Title: A century of demographic ageing in Arctic Canada (1950–2050)

Corresponding author:

Anastasia Emelyanova, Dr. (Health Sciences/Arctic Health)

1. Arctic Futures Initiative / World Population Program, International Institute for Applied Systems Analysis, Austria

Mailing address: Schlossplatz 1, A-2361, Laxenburg, Austria

E-mail: emelyan@iiasa.ac.at

Telephone: +43 664 262 3051

2. Thule Institute, University of Oulu, Finland (second affiliation)

Mailing address: Pentti Kaiteran katu 1, University of Oulu, Oulu, Finland

E-mail: anastasia.emelyanova@oulu.fi

Contributing author:

Arja Rautio, Research Professor, MD, PhD, Head

1. Centre for Arctic Medicine, Thule Institute, University of Oulu, Finland

Conflict of Interest: The authors declare that they have no conflict of interest.

Acknowledgements: (if accepted to the journal)

The authors are grateful to Prof. Warren Sanderson and Sergei Scherbov for their valuable insights on the prospective ageing methodology. The authors also thank the Canadian Human Mortality Database as well as Statistics Canada for available population data. Constructive suggestions from the editor and two anonymous reviewers have been of high beneficence to the quality of this paper.

1. Introduction

Background Studies and Aims

As part of increasing awareness of the region's importance, there is a growing interest in population dynamics in the Arctic. Recently, major differences between the Arctic and southern populations of the same countries have been recognized (Arctic social indicators 2010; Megatrends in the Arctic 2012; Young et al. 2012; Larsen and Fondahl 2015). In parallel with the increasing scientific attention, specialized sources such as the ArcticStat, the Circumpolar Health Observatory, and the Arctic Health portal have been accumulating data on diverse aspects of the demography and health of northern peoples (ArcticStat 2016; CircHOB 2016; Arctic Health 2016).

There are fewer studies and data available on population dynamics at the sub-national level of Arctic countries, and to contribute to filling that knowledge gap we focus on Canada's northern areas, which makes up a large share of the Arctic. We examine population ageing, which has been underrepresented as a research theme in this part of the Arctic, despite the fact that it is a strong trend in the Arctic (Hansen et al. 2012). Only a small number of publications shed light on population ageing in areas in Northern Russia, the Barents and North Atlantic regions of the Arctic (Emelyanova and Rautio 2012; Emelyanova and Rautio 2013; Emelyanova 2015; Emelyanova and Rautio 2017).

The Arctic regions of Canada are located to the north of 60º N latitude (CircHOB 2016), and include three northern territories: the westernmost Yukon, the most populous Northwest Territories (NWT), and Nunavut, which forms the largest, least populated, and newest territory of Canada (Fig. 1). Nunavik in northern Québec and Nunatsiavut in Labrador have been excluded due to data obstacles (briefed in *Data Characteristics* below).

Fig. 1 Map of Canada's Arctic territories (Yukon, Northwest Territories, Nunavut). Source: https://commons.wikimedia.org/wiki/File:Political_map_of_Canada.png

Place Fig. 1 here

We aim to identify historical patterns of population ageing in the Arctic Canada (1950 to 2010) and to predict future ones in the region (2015 to 2050). In order to facilitate cross-regional comparisons of ageing, the oldest and youngest territories will be identified. Arctic regions will be compared to Canada's national average and the dynamics of the process will be investigated, looking at those territories ageing the fastest and slowest (or possibly, rejuvenating). Finally, we will determine whether the ageing trends in the three parts of the region have been converging or diverging over the studied century.

In summary, this paper introduces a long-term dataset on ageing in Canada for the period from 1950 to the present day, by accessing the available historical data (*Data Characteristics*), projecting forward to 2050 (*Projection Assumptions*), and applying both conventional and adapted to life expectancy's growth methods on

ageing (*Methods*). This work can help devise policies for coping with the population ageing in the North of Canada. This is a particularly important contribution at a time when there is neither comprehensive evidence nor policy dealing with ageing in the studied territories (Wilson *et al.* 2012).

Regional Ethnic Patterns

The studied population in Arctic Canada is tiny despite the fact that geographically the northernmost territories make up a huge proportion of the country's area (Fig. 1). The population in the region has grown in recent decades, reaching 118,169 people in 2015 (Statistics Canada 2016). However, the share of the population in the Yukon, NWT and Nunavut territories in 1950 was only about 0.2% of that of Canada and 0.3% in 2010. Population growth in the northern territories of Canada is firstly the result of more births than deaths, especially among the Aboriginal population (NWT and Nunavut). In Yukon, population growth was largely fuelled with a great number of immigrants following the same boom and bust patterns in mining and resource development found elsewhere in the Arctic (Southcott 2010). To a minor degree, population growth was also supported by an expanding service sector, including health care services. The population of Canada's Arctic is expected to continue to grow in the 21st century (Larsen and Fondahl 2015), and the projections made for this study show that it will likely reach 0.4% of the Canada's population by 2050.

The population living in the Canadian Arctic is ethnically nuanced. The ethical complexity provides an important context of ageing in the region. Two groups of people live together in the Canadian Arctic: firstly, people whose ancestors have lived in the area for hundreds of years and who are specified as Aboriginal. The Aboriginal population is divided into three main sub-groups: First Nations (North American Indian), Métis, and Inuit people. The rest of the residents are non-Aboriginal people who came to the area (or whose ancestors did) from non-Arctic Canada or, more recently, from other countries to work. The Arctic's mixed economy was historically dominated by large-scale mining, the petroleum industry, and the military, but also includes traditional hunting, herding, berry-picking, and fishing. Recently, the service sector has become attractive to foreigners, as it has comparatively high wages and is an easier path to permanent residency. A small but growing group has taken up these opportunities in the North, with Filipinos as the largest diaspora (Wingrove 2014). The non-Aboriginals (so far mostly Canadians) are usually at later stages according to the theories of the demographic and health transitions, as seen when comparing data for Aboriginal and non-Aboriginal population or when examining regions that have predominantly Aboriginal populations (Larsen and Fondahl 2015).

With increased migration in the recent decades, the proportion of Aboriginals has declined and the entire Canadian North is now roughly only half Aboriginal (Heleniak 2014). However, the proportions of Aboriginals in the Canadian Arctic regions vary. According to the 2011 Canadian census, Aboriginal peoples make up 86% of the Nunavut population (27,360, predominantly Inuit), NWT of 48% (21,160, mostly First Nations with 6–8% of Inuit and Métis), and 23% in Yukon (7,710, the majority of these are First Nations peoples) (Statistics Canada 2016). Such ethnic composition greatly affects demographic indicators of birth, death and mobility; urban-rural residence; and household structure.

The health of people living in rural, remote Aboriginal communities in the north is poorer than that of their urban counterparts and non-Aboriginal people. Health Canada indicates that health status declines with distance from urban centres. It further stated that compared with urban residents, people living in rural communities have shorter life expectancies, higher death rates and higher infant mortality rates (Health Canada 2002). Census 2011 reported the median age for Aboriginals in Arctic Canada as 28 years, whereas for non-Aboriginals in Yukon, NWT and Nunavut the same indicator was 39 years (Statistics Canada 2011b). The three northern territories have the highest infant mortality rates in the country with Nunavut consistently the highest (Larsen and Fondahl 2015). As discussed later in this paper, the Aboriginal population also has a much younger age structure and distinct male-female gender ratio.

Population changes are largely associated with spatial distribution and rurality. It is important to note that the majority of the non-Aboriginal population resides mainly in the few urban centres in each territory, whereas the Aboriginal population is more widely dispersed in small fishing and hunting settlements. In northern Canada, only Yukon has a large share of its population residing in urban areas (76%), and this is concentrated into the capital of Whitehorse that is near that of the percent of urban population in Canada total (81%). A network of tiny communities (ranging in size from 100–1500 people with substantial First Nations populations) and mine sites with mobile workers is spread across two-thirds of Yukon (State of Rural Canada 2015). In NWT, share of the rural population is slightly more than 55% and in Nunavut 68%, in both regions these populations are still heavily involved in fishing and hunting. The low share of urban dwellers in Nunavut might also be associated with a deliberate governmental effort to decentralize jobs in the area and higher natural increase in rural settlements, which led the proportion of the territory's population living in the capital Iqaluit to decline from 21.1% in 2006 to 20.3% in 2013 (Larsen and Fondahl 2015).

The disparities in lifestyle between urban and rural areas include access to urban amenities such as reasonably priced food, reliable telecommunications services, job opportunities, security of affordable housing and energy, and education (State of Rural Canada 2015). These drive changes in migration, health, and demography, affecting ageing in particular. The challenge of addressing the health needs of older Aboriginal people living in small communities dispersed across the vast land mass of Arctic Canada remains. It requires structural changes in the recruitment of doctors and geriatricians along with specialists in mental health, addiction/substance abuse, and diagnostics, all culturally sensitive to Aboriginal approaches to lifestyle, treatment and healing. Much policy effort is needed to attract these professionals to the small health centres and nursing stations in the Canadian Arctic. In addition, as climate and environmental change affects living conditions, these changes also impact health, well-being, and quality of life of older people in the northern areas.

Another noticeable pattern is that urbanization in the Canadian Arctic is accelerating, propelled by local, national, and global drivers. To quote Larsen and Fondahl "there is a continued trend of increased urbanization and concentration of the populations in nearly all Arctic regions in the capital cities" (Larsen and Fondahl 2015, p. 102). The processes of out-migration from rural areas to larger settlements and cities, as well

as increased concentration of both Aboriginal and non-Aboriginal population in the cities are all contributing to rural depopulation, "brain drain" and "brain waves" related to changes in the economy and resource development and to growing aspirations for formal education and career, contributing to rural population ageing and changing dependency ratios (Larsen and Fondahl 2015). Also, decreases in federal transfers in recent decades and the withdrawal of the state from economic and social planning led to increased hardship in smaller villages, causing their abandonment and concentration of the populations into larger communities (Southcott 2010; Heleniak 2014).

