○ Offer incentives to employees to use mass transit or carpool to work.(111)
		  ○ Allow employees to schedule their time to accommodate carpooling.
		• Investigate low-cost community-wide bicycle access, sharing and recycling programs (e.g. currently exists in Portland, Paris, Zurich).(101)
		• Encourage Business Improvement Areas and revive deteriorated commercial areas to create environments that support

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		increased physical activity such as bike racks, improved lighting and wider sidewalk.(101;112) • Foster partnership and collaboration opportunities between health, planning, transportation and other sectors to work together to create healthy communities.(31;32) • Provide forums for community members, planners, developers and interested stakeholder to discuss healthy community strategies.(31;32)
2. Obesity	• Almost half of Ontario adults were overweight or obese(47) • The proportion of Simcoe Muskoka adults surveyed was heavier as compared to proportion of surveyed adults from Ontario as a whole(49;50) • The prevalence of obesity in children more than doubled over that period, from 5 per cent to 13.5 per cent for boys and 11.8 per cent for girls(113) • Adults who lived in large Canadian cities in 2004 were far less likely to be obese than were their counterparts who lived outside such metropolitan areas. Overall, 20 per cent of census metropolitan area (CMA) residents aged 18 or older were obese in 2004, compared with 29 per cent of those who lived outside a CMA. The national average for obesity was 23 per cent.(60) • Residents had a 0.2 per cent increased risk of being overweight and a 0.5 per cent increased risk of being obese for every one-point increase in the sprawl index.(as cited in Bray, 2005) • For every hour spent driving in a car, the likelihood of being obese increased by six per cent.(Frank, L et al, SMARTRAQ, 2004 as cited in Atlanta Regional Health Forum and Atlanta Regional Commission,	**Decrease the prevalence of obesity among adults and children through the following changes to the built environment:** Increase support for attaining and maintaining a healthy weight for adults and children. Create more opportunities for healthy eating. • Provide financial incentives (such as reduced taxes) for grocery stores and vegetable and fruit stands to move into areas with current poor access.(4) • Increase the number of community gardens, which provides physical activity and local inexpensive vegetables and fruit.(4;101) • Improve public transit access to grocery and fresh food stores.(4) • Develop policies that promote healthier

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
	2006) • A typical white male living in a compact, mixed-use community weighs about 4.5 kilograms (10 pounds) less than a similar man in a subdivision containing nothing but homes(61)	food choices by consumers and healthier menu offerings in fast food outlets.(4) See recommendations for: • Physical Inactivity
3. Injury – Non-Fatal	• As people spend ever more time in cars, their risk of being in an accident increases(57) • The average distance driven varies remarkably depending on the degree of compactness or sprawl characterising different American cities. In a sprawling city like Atlanta, the estimated driving distance is 35.1 miles/day on average (TTI as cited by Bray, 2005) compared with more compact cities like Philadelphia, with 16.7 miles/day on average, Chicago with 19.7 miles/day on average and San Francisco with 21.1 miles/day on average. • Sites with the highest traffic volumes had 13 times greater risk of injury than that at the least busy sites. (Roberts et al as cited by Ewing, Frank, Kreutzer, 2006) • As the number of lanes increases, more accidents occur. (Burden and Lagerwey, as cited by Ewing, Frank, Kreutzer, 2006) • Conversion of an urban two-lane undivided road to four lanes typically produces a substantial increase in accident rates. (Harwood as cited by Ewing, Frank, Kreutzer, 2006) • Among the 43 case studies with traffic calming measures, collision frequencies declined by anywhere from eight to 100 per cent. Apparently in no case did collisions increase with traffic calming. (Safety Benefits of Traffic Calming, as cited by Ewing, Frank, Kreutzer, 2006) • Traffic circles and chicanes (s-shaped curves) had the most favorable impacts on safety, reducing collision frequency by an average of 82 per cent. (Insurance Corporation of British Columbia as cited by Ewing, Frank, Kreutzer, 2006) • As the density of access points (areas of access to a roadway)	**Reduce non-fatal injuries due to crashes and collisions through the following changes to the built environment:** • Focus community design goals towards pedestrians and cyclists and away from vehicles.(4) • Make communities safer for child and adult pedestrians and cyclists. (Richard Jackson – "Creating a Healthy Environment") o Set and enforce lower speed limits in residential areas.(43) o Identify problematic traffic areas and work with local police for more rigourous enforcement of laws.(67) o Protect pedestrians in crosswalks by using pedestrian activated signals.(Geoplan, as cited by Ewing, Frank & Kreutzer, 2006) o Institute and enforce traffic calming measures such as traffic circles or speed bumps.(52;112) o Provide sidewalks and pedestrian walkways.(Tobey et al, 1983;

