



**Infrastructure
Canada**

*Part of the Transport, Infrastructure
and Communities Portfolio*

Population Aging and Public Infrastructure: a Literature Review of Impacts in Developed Countries

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Economic Analysis & Research
Infrastructure Canada
April 2008

Canada

A study prepared for Infrastructure Canada's Economic Analysis and Research Division. This report is distributed for information purposes only. The opinions and conclusions expressed herein are those of the consultants and do not necessarily represent the views of the Government of Canada.

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1. Introduction & Purpose

Canada faces significant demographic shifts in its population as the proportion of seniors increases at a higher rate than any other age cohort for the first time in its history. This demographic shift will have significant consequences on a wide range of issues that affect all Canadians. The effects of aging demographics will impact demand for health services, labour markets, public finances, and the provision of public infrastructure.

Demographic trends associated with aging impact the provision of public infrastructure in a variety of ways. While not exhaustive, these may include shifts in demand for public goods, which would influence how public goods are consumed by Canadians. Another impact may be on the supply side of public goods as a smaller working population contributes to a narrower tax-base and reduces funds available to public institutions.

The objective of this paper is to conduct a literature review that assesses the impacts of aging demographics on public infrastructure in developed countries. Specific emphasis will be placed on the challenges and opportunities faced in Canada.

The term infrastructure is generally used to describe the structural elements that provide the framework for supporting an economy. More specifically, public infrastructure may be defined as:

*A set of assets that underpin the economic, social, cultural, institutional and environmental well-being of society by enabling activities that provide collective public benefit. These assets are publicly owned, or privately owned and regulated by governments to ensure adequate quality, quantity and price.*¹

The field of research which focuses on the impacts of aging demographics is not a new one. However, literature which focuses specifically on the implications for the design, construction, planning and management of public infrastructure is scarce and heavily focused on certain sectors (mostly transportation and its implications for urban planning). In addition to a lack of analytical depth for non-transport-related asset types, there are also no solid empirical forecasting tools which provide authoritative hypotheses on the ability of governments to continue to fund public infrastructure when the Baby Boomers reach their retirement peak. Further, the important question of whether the aging population cohorts will prefer to stay in the suburbs or move to more densely populated areas has been answered one-sidedly in the literature reviewed. The “stay-in-place” (i.e., suburbs) thesis seems to be the dominant trend. As will become evident in the sections below, this thesis has serious implications for a number of infrastructure-related services. We suspect, however, that as more empirical evidence becomes available over time, this thesis will need to be tested rigorously.

Given the availability of issues covered in the literature, this review is therefore limited in its focus and its findings appear inconclusive in some areas. It nevertheless constitutes a first

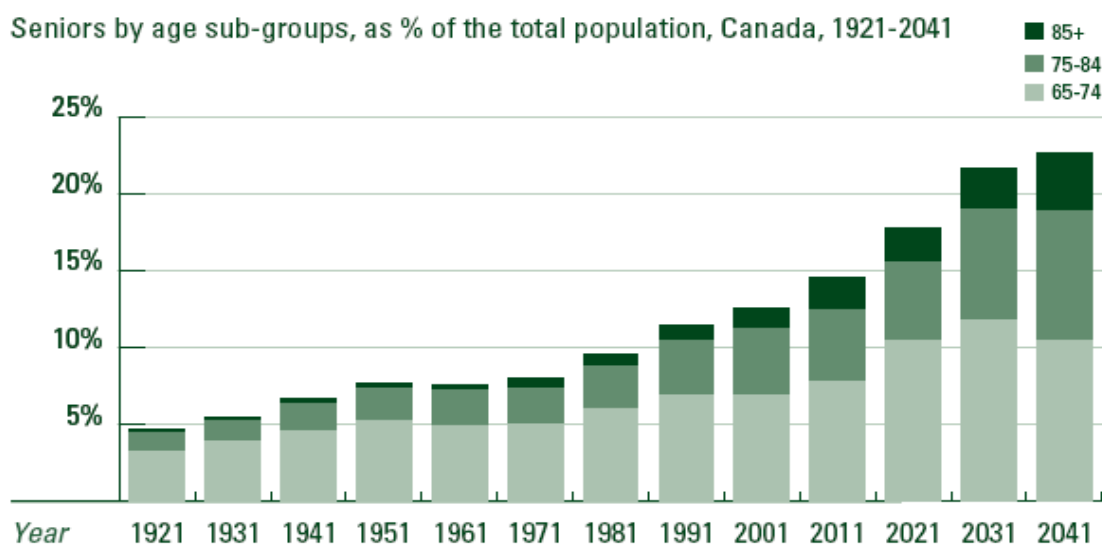
¹ PricewaterhouseCoopers LLP. Public Infrastructure: A Literature Review. PwC: Ottawa, 2006.

knowledge map which should inform further work. This paper introduces introduce the demographic context and its broad implications for the provision of public services, such as public infrastructure. It then focuses on the impacts for engineering works (i.e., transport networks, and water and wastewater systems) and social infrastructure (which encompasses educational and health).

2. Profile of Aging

The demographic profile of Canada is shifting (see Figure 1). The median age of Canadians rose from 27.2 in 1956 to 39.5 in 2006, and the share of elderly, those aged 65 and older, has climbed from 7.7 percent of the population to 13.7 over the same period.² According to the 2006 Census, this demographic trend is rapidly increasing. Over the 2001-2006 period, the 65+ cohort increased by 11.5 percent while the “under 15” cohort decreased by 2.5 percent (it now stands at 17.7 percent, the lowest share ever).³ These trends are projected to continue for the next three decades. By 2026, the median Canadian age is projected to reach 43.3 with 21.2 percent of the population in the 65+ cohort. By 2051, these figures are expected to increase to 46.8 years and 26.4 percent, respectively.⁴

FIGURE 1: SENIORS AS A PERCENTAGE OF TOTAL POPULATION⁵



The dominant feature affecting the demographic shifts is the aging of the ‘baby boom generation’, individuals born between 1946 and 1965 who in 2006 represented one third of the

² Statistics Canada. Portrait of the Canadian Population in 2006, by Age and Sex, 2006 Census. Statistics Canada: Ottawa, 2007.

³ *ibid.*

⁴ Foot, David K. "Population Aging." In J. Leonard, C. Ragan and F. St-Hilaire (eds.): A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being. Institute for Research on Public Policy: Montreal (2007) pp181-213.