While acknowledging aforementioned differences in health status and demographics between Aboriginal and non-Aboriginal populations in the Canadian North (see more in Hamilton 2008; Southcott 2010; Wilson et al. 2010; Young et al. 2012; Heleniak 2014; Larsen and Fondahl 2015), this ageing analysis is undertaken with only a partial reference to ethnic distinction because of scarce and incomplete data on different Aboriginal groups residing in the studied region. The computation of ageing measures is restricted to only the total populations living in the studied regions.

Methods

A number of indices have been applied to examine the complex and diverse trends of population ageing, and they can be roughly divided into two groups. The first group is "chronological", that is, conventional or standard indices for ageing. These use chronological age, the number of years lived by an individual or by a population, and characterize ageing with a variety of parameters (e.g., Life Expectancy at birth (LE) or in older ages; Median Age (MA); Proportion of People Aged 60 Years and Over (Prop 60+); Old Age Dependency Ratio (OADR); and Ageing Index (AI) (United Nations 2015). MA is the line that divides the population in half so that there are equal numbers of older and younger individuals. Prop 60+ or 65+ relate the population aged 60 or 65 and over to the size of the total population. OADR is the ratio of the people 60 or 65 years and over divided by the population within the age range 15 to 59 or 15 to 64. AI represents the percentage of people 60 or 65 years and older in proportion to children aged 0 to 14.

The second measurement approach is "prospective" and has been detailed in a series of articles by Sanderson and Scherbov (2007–2016). Prospective age relates to the number of years that people have left to live, instead of counting those years already lived (which would be chronological age). The authors argue that it is important to adjust standard ageing measures to changing population characteristics, since large gains have been recently made in terms of health and cognition in older people. In fact there has been a dramatic increase in life expectancy all around the world in recent decades (Caldwell 2001; Oeppen and Vaupel 2002; Foger 2004). Sanderson and Scherbov further state that ignoring age-specific changes and referring only to fixed chronological age can create a misleading picture indicating that ageing rates are increasing too rapidly. Therefore, this study has measured ageing not only conventionally, but also prospectively.

Five prospective indices, such as the Age at which Remaining Life Expectancy (RLE) is Equal to 15 (Age RLE 15); Prospective Median Age (PMA); the Share of People with a Remaining Life Expectancy of 15

Years or Less (Prop RLE 15-); Prospective Old Age Dependency Ratio (POADR); and Prospective Ageing Index (PAI), make adjustments for the dynamic changes in ageing in Canada and its Arctic territories, and complement conventional measures.

PMA is the age derived from the standard life table where RLE is the same as it is at the MA in the index year (Canada in 2005 in this study). For example, the PMA in 1970 is the age of a person in 2005 who had the same remaining life expectancy as the median aged person in 1970. Prop RLE 15- is calculated as the number of people in age groups where the RLE is 15 years or less in comparison to the total population. POADR takes the share of people older than the RLE 15- old age threshold as the numerator to be divided by the number of people aged from 15 to the old age threshold. PAI relates the number of people older than RLE 15- to the number of children aged 0 to 14 (more on how to calculate prospective indicators in Sanderson and Scherbov, 2007–2016).

The threshold age for prospective indices is the age at which LE is 15 years or less. This refers to a floating number of prospective years left to live and substitutes the age of 60 or 65 that provides the dividing line between "young" and "old" in the chronological indices. By adopting both chronological and prospective approaches, we categorize the population as being "old" not only at age 60 or 65, after which many individuals are still relatively healthy and productive, but also when people have 15 years left to live, the timeframe when they can be expected to be a higher burden on the health and social care services.

We produced the values of chronological ageing indices based on both the 60 and 65-year threshold to provide a comparison to other ageing studies. In the sections below, the results are discussed applicable to the 60-year old threshold only. We use chronological measures because they have been widely applied in demography and our findings can therefore be easily compared across most countries of the world. In contrast, the novel prospective approach has less possibilities for comparisons, mostly only national rates available from the European Demographic Data Sheets series from 2008 onwards (VID 2016). In addition to the complexity of the prospective approach, prospective analysis requires not only access to population accounts as baseline data, but also mortality numbers or life tables by age and sex, which are not always available at the sub-national level of Arctic countries.

Projection Assumptions

In order to project ageing indices, we forecasted LEs and consequently constructed mortality tables on the basis of known life expectancies for the future as well as population size by age and sex. The projection horizon spans 2015–2050 in 5-year intervals, given a number of assumptions. For reasons of simplicity, only one scenario was assumed for mortality and fertility. Similarly, one migration pattern was used, with net male and female numbers constant as of the 2014 baseline year. For each projection period, these migration numbers were scaled to match the net migration. Mortality was set using the United Nations World Population Prospects 2030/2050 medium forecasts in LEs (United Nations 2015), showing majorly an upward trend by 2050, of around 5 years for men and 4 years for women increased in comparison to LEs in 2015. The Arctic regions of

Canada followed the same speed of change as the national Canadian pathway. The life tables were projected using a Brass logit transformation model which incorporates age-specific mortality schedules in the studied regions in 2014 and earlier assumed life expectancy forecasts (Table 1).

Table 1. The life expectancies at birth applied to construct life tables and project ageing indices, Arctic Canada, 2015−2050

Place Table 1 here

The same assumption is chosen for fertility, using the UN 2030/2050 medium forecasts for the Total Fertility Rate (TFR) as well as age-specific fertility rates, which show a slight growth over the period (e.g. Canada's TFR changes from 1.6 in 2015 to 1.7 in 2050, and in Yukon from 1.7 to 1.8). The sex ratio at birth is calculated using data on live births for Canada and provinces (Statistics Canada 2016). The base population for these projections is derived from the official estimates of the population for Canada and provinces (Statistics Canada 2016).

To stay consistent with the historical analysis of ageing based on Canadian Human Mortality dataset (CHDM) where life tables are given jointly for NWT and Nunavut (CHMD 2016) our projections and consequently ageing indices are calculated for NWT and Nunavut combined (henceforth abbreviated as NN). Another reason for this is because the population sizes of these two territories are rather too small to make separate projections with confidence. In particular, this may help preventing the upward bias in mortality that can occur when estimating life expectancies in territories with a small population size (Scherbov and Ediev 2011).

Data Characteristics

For this study we referred to the publications made available by national and territorial statistical bureaus. Canada's socioeconomic database from Statistics Canada (CANSIM) and the CHMD are the two main sources of regional and national population data (CHMD 2016; Statistics Canada 2016). The CANSIM database publishes online abridged life tables, the most up-to-date are available for only the period 1995–2012. Because the CHMD provides life tables subdivided by sex, in an unabridged format, and starting from 1950, it allows better comparability and was chosen as the main data source.

Three other factors must be emphasized with respect to data quality. First, the definition of the "Canadian Arctic" is rather problematic. Only three Canadian territories are considered Arctic in our study: Yukon, NWT, and Nunavut. While the Nunavik region in northern Québec and the Nunatsiavut region of Labrador are sometimes regarded as part of the Canadian Arctic, it is not possible to obtain data on age and sex specific mortality, health, and some other factors for these areas because the data is available only for the entire provinces of which they are part (CircHOB 2016). They were therefore excluded from the analysis.

Secondly, recent territorial changes in the Canadian regions further limited the availability of sub-national population data. Differentiated population estimates for NN were available from 1991. Before this, data for the period 1980−1990 were available for NN combined. Chronological indices on ageing were created for the three Canadian territories separately, starting from 1991 (available from the authors by request). However, prospective analysis could only be carried out for two territories, Yukon and the combined NN, from the territory-specific life tables published by the CHMD.

Finally, ageing dynamics were assessed separately for male and female populations, as there are well documented large differences in the determinants of longevity between the sexes (Gavrilov and Gavrilova 2015).

2. Results

The assessment of population ageing is divided into two parts (following Gavrilov and Heuveline 2003), starting with the measures of longevity: LE at birth and the age at which RLE is equivalent to 15 years, the MA and PMA of populations. It continues with the so-called statistical head-count and inter-generational ratios (proportion of older people, elder-child ratios, and old age dependency) that reveal the changing balance between major age categories. The inter-territorial differences in ageing development are summarized in Appendix 1, where data on population ageing at the national level and for the Arctic regions of Canada are presented for the study period from 1950 to 2050 by sex.

Life Expectancy and Remaining Years to Live

World LE at birth has increased from 47.7 to 67.9 years between 1950 and 2010 (Larsen and Fondahl 2015). In the Arctic regions of Canada, the same indicator has increased from 51.6 to 76.9 years over the same period, with the fastest growth occurring between 1950 and 1970. In that period, the most impressive growth was among women: an increase of 16 years of LE for those in Yukon and 26 years for women in NN. This caused the gap between the sexes to grow, and indeed although in 1950 the sex gap in life expectancy in Canada's Arctic regions was negligibly small, in 2010 women lived already five years longer than men. However, Arctic Canada still has one of the smallest gaps in life expectancies between the sexes across the Arctic (with the largest found in the Russian Arctic). In future, however, the gap is expected to decrease to a single year by 2050.

It is not possible to study LE at birth by ethnicity for Canada's Aboriginal population, because of a lack of ethnicity information on death registrations. One study found that life expectancy in Inuit-inhabited areas (NWT and Nunavut) in 2001 was over 12 years less than for Canada as a whole, a gap that had widened during the previous decade (Statistics Canada 2016). Inuit-inhabited areas have lower levels of education and income and poorer housing conditions compared with Canada as a whole, a series of health reports and census

information from Statistics Canada have shown. These factors, in addition to risks associated with lifestyle and environment, could be responsible for the lower life expectancy of populations living in these areas.