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	decreases, crash rates decrease. (Gluck et al as cited by Ewing, Frank, Kreutzer, 2006) • As conflicts between opposing traffic are eliminated by raised medians (non-traversable medians, which limit access), crash rates decline. (Gluck et al as cited by Ewing, Frank, Kreutzer, 2006) • The inclusion of features such as trees and concrete planters resulted in statistically-significant reductions in the number of mid-block crashes along all five of the roadways, with the number of crashes decreasing from between five and 20 per cent as a result of the streetscape improvements. (Naderi, 2003, as cited by Ewing, Frank, Kreutzer, 2006) • Pedestrian collisions are more likely on street sections without sidewalks than those with them, two and one-half times more likely according to one study. (Tobey et al., 1983; Knoblauch et al., 1988 as cited by Ewing, Frank, Kreutzer, 2006).	Knoblauch et al, 1988, as cited by Ewing, Frank & Kreutzer, 2006) o Provide overpasses, underpasses or tunnels for pedestrians and cyclists to bypass particularly dangerous roads and intersections.(31)(p.119) • Educate citizens regarding pedestrian and bicycle laws and safety. o Offer bike safety programs in the community.(112) o Conduct awareness campaigns about safe pedestrian behaviour.(112)
4. Injury - Fatal	• In Ontario, unintentional injury ranks fourth among the leading causes of death after cancer, circulatory system diseases and respiratory diseases. (Ministry of Health and Long-Term Care, as cited in Toronto Public Health Department, 2006) • Wide residential streets encourage increased speeds and thus are more dangerous; 55 per cent of the 6,000 vehicle-related pedestrian deaths each year occur on residential streets.(56) • Increases in lane widths accounted for over half of the total increase in fatalities and about one quarter of the increase in injuries. Another study examining 20,000 crashes in the City of Longmont, Colorado, found that crash rates increased exponentially with an increase street width (Swift et al., as cited by Ewing, Frank, Kreutzer, 2006). • The higher the density, the finer the mix of homes, shops and workplaces, and the more centered the development pattern, the fewer highway fatalities per capita occur. (Ewing et al. as cited by Ewing, Frank, Kreutzer, 2006)	**Reduce fatal injuries due to crashes and collisions through the following changes to the built environment:** See recommendations for: • Injuries – Non Fatal

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	• A 1 per cent increase in the sprawl index function – i.e. increasing density – is associated with a 1.5 per cent decrease in the fatality rate.(Ewing as cited by Bray, 2005) • Puget Sound region found that per capita traffic casualties are about four times higher for residents in low-density suburbs than for residents in higher density urban neighborhoods.(Durning as cited by Ewing, Frank, Kreutzer, 2006)	
5. Heart Disease & Stroke	• Among overweight American children from ages 5 to 10 years old, approximately 60 per cent will exhibit at least one physiological cardiovascular disease risk factor(52). • Pope (2002) found that exposure to particulate matter (PM) was linked to cardiopulmonary mortality, and that an increase of PM increased the risk of death due to lung cancer. • A lower level of social support is linked to the development of coronary artery disease. This was the conclusion of a 1993 Swedish study, in which researchers found that men who have lower levels of social and family support, attachment and social integration were more likely to develop the disease. (Orth-Gomer, 1993, as cited in Frumkin et al, 2004). • Studies have also shown that social capital is connected to lower incidence of death for people who have had heart attacks, cancer, heart disease and stroke.(52)	**Reduce incidence of heart disease and stroke through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Air pollution • Lack of Social Support/Networking
6. Cancers	• The grouping of physical inactivity, unhealthy diet, and excess body weight is a powerful determinant of cancer risk. • One quarter to one-third of cancers of the breast, colon, esophagus, kidney and uterus are attributed to excess body weight and physical inactivity. (The International Agency of Research on Cancer, as cited in Canadian Fitness and Lifestyle Research Institute, 2005) • "… long-term exposure to air pollution causes lung cancer, may cause	**Reduce incidence of cancers through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Obesity • Air pollution

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
	asthma (as opposed to aggravating pre-existing asthma), and most importantly, may affect normal development and growth of the lungs in children."(p 16)(43) • Pope (2002) found that exposure to PM was linked to cardiopulmonary mortality, and that an increase of PM increased the risk of death due to lung cancer. • Studies have also shown that social capital is connected to lower incidence of death for people who have had heart attacks, cancer, heart disease and stroke.(52)	
7. Type 2 Diabetes	• Being obese increases the risk of type 2 diabetes by forty fold. (Hu et al. in Frumkin et al, 2004)	**Reduce incidence of Type 2 Diabetes through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Obesity
8. Premature Death	• A mile of motor vehicle travel has a higher likelihood of resulting in a traveler's death than a mile of airplane, bus or train travel. (Halperin as cited in Frumkin et al., 2003) • Deaths due to trauma are the leading cause of potential years of life lost for Canadians under the age of 45. (CIHI, 2001, as cited in Injury Control Facts for Canada and Alberta) • Children accounted for approximately 1,500 of these deaths, about 14 per cent of all traffic fatalities. Even though only 13 per cent of the American population is elderly, 22 per cent of all traffic fatalities occur among pedestrians older than 65 years of age.(Surface Transportation Policy Project, as cited by Jackson and Kochtitzky, 2001) • Numerous studies have found that exposure to high levels of ozone (>80 parts per billion) over a period exceeding eight hours results in	**Reduce incidence of premature death through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Obesity • Injury – Non-Fatal • Type 2 Diabetes • Heart Disease and Stroke • Cancers • Hypertension

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
	adverse affects, including severe asthma, a reduction in lung capacity and airflow, and a negative impact on life expectancy. (U.S. EPA, 2003; Hoek et al, 2002; Friedman et al, 1998, as cited in Ewing et al, 2006 and McConnell et al, 2002; Korrick et al, 1998, as cited in Frumkin et al, 2004) • Finkelstein et al (2004) found an association between higher mortality risks for people living in close proximity to a major traffic route. The advancement period for this mortality risk was 2.5 years.(79) • Kawachi et al (1997, as cited in Frumkin et al, 2004) conducted a cross-sectional study that looked at 39 states and compared each state's mortality rate with its level of social capital. The researchers concluded that age-adjusted mortality decreased as the state's level of social capital increased.	
9. Hypertension	• Sturm and Cohen (2004) used a sprawl index to look at connections between sprawl and physical and mental health. The researchers found significant relationships between several chronic medical conditions (such as asthma and hypertension) and sprawl. • White (1998, as cited in Frumkin et al, 2004) found that individuals who drove their car across a city for 45 minutes experienced high heart rates and blood pressure. • Curbow (1999) found that several traffic-related factors, such as exposure to vehicle fumes, traffic volume, visual distractions on the road and the anxiety and stress that results from driving in heavy traffic, can lead to increased blood pressure and headaches. • Commuting can also cause significant stress to a person. In a study of commuters in Washington, DC, Schaeffer et al (1988, as cited in Frumkin et al, 2004) found that those who constantly travelled in regular traffic congestion reported lower work performance levels and higher blood pressure than those who did not travel in these conditions.	**Reduce incidence of hypertension through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Obesity • Heart Disease and Stroke • Air Pollution