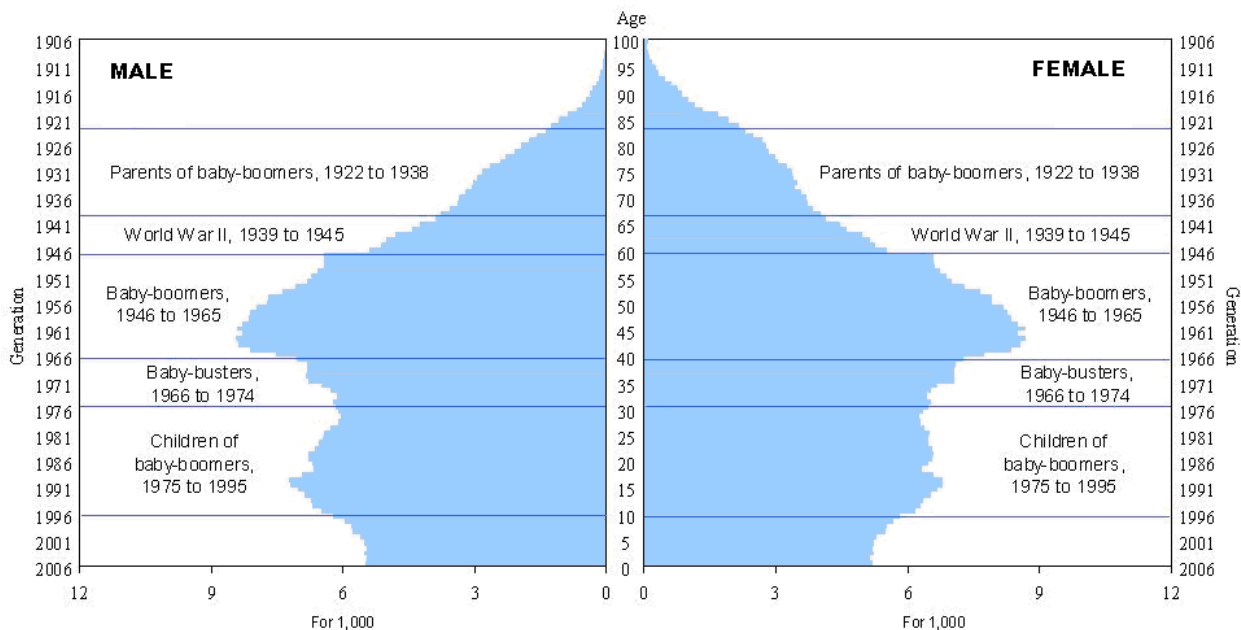
⁵ Health Canada. Canada’s Aging Population. Health Canada: Ottawa, 2002. (p.3)

population. This feature is reflected in the bulge found in the population pyramid (see Figure 2). The first Canadian ‘boomers’ will reach age 65 in 2011, thus marking the beginning of a unique aging trend marked by subsequent waves of retirement which have been the subject of concern about pension funding and healthcare policy for well over a decade.⁶

A number of demographic characteristics contribute to how Canada’s population is aging. They include better health and longer life expectancy; however, the dominant characteristic underlying this demographic shift is below-replacement fertility rates. Estimated at 1.6%, Canada’s fertility rate is well below the 2.1% required to replace natural declines in the population. The difference is made up only by positive net immigration.⁷

Declining fertility over the late 60s and early 70s, from a high of almost 4 children per woman during this period to about 1.7 in the mid 1970s, represents what has been termed the ‘baby bust generation’, or ‘generation X’. Boomers started having children in the latter half of the 1970s, marking the ‘baby boom echo generation’. Forecasts predict that the fertility rates of the echo generation will represent a historic national low, and the bottom of the pyramid in Figure 2 is suggestive of this.⁸

FIGURE 2: DIFFERENT COHORTS AMONG THE AGE PYRAMID OF THE CANADIAN POPULATION IN 2006⁹



⁶ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): Urban Policy Issues: Canadian Perspectives. Oxford University Press: Toronto, (2002) pp17-35.

⁷ Statistics Canada. Portrait of the Canadian Population in 2006, by Age and Sex, 2006 Census. Statistics Canada: Ottawa, 2007.

⁸ *ibid.*

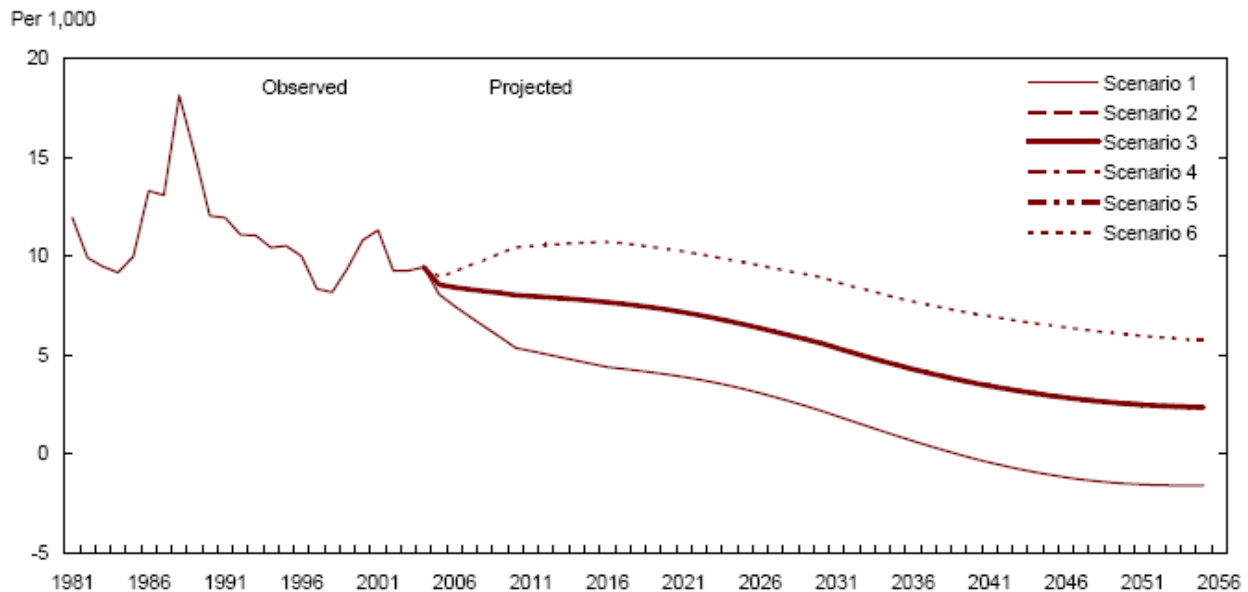
⁹ Statistics Canada. Portrait of the Canadian Population in 2006, by Age and Sex, 2006 Census. Statistics Canada: Ottawa, 2007. (p.12)

Evidence suggests that the echo boom has not occur uniformly across Canada. The westward drift of the Canadian population, coupled with lower fertility rates in Quebec and the Atlantic provinces, has resulted in a bigger echo in Ontario and the West, with a less pronounced echo in the East.

Between 2001 and 2006, Canada's population grew by 1.6 million, which represents a growth rate of 5.4%, higher than the rate for the period between the 1996 and 2001 censuses (4.0%).¹⁰ Nevertheless, Canadian population growth is projected to slow from now until 2056. Figure 3 offers a range of projected population growth rates for the coming five decades.

Given low fertility rates, immigration in developed countries is called upon to increase population. Immigrants tend to be younger and of working age, and while they may contribute to population growth and slightly reduce the average age, the overall effect is too small to significantly alter domestic trends. This is true even of Canada, which experiences one of the highest immigration rates in the developed world.