Mortality has been generally higher in Arctic territories, including those under study, resulting in a lower LE than found nationwide. The only Arctic exception is the Faroese residents, who enjoy a LE higher than the inhabitants of mainland Denmark. In Arctic Canada, however, deaths per year were similar across areas and were higher than in Canada. For example: 7.5‰ in Yukon and 6.3‰ in NWT versus Canada's 4.9‰ (2011). The highest number of deaths was registered in Nunavut (11.2‰, 2011) and the region has the lowest LE of any Canadian territory. In fact, the LE of a new born baby was 71 in 2014 (both sexes combined), which is 11 years less than in the country in total. Ethnicity should be taken into account here: Inuit make up 86% of Nunavut population, and their LE may be affected by the factors mentioned above. In contrast, LE in Yukon is only three years less than that of the whole of Canada and Yukon's Aboriginal population accounted for only 23% in 2013 (Statistics Canada 2016).

The population in the northern corner of Canada was part of the "baby boom" phenomenon in the 1950s and these individuals have been moving into retirement. The current remaining LEs of this generation are higher than in previous decades. The indicator used for this assessment − Age RLE 15 − has increased by ten years over the last six decades, but is growing noticeably slower than the LE at birth. The Age RLE 15 of Arctic Canada's males increased from 60 in 1950 to 67 in 2010. For females, it increased substantially more, from 55 in 1950 to 70 in 2010. There was no difference in Age RLE 15 between the sexes in Arctic territories in 1950. However, by 2010 female Age RLE 15 was three years longer than male and this gap is forecasted to disappear by 2050. Canada's all-nation indicator showed consistently higher Age RLE 15 for both sexes, with females the highest at 65.5 years in 1950 and 73.4 in 2010, predicted to rise to 78.1 years in 2050. In general, this index contributes to the notice of the divergence tendency between the territories under study.

Median Ages

In 2010, the median age of the global population was 29 years. In less developed countries it was 27 years and in more developed countries it was 40 years, highlighting population ageing (Larsen and Fondahl 2015). In the Canadian Arctic, the ethnicity of the studied populations contributes to the difference in the MAs. The MA of Nunavut (86% Inuit-inhabited) is almost ten years younger than the national average and increased from 21.8 to 25.7 years for men and from 20.5 to 25.1 for women between 1991 and 2013. In 2013, the MA in NWT (32 years) was higher than in Nunavut, which could be because a smaller proportion of the population is Aboriginal in NWT (48% against 86% Inuit in Nunavut). From a broader perspective, people living in the NN joint area have one of the lowest MAs, similar to native people in Greenland, Siberian Sakha and Chukotka. Yukon's population had an MA of 39 years in 2015, the highest of the three studied regions and close to the level of most developed countries and the whole of Canada itself (40 years). According to our projection model, in 2050 the lowest MA will still be in Nunavut and NWT at 34.0 years for men and 36.1 years for women, 13 years less than in Yukon and 15 less than that of the whole of Canada.

It should be noted that the NN territories' population experienced a dramatic growth of inequality over the period 1950 to 2050. In 2015 the MA of women in NN was 12 years lower than in Canada as a whole and there was a 10 year difference for men. This is a dramatic change from 1950, when MA of females in the NN territories was only seven years lower than Canada as a whole, and four years for males. This gap between the north and Canada as a whole will likely continue to grow in the future, reaching 15 years of difference by 2050 according to our scenario.

However, a person who is of median age (35) in NN in 2050 might well behave like a 25-year-old person nowadays, as life expectancies continue to rise. Adjusting MAs to the gradual increase in life expectancies highlights some important patterns in the Canadian Arctic. For instance, by 2050 Canada will no longer have the highest MAs if changes in longevity are accounted for. Yukon males will have the highest PMA, with female PMA becoming highest in around 2030 (Fig. 2).

Fig. 2 Prospective median ages for Canada total and Yukon, by sex, 1970−2050
Place Fig. 2 here

Where Yukon has been converging with nationwide rates in PMAs, in contrast the gap between the Canada as a whole and the NN region has widened. In fact, the PMA for the NN region has remained the lowest of the whole of the Arctic and in 2010 it was eight years less than that of the neighbouring Yukon. These gaps seem to widen in the future (Appendix 1).

Proportion of Older Population in Regional Age Structure

The section above examined changes in the population longevity. This section describes changes in the age, sex, and to a certain extent the ethnic and inter-generational composition of the populations in Arctic Canada. We assume that the age structure of Arctic populations might be noticeably different from the structure of the Canada-wide population, as elaborated above in the introductory chapter on regional ethnic patterns and has been claimed in the Arctic Human Development Report−II (Larsen and Fondahl 2015).

Looking at the age structure, the largest age cohorts are increasing in age — except in the NN (Table 2), which has remained among Canada's youngest regions. Over the period, the NN territories have shown no significant change in the numbers of newborns and the youngest age-class of children because of earlier stated high fertility. To be precise, in the last decade, TFR has been high, with 3.2 children per woman in Nunavut. One reason for this is a lack of education, which is commonly known to drive fertility (references in Lutz et al. 2014). While only 15% of the Canadian population between the ages of 25 and 64 in 2006 had less than a high school diploma, this figure was 46% in Nunavut (State of Rural Canada 2015). TFR in NWT was 2.0, compared to 1.5 in Yukon and Canada as a whole. In 2015, this index started to fall slightly to 2.9 (Nunavut) and 1.9 (NWT), Yukon and Canada being relatively stable. However, as can be seen from the last column of Table 2, the number of children of age 0−4 in the NN region remains the largest in relation to cohorts in other age groups

but is steadily falling, from 15% in 1950 to 8% in 2015. This is a sign of a still very young population. On the other hand, in the whole of Canada and Yukon there has been a gradual shift to the older population groups as being the largest in total population, signifying substantial ageing (Table 2).

Table 2. The largest population groups in Arctic Canada, proportion in the total population, 1950−2050.
Place Table 2 here

Fig. 3 illustrates the gradual upward trends in the Prop 60+ index, subdivided by sex. The steepest curve of the Prop 60+ growth occurred in the male population of Yukon, doubling time from 7.7% to 14.7% (1950 to 2010). Although it is quickly catching up, Yukon is still younger than the Canadian average, which, despite the slowest Prop 60+ growth, reached one fifth of population older than 60 in 2010. Fig. 3 also demonstrates a negligible difference in the ageing of men and women in Canada's Arctic. This currently small gender gap is an exception to the pattern across the Arctic, where women in the oldest ages largely outnumber older men (Larsen and Fondahl 2015). In this study, only after the 2030s the projection suggests an acceleration of female ageing and a faster growth of proportion of elderly women in the Arctic. After the separation of the statistical registers in 1991, the youngest age structure could be found in Nunavut. Of the 60+ population, males had a Prop 60+ ratio of 5.8% and females 5.4% in 2010. Even combined with NWT, which are at a later stage of demographic transition, the two NN regions still have the youngest age structure — twice as young as Yukon and three times younger than the whole of Canada in 2010.

Fig. 3 The proportion of people aged 60 years and over (Prop 60+) for the Canadian total and Canada's Arctic, by sex, 1950−2050
Note: NN = Northwest Territories together with Nunavut.
Place Fig. 3 here

Fig. 4 The proportion of people with a remaining life expectancy of 15 years or less (Prop RLE 15-) for the Canadian total and Canada's Arctic, by sex, 1950−2050
Note: NN = Northwest Territories together with Nunavut.
Place Fig. 4 here

It is informative to distinguish between people at age 60–84 and 85 or older, to find out which of these age categories is growing faster. Our projection suggests that 85+ will be the age group growing most rapidly in Canada's Arctic. Between 2015 and 2050, their numbers will likely rise to 4.6% of all northerners, increasing nine times from the percentage in 2015 (0.5%). In contrast, the 85+ group is expected to make up 8% percent of all Canadians in 2050. The overall Prop 60+ population growth in the Canadian Arctic will only double in the same time horizon. Our period life tables show that in Arctic Canada, the probability of dying between age

60 and 85 is expected to be 53% among people of both sexes in 2050 (only 35% for Canadian total). For those between age 85 and 100, the probability of dying will be 88% for both males and females of the three territories in 2050, against the Canadian average of 77%. This type of data highlights the need for more palliative care and hospices, as the greatest percentage of deaths occurs at the age 85 and over, and more intensely in the north.

If advances in LE are taken into consideration, the prospective indicator Prop RLE 15- reveals noticeable trends in all study regions. Fig. 4 shows occasional 'rejuvenation' trends — in other words a lowering of the number of people considered 'old' using this indicator (with 15 years and less left to live). Between 1950−2010, ageing increased rather slowly, with the lowest growth in NWT/Nunavut: 1–2% Prop RLE 15- reaching 3% by 2010. This index is projected to steadily increase in the decades to come, albeit at a slower pace than Prop 60+ (Fig. 3). Note that men have a slightly higher Prop RLE 15- than women. In the early decades of the studied period, the in-migrants to Arctic Canada were predominantly male due to the character of labour market there, which contributed to estimates being higher for men both in the total population and at older ages.

Fig. 3 and 4 also illustrate the regional ageing patterns in comparison to nationwide. Both the chronological and prospective indices have remained below those of Canada, having two to three times lower proportions of people in old age in Yukon and NN than in Canada. Yukon, however, has been quickly catching up. This indicates that Nunavut and NWT may require demographic policies that consider the opportunities associated with a younger age structure and slower ageing pathway. The ethnic origin of the older population is also important, as the share of the Aboriginal seniors (over 65 years old) has remained the largest in northern Canada. In Nunavut, 91% of seniors were Aboriginal in 2010 as were 65% of seniors in NWT and 21% of seniors in Yukon (Statistics Canada 2011a). Among migrants, non-Aboriginal people in the north who retire or become unemployed tend to relocate to southern Canada (Young and Bjerregaard 2008), this reinforces the fact that the older portion of the population is dominated by Aboriginal peoples.