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
10. Asthma	• "… long-term exposure to air pollution causes lung cancer, may cause asthma (as opposed to aggravating pre-existing asthma), and most importantly, may affect normal development and growth of the lungs in children." (p 16)(43) • Numerous studies have found that exposure to high levels of ozone (>80 parts per billion) over a period exceeding eight hours results in adverse affects, including severe asthma, a reduction in lung capacity and airflow, and a negative impact on life expectancy (U.S. EPA, 2003; Hoek et al, 2002; Friedman et al, 1998, as cited in Ewing et al, 2006 and McConnell et al, 2002; Korrick et al, 1998, as cited in Frumkin et al, 2004). • Bray et al (2006) cites research that found the onset of a viral respiratory infection combined with exposure to NO_2 is associated with increased severity in asthma. (Pathmanathan 2003, and Chauhan 2003). • Air pollution & asthma – In Canada, the prevalence of physician-diagnosed asthma among children aged 4-11 years was 15.2 per cent in 1999. (76) • Recent studies suggest that exposure to air pollution may lead to the development of asthma.(72) • Research shows a relationship between increased adverse affects of breathing air pollution with increased physical activity levels, and that these effects "tend to be most pronounced in people with underlying health conditions such as asthma."(p. 1)(75) • Lower levels of vehicular traffic during the Atlanta Olympic Games (1996) resulted in a decrease of daily ozone concentrations by 27.9 per cent. This coincided with a drop of asthma-related emergency medical visits by 41.6 per cent, in particular, with a reduced rate of asthma attacks in children. (Friedman, 2001) • Sturm and Cohen (2004) used a sprawl index to look at connections between sprawl and physical and mental health. The researchers found significant relationships between several chronic medical conditions (such as asthma and hypertension) and sprawl.	**Reduce incidence of asthma through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Air Pollution

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
11. Impaired Physical Development in Children	• "… long-term exposure to air pollution causes lung cancer, may cause asthma (as opposed to aggravating pre-existing asthma), and most importantly, may affect normal development and growth of the lungs in children."(p 16)(43) • Impacts from air pollution on child physical development – small lungs, narrow airways and rapid breathing.(Frumkin et al 2004) • Outdoor play and recreation activities place children in areas where pollution levels are highest, and exposure to ozone is most likely. (Frumkin et al, 2004) • Children experience reduced lung growth when exposed to increasing levels of NO_x, acid vapour and particulate matter.(Gauderman et al 2000 and 2002, as cited in Frumkin et al 2004) • Children living in communities with higher levels of traffic-related pollution had lung function growth that was approximately 10 per cent slower than that of children in lower air pollution communities. The rate of lung function growth improved in children who moved to lower pollution areas.(43) • Study results showed an association between vehicle exhaust, both inside and outside of schools, and asthma, coughing, wheezing and overall decreased lung function in children. (van Vliet, 1997; Guo, 1999; Hirsch, 1999; Brunekreef 1997)	**Reduce and prevent impaired physical development through the following changes to the built environment:** **Promote healthy physical development through the following changes to the built environment:** See recommendations for: • Air Pollution • Physical Inactivity
12. Impaired Emotional/ Intellectual Development	• The intellectual and emotional development of children is more advanced in communities that are walkable and that combine a mix of land uses. This is attributable to a child's opportunity to experience independence and engage in physical activity in a community that is more cohesive and close-knit; generally a community that has a higher level of social capital. (Gilbert and Obrien, 2005; Hertzman, 2002; as cited in Frank et al, 2005).	**Reduce and prevent impaired emotional/intellectual development through the following changes to the built environment:** **Promote healthy emotional/intellectual development through the following changes to the built environment:**

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
		See recommendations for: • Physical Inactivity • Loss of Social Capital
13. Impaired Fetal and Newborn Development	• Poor air quality can affect newborns through increased cancer risks, premature birth and low birth weights.(52) • Study conducted by Wilhelm (2003, as cited in McKeown, 2006) determined that pregnant women living in Los Angeles who were exposed to air pollution from traffic emissions due to traffic volume and proximity of where they lived to busy roadways, had a higher rate of having a low birth weight baby (risk ratio 1.08).(80)	**Reduce and prevent impaired fetal and newborn development through the following changes to the built environment:** **Promote healthy fetal and newborn development through the following changes to the built environment:** See recommendations for: • Air Pollution
14. Waterborne Disease	• Four billion people suffer from waterborne diseases each year, and two million people will die annually due to the ingestion of contaminated drinking water.(88) • Waterborne-related contamination can have negative health effects on healthy people, but particularly can affect the fetus, children, the elderly and those who are immuno-compromised.(88) • Waterborne bacteria can cause gastrointestinal illness, as well as more severe illnesses such as: Guillain-Barre paralysis, kidney failure, pneumonia, dysentery and cholera. Waterborne viruses can also cause gastroenteritis, as well as other illness like meningitis, fever, eye infections and respiratory disease.(88)	**Reduce and prevent waterborne disease through the following changes to the built environment:** See recommendations for: • Contamination of Water/Negative Water Quality
15. Stress	• Heavy traffic volume streets scored the worst … in all categories - privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution. (Appleyard and Lintell as cited in Frank and	**Reduce stress through the following changes to the built environment:**