FIGURE 3: AVERAGE ANNUAL POPULATION GROWTH RATE OBSERVED (1981 TO 2005) AND PROJECTED (2006 TO 2056)¹¹



Concern over patterns in aging is not uniquely Canadian; demographic shifts are monitored in all developed nations. Interestingly, Canada has one of the youngest populations of the G8 countries; only the U.S. has a lower proportion of elderly at 12.4%. While the U.S. exhibits a similar demographic profile to Canada's, other industrialized nations do not. Japan, Germany and Italy have the highest proportions in the world of elderly persons with approximately one

¹⁰ Statistics Canada. [internet on-line] "Portrait of the Canadian Population in 2006: National Portrait" available from: <http://www12.statcan.ca/english/census06/analysis/popdwell/NatlPortrait1.cfm>

¹¹ Statistics Canada. Population Projections for Canada, Provinces and Territories 2005-2031. Statistics Canada: Ottawa, 2005. (p.39)

person in five 65 years of age or older. By comparison, Canada will not reach the 20% mark until about 2024. Despite a low fertility rate, Canada is currently experiencing the highest population growth among the G8 countries. While the number of Canadians increased by 5.4% in the five years preceding the 2006 census, the growth rate was 3.1% in Italy and France, 1.9% in the United Kingdom, and nearly zero in Japan and Germany. During the same period, Russia's population decreased by 2.4%. While each country's demographic trend reflects its individual socio-economic history, the one common element among them (including in Canada) is sustained below-replacement fertility rates.¹²

3. General Overview of Aging Impacts

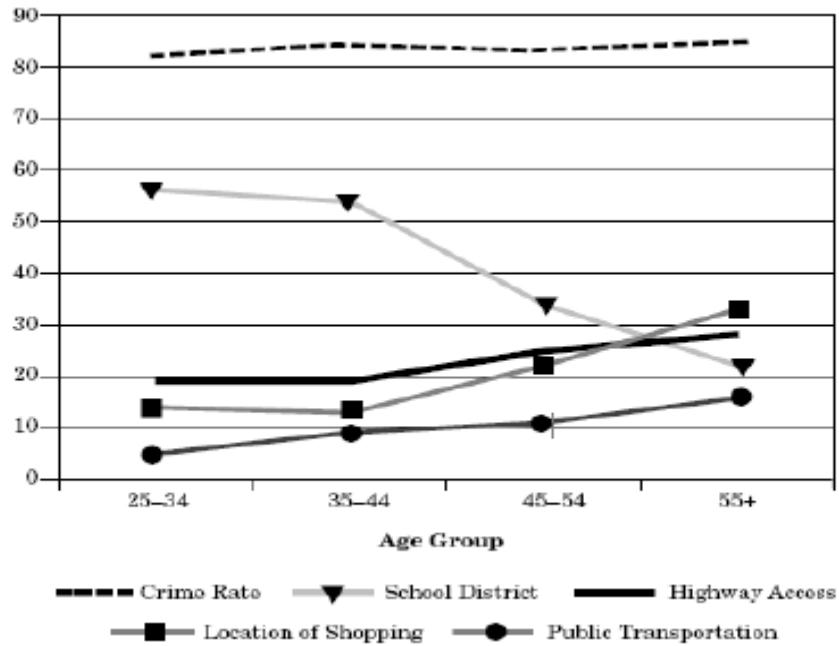
Aging demographics are expected to result in a variety of impacts. The key types of impacts will be explained here and then explored in greater detail in Section 4.

3.1 Shifts in Demand for Public Services

As the boomers enter their senior years, evidence suggests that they will be relatively healthier, more independent, better educated, wealthier and lead more active lifestyles than any senior population to precede them. This situation will put a different emphasis on public priorities and the demand for public goods as the elderly represent a higher percentage of the population. Figure 4 illustrates that preferences for various types of urban amenities are related to age. Shopping, public transportation, and highway access are perceived as more important as people age, while schools are viewed as less significant. These changes in preferences may reflect actual changing needs and, therefore, will require adjustments in the supply of infrastructure-related services.

¹² Statistics Canada. [internet on-line] "Portrait of the Canadian Population in 2006: National Portrait" available from: <<http://www12.statcan.ca/english/census06/analysis/popdwell/NatlPortrait1.cfm>>

FIGURE 4: PERCENTAGE CALLING A PARTICULAR FACTOR VERY IMPORTANT IF BUYING A HOME TODAY¹³



3.2 The Increasing Dependence of the Senior Age Cohort

“Dependency ratios” are demographic indicators used to reveal economic relationships within the population age structure. The ratios are established when the population is divided into two related groups: the first represents “dependents”, and the second represents “providers”. The ratio of the number of people in the first group relative to the number of people in the second group produces an indicator that measures a population ability to support itself.¹⁴ A number of formulations for dependency ratios have been proposed, with the three most conventional being the *age dependency ratio*, the *economic dependency ratio*, and the *elderly dependence ratio*. Other formulations are possible and their particular merits are based on the context of use.¹⁵

Over the 1950s and 1960s, Canada has experienced high total dependency ratios as a result of the large increases in child “dependents” associated with the baby boom. This was followed by a sharp decline to historical lows in the dependency ratio as the boomers entered the work-force. Dependency ratios are predicted to continue at current lows until approximately 2011, when the oldest of the baby boomers begin to retire (assuming a retirement age of 65) and increase steadily afterwards as the proportion of the population aged 65 and older rises significantly.¹⁶ In all but a

¹³ Myers, Dowell and Elizabeth Gearin. “Current Preferences and Future Demand for Denser Residential Environments” *Housing Policy Debate*, 2001, 12(4): 633-659.

¹⁴ Denton, Frank T. and Byron G. Spencer. “Population Aging and its Economic Costs: A Survey of the Issues and Evidence” *SEDAP Research Paper No.1*, McMaster University: Hamilton (1999).

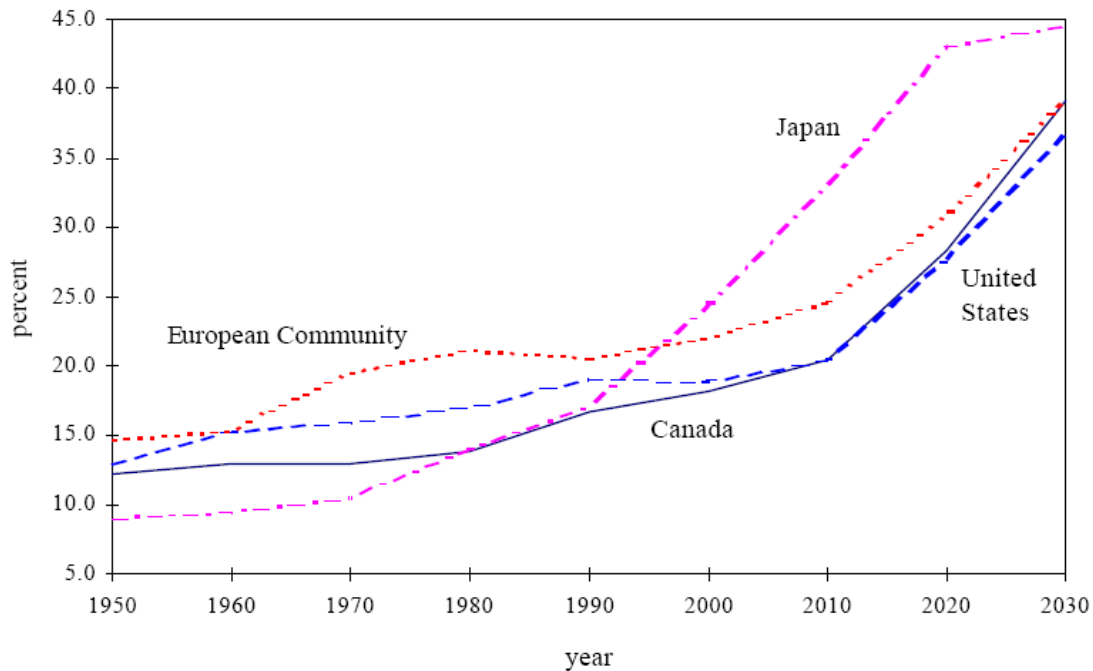
¹⁵ The *age dependency ratio* is defined as the ratio of the combined population 0-14 years of age and 65 and over to the population 15-64. The *economic dependency ratio* is defined as the ratio of non-labour force population to the labour force. The *elderly dependence ratio* is defined as the ratio of the population 65+ to the population 15-64.