Elder-Child Ratios

Many analysts use the Ageing Index because it illustrates the growth of the older proportion of the population in relation to the youngest cohort, which is particularly useful in identifying whether there should be more investment in education and training for the young or whether more public money should be allocated to services and care for the elderly. Population ageing according to the chronological AI is a growing trend in many places of the world.

In Arctic Canada, the conventional AI reflects this trend and indicates that all the territories have been rapidly ageing. A striking increase in AI for the period 1950−2010 was registered for national total, the jump was most extreme for women in Canada (an increase from 37 to 134 AI, meaning 134 females at age 60+ per each 100 girls aged 0 to 14). The territory closest to the national ratio is Yukon, which had a female AI of 12 in 1960, and reached 82 in 2010, an eight-fold increase.

There were major AI differences between the territories in the Canadian Arctic. The AI in Yukon was the highest at 84 for both sexes in 2010, followed by NN territories with an AI as low as 29. The NN territories

were four times lower than Canada because of the higher share of youths in NN, especially in Nunavut. With regard to differences between sexes, the Arctic regions show a significantly different pattern to the national one. This again relates to the age structure and larger proportions of the youth in comparison to older people in the north. After 2040 the projection showed a slight dominance of the female index over the male one in the north, whereas before male and female AIs have shown similar dynamics of the growth (Fig. 5).

Fig. 5 Chronological Ageing Index (AI) in Canada's Arctic by sex, 1950–2050
Note: NN = Northwest Territories together with Nunavut.
Place Fig. 5 here

Fig. 6 Prospective Ageing Index (PAI) in Canada's Arctic by sex, 1950–2050
Note: NN = Northwest Territories together with Nunavut.
Place Fig. 6 here

As Fig. 5 illustrates, the AI for the Canadian Arctic continues to increase against a background of declining fertility, especially among the Aboriginal population. However, the majority of Canada's Arctic still has TFRs that are above the national average. Fertility in Nunavut's is the highest in the Arctic and far above replacement level, at three children per women in 2015. This level, combined with a young age structure, will ensure continued rapid population growth in the region, as shown in our projection scenario. At present 42% of the population of Nunavut is below the age of 20 years, whereas only 23% of Canadians are below that age (Larsen and Fondahl 2015).

Fig. 6 shows slight declining trends in the PAI in Canada's Arctic in the 1960s and 1970s. This later changed to growth, although it was not as rapid as the growth rates given by the conventional AI. There were sex variations in 2010: men in Yukon had a PAI that was the closest to the whole of Canada (39 and 49, respectively), meanwhile women in Yukon were much "younger" than in Canada as a whole (28 and 55, respectively).

Fig. 5 and 6 show that at present Canada as a whole has a PAI nearly twice as high as males and three-fold times higher than females in the country's northern areas. We project that population of the NN area will diverge further from Canada and Yukon in the future.

Policy solutions can be sensitive to changes in the elder-child ratios depending on whether they are measured conventionally or prospectively, particularly when planning for the future. A figure of 255 AI in Yukon (2050) means that there will likely be 255 older women for every 100 girls under 15; however, a prospective approach halves this ratio, meaning only 135 women considered 'old' (with RLE of less than 15 years) per 100 girls. Decisions on redistribution of public funds should be made with a clear understanding of the index used to create the elder-child ratio and the definition of the 'old' threshold.

Old Age Dependency Changes

Longer healthy, disability-free LEs means that the majority of individuals over the age of 60 place fewer demands on the social and health services. We support the idea that better estimations of dependency can be made if the age at which an individual can expect to live for 15 more years replaces the 60-year cut-off in the denominator of the dependency ratio. Indeed, our dataset (Appendix 1, Table 3) demonstrated significantly different patterns of ageing when the POADR is applied rather than the standard OADR index.

Over the period 1950−2050, the regions experience a transition from men dominating the old age dependency (i.e., more older men) to more older women depended on the working age population. In the standard OADR assessment, women took the lead for the index in Canada as a whole in 1960, whereas with the POADR this transition occurs significantly later, even at the end of the projected period (2050) — for Yukon and the entire Canadian population. Moreover, POADRs show minimal differences between the sexes in NWT, Nunavut, and Canada, as well as twice lower indication of a dependency associated with the old age, in comparison to OADRs.

Table 3. Chronological (OADR) vs. Prospective (POADR) Old-Age Dependency Ratios in Arctic Canada by sex, %, 1950−2050.
Place Table 3 here

As with the other indices analyzing ageing, OADRs generally reflect a steeper upwards curve of the index's values than POADRs (Table 3). Yukon has the fastest OADR growth for its male population, gaining 10% on the index from 1950 to 2010. The OADR is often considered a rough estimate of labour force participation, receipt of net transfers, health care and pension costs, and given this, the OADR's values for NN territories, which increased only from 1950 (8%) to 2010 (11%), can be interpreted as a sign of young population with low dependency costs. While the OADR is expected to increase dramatically to 40% by 2050 or using the POADR gives an increase of only 16%.

3. Discussion

Analysing the data discussed above, the next research questions can be addressed:

1. What are the youngest and oldest territories in Arctic Canada?

Yukon has experienced the largest increases in ageing indices (particularly among the conventional indices), is the oldest region in Canada's Arctic (catching up with Canada), and is expected to keep this leading position in the decades to come. NWT and Nunavut have substantially lower population ageing than Yukon, this may be because of the migration that has been the largest component of population change in Yukon. Its population consists largely of people from outside the Arctic, and consequently represents a fairly small share

of the Aboriginal population compared to the NN. Hence, due to the many immigrants from various Canadian regions, Yukon shows much of the Canadian-average patterns in demographics. This territory started quickly catching up with Canada after the Second World War due to a more developed road system which connected to almost every community. In addition to the construction of several highways by Canada and the US (including thousands kilometres through Yukon) airports and airstrips were built, initially as routes to resources but later for the tourism and relocation as well. Infrastructural development, from internet to medical care, is better developed in Yukon than in the rest of the vast provincial areas of northern Canada. The First Nations of Yukon are also very entrepreneurial and have used their financial resources and economic authority to overcome the demographic and economic challenges (State of Rural Canada 2015).

In contrast, NN had the lowest ageing rates and the youngest population according to all indices. For instance, NN was 10 years younger according to the MA index, and three years lower according to LE0 than Yukon in 2010. This can be explained by the Aboriginal-dominated populations in NN that are at an earlier stage of demographic transition. It differs from Yukon, where changes were driven by migration, as changes here are mostly due to a natural increase of the Aboriginal population, with a high percentage of younger population of Inuit and Métis. Another reason for the differences in NN could be the peak of emigration among the most productive ages 20−44 (migration data available from Statistics Canada 2016), increasing the share of children and older people in the age structure. However, both NN's in- and out-migration are limited primarily to non-Aboriginal migrants working in the public sector, whereas the Aboriginal population of the region displays a strong attachment to their home communities (Southcott 2010).

2. What are the dynamics of ageing change?

The chronological indices on ageing have shown that ageing is intensifying with every decade. Yukon experienced the fastest ageing transformation of all the regions under study. Its population is expected to reach national ageing rates in the 2025−2030. In certain indicators, such as PMA, Yukon has already left Canada behind. This is an interesting finding, since Yukon used to be as young as NN in the 1950s according to the Age RLE 15 (57.5 years, both sexes). Over the entire period, Yukon has gained more years under this index than most of the other territories under study. As noted above, this is because of advancements in infrastructure, transportation and an immigration boom in the middle of the 20th century. The fastest growth was recorded for the ageing indices AI and PAI. For instance, the chronological AI displays a steep 16-fold increase for Yukon from 15% in 1960 to 241% forecasted in 2050, much steeper than in the NN territories (11% to 96%).

The alternative prospective indicators reveal slower dynamics of ageing than the chronological indicators, in some instances showing small decreases in the indices' values, that is, rejuvenation. In the studied territories prospective ageing indices have remained almost at the same level for many decades from 1955 to 2010, but their values have started to rise rapidly and will likely to continue so in the coming future.

These dynamics of ageing, from both the chronological and prospective analysis of ageing indicators, suggest that care, housing, and other arrangements for seniors in Arctic Canada need to be reappraised and

developed. For instance, how will welfare needs, care and nursing for the growing number of the oldest citizens be met? What should the scope of homecare versus institutional care in urban and rural areas across Arctic Canada be? What about environmental gerontology and making supportive places to live in old age (such as a mix of assisted living facilities and lodges or other senior friendly buildings)? Studies have shown that older people living in remote rural areas in Russia's Arctic, another vast area on top of the world, traditionally rely on the support of their family, close friends and social contacts in community during their everyday activities. This is because the resources of the welfare system, protection and medical–social services are less available than in urban centres and elsewhere in the country outside the north (Golubeva 2016). Similar research is needed for Arctic Canada, even more so in terms of solutions for Aboriginal peoples.

3. How the Canadian Arctic is ageing in comparison to the national Canada's average?

As seen from earlier sections and Appendix 1, ageing has been faster in Canada's Arctic (three territories averaged) than in the Canadian total, thus the gap between the Arctic and Canada as a whole appears to be narrowing and disappearing according to most chronological indices, but less so with prospective ones (e.g. the gap is still growing when measured with Age RLE 15). However, closing this gap is true more for Yukon, which has been converging and at times already surpassing the nationwide level of population ageing. Today, Yukon is at a similarly advanced stage of ageing and demographic transition as the rest of Canada. In fact, the gap to the national ageing level widened in the NN, suggesting that these territories of Canada will stay younger than the national average; an observation in line with both chronological and prospective analyses.