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	Engelke, 2006)	Promote healthy strategies, supportive environments and healthy policies to address stress. See recommendations for • Lack of Sense of Wellbeing • Air Pollution
16. Lack of Sense of Wellbeing	• Pedestrian amenities or street furniture such as trees, telephones, bus stops and sculpture all contribute to the perception of a pleasant experience. (Untermann as cited in Frank and Engelke, 2006) • Two studies done in hospitals show positive correlations between quicker healing times and pain control for patients who have a view of the natural environment. (Ulrich, 1984 and Diette et al, 2003, as cited in Frumkin et al, 2004) • Bray et al (2005) note that one of the results of sprawl is a lack of diversity which "…forces people to be transient because they cannot grow old in these communities, due to the isolating and restrictive layout."(p. 34)(43). Staying in the same house or community as one ages – being familiar with the area, the neighbours, the services – is an important component of feeling secure and being part of a community. Not having a sense of continuity and belonging can affect a person's overall sense of wellbeing. • Canadians who were physically inactive were more likely to perceive their level of mental health to be fair or poor, compared to those who were active.(91) • Bray et al (2005) point out several studies that indicate negative mental and physical health effects of commuting, including increased cardiovascular disease, back pain (Koslowsky et al, 1995), headaches, asthma, arthritis (Sturm and Cohen, 2004), and lower feelings of overall life satisfaction and a perception that work performance was impaired (Novaco, 1990).	**Increase sense of wellbeing through the following changes to the built environment:** • Design communities with open spaces such as parks, trails, greenways, gardens and heritage space. o Conduct an open space inventory to identify areas which lack open space or require improvements to existing open space.(101) o Consult citizens to identify open space opportunities, use, accessibility, and appeal.(101) o Ensure ongoing maintenance and upkeep of all open spaces.(101) o Place parks in areas that are safe, have few barriers to access and are within 10 minutes walk from residential areas.(101) • Design communities to address all stages and aspects of the life cycle. o Include playgrounds, recreational facilities, health care services, facilities for seniors, support

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	• Communities that have lower levels of social capital may have a larger proportion of the population that experience isolation and loneliness, which can lead to depression, poor mental health and poor overall health status. Putman (as cited in Ewing et al, 2006) states: "The single most common finding from a half century's research on the correlates of life satisfaction, [from] around the world, is that happiness is best predicted by the breadth and depth of one's social connections."(p 92)	services, etc. in community design.(101) • Design communities that incorporate sufficient common areas, meeting places and open spaces to create opportunities for social interaction and connectedness among citizens.(6)
17. Depression	• Symptoms of depression were more commonly reported in neighbourhoods that were socially and economically disadvantaged than neighbourhoods that were less disadvantaged. (Ross, 2000, as cited in Ewing et al, 2006). • Residents who lived in neighbourhoods with a high turnover rate had higher levels of anxiety and depression than those who lived in more stable neighbourhoods, with both neighbourhoods experiencing the same low poverty level. (Ross et al, as cited in Ewing et al 2006) • Traffic stress is associated with depression and lower overall health status. (Gee and Takeuchi, 2003 & 2004 as cited in Bray et al, 2005)	**Reduce incidence of depression through the following changes to the built environment:** See recommendations for: • Lack of Sense of Wellbeing • Economic Segregation • Poverty • Physical Inactivity
18. Anxiety	• Residents who lived in neighbourhoods with a high turnover rate had higher levels of anxiety and depression than those who lived in more stable neighbourhoods, with both neighbourhoods experiencing the same low poverty level. (Ross et al, as cited in Ewing et al, 2006)	**Reduce incidence of anxiety through the following changes to the built environment:** See recommendations for: • Lack of Sense of Wellbeing • Economic Segregation • Poverty • Physical Inactivity

HEALTH IMPACT	EVIDENCE THAT THE BUILT ENVIRONMENT IMPACTS HEALTH	RECOMMENDATIONS TO IMPROVE HEALTH THROUGH CHANGES TO THE BUILT ENVIRONMENT
ECONOMIC IMPACTS		
19. Health Care Costs	• Injuries rank fourth in expenditure after cardiovascular diseases ($18.5 billion), musculoskeletal diseases ($16.4 billion) and cancer ($14.2 billion). (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta) • At a national level, the economic burden of unintentional and intentional injuries is estimated to be $12.7 billion per year which is 8 per cent of the total cost of illness in Canada for direct and in-direct costs. (Lane (Moore) and Desjardins, 2002, as cited in Injury Control Facts for Canada and Alberta) • Based on 1996 data, it is estimated that these injuries result in Ontario spending nearly $3 billion in direct (health care) and indirect (social and economic productivity losses) provincial costs.(66) • For each one per cent reduction in vehicle-miles, total crash costs are reduced by 1.0 to 1.4 per cent. (Litman as cited by Ewing, Frank, Kreutzer, 2006) • Simcoe Muskoka experienced 211 premature deaths, 550 hospital admissions and 2,052 hospital emergency visits as a result of air pollution in 2005. The estimated health care cost resulting from air pollution for Simcoe Muskoka totalled $15.86 million.(66) • Buckeridge (2002, as cited in Bray et al, 2005) showed an association between hospital admissions for respiratory problems, including pneumonia, bronchitis and asthma, and being exposed to vehicle emissions from living in close proximity to a high traffic volume route.	**Maintain and/or reduce acute health care costs through the following changes to the built environment:** • Ensure health impact is considered in all land use, transportation and community design decision-making processes.(31)(p.219)(57) • Consider long-term health care costs of all land use, transportation and community design planning proposals.(31)(p.219)(57) • Weigh the long-term savings gained in promoting health and the decrease in acute health care costs with the potential increase in costs for developing and/or retrofitting communities in the planning process.(31)(p.219)
20. Lost Productivity	• In Simcoe Muskoka lost productivity due to air pollution was estimated at $11.87 million.(66)	**Increase productivity through the following changes to the built environment:** See recommendations for: • Air Pollution