¹⁶ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): *Urban Policy Issues: Canadian Perspectives*. Oxford University Press: Toronto, (2002) pp17-35.

few formulations,¹⁷ the ratios projected over the next half century will never attain the highs seen during the baby-boom as a result of the high relative proportion of youth in the 1960s.

Figure 5 shows Canada's *elderly* dependency ratio projected to 2030 compared with selected other OECD countries. Note that the total dependency ratios discussed above are not directly comparable with the *elderly* dependency ratios depicted in the graphic below.¹⁸ Nevertheless it represents the key component which will fuel rises in the overall dependency ratio.

FIGURE 5: ACTUAL AND PROJECTED ELDERLY DEPENDENCY RATIOS, 1950-2030¹⁹



Given that Canada will likely not be experiencing massive waves of retirement until the middle of the coming decade and that it enjoys a relatively strong population growth, Canada appears to be relatively better positioned to deal with the potential impacts of aging demographics compared to many other industrialized nations.²⁰

3.3 Implications for Public Finances

Shifts in demographics may put a strain on the resources available for public spending for two reasons. As the total working population declines, personal income taxes, which account for

¹⁷ By assigning much higher expenditure weights to the older age group than the youngest, Foot (1989), predicts historically high dependency ratios by the year 2021.

¹⁸ It is important to note that any significant changes in fertility, mortality and immigration patterns could alter these trends in the long-run.

¹⁹ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): *Urban Policy Issues: Canadian Perspectives*. Oxford University Press: Toronto, (2002) pp17-35. (p.34)

²⁰ Denton, Frank T. and Byron G. Spencer. "Population Aging and its Economic Costs: A Survey of the Issues and Evidence" *SEDAP Research Paper No.1*, McMaster University: Hamilton (1999).

approximately 30% of government revenues,²¹ may also fall. At the same time, expenditures on age-related services may increase.

Increased demand for age-related services may increase pressure on some areas of government expenditure, but shifts in demographics may also significantly reduce the need to provide other types of public services, namely those for a younger population and a larger labour force. As discussed above, the decreasing proportion of young as a result of falling fertility is as much an issue as the aging baby boom. With fewer children, one might expect less fiscal pressure on education. Also, should our labour force eventually begin to shrink because of aging and insufficient immigration, one may expect a reduction in most employment program related expenditures. Unfortunately, the literature is unclear on what the net effect on government expenditures may prove to be.

Further, while dependency ratios may offer insight into the relative structure of the population, they say nothing about the financial situation of the population. For example, high dependency ratios during the 1960s were a result of a relatively large young population. Dependency ratios in the near future will reflect that same population segment years later; however, these same ratios say nothing of the boomer's lifetime of productivity, ability to generate wealth, and wealth held in savings. While the mix of dependents has changed, so too has the wealth of that mix. The seniors of tomorrow (the Boomers) may be in a much greater position to finance their own retirements. This may ease the pressure on some government funded social services for the elderly.

The fiscal impacts of aging demographics will depend on two major questions: (1) to what extent will conflicting demand pressures compensate one another (increasing for some infrastructure-related services and decreasing for others) and (2) to what extent will the baby boom generation support the financing of infrastructure-related services?²² Unfortunately, conclusive empirical evidence has yet to be generated on these two questions.

By using an augmented balance sheet formulation, one study estimated the net present value of the public liability over the next 50 years (due to demographic changes in the population and associated changes in demand) at over \$300 billion (or approximately 28% of 2001 GDP).²³ From a distributive perspective, the federal government is projected to fare much better than the provinces because of the jurisdiction distinction between services.²⁴ This long term accounting exercise supports conclusions drawn through generational accounting measures that the average future tax payer will be responsible for paying a greater price for government services and transfers than he/she will receive in return.²⁵

²¹ Statistics Canada, CANSIM, Table 385-0001.

²² *ibid.*

²³ Robson, William B.P. "Time and Money: The Fiscal Impact of Demographic Change in Canada." *C.D. Howe Institute Commentary*, 2003, no.185. (p.15)

²⁴ It is worthwhile to note that since this particular study was published federal transfers to the provinces for health and social spending have been repetitively extended and increased.

²⁵ Robson, William B.P. "Time and Money: The Fiscal Impact of Demographic Change in Canada." *C.D. Howe Institute Commentary*, 2003, no.185.

Other evidence suggests that demographically induced increases in fiscal requirements, net of any off-setting budgetary decreases, will grow at about the rate of population increase, and below the growth rate of GDP.²⁶ Further, some projections show that when these expenditure increases are compared with projected increases in the productive capacity of the economy, it seems likely that the needs in these spending categories will be smaller as a percentage of GDP than at present, even though there will be large spending increases on health and social security.²⁷

Even the most optimistic projections of impacts on public finances come with cautionary notes that while there is no impending aging crisis, there are significant risks to be managed effectively, including significant changes in public spending.²⁸ As such, a major determinant impacting whether infrastructure requirements are met may be dependent on public willingness to pay, either through general taxation, specific taxes, usage charges, and commercialisation principles, such as public private partnership (P3).

4. Sectoral Impacts

4.1 Transport Systems

Public Transit

The highest use of public transportation is made by individuals in their teenage years as they become more independent but before they can afford to purchase a vehicle. Public transportation usage by age cohort falls off significantly in older groups. This is typified by the historical trend of boomer usage of public transport. When the boomers reached middle years, their usage rates fell away and many cities' public transport infrastructure operated at well below capacity. The echo generation is currently in the peak usage period of their life, but usage rates may begin to fall away again in the next decade if historical trends continue. As such, the mixed of investments in maintenance versus expanded capacity needs to be carefully considered.²⁹

In the U.S., evidence suggests only 3% of seniors take public transport for meeting their need to travel within their urban communities, though this figure is higher in densely populated metropolitan areas.³⁰ Public transport systems, especially fixed-route bus service, face important

²⁶ Denton, Frank T. and Byron G. Spencer. "Population Aging and its Economic Costs: A Survey of the Issues and Evidence" *SEDAP Research Paper No.1*, McMaster University: Hamilton (1999). (p.19)

²⁷ *ibid.* (p.23)

²⁸ Robson, William B.P. "Time and Money: The Fiscal Impact of Demographic Change in Canada." *C.D. Howe Institute Commentary*, 2003, no.185.; and Denton, Frank T. and Byron G. Spencer. "Population Aging and its Economic Costs: A Survey of the Issues and Evidence" *SEDAP Research Paper No.1*, McMaster University: Hamilton (1999).; and Foot, David K. "Population Aging." In J. Leonard, C. Ragan and F. St-Hilaire (eds.): *A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being*. Institute for Research on Public Policy: Montreal (2007) pp181-213; and Hogan, Seamus and Sarah Hogan. "How Will the Aging of the Population Affect Health Care Needs and Costs in the Foreseeable Future?" Commission on the Future of Health Care in Canada: Discussion Paper no.25: Ottawa, 2002.

²⁹ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): *Urban Policy Issues: Canadian Perspectives*. Oxford University Press: Toronto, (2002) pp17-35.

³⁰ Stutts, Jane and Ingrid Potts. [internet on-line] "Gearing up for an Aging Population" *Public Roads*, 2006, 69(6). available from: < <http://www.tfhr.gov/pubrds/06may/07.htm>>

challenge in meeting the needs of the elderly for responsive, convenient transport, especially as they represent a growing proportion of the population.