Since the difference is so large between Yukon and the NN areas, the mean of these three territories of, for example, head-count ratios, is in many cases half the Canadian total. Between the sets of methods, the prospective head-count rates are two to three times lower than those obtained from a chronological measurement. The gap in MA between the North and nationwide values has grown over the years. For example, it was 22.5 (Arctic) and 26.1 (Canada-wide) in 1960, and in 2010 33.6 (Arctic) and 39.7 (Canada-wide). In 2050 nine years of difference is projected: 41.3 in the Canadian Arctic and as high as 50.0 years and Canada as a whole. In the case of PMA, Canada's value has also been greater of that in the Arctic territories, stayed stable enough at around two to three years of difference.

4. Are there any cross-territorial gaps in ageing patterns within the Arctic territories of Canada?

The inter-territorial analysis of population ageing reveals how rates of ageing have been diverging. Projections show that the regional differences will continue to increase in the next decades. However, by undertaking the analysis with two distinct sets of ageing indicators, we have the opportunity to see a more nuanced set of observations. Yukon has reached an advanced stage similar to Canada. However, the gap between NN and both Yukon and Canada is large and forecasted to increase further. Nunavut is the youngest territory not only in Canada's Arctic but in the Circumpolar area overall, comparable to only Chukotka, the youngest Russian region in the Far East.

This is the story that unfolds when measuring ageing conventionally. In contrast, some of the prospective indices demonstrate that the ageing gap between the territories tended to shrink (POADR and Prop RLE 15-). The gap has widened only for the PAI indices, and has grown significantly for Canada and Yukon. This suggests a more targeted focus to Nunavut and NWT is needed to balance the inequality stemming from the age structure and higher mortality in these regions.

5. Variation between the sexes

Canada's Arctic had higher numbers of older men than women, which is a rare situation globally. One possible explanation relates to the historical character of the regional economies that used to favour traditionally male occupations. This was because many smaller settlements had a narrow economic base (e.g. mining and natural resources' exploration, transportation, energy, fishing, forestry, military sector), but more analysis should be done to understand the reasons for these patterns. As the economies of the Canadian North and other Arctic regions have diversified and some of the gender-based division of labour is disappearing (Hansen et al. 2012; Larsen and Fondahl 2015), the ratio of men-to-women has been changing but still remains above the national and global ratios.

4. Concluding Remarks

The study identified that from 1950 to 2050 a significantly diverse ageing has changed population structure in the three Canadian Arctic territories, influenced not only by demographic, socio-economic and ethnic context of regional changes but also by the methods used to assess the ageing phenomenon. This study highlights key knowledge gaps regarding population ageing in the Canadian Arctic that are also applicable for the rest of the Arctic. For instance, future research on ageing in the Canadian Arctic must take into account the fact that non-Aboriginal and Aboriginal populations exhibit different age structure patterns. That is, most Aboriginal populations are at an earlier stage of the demographic and health transitions or, put another way, much younger. Also, exploring the links between population ageing and the social, economic, and environmental patterns can help understand the ageing process. In particular, qualitative and longitudinal studies on local people in old age (societal inclusion, lifestyle and quality of life, dietary patterns, health practices) are widely absent and yet such data could help finding associations between longevity and mortality, migration in old age, elderly care services and life satisfaction, etc.

It would also be strongly beneficial to evaluate urban-rural differences in ageing, but in reality this is difficult because of the non-availability of detailed population and mortality statistics at these levels of granularity. The Aboriginal population predominantly lives in rural areas and has younger age structures, these differences may mean that they require specific care-service solutions, distinct from their city-living and non-Aboriginal counterparts.

Increases in life expectancy also alter the need for 'old age' health care, since the provision of services for older people and other economic and social public finances depends on the number of remaining years of population to live. It is important that decision- and policy-makers take into account the causes and complex consequences of the societal ageing in the short and long run. We showed that the adoption of prospective measures of ageing, when the threshold age of who is considered old depends on the moving life expectancy, provides a considerably more nuanced, up-to-date view on population ageing.

Appendix 1. Population ageing indicators for Arctic Canada, by sex, 1950–2050.

Place Appendix 1 here

REFERENCES

ArcticStat. (2016). http://www.arcticstat.org/. Accessed 22 December 2016.

Arctic Health. (2016). https://arctichealth.nlm.nih.gov/. Accessed 22 December 2016.

Arctic Social Indicators – a Follow-up to the Arctic Human Development Report. (2010). Copenhagen, Denmark: TemaNord, Nordic Council of Ministers.

Caldwell, J. C. (2001). Population health in transition. *Bulletin of the World Health Organization,* 79(2), 159–170.

CHMD. The Canadian Human Mortality Database. (2016). http://www.bdlc.umontreal.ca/chmd/. Accessed 20 December 2016.

CircHOB. (2016). http://circhob.circumpolarhealth.org/. Accessed 13 December 2016.

Emelyanova, A. & Rautio, A. (2012). Ageing population in the Barents Euro-Arctic region. *Journal of European Geriatric Medicine,* 3(3), 167–173.

Emelyanova, A. & Rautio, A. (2013). Perspectives for population ageing in the Russian North. *Journal of Population Ageing*, 6(3), 161−187.

Emelyanova, A. (2015). Cross-regional analysis of population ageing in the Arctic. Academic doctoral dissertation. *Acta Universitatis Ouluensis D Medica* 1326. Juvenes Print Tampere. http://herkules.oulu.fi/isbn9789526210049/isbn9789526210049.pdf. Accessed 23 August 2016.

Emelyanova, A. & Rautio, A. (2017). Population ageing dynamics in the North Atlantic region of the Arctic. *Vienna Yearbook of Population Research*. Forthcoming.

Fogel, R. W. (2004). *The Escape from Hunger and Premature Death, 1700–2100: Europe, America, and the Third World.* New York: Cambridge University Press. Cambridge Studies in Population, Economy and Society in Past Time.

Gavrilov, L. & Heuveline, P. (2003). Ageing of Population. In P. Demeny & G. McNicoll (Ed.), *The Encyclopedia of Population.* New York: Macmillan Reference USA.

Gavrilov, L. & Gavrilova, N. (2015). New development in the biodemography of ageing and longevity. *Gerontology* 61(4), 364–371.

Golubeva, E. (2016). System analysis of factors affecting the quality of life of aged people in their use of different forms of social services. *Advances in Gerontology,* 6(4): 338–342.

Hansen, K. G., Rasmussen, R. O., Olsen, L. S., Roto, J. & Fredricsson, C. (2012). Megatrends in the Arctic. New inspiration into current policy strategies. *Nordregio Working Paper,* 8: 1–50.

Hamilton, L. (2008). Footprints: Demographic effects of outmigration. In L. Huskey & C. Southcott (Ed.), *Migration in the Circumpolar North: Issues and context.* Edmonton, Alberta: Canadian Circumpolar Institute.

Heleniak, T. (2014). Migration in the Arctic. In L. Heininen (Ed.), *Arctic Yearbook 2014*. Northern Research Forum, 82–104.

Human Mortality Database. (2015). University of California, Berkeley, United States; the Max Plank Institute for Demographic Research, Germany. http://www.mortality.org/. Accessed 22 June 2016.

Larsen, J. N. & Fondahl, G. (Ed.). (2015). *Arctic Human Development Report. Regional Processes and Global Linkages.* Copenhagen, Denmark: Nordic Council of Ministers, doi:10.–27/TN2014-567.

Megatrends. (2011). Copenhagen, Denmark: Nordic Council of Ministers.

Lutz, W., Butz, W. & KC, S. ((2014). World population and human capital in the 21st century. Oxford University Press.

Moore, E. G. & Pacey, M. A. (2004). Geographic dimensions of ageing in Canada, 1991–2001. *Canadian Journal on Ageing / La Revue Canadienne du Vieillissement,* 23(suppl.): 5–21.

Oeppen, J. E & Vaupel, J. W. (2002). Broken limits to life expectancy. *Science,* 296:5570: 1029– 1031.

Health Canada. (2002). Rural Health in Rural Hands: strategic directions for rural, remote, northern and Aboriginal communities. http://publications.gc.ca/pub?id=9.689374&sl=0. Accessed 30 June 2017.

Sanderson, W. & Scherbov, S. (2007). A new perspective on population ageing. *Demographic Research,* 16: 27–57.

Sanderson, W. & Scherbov, S. (2008). Rethinking age and ageing. *Population Bulletin* ,63(4): 1–16.

Sanderson, W. & Scherbov, S. (2010). Remeasuring Ageing. *Science,* 329(5997): 1287−1288.

Sanderson, W. & Scherbov, S. (2013). The characteristics approach to the measurement of population ageing. *Population and Development Review,* 39(4): 673–685.

Sanderson, W. & Scherbov, S. (2015). Faster increases in human life expectancy could lead to slower population ageing. *PLoS ONE,* 10(4): 673–685.

Scherbov, S. & Sanderson, W. (2016). New approaches to the conceptualization and measurement of age and ageing. *Journal of Ageing and Health,* 28(7): 1159−1177.

Scherbov, S. & Ediev, D. (2011). Significance of life table estimates for small populations: simulation-based study of standard errors. *Demographic Research,* 24(22): 527–550.

Southcott, C. (2010). Migration in the Canadian North: An Introduction. In L. Huskey & C. Southcott (Ed.), *Migration in the Circumpolar North: Issues and Contexts*. Edmonton, Alberta: Canadian Circumpolar Institute.

State of Rural Canada Report. (2015). http://sorc.crrf.ca/. Accessed 03 July 2017.

Statistics Canada. (2006). *A portrait of seniors in Canada*. http://www.statcan.gc.ca/pub/89-519-x/89-519-x2006001-eng.pdf. Accessed 30 June 2017.