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21. Decreasing Employment Opportunities	• Expanded transit infrastructure, along with development that was centred around the transit system, could double over 30 years the number of employment opportunities and households within the acceptable traffic congestion levels, inferring that public transit would be a highly used mode of transportation. (Replogle, 1993, as cited in Ewing et al, 2006)	**Increase local and regional employment opportunities through the following changes to the built environment:** • Revitalize main streets and downtown public spaces to encourage local business development and increase pedestrian traffic and access.(101) • Develop brownfield sites that are close to existing neighbourhoods into mixed use development that includes businesses, stores and services.(101) • Locate new commercial and business activities closer to residential areas.(101) • Ensure public transportation infrastructure and systems are addressed in all aspects of planning.(4)

22. Poverty & Economic Segregation	• Residents who lived in neighbourhoods with a high turnover rate had higher levels of anxiety and depression than those who lived in more stable neighbourhoods, with both neighbourhoods experiencing the same low poverty level. (Ross et al, as cited in Ewing et al, 2006)
	• Symptoms of depression were more commonly reported in neighbourhoods that were socially and economically disadvantaged than neighbourhoods that were less disadvantaged. (Ross 2000, as cited in Ewing et al 2006)
	• Sprawl creates economic stratification due to residential development patterns that segregates housing into different price ranges. Segregation results in neighbourhood homogeneity that can negatively affect cohesion and connectedness, and tends to highlight income inequality within a community. (Frumkin 2002)
		Reduce and/or eliminate poverty through the following changes to the built environment:
		• Design communities to include access to grocery stores and healthy local food.(4;101)
		  ○ Facilitate and promote farmers' markets and community gardens.(4)
		  ○ Provide incentives for food businesses to locate in underserved communities.(4)
		• Design communities that provide a mix of housing types for varying income

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	• "…to the extent that sprawl is associated with social stratification and loss of social capital and these phenomena are in turn associated with increased morbidity and mortality, sprawl may have a negative health impact on this broad scale." (Frumkin 2002, p. 209)	levels.(4;112) • Design complete communities that provide access to employment, public transportation, services and schools.(101) **Increase number of neighbourhoods that include a variety of housing options and mixed uses through the following changes to the built environment:** • Plan smaller lot sizes in neighbourhoods to reduce housing prices.(101) • Set planning requirements for mixed residential development for a mix of income levels to include single-family homes, duplexes and townhouses in the same neighbourhood.(4;112) • Set inclusionary zoning requirements.(101) • Set property tax caps and exemptions for targeted populations such as older adults on fixed incomes and others.(101)
SOCIAL IMPACTS		
23. Loneliness, Isolation & Alienation	• The Public Health Agency of Canada states that: "Good mental health and positive self-esteem enable an individual to connect with and embrace a community of people."(p.12)(91). In a 2002 survey, only 18.5 per cent of Canadians 15 years and over reported having a very strong sense of being part of their community, while almost 40 per cent reported a somewhat strong feeling of belonging.	**Reduce incidence of loneliness, isolation & alienation through the following changes to the built environment:** See recommendations for: • Lack of Sense of Wellbeing

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	• According to Frumkin (2002), suburbs offer little appeal for older people to stay in the family home. Large, low-density residences and lots make it difficult for older adults to maintain their home and property, especially once their children have left home. Often feelings of isolation grow. Poorly planned communities may not have the health, long-term care, recreational and social service facilities that some older adults require. All of these factors can detract from social capital when it fosters isolation and results in an exodus of long-time residents to another community that has these facilities. • Freeman (2001) argues that although studies have found that sprawl negatively affects social capital, there are also studies that show high density urban neighbourhoods can also have the same affect. In a 1996 study, Wilson and Baldassare (as cited in Freeman, 2001) concluded that sense of community was diminished by higher density. Michelson (1977, as cited in Freeman, 2001) found that making or keeping friends was no different for those who lived in an urban area than for those who lived in a suburban area.	• Lack of Social Supports/Networks • Economic Segregation
24. Loss of Community	• Bray et al (2005) note that one of the results of sprawl is a lack of diversity which "…forces people to be transient because they cannot grow old in these communities, due to the isolating and restrictive layout."(p. 34)(43). Staying in the same house or community as one ages – being familiar with the area, the neighbours, the services – is an important component of feeling secure and being part of a community. Not having a sense of continuity and belonging can affect a person's overall sense of wellbeing.	**Create sense of community and personal identification and involvement with the community through the following changes to the built environment:** See recommendations for: • Lack of Sense of Wellbeing • Lack of Social Supports/Networks
25. Loss of Social Capital	• "For each additional ten minutes spent in daily commuting time cuts involvement in community affairs by 10 per cent."(p 93) • "…to the extent that sprawl is associated with social stratification and loss of social capital and these phenomena are in turn associated with	**Increase social capital through the following changes to the built environment:** • Design complete communities where the