Survey evidence from the U.S., Australia, and Europe suggest that personal vehicle use is the preferred mode of transport for seniors. While seniors drive up to 30% less than younger age cohorts, the 65+ cohort is the only one which has increased its rates of driving over the recent past (with a 26% increase in German case over an 8 year period).³¹ This increase has been characterised by rising trip rates and distances, though this tends to fall off at around 80 years of age when usage rates of public transport begin to rise again.³²

The preponderance of high automobile dependency in developed countries is due in large part to the suburban sprawl characterised by city planning over the latter half of the twentieth century. Today in Canada, over 60% of seniors live in single family homes in the suburbs.³³ This demographic is set to account for an increasing percentage of the population and will therefore account for a larger share of the driving population.³⁴

The boomer generation of Canadians has higher expectations for mobility than any to precede it, often viewing access to the mobility that a license offers as a right. Quality of life for this population segment may be implicitly tied to mobility, the loss of which may be equated to a lower standard of living. As such, they may be reluctant to let go of the freedom that mobility affords.³⁵ If current preferences and trends persist, many of the boomers of today may chose to 'age in place',³⁶ staying in suburban communities with falling population densities. In which case, there may be a growing need for community buses which are smaller, more accessible, and which offer flexible services in areas without sufficient demand for mainline bus routes.³⁷ This may be reinforced by the fact that demand for activities outside the home may not drop at the same rate as skill levels or mobility resources.³⁸

³¹ Just, Tobias. "Demographic Developments will not Spare the Public Infrastructure" *Current Issues: Demography Special*. Deutsche Bank Research: June 7, 2004. 1-24.

³² Alsnih, Rahaf and David A. Hensher. "The mobility and Accessibility Expectations of Seniors in an Aging Population" Institute of Transport Studies Working Paper: March 2003.

³³ Miller, Glenn and Gordon Harris and Ian Ferguson. "Bracing for the Demographic Tsunami: How Will Seniors Fare in an Aging Society?" *Plan Canada*, 2007, 47(4): 20-21.; and Alsnih, Rahaf and David A. Hensher. "The mobility and Accessibility Expectations of Seniors in an Aging Population" Institute of Transport Studies Working Paper: March 2003.

³⁴ Foot, David K. "Population Aging." In J. Leonard, C. Ragan and F. St-Hilaire (eds.): *A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being*. Institute for Research on Public Policy: Montreal (2007) pp181-213.

³⁵ Miller, Glenn and Gordon Harris and Ian Ferguson. "What Drives Quality of Life for Seniors? Driving." *Globe and Mail Update* July 18, 2007.

³⁶ See: The Aging in Place Initiative @ aginginplaceinitiative.org; The Aging at Home Strategy by the Ontario Ministry of Health and Long-Term Care; European Conference of Ministers of Transport. *Transport and Aging of the Population*. February 2002.; OECD. *Aging and Transport: Mobility needs and Safety Issues*. OECD: Paris, 2001.; Alsnih, Rahaf and David A. Hensher. "The Mobility and Accessibility Expectations of Seniors in an Aging Population" Institute of Transport Studies Working Paper: March 2003.; Miller, Glenn and Gordon Harris and Ian Ferguson. "Bracing for the Demographic Tsunami: How Will Seniors Fare in an Aging Society?" *Plan Canada*, 2007, 47(4): 20-21.

³⁷ European Conference of Ministers of Transport. *Transport and Aging of the Population*. February 2002.

³⁸ European Conference of Ministers of Transport. *Transport and Aging of the Population*. February 2002.

Transportation Infrastructure

The trends associated with senior mobility suggest an increasing demand for new or altered markets in transport infrastructure, with a need to define strategies in terms of accessibility and safety. It has been suggested that this approach should be characterised by the provision of safer roads for drivers, roadside environments for pedestrians, cyclists, and users of electric wheelchairs/scooters, and more user friendly and accessible public transport systems.³⁹ Improvements might include road systems which are more forgiving to driver error with improved road geometrics, signage, and advisory systems, with consistency across jurisdictions.

There are also a number of other suggestions for improvements in the design of roadside environments which would cater to the needs of an aging population. These include: dedicated pathways for electric wheelchairs/scooters; curb extensions to minimize exposure time in crosswalks; improved access points to public transport and commercial areas; reactive crosswalks which adjust to the users' pace; tactile paving in sidewalk design; ramps and street furniture for lower impact mobility; pedestrian only areas where possible; and increased parking dedicated to the functionally disabled.⁴⁰ These and a multitude of other design specifications have become commonplace in Japan's 'Universal Design' drive to accommodate their aging demographics.⁴¹

It is important to note that the predominant types of infrastructure that may be required, especially road and roadside environment changes, are all true public goods. Consequently, unlike the use of public transportation which can operate in part or total as a user pay system, these infrastructure changes may need to be funded through the public accounts (unless toll charge usages increases substantially). An important externality arises with any infrastructure improvements designed specifically for older people: all users of all age groups, including the disabled, will benefit from infrastructure which provides for a safer and more accessible environment.

Driver Safety

Driver safety is another issue to consider. The elderly are responsible for fewer reported accidents per capita than any other age cohort,⁴² but account for as many accidents per kilometre driven as does the youngest cohort. Further, they exhibit a greater at-fault tendency. When they are at fault the severity of accidents is generally much worse. The 65+ cohort is over represented in multi-car accidents, and account for a much higher death rate when involved (largely associated with greater frailty).⁴³ Given these trends, driver safety programs and education campaigns for older cohorts may play a role in addressing their particular safety needs.⁴⁴

Highway Travel

³⁹ OECD. *Aging and Transport*. OECD: Paris, 2001.

⁴⁰ OECD. *Aging and Transport*. OECD: Paris, 2001. (see chapters 4 and 6)

⁴¹ Miller, Glenn and Gordon Harris and Ian Ferguson. "Aging and Mobility: What Other Countries are Doing" *Ontario Planning Journal*, 2006, 21(5): 9-10.

⁴² *ibid.*

⁴³ European Conference of Ministers of Transport. *Transport and Aging of the Population*. February 2002.

⁴⁴ OECD. *Aging and Transport*. OECD: Paris, 2001.

The Strategic Highway Safety Plan, a U.S. initiative, was designed to reduce highway fatality rates with planning strategies for improving roadway environments directed at the growing senior population. The Strategy suggests that specific roadway design and traffic operation changes – including signage, intersection design, traffic control operations, and roadway delineation – can improve safety. Localized testing across a number of States has shown results in diminished accident rates. In many cases, these needed changes can be made gradually and at low cost if these designs are incorporated into scheduled maintenance, reconstruction and new-build projects.⁴⁵

4.2 Water and Wastewater Systems⁴⁶

Water supply and wastewater management infrastructure generally comprise four main systems. These include:⁴⁷

1. Water abstracted for agricultural use – for rural communities and small urban areas. Most of this is ground water.
2. Water resources – abstraction (and possibly storage) for human needs. The sources can be upland rivers, lakes, lowland surface water, groundwater, sea or brackish sources or from evaporation systems.
3. Water supply networks, including inputs from abstractions, treatment, storage and distribution, and outputs, including management of residual sludge.
4. Wastewater network, including storm-water and sanitary drainage, treatment, effluent disposal and management of residual sludge.

Of these, the networks in 3) and 4) are generally very capital intensive. Water related services are more capital intensive than other utilities, requiring twice the capital compared to electricity with the same annual operating expenses. Given the value of this type of infrastructure, it has been recognized by the OECD that aging demographics will impact the needs for water infrastructure provision through both changes in the demand schedule, and by altering the composition of public finances as the tax base shrinks.⁴⁸

Evidence from Holland suggests that people aged 65+ use 118.6 litre/capita/day (water and wastewater), less than any other age group aside from children 0-12 and over 20% lower than the

⁴⁵ Stutts, Jane and Ingrid Potts. [internet on-line] “Gearing up for an Aging Population” *Public Roads*, 2006, 69(6). available from: < <http://www.tfhr.gov/pubrds/06may/07.htm>>

⁴⁶ There are few references to demographic impacts on waste and water systems in the Canadian context. The majority of occurrences on this topic are highlighted in publications by international organizations or in the German context where large infrastructure projects were undertaken following reunification and which are now experiencing severe under usage associated with population decline and aging.