Statistics Canada. (2011a). National Household Survey, AANDC tabulations. https://www.aadnc-aandc.gc.ca/eng/1370438978311/1370439050610. Accessed 30 June 2017.

Statistics Canada. (2011b). Number and distribution of the population reporting an Aboriginal identity and percentage of Aboriginal people in the population, Canada, provinces and territories, 2011. http://www.statcan.gc.ca/pub/89-519-x/2006001/t/4122074-eng.htm. Accessed 17 January 2016.

Statistics Canada. (2015). Median age. http://www.statcan.gc.ca/start-debut-eng.html Accessed 23 June 2015.

Statistics Canada (2016). CANSIM socioeconomic database. http://www5.statcan.gc.ca/cansim/a29?lang=eng&groupid=051&p2=17. Accessed 03 January 2016.

United Nations, Department of Economic and Social Affairs, Population Division. (2013). *World Population Ageing 2013*. ST/ESA/SER.A/348. New York, NY: United Nations.

United Nations, Department of Economic and Social Affairs, Population Division. (2015). *World Population Prospects. The 2015 Revision*. ESA/P/WP.241. New York, NY: United Nations.

VID. European demographic data sheets. (2016). Vienna, Vienna Institute of Demography. http://www.populationeurope.org/. Accessed 02 January 2017.

Wilson, D. M, Osei-Waree, J., Hewitt, J. A. & Broad, A. (2012). Canadian provincial, territorial, and federal government ageing policies: a systematic review. *Advances in Ageing Research,* 1(2): 38–46.

Wilson, K., Rosenberg, M. W., Abonyi, S. & Lovelace, R. (2010). Ageing and health: an examination of differences between older Aboriginal and non-Aboriginal people. *Canadian Journal of Ageing,* 29: 369–382.

Wingrove, J. (2014). Filipinos find opportunity and community in Canada's North. The Globe and Mail. https://www.theglobeandmail.com/news/national/the-north/filipinos-find-opportunity-and-community-in-canadas-north/article16461916/. Accessed 06 July 2017.

Young, T. K. & Bjerregaard, P. (Ed). (2008). *Health Transitions in Arctic Populations*. Toronto, Canada: University of Toronto Press.

Young, T. K., Rawat, R., Dallmann, W., Chatwood, S., Bjerregaard, P. (Ed). (2012). *Circumpolar Health Atlas*. Toronto, Canada: University of Toronto Press.