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	increased morbidity and mortality, sprawl may have a negative health impact on this broad scale." (Frumkin, 2004, (pg 209) • People who lived in mixed-use walkable neighbourhoods had an increased level of social capital compared with those who lived in sprawled car-dominated suburbs. (Leyden, 2003)	daily needs of people are met – jobs, school, housing, retail, services, infrastructure, transport, etc. o Locate areas of employment close to residential areas in order to decrease commuting times.(101)
26. Crime	• The way that communities are designed and the types of structures that are built can influence the level of crime that occurs there. Crime levels impact the amount of fear that people feel and their perceived sense of safety. For example, spread out commercial and industrial areas that are commonly associated with sprawl are usually abandoned at night. The result is few or no 'eyes on the street', making the area more vulnerable to crime. This is also true of low density residential areas.(94) • Dannenberg et al noted that communities in the United States that adopted a Crime Prevention Through Environmental Design (CPTED) strategy in the 1970's – that included recommendations for layout of housing, maintenance and land use design - showed a reduction in crime. They conclude that: "Implementation of CPTED recommendations may have consequences on the health of a community beyond crime prevention, such as improvements in physical activity, mental health, and social capital."(Dannenberg et al, 2003 p.1504) • Kennedy et al (1998, as cited in Frumkin et al, 2004) found social capital to be associated with a decrease in the rate of crime.	**Reduce crime through the following changes to the built environment:** Encourage law compliance and crime prevention. See recommendations for: • Lack of Sense of Safety and Security • Lack of Social Capital
27. Lack of Sense of Safety & Security	• As walking and bicycling decline, driver awareness declines as well, making the street environment conditions even more dangerous for pedestrians.(57) • Correlation found between feelings of being safe in one's community to increased levels of physical activity. (Frumkin et al, 2004)	**Ensure safety and security through the following changes to the built environment:** • Design communities for walkability to increase the number of people visible in

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	• Australian researchers found that walking nearly doubled amongst people who perceived the walking paths to be safe (Booth et al 2000, as cited in Frumkin et al, 2004) • The most common fears in communities include crime, traffic, lack of lighting or streetlights, roads built for speed, roads fronted by large apartments and/or commercial and industrial space, few crosswalks, and lack of sidewalks. (Hancock, 2000 and Hanzlick, 1999, as cited in Bray et al, 2005)	the community.(116) • Increase crime prevention and awareness among community residents.(101) • Implement initiatives that encourage neighbours to watch out for each other • Involve police in planning for safety.(101) aspects of trails, parks, and streetscapes o Identify solutions for safety concerns such as lines of sight, lighting, frequency of foot traffic, etc.(101) • Increase community policing strategies including foot and bicycle patrols.(101) • Plan smaller lot sizes in neighbourhoods and orient homes toward the street to increase comfort and security of residents.(101)
28. Road Rage & Aggression	• Vehicle operating speeds decline somewhat as individual lanes and street sections are narrowed (Farouki and Nixon, 1976; Heimbach et al., 1983; Clark, 1985; Harwood, 1990; Gattis and Watts, 1999; Fitzpatrick et al., 2001; and Gattis, 2001 as cited by Ewing, Frank, Kreutzer, 2006). Drivers seem to behave less aggressively on narrow streets and one indication of this is running fewer traffic signals (Untermann as cited by Ewing, Frank, Kreutzer, 2006). Also, drivers may feel less safe and drive more cautiously on narrow streets. (Mahalel and Szternfeld, 1986 as referenced in: Noland, R. B., 2003 as cited by Ewing, Frank, Kreutzer, 2006) • Drivers reported feelings of frustration, unease, distress and loss of temper when they drove in the city.(Hennessy and Wiesenthal,1997, as cited in Frumkin et al,2004). • Curbow (1999) found that several traffic-related factors, such as	**Reduce and/or eliminate road rage and aggression through the following changes to the built environment:** See recommendations for • Physical Inactivity • Lack of Sense of Wellbeing • Air Pollution

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	exposure to vehicle fumes, traffic volume, visual distractions on the road, and the anxiety and stress that results from driving in heavy traffic, can lead to increased blood pressure and headaches and incidents of road rage. • In cities where a higher proportion of commuters used bus or train transportation there was a 34 per cent lower risk of a commuter dying as the result of an aggressive driving crash. "States (in the United States) with fewer aggressive driving deaths had a significantly higher percentage of residents walking to work."(95)	
29. Lack of Social Support/ Network	• Heavy traffic volume scored the worst … in all categories - privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution.(Appleyard and Lintell as cited in Frank and Engelke, 2006) • "People with strong social networks live longer." (Frumkin et al,2004) • A lower level of social support is linked to the development of coronary artery disease (Orth-Gomer,1993, as cited in Frumkin et al,2004) • People living in a walkable community were more likely to report knowing their neighbours and to trust others, as well as to be politically and socially engaged.(102) • Residents of a mixed-use neighbourhood felt a significantly higher sense of community as compared to residents of a single-use neighbourhood.(Nasar and Julian 1995)(103) • A sense of community was most likely predicted by the walking environment (safety and aesthetic features), positive attitudes towards walking and an opportunity for interaction during walking episodes.(Lund 2002, as cited in Frumkin et al,2004) • Automobile dependency is not conducive to the creation of social capital. "Every 1 per cent increase in the proportion of individuals driving to work [in a neighbourhood] is associated with a 73 per cent decrease in the odds of an individual having a neighbourhood social	**Encourage the development and maintenance of social support and networks through the following changes to the built environment:** • Locate schools, services and retail within walkable distance of residential neighbourhoods in order to establish social interactions and sense of community, and to reduce vehicle dependency and need for commuting to work.(101) ○ Encourage joint-use agreements between school boards and other public entities so that the facilities can be accessed by all members of the community.(101) • Locate employment areas in close proximity to residential areas to reduce vehicle dependency and need for commuting to work, and to increase time for social capital and leisure