⁴⁷ OECD. *Infrastructure to 2030: Telecom, Land Transport, Water, and Electricity*. OECD: Paris, 2006. (p.249-50)

⁴⁸ OECD. *Infrastructure to 2030 Volume 2: Mapping Policy for Electricity, Water and Transport*. OECD: Paris, 2007.

next most intensive using cohort.⁴⁹ Comparable statistics by age cohort are unavailable for Canada, however, a 2007 publication reports that the average Canadian consumed 329 l/d in 2004, or 609 l/d when industry usage is included.⁵⁰ Canadian citizens are the second most intensive users of waste and water services globally next to Americans. Consequently, assuming the pattern for use by age in Canada is similar to that in Holland, aging of the population could be associated with substantial declines in demand.

Grid-based infrastructure is sensitive to reduced demand. A reduction in water consumption and sewage generation associated with a reduced demand brought on by an aging demographics can cause problems associated with water supply, including economic and health risks. If demand flow falls below a critical level in supply lines, it can have serious hygiene and efficiency implications, as well as associated costs.

- With respect to drinking water, a decrease in consumption and the related reduced flow quantity can impair proper functioning of supply networks and create stagnation zones. Stagnant drinking water can lead to bacteria reactivation. In turn this can require flushing or re-chlorination, reducing water quality and system efficiency.⁵¹
- With regard to sewage and waste disposal, decreased flow can cause build up of solids in pipes designed for higher throughput. This may result in the need for frequent flushing, thereby negating water conservation efforts. Still, sewage water can increase corrosion rates and anaerobic conversion processes, resulting in increased corrosion which can have negative effects on ground water.⁵²
- Water supply and disposal infrastructure, with a desired life-span between 50 and 100 years, have generally been designed to accommodate growing populations and increasing demand. Given the inflexibility of such infrastructure, it is generally ill-equipped to respond to significant changes in demand flows, raising the danger of technical and economic inefficiency.

In addition, the issue of water contamination and treatment presents a serious concern. As population ages, there will likely be a higher reliance on personal care and pharmaceutical products containing complex synthetic substances that “may be persistent, cumulative and toxic if these enter environmental systems through toilet flushing”.⁵³ The impacts of these and other xenobiotics may require the installation of more advanced wastewater treatment systems.

There has been a substantial amount of research in this area in Germany. The German demographic profile is characterized by one of the highest proportions of elderly in the world, near zero population growth, and many areas in former East Germany are experiencing marked

⁴⁹ OECD. Household Energy & Water Consumption and Waste Generation: Trends, Environmental Impacts and Policy Responses. OECD: Paris, 2002.

⁵⁰ Environment Canada. 2007 Municipal Water Use Report (2004 Statistics). Environment Canada: Ottawa, 2007.

⁵¹ Hummel, Diana and Alexandra Lux. “Population Decline and Infrastructure: the Case of the German Water Supply” *Vienna Yearbook of Population Research*, 2007: 167-191.

⁵² *ibid.*

⁵³ OECD. Infrastructure to 2030: Telecom, Land Transport, Water, and Electricity. OECD: Paris, 2006. (p.286)

population decline. From these cases certain lessons may be drawn about the economic costs and implications of significant underutilization of waste and water supply infrastructure.

Over the last half century water systems built in the former East Germany were often designed to supply continued economic and industrial growth, often resulting in supply networks which are oversized for current and future usage. The current price structure (approx 12% basic price and 88% quantity price) does not reflect the cost structure (80% fixed costs) faced by suppliers. Since variable costs are small compared to fixed costs borne by the supplier, 75% of sewage costs are incurred regardless of volumes used. Therefore, reduced demand does not result in a proportionate decrease in production costs. As the population declines, the fixed costs are borne by fewer consumers and result in increased prices per household. Assuming the demand for water is relatively price elastic, a vicious cycle of increasing prices and falling demand may be set in motion in areas of significant population decline.⁵⁴

Germany is in a particularly difficult position due to the fact that much of its grid infrastructure in the former West is due for replacement while grand infrastructure projects in the former East are seriously underutilized.⁵⁵ This situation will require significant investments in new infrastructure, dismantling, and maintenance.

Unlike Germany, regionalized water systems used in Canada and the U.S. enable better economies of scale by banding together multiple municipalities. This system leads to “reduced costs, shared expertise, improved performance, enhanced water supply security in uncertain climate conditions, and increased flexibility” to changes in demand.⁵⁶ The effects of reduced demand in Canada may therefore be less severe than in Germany.

One of the primary issues relating to water services in Canada is pricing. In Canada, water and waste services are predominantly provided through public enterprises. Private water and sewerage services account for 4% and 2% of market share, respectively.⁵⁷ Only 75% of the cost of maintaining and operating water infrastructure is actually being recovered from users through tariffs, the rest being financed through taxes. Current pricing structures and metering rates do not provide incentive for residential water conservation. “Only about 45 percent of the population served was found to be under a rate structure that provided a definite incentive to conserve water: 36 percent were under a *constant rate* structure (where the bill to the consumer climbs uniformly with the volume used); and 9 percent were under an *increasing block rate* structure (where a successively higher price is charged as larger volumes of water are used).”⁵⁸ The rest of the population are generally unmetered users. Under this pricing structure, a move towards full-cost pricing coupled with reduced demand due to aging demographics may put upwards pressure on prices.

⁵⁴ Just, Tobias. “Demographic Developments will not Spare the Public Infrastructure” *Current Issues: Demography Special*. Deutsche Bank Research: June 7, 2004. 1-24.

⁵⁵ *ibid.*

⁵⁶ OECD. *Infrastructure to 2030 Volume 2: Mapping Policy for Electricity, Water and Transport*. OECD: Paris, 2007. (p.271)

⁵⁷ *ibid.*

⁵⁸ Environment Canada. [internet on-line] “The Management of Water.” available from: http://www.ec.gc.ca/water/en/manage/effic/e_rates.htm

Since the mid 1990s, full cost recovery plans have been more aggressively promoted and prices have been rising to reflect the unsubsidized value of water and waste services. Given the German experience, there may be some threats to the water systems in Canada associated with aging demographics, though more efficient Canadian designs are noted to be particularly robust in their security and adaptability. Future concerns for Canada in this respect rest mainly in ensuring efficient wastewater treatment, upwards pressure on prices, and the public's willingness to pay.

4.3 Health Infrastructure

By the late 70s, governments and policy analysts had become increasingly aware of the pressures that an aging demographics could cause on public health programs and associated budgets. By the mid 90s, this had become a major area of Canadian public policy debate, covering a range of issues which included P3s, user-fees, and universality.⁵⁹ Estimates of how the aging demographics will impact the healthcare sector are difficult to review and summarise as they span a wide spectrum, from economically devastating to negligible.⁶⁰

What seems to draw a wide consensus is the basic fact that the demand for health services tends to rise as populations age. A survey conducted in the late 90s showed that 96% of seniors utilized healthcare services at least once per year, 84% reported taking some form of medication, and were generally more likely to require hospitalization for a variety of age-related ailments.⁶¹ If these trends continue, they may bring about a significant increase in the demand for health services. Further, the peak of this increase may last longer as a consequence of increased life expectancy.