Figure_1

Click here to download Figure Fig.1.png

Figure_2

Click here to download Figure Fig.2.png

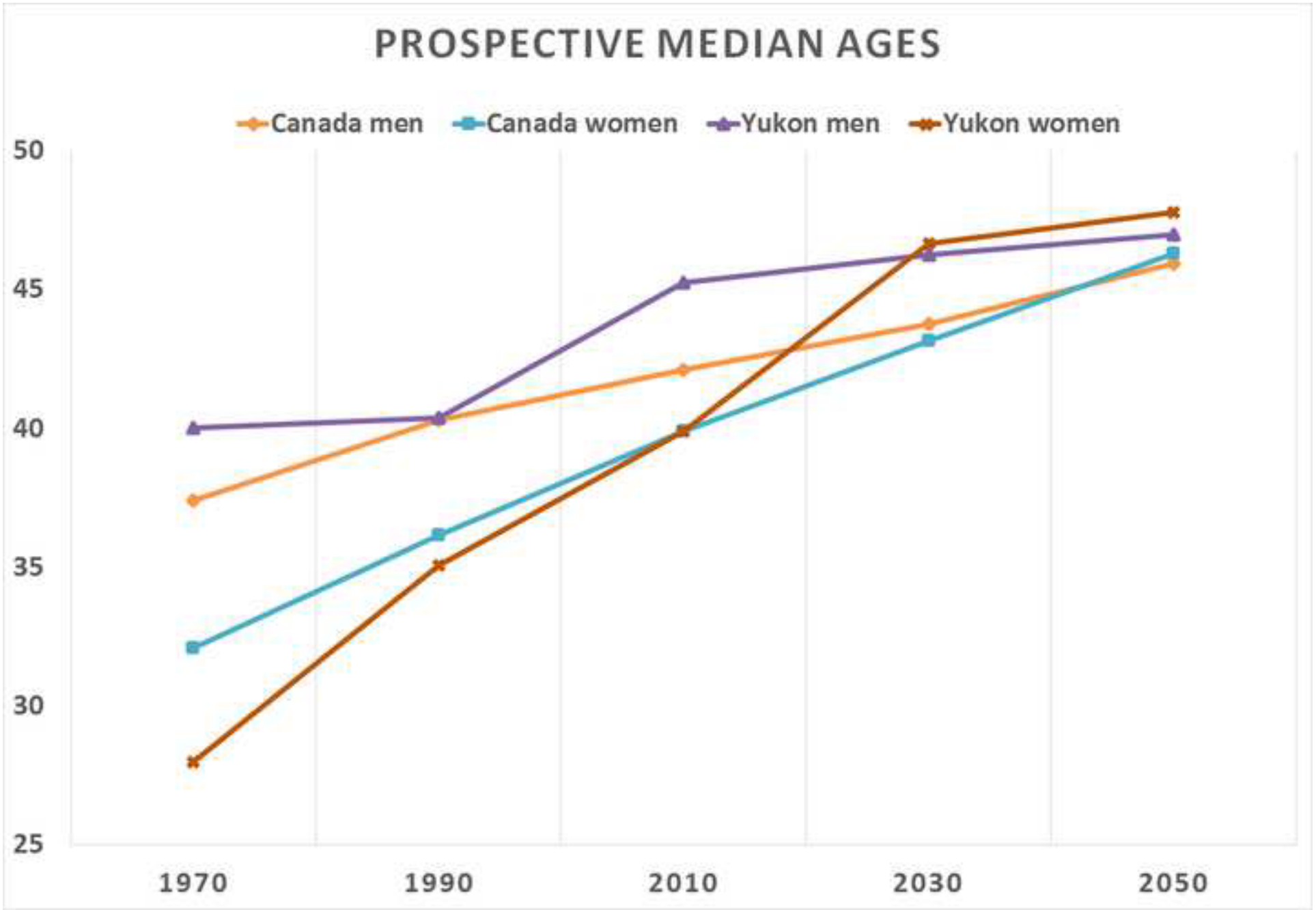

Figure_3

Click here to download Figure Fig.3.png

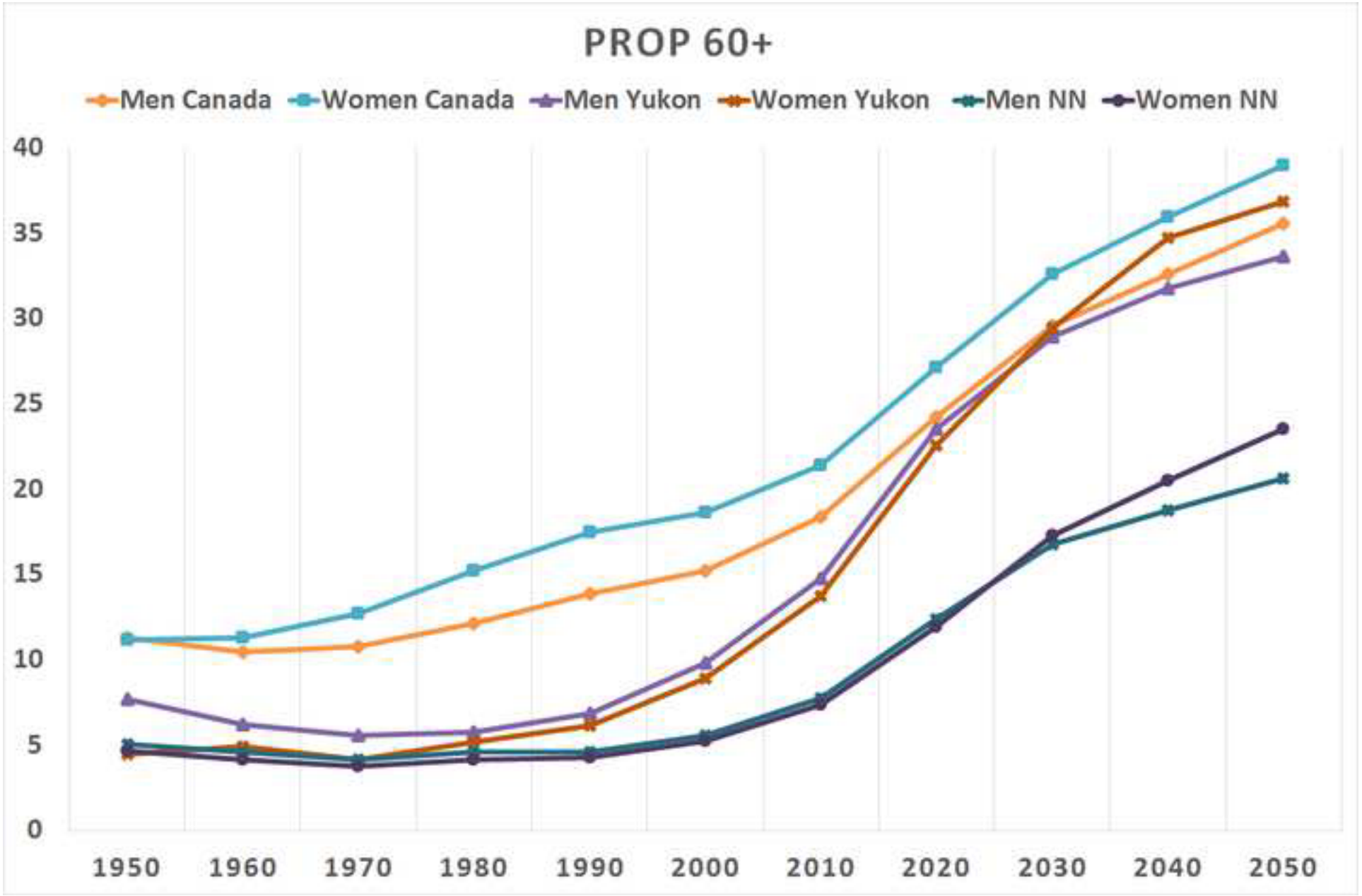

Figure_4

Click here to download Figure Fig.4.png

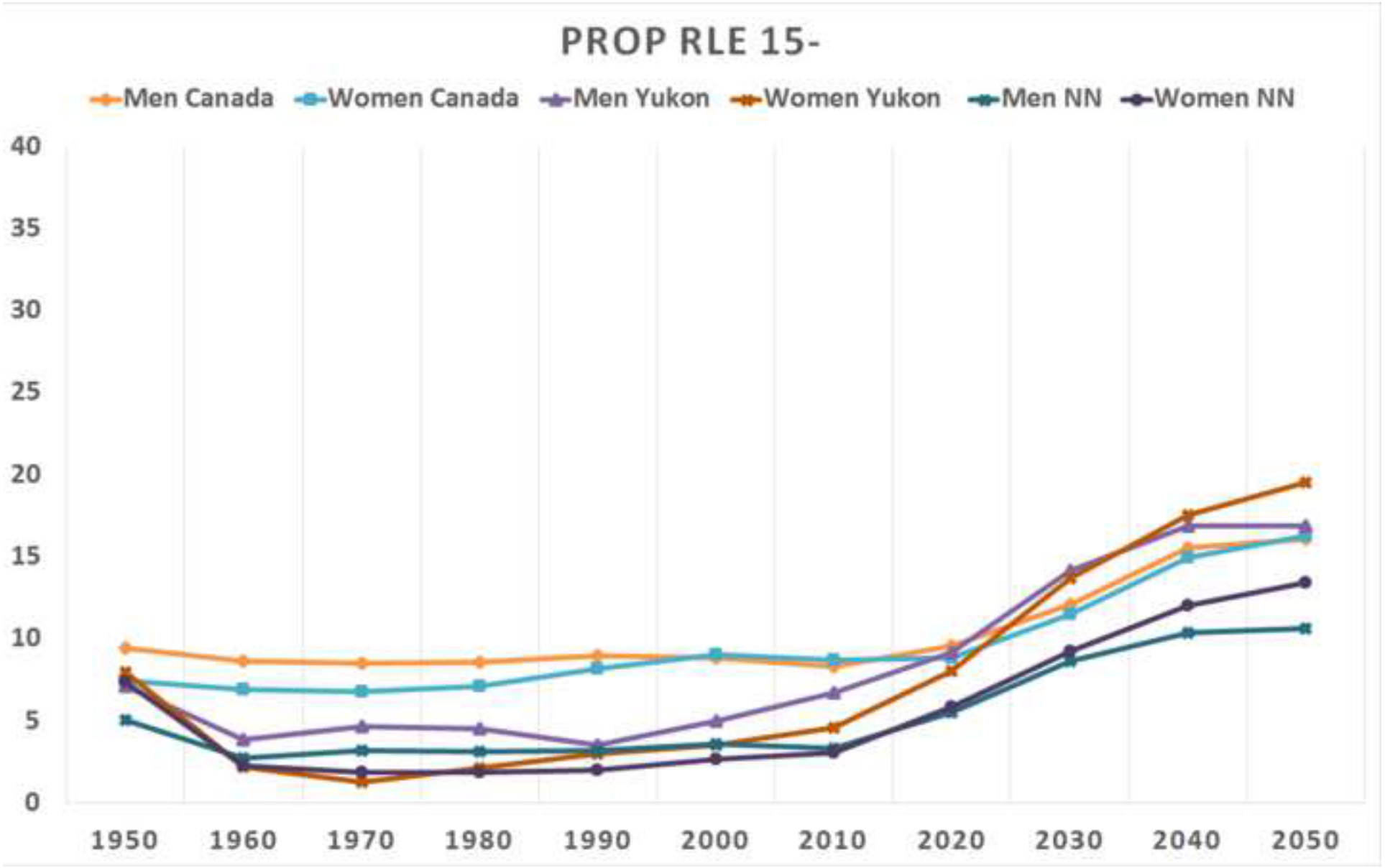

Figure_5

Click here to download Figure Fig.5.png

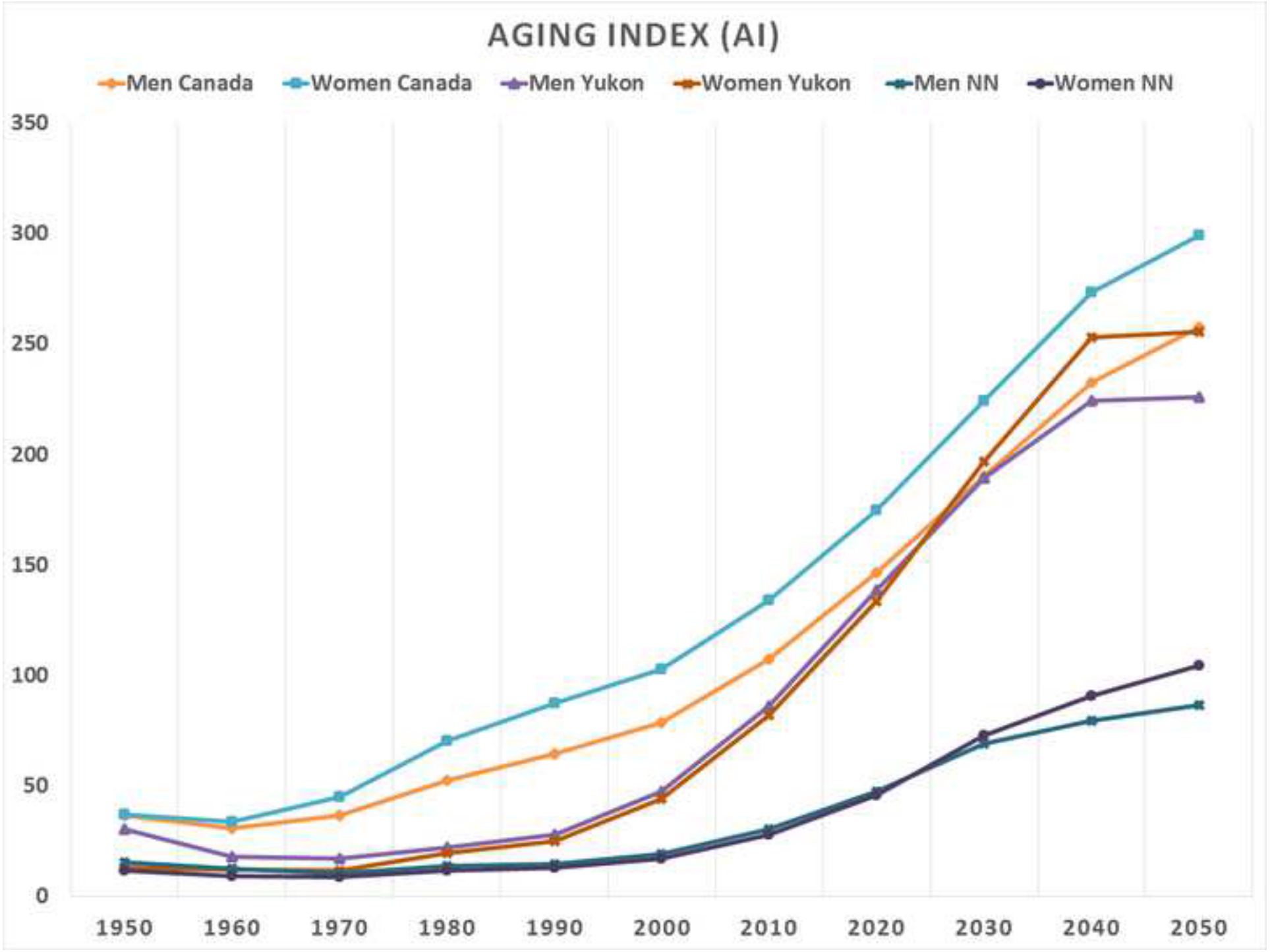

Figure_6

Click here to download Figure Fig.6.png

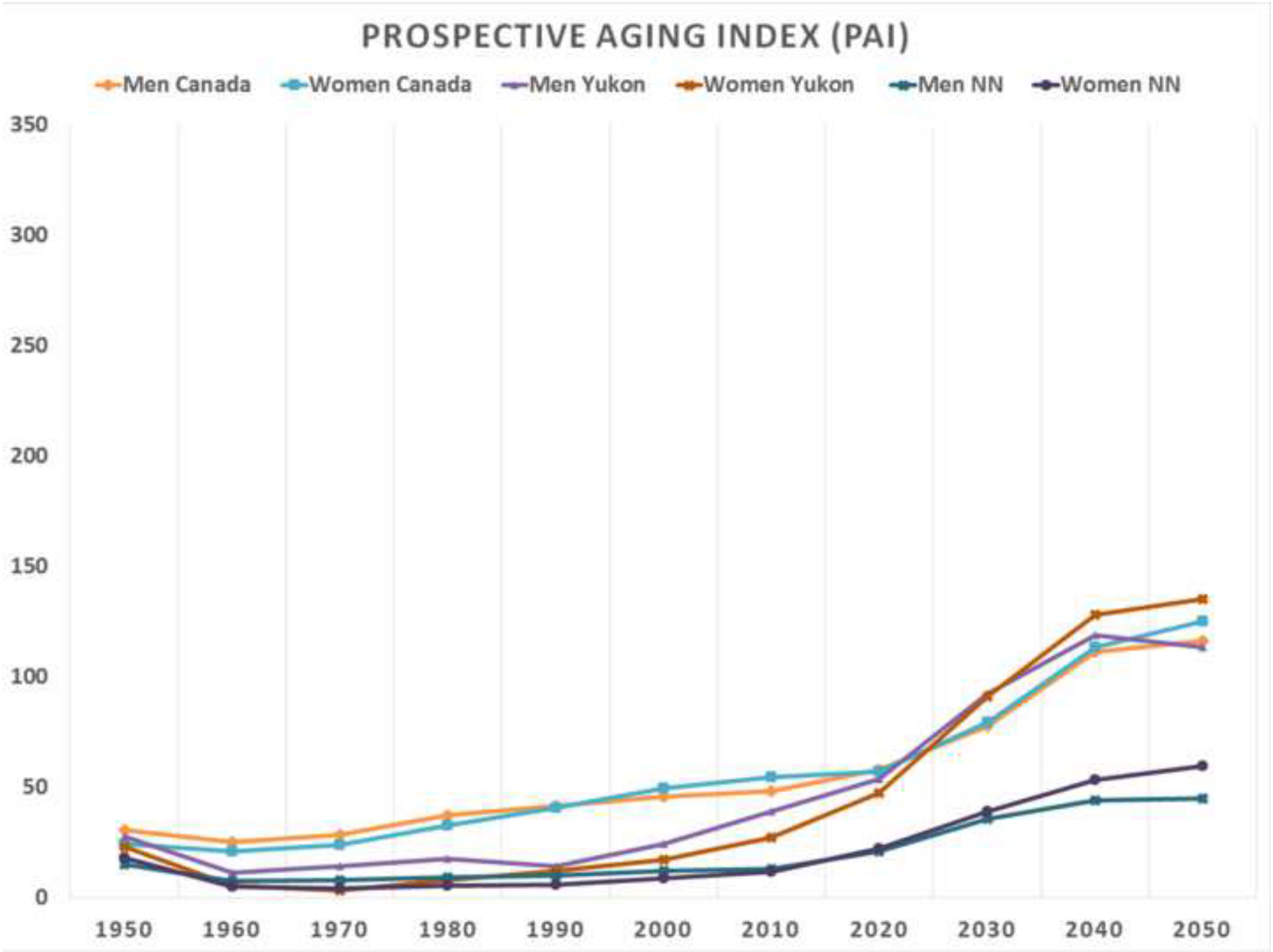

Table_1

Table 1. The life expectancies at birth applied to construct life tables and project ageing indices, Arctic Canada, 2015−2050

Region	Sex	2015	2020	2025	2030	2035	2040	2045	2050
Canada	Men	79.92	81.10	82.28	83.46	83.94	84.43	84.91	85.96
Nunavut		70.54	71.58	72.62	73.66	74.09	74.51	74.94	75.36
NWT		76.94	78.07	79.21	80.35	80.81	81.28	81.74	82.21
Yukon		77.39	78.53	79.67	80.82	81.28	81.75	82.22	82.69
Canada	Women	84.05	84.82	85.59	86.36	86.81	87.27	87.72	88.17
Nunavut		72.12	72.78	73.44	74.10	74.49	74.88	75.27	75.66
NWT		80.87	81.62	82.36	83.10	83.53	83.97	84.40	84.84
Yukon		79.97	80.70	81.44	82.12	82.60	83.03	83.46	83.89

Table_2

Table 2. The largest population groups in Arctic Canada, proportion in the total population, 1950−2050.

Year/Region	Canada		Yukon		NWT and Nunavut	
	Age group	Proportion	Age group	Proportion	Age group	Proportion
1950	0-4	0.121	0-4	0.145	0-4	0.155
1970	10-14	0.106	5-9	0.116	0-4	0.154
1990	30-34	0.091	30-34	0.114	0-4	0.123
2010	45-49	0.081	45-54	0.092	0-4	0.095
2030	55-59	0.068	45-54	0.069	0-4	0.081
2050	85+	0.081	65-69	0.067	0-4	0.080

Note: Authors' calculations are used for 2015−2050, Canadian Human Mortality Database data is used for 1950−2010.

Table_3

Table 3. Chronological (OADR) vs. Prospective (POADR) Old-Age Dependency Ratios in Arctic Canada by sex, %, 1950−2050.

Index	Sex, region	1950	1970	1990	2010	2030	2050
OADR	♂ Canada	19.51	18.13	21.39	28.57	53.93	70.21
	♀ Canada	19.16	21.62	27.94	34.24	61.67	81.21
	♂ Yukon	11.51	8.91	9.99	21.66	51.86	65.38
	♀ Yukon	7.41	6.88	8.91	19.79	53.08	75.74
	♂ NN	8.17	7.52	7.20	11.62	28.52	37.06
	♀ NN	8.46	7.02	6.79	11.11	29.37	43.62
POADR	♂ Canada	13.63	12.04	11.38	10.05	14.30	18.65
	♀ Canada	10.67	9.46	10.21	10.40	13.49	18.75
	♂ Yukon	9.56	6.84	4.65	8.11	16.69	19.86
	♀ Yukon	12.24	2.00	4.02	5.54	16.08	22.79
	♂ NN	7.55	5.33	4.64	4.52	11.41	13.99
	♀ NN	12.37	3.26	2.96	4.17	12.12	17.34

Note: The character ♂ defines male population, ♀ − female population. NN = Northwest Territories and Nunavut. Authors' calculations based on data from Statistics Canada 2016.