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	tie… [and a] 71 per cent decrease in the odds of a respondent having relatively more neighbourhood social ties." (Freeman, 2001, p 74)(93) • Neighbouring was strongly predicted by lower density dwelling, as well as the availability of greenspaces, such as parks and gardens, located near people's homes. Public greenspaces provide an opportunity for people to spend time outside, which increases the chance for interaction amongst neighbours. (Skjaeveland and Garling, 1997, as cited in Frumkin et al, 2004) • People who lived in buildings with greenspace around them reported better relationships with their neighbours, were able to handle domestic conflicts in less violent ways, and had a greater sense of community cohesion (Sullivan and Kuo, 1996, as cited in Jackson and Kochititzky, 2001).	activities.(101)
30. Lack of Time	• According to the National Active Transportation Survey 2004, 62 per cent of Canadians travel to work regularly by car.(81) Statistics Canada reports that in 2005 the average Canadian driver spent 12 full days commuting to and from work. This breaks down to 275 commuting hours per year (based on 260 working days), or an average of just over one hour (63 minutes) of round-trip commuting each day.(82) • Mixing employment areas with housing can decrease vehicle use, particularly with commuting. Those living in a balanced area commuted less (by one third) than those who lived in an area dominated by housing. (Ewing 1994, as cited in Ewing et al, 2006) • "For each additional 10 minutes spent in daily commuting time cuts involvement in community affairs by 10 per cent".(p 93)	**Increase amount of time people time to engage in leisure and other activities through the following changes to the built environment:** See recommendations for: • Physical Inactivity • Lack of Sense of Wellbeing • Lack of Social Support/Network • Air Pollution
NATURAL IMPACTS		
31. Erosion	• Storm water runoff can have negative impacts on the natural stability of	**Decrease and/or prevent erosion through the**

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	water courses (e.g. stream and riverbank erosion, alteration of the foundations of riverbeds). • Erosion can actually change the ecology of the water, thus affecting aquatic vegetation, life and water quality.(31)	**following changes to the built environment:** **Increase soil preservation through the following changes to the built environment:** See recommendations for: • Contamination of Water/Negative Water Quality
32. Contamination of Water/ Negative Water Quality	• Waterborne-related contamination can have negative health effects on healthy people, but it particularly can affect the fetus, children, the elderly and those who are immuno-compromised.(88) • Outbreaks due to surface water contamination were most strongly and immediately related while outbreaks due to groundwater contamination were most often delayed by a month or two. • Suburban sprawl areas produced 43 per cent more runoff as compared to higher density areas. (Schmidt 1998, as cited in Bray et al, 2005) • Low density areas contributed most negatively to water quality due to two factors: more paved roads (thus creating more impervious surfaces) and more large lawns (contributing to water pollution from lawncare chemicals). (Goonetilleke et al, 2005, as cited in Frank et al, 2005) • "Any disruption to a watershed, even at very minor levels, has relatively large impacts – construction sediment, loss of trees, topsoil and ground cover, increased impervious surfaces and disruption of the natural water flows – all of which degrade water quality." (Frank et al, 2005, p 31) • Studies have also shown a link to a negative effect on water quality by pollutants attributed to gasoline and more directly to driving. In urban areas, increased roadways and vehicles contribute to water pollution through contaminants and chemicals that collect onto impervious surfaces and are then washed away as runoff and enter a water source either though groundwater or through streams and rivers.(31) • "Uncontrolled development has already threatened potable water	**Decrease contamination of water/negative water quality through the following changes to the built environment:** **Increase water quality through the following changes to the built environment:** • Review regulations and permit procedures to better address water quality issues.(57) • Increase density and preserve open spaces in order to prevent water runoff caused by increased impervious surface area associated with low density and sprawl development.(101) ○ Limit parking lot sizes of commercial and business developments.(57) ○ Invest in surface-cover products that provide a permeability for water run-off.

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	supplies across the United States." Heisig (1999) found that some major reservoirs in the United States are "…now threatened by the sprawl-related runoff of street salts, nutrients, and hazardous contaminants." (as cited in Greenberg et al, 2003)(p. 1522).	
33. Decreased Water Supply	• As development increases less rainfall falls in the natural environment, thus less water is absorbed directly into the earth's groundwater system. Less rainwater soaking into the water table can be detrimental to the earth's water supply.(31).	**Maintain and sustain fresh water supply through the following changes to the built environment:** See recommendations for: • Contamination of Water/Negative Water Quality • Global Warming
34. Water Pollution	• 15 per cent of rainfall on land covered by an artificial hard surface became runoff, as compared with only 4 per cent of rain that fell on undeveloped land. (Zheng et al 1999, as cited in Bray et al, 2005) • In urban areas, runoff from wide roads and parking lots was found to be the largest source of water pollution. (USGS 1999; Bannerman et al, 1993, as cited in Frank et al, 2005)	**Decrease and/or prevent water pollution. through the following changes to the built environment:** See recommendations for: • Contamination of Water/Negative Water Quality
35. Air Pollution	• Heavy traffic volume streets scored the worst … in all categories - privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution. (Appleyard and Lintell as cited in Frank and Engelke, 2006) • In Ontario, 37 per cent of volatile organic compounds (VOC) emissions and 62 per cent of NOx emissions were contributed by the transportation sector in 2005. Vehicles and the transportation sector were also responsible for 18 per cent of particulate matter emissions, and 86 per cent of carbon monoxide emissions.(71)	**Decrease and/or prevent air pollution through the following changes to the built environment:** • Locate commercial and business activities closer to residential areas to reduce commuting and encourage walking and cycling to employment.(116) • Increase density to make public transit