Those aged 65+ are the most intensive users of health services. Average per capita provincial/territorial health spending in Canada was about \$2,630 in 2004, while spending for those aged 65-69 was about \$5,016, and spending on those aged 80-84 was roughly \$11,902.⁶² The current generation making intensive use of the health care system is the relatively small group born during the 1930's Depression, allowing Canada a window of preparation before the boomers start to cause high growth in demand on the health sector throughout the 2020s and 2030s.

While some still believe funding to be the primary issue facing healthcare, staff shortages are considered by others to be even more problematic. Reduced birth rates have shrunk the size of cohorts available for recruitment into the healthcare sector. As a result, Canada is currently experiencing a marked shortage of human capital in the healthcare sector, specifically in the area

⁵⁹ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): Urban Policy Issues: Canadian Perspectives. Oxford University Press: Toronto, (2002) pp17-35.

⁶⁰ See: Rich, Pat. [internet on-line] "Canada's Aging Population: Demographic Time-Bomb or Economic Myth?" *Elder Care Magazine*, 2005.; and Robson, William B.P. "Time and Money: The Fiscal Impact of Demographic Change in Canada." *C.D. Howe Institute Commentary*, 2003, no.185.; and Andrews, Doug. "Assessing Alternative Financing Methods for the Canadian Health Care System in View of Population Aging" *SEDAP Research Paper No.224*, McMaster University: Hamilton, 2007; and Hogan, Seamus and Sarah Hogan. "How Will the Aging of the Population Affect Health Care Needs and Costs in the Foreseeable Future?" Commission on the Future of Health Care in Canada: Discussion Paper no.25: Ottawa, 2002.

⁶¹ Health Canada. Canada's Aging Population. Health Canada: Ottawa, 2002.

⁶² Esmail, Nadeem. "Health Care and the Aging Population." National Post July 23, 2007.

of geriatric medicine.⁶³ Education (and immigration) policies to promote an influx of people into healthcare occupations appear to be critical.

More closely related to tangible health infrastructure, is the concentration of aging boomers in sparsely populated suburbs and their alleged preference to ‘age in place’ rather than move towards city centers. This could represent an increasing disconnect with the fact that hospitals and other care providers are predominantly located in city centers. Given this potential contradiction between future primary users and service location, Canada may need to rethink the geographical delivery of healthcare services.⁶⁴ The use of nurse practitioners as mobile homecare providers could also save on the use of more expensive physician and hospital infrastructures. This may improve service delivery for the mobility impaired and reduce wait times at hospitals or clinics, ameliorating health problems across the population.⁶⁵ Furthermore, separate stand alone clinics providing specialized health care services common to the elderly may improve efficient service delivery to that population segment and reduce the impact of increasing hospital usage on the rest.⁶⁶

As alluded to above, healthcare financing may not be as important as we think in the context of Canada’s aging demographics. A key reason for this may be that taxes on future pension withdrawals could finance a large proportion, if not all, of the future health care costs of the boomer generation.⁶⁷ Given the current use of tax-deductions and tax-deferral allowances, boomers may continue to significantly support fiscal revenues during their retirement as they withdraw their savings and indirectly self-finance, to some degree, their healthcare needs.⁶⁸ Health care financing may also be reinforced as public authorities divert funding from education to health care, as demand for the former falls.

However, one should not lose site of that fact that aging is more pronounced in some provinces than others. Elderly dependency ratios are projected to be much higher in the Atlantic Provinces and Quebec compared to Ontario and the western provinces, given the smaller echo generation, lower immigration and higher out-migration among younger generations. Figure 6 shows the median age of Canadians by province. Given that provinces are responsible for providing health services, those with higher elderly dependency ratios or less deferred income tax to tap into may be faced with greater financial pressures.⁶⁹

⁶³ *ibid.*

⁶⁴ Foot, David K. "Population Aging." In J. Leonard, C. Ragan and F. St-Hilaire (eds.): A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being. Institute for Research on Public Policy: Montreal (2007) pp181-213.

⁶⁵ *ibid.*

⁶⁶ *ibid.*

⁶⁷ Daw, J. "How Boomers Could Fund Future Health Care." Toronto Star July 9, 2002.

⁶⁸ Foot, David K. "Population Aging." In J. Leonard, C. Ragan and F. St-Hilaire (eds.): A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being. Institute for Research on Public Policy: Montreal (2007) pp181-213.

⁶⁹ Denton, Frank T. and Byron G. Spencer. "Population Aging and its Economic Costs: A Survey of the Issues and Evidence" SEDAP Research Paper No.1, McMaster University: Hamilton (1999).

FIGURE 6: MEDIAN AGE OBSERVED (2005) AND PROJECTED (2031) ACCORDING TO SIX DIFFERENT SCENARIOS⁷⁰

	2005	Scenario (2031)					
		1	2	3	4	5	6
	median age (in years)						
Canada	38.5	45.6	44.3	44.3	44.4	44.3	43.3
Newfoundland and Labrador	40.5	50.5	50.8	49.9	49.3	52.9	49.2
Prince Edward Island	39.3	47.8	46.9	46.3	45.7	46.8	45.3
Nova Scotia	40.4	48.8	48.5	48.1	47.8	48.3	47.1
New Brunswick	40.3	49.3	49.3	48.7	48.2	49.0	47.9
Quebec	40.1	47.4	46.0	46.0	46.0	46.2	45.0
Ontario	37.9	44.7	43.2	43.4	43.6	43.3	42.3
Manitoba	37.1	43.1	41.6	41.8	42.1	41.6	40.8
Saskatchewan	37.3	44.9	44.0	44.2	44.5	42.9	43.2
Alberta	35.5	43.3	42.0	42.5	43.1	42.0	41.5
British Columbia	39.5	46.6	46.2	45.1	44.2	46.0	44.0
Yukon	37.4	42.3	44.2	40.7	38.2	43.3	39.4
Northwest Territories	30.7	37.4	36.6	35.7	34.6	35.4	34.3
Nunavut	23.0	26.0	24.5	24.5	24.4	24.8	23.1

Source(s): Statistics Canada, Demography Division.

4.4 Education Infrastructure

As result of the baby boom, the 1950s and 60s saw rapid increases in elementary and secondary school enrolment. This resulted in considerable education infrastructure development to meet the rapidly growing demand for primary and secondary education. The baby bust generation which followed created considerable excess capacity in the 1970s and early 80s. This had significant impacts on infrastructure as well as on human capital. Facilities were closed, hiring frozen and early retirement packages were proposed to deal with a surplus of teachers. As the baby boom echo generation began going through its education years, there was a subsequent increase in enrolment. By 2011, when the time the oldest of the baby boomers begin to retire, the youngest of the echo will be finishing high school. Enrolment rates will likely have started to decline well before then, and we will likely enter another period of excess capacity.⁷¹ Since many of the Boomers moved to the suburbs to raise their echo children, these population trends are likely to be especially apparent in Canada's urban periphery.⁷²

Thus, decreased demand for education at all levels is likely to occur in the future. Figure 7 shows decreasing enrolment rates in primary and secondary public schools for Canada and the provinces. Figure 8 shows the difference in post secondary enrolment statistics in Canada by age group. This measure exhibits an initial increase in enrolments as the echo generation ages, followed by decreased enrolment through 2031.

⁷⁰ Statistics Canada. Population Projections for Canada, Provinces and Territories 2005-2031. Statistics Canada: Ottawa, 2005.