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	• "Breathing higher concentrations of CO, VOC, fine particulate matter (< 2.5 microns) and other emissions released from tail pipes has consistently been shown to induce detrimental health outcomes." (Frumkin et al, 2004, p 4)(52) • Zhu (2002) found that pollutants from vehicular emissions exist at higher levels near roadways containing large amounts of traffic. Other studies show that particulate matter can be at levels up to 30 per cent higher near busy roads, and that NO_x and CO display the same type of patterns. (Brook, 2002 and Zhu, 2002, as cited in Bray et al, 2005) • People who lived near a busy street experienced two to three times the exposure rate to CO, NO_x, VOCs and PM compared to those living near streets with less traffic. The Amsterdam studies found that exposure effects were not just confined to the outside of buildings, but in fact were also present within buildings. (Roemer et al, 2000, as cited in Ewing et al, 2006) • Each 1 per cent of automobile travel replaced by active transportation decreases motor vehicle air pollution emissions by 2 per cent to 4 per cent.(p. 20)(84) • High density neighbourhoods with mixed land use, pedestrian access and public transit services produced about 30 per cent fewer Vehicle Miles Travelled (VMTs). In a 2000 follow-up to the 1994 study, Holtzclaw et al (2002, as cited in Ewing et al, 2006) found that a doubling in the density of an area resulted in reduced VMT by as much as 43 per cent, and that higher density was correlated with less vehicle ownership. • Frank et al (2000, as cited in Ewing et al, 2006) showed a substantial decrease in emissions as both household and workplace densities increased. • Limiting growth to existing urban or developed areas (that is, increasing the density of already developed land) results in decreased VMT (as cited in Ewing et al 2006). • "Increasing transit access helps reduce air pollution by shifting travel	feasible, affordable and accessible. • Provide accessible, affordable public transportation systems to decrease private vehicle use and provide incentives for carpooling to reduce one-vehicle commuting trips.(4;32) • Reduce idling times of vehicles.(134) o Enact and enforce municipal policies/guidelines that govern idling practices of their fleets, including time restrictions for idling, converting fleet power sources to non-diesel generated sources. o Limit drive-through services. o Implement awareness programs and policies to reduce idling practices of drivers at schools. o Enact policies to reduce idling times by school buses. o Establish no-idling zones at all municipal facilities (i.e. community centres, town halls, etc.). o Implement public awareness initiatives, social marketing campaigns and other interventions to change people's idling behaviour. • Provide incentives to encourage alternative forms of energy use by drivers.(134) o Provide public transit vehicles that

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	from vehicle to transit trips and by reducing rate of vehicle ownership." (Ewing et al, 2006)(p. 26) • The result of a toll on private vehicles going into the City of London was a 20 per cent increase of kilometres traveled by buses within the fee zone, as well as 25 per cent increase in bus use and a 29 per cent decrease in vehicle kilometres traveled. Overall, these changes resulted in a reduction of NO_x and PM emissions by 12 per cent, and CO_2 by 19 per cent (Beevers, 2004, as cited in McKeown, 2006) • Development taking place on an infill site, as compared to a new or greenfield site, generates fewer vehicle miles and emissions. Significantly lower emissions of CO, NOx, SOx, PM and CO2 (ranging from 47-110 per cent lower) with the infill development. (Allen et al, 1999, as cited in Ewing et al, 2006). • A community that was closer to downtown Nashville, and that had a street grid pattern and a higher density, had vehicle emission rates 30 per cent lower than the low density neighbourhood located closer to the suburbs (Allen 2003, as cited in Ewing et al, 2006) • "…mixing land uses is associated with shorter trips and a shift in mode from automobiles to pedestrian, bicycle and transit travel... This, then, reduces the total number of trips taken by automobile and thus reduces emissions."(p 20)(52) • Air pollution impacts on children's play – outdoor play and recreation activities place children in areas where pollution levels are highest and exposure to ozone is most likely. (Frumkin et al, 2004)	use non-diesel sources of energy. o Provide subsidies for citizens driving low energy vehicles. • Encourage and support programs to decrease total vehicle miles traveled.(116) • Encourage active transportation to reduce vehicle emissions. o Investigate low-cost community-wide bicycle access and sharing programs (e.g. currently exist in Portland, Paris, Zurich).(116) o Create bicycle–recycling programs.(116) • Locate schools, services and retail within walkable distance of residential neighbourhoods.(116;129) • Design buildings and communities that use environmentally-friendly and sustainable forms of energy (wind power, solar power, etc.).(111) • Adopt regulations to preserve tree cover and open spaces and that integrate landscape trees into commercial and residential development.(57)
36. Climate Change/ Global Warming	• "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."(p 10)(74) • Environmental impacts of global warming could include more frequent and intense storms, extreme temperatures, flooding, droughts, and	**Decrease climate change/global warming through the following changes to the built environment:** • Protect greenspaces in order to decrease

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	rising ocean levels. These climatic events, should they occur, will flood populated coastal areas, kill coral reefs, and increase the number and range of mosquitoes (a significant vector of disease), other insects, pests, and weeds. "Such events, in turn, will influence our food supply, our access to clean water, our health, and the economic and social conditions of families and communities around the world."(73)	warming temperatures. o Preserve forest, farmland, wetlands, marches, etc. o Develop partnerships with local, regional, provincial and national organizations for joint funding and collaboration to improve parks and greenspaces.(111) • Adopt "green roof" design practices in commercial, industrial and high density development, as well as for public facilities. See recommendations for: • Air Pollution • Water Pollution • Contamination of Water/Negative Water Quality

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