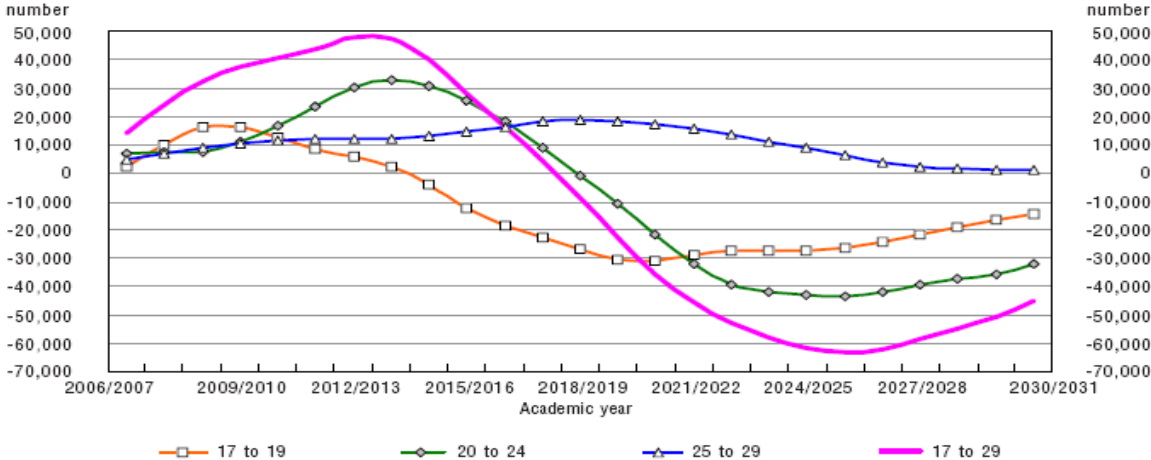
⁷¹ Foot, David K. "Urban demographics in Canada." In E. Fowler and D. Seigel (eds.): Urban Policy Issues: Canadian Perspectives. Oxford University Press: Toronto, (2002) pp17-35.

⁷² Foot, David K. "Canadian Education: Demographic Change and Future Challenges." *Education Canada*, Spring 2001. available at: <<http://www.footwork.com/edcan.asp>>

FIGURE 7: PROJECTED ENROLMENT GROWTH IN PRIMARY AND SECONDARY PUBLIC SCHOOLS

	2004-05 to 2008-09	2008-09 to 2012-13
	% change	
Canada	-4.0	-4.3
Newfoundland	-11.6	-9.4
PEI	-10.2	-11.0
Nova Scotia	-9.6	-9.3
New Brunswick	-8.1	-8.2
Quebec	-4.6	-6.3
Ontario	-1.7	-2.9
Manitoba	-4.6	-4.4
Saskatchewan	-8.0	-5.2
Alberta	-2.6	-0.9
British Columbia	-6.7	-5.8

FIGURE 8: DIFFERENCES IN POSTSECONDARY ENROLMENTS IN CANADA⁷³
 Difference in full-time postsecondary enrolment¹ between the 2003/2004-to-2005/2006 average and the projected enrolment: Canada, 2006/2007 to 2030/2031



1. Enrolment difference is calculated by subtracting the 2003/2004-to-2005/2006 average enrolment from the projected enrolment.
 Note: The line at zero indicates no difference between the projected enrolment and the 2003/2004-to-2005/2006 average enrolment.

These trends suggest an overall decrease in demand for school and university services over the next two and a half decades. If the recent past offers an example of how this may impact the provision of educational services, Canadians will pass through another period of excess capacity similar to that experienced in the late 70s and early 80s. As such, it is expected that there will be a reduced need for education professionals and buildings. Maintenance investments may also begin to comprise the greatest amount of spending in education infrastructure.⁷⁴ In sparsely populated areas, education costs per pupil will likely climb, making comprehensive schools more cost effective.⁷⁵

⁷³ Hango, Darcy and Patrice de Broucker. *Post Secondary Enrolment Trends to 2031: Three Scenarios*. Statistics Canada: Ottawa, 2007. (p.49)

⁷⁴ Just, Tobias. "Demographic Developments will not Spare the Public Infrastructure" *Current Issues: Demography Special*. Deutsche Bank Research: June 7, 2004. 1-24.

⁷⁵ *ibid.*

As stated before in the context of increasing health care costs, some suggest that reduced future educational needs will alleviate pressure on provincial budgets, allowing these resources to be redirected to areas of increased demand brought on by aging demographics. In areas of significant younger cohort decline, conversion of existent education infrastructure into mixed, flexible use facilities may be feasible. It has been suggested that some of this infrastructure could be altered to accommodate the needs of an aging population. Examples of how this infrastructure may be put to new use in this context include driver retraining centers, specialized health clinics, and community resource and social service centers. All of these examples could alleviate mobility pressures on the aging population.

5. Key Findings

In summary, the aging of the baby boomers, and subsequently of the population is projected to lead to a host of changes in demand, ability to pay and optimal fiscal and financial models. The expected impacts on demand by type of infrastructure are varied.

- While aging demographics are not expected to lead to an increased need for transportation infrastructure, modifications to public transit and roadways may be required to make them more accessible and safer. These investments may present challenges in terms of the optimal funding model, given the public nature of these assets.
- Demand for water is likely to decline as population ages. This trend is due to reduced demand among the elder cohort, slow population growth overall, and improvements in production efficiency. However, reduced demand may generate two types of problems. First, sub-optimal use of water facilities may lead to degradation in those facilities. Second, the current balance of fixed versus user charges may need to be reassessed, given the large fixed component in costs.
- Demand for health services is expected to increase as population ages. Given evolutions of health care practices, implications on health-related infrastructure will require further research to clarify.
- Despite efforts towards Lifelong Learning, average demand for educational facilities will likely decline as the echo boom generation moves beyond school-aged years. Maintenance and use of these facilities will present both a challenge and an opportunity.

Overall, demand for some types of public services and infrastructure will increase, while it will decrease for others. The net impact remains elusive at this point in the literature.

Aging of the population will also lead to an increase in the dependency ratio of the non-working population on the working population. However, it is important to note that even at its projected peak, the dependency ratio will still be lower than its peak in the baby boom years. Hence, the financial impacts are mixed. While there will be fewer people working, there are two important considerations. First, unlike the youth who were driving up dependency ratios in the baby boomer years, aging baby boomers will have savings in order to pay for new, modified and/or enhanced services and infrastructure. Second, the drawing down of these savings will be taxed, and thus further augment government revenues. The literature seems to suggest that these factors

may not completely offset the negative impact of increased demands on a lower tax base, but the situation may not be as severe as some authors have professed.

Population growth is expected to be slow over the next several decades. Consequently, population growth will likely not translate into increased levels of demand for public infrastructure. However, it is not clear what the impacts, if any, of technological evolution may be on public infrastructure. This issue which is not considered in the literature on aging and infrastructure may significantly affect the ultimate outcomes.

This paper illustrated some of the key considerations for policy. For example, alternative funding strategies and models will likely need to be developed. Secondly, better, more relevant land and capital use planning will be required in order to anticipate and avoid problems associated with infrastructure degradation, shortages and misplacement.

This study also illustrated that there are several key areas that merit further research.

- First, few of the studies are Canadian. Hence, there is a need for Canadian research on Canadian data.
- Second, because of the confounding impacts, modelling of all of the different impacts would help to present scenarios of what the net impacts will be.
- Third, further investigation is probably merited into the opportunities offered by “smart growth” for the elderly.
- Fourth, the preference to “stay in place” should be examined more closely via additional secondary and primary research.

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