Appendix 1. Population ageing indicators for Arctic Canada, by sex, 1950–2050.

1. CANADA TOTAL											
MALES											
Year	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*	*2010*	*2020*	*2030*	*2040*	*2050*
MA	27.61	25.84	25.98	29.03	32.65	36.44	38.91	41.10	44.17	47.13	48.66
PMA	39.87	37.70	37.43	38.55	40.29	41.86	42.12	42.90	43.79	45.85	45.96
LE at 0	66.64	68.43	69.56	72.32	74.57	77.08	79.34	81.10	83.46	84.42	85.96
LE at 60	16.65	16.77	17.07	18.13	19.33	20.97	22.86	24.18	25.87	26.59	27.78
Age RLE 15-	62.50	62.73	63.13	64.54	65.97	67.86	70.10	72.11	73.73	74.39	75.50
Prop 60+	11.31	10.48	10.82	12.12	13.85	15.23	18.41	24.27	29.59	32.60	35.56
Prop 65+	7.70	7.30	7.25	8.25	9.69	10.97	12.62	17.34	23.35	26.38	28.88
Prop RLE 15-	9.45	8.66	8.49	8.58	8.95	8.87	8.33	9.61	12.08	15.58	16.08
OADR 60+	19.51	18.92	18.13	18.68	21.39	23.28	28.57	41.01	53.93	61.06	70.21
OADR 65+	12.50	12.45	11.46	12.00	14.06	15.75	17.96	26.23	38.20	44.24	50.38
POADR	13.63	13.15	12.04	11.15	11.38	11.00	10.05	11.52	14.30	18.12	18.65
AI 60+	36.83	30.71	36.65	52.63	64.75	78.56	107.42	146.45	190.42	232.83	257.87
AI 65+	25.07	21.38	24.56	35.84	45.30	56.62	73.61	104.64	150.24	188.37	209.46
PAI	30.76	25.38	28.75	37.27	41.82	45.78	48.59	57.99	77.73	111.25	116.60
FEMALES											
MA	27.55	26.43	26.96	30.39	34.24	38.22	40.59	43.01	46.37	49.42	51.22
PMA	36.05	33.00	32.09	33.55	36.18	39.07	39.92	41.30	43.19	45.37	46.32
LE at 0	71.48	74.54	76.64	79.28	80.80	82.04	83.60	84.82	86.36	87.26	88.17
LE at 60	19.02	20.21	21.56	23.01	23.86	24.70	26.04	27.17	28.36	29.08	29.80
Age RLE 15-	65.51	66.93	68.58	70.38	71.21	72.01	73.45	75.60	76.77	77.44	78.10
Prop 60+	11.20	11.30	12.75	15.26	17.48	18.62	21.43	27.13	32.60	35.93	38.98
Prop 65+	7.75	8.06	9.02	10.97	13.16	14.28	15.60	20.20	26.37	29.65	32.32
Prop RLE 15-	7.43	6.95	6.79	7.10	8.17	9.03	8.74	8.88	11.53	14.93	16.31
OADR 60+	19.16	20.37	21.62	24.18	27.94	29.43	34.24	47.28	61.67	70.55	81.21
OADR 65+	12.51	13.73	14.39	16.27	19.68	21.12	22.79	31.43	44.62	51.82	59.13
POADR	10.67	10.41	9.46	9.06	10.21	11.02	10.40	10.50	13.49	17.18	18.75
AI 60+	36.93	33.96	45.06	70.48	87.56	102.79	134.26	174.95	224.45	273.63	299.33
AI 65+	25.55	24.23	31.89	50.66	65.93	78.83	97.69	130.31	181.54	225.77	248.20
PAI	24.50	20.89	23.99	32.80	40.92	49.84	54.74	57.24	79.38	113.67	125.26
2. YUKON											
MALES											
MA	28.53	26.92	25.33	27.69	31.49	36.08	38.78	40.92	44.34	46.57	46.83
PMA	43.76	38.35	40.02	40.21	40.41	43.16	45.29	45.08	46.29	47.60	47.02
LE at 0	58.88	67.05	64.79	67.77	72.48	74.49	75.76	78.53	80.82	81.75	82.69
LE at 60	16.01	18.59	16.17	16.75	19.05	20.00	20.35	22.66	24.14	24.77	25.43
Age RLE 15-	61.38	66.31	61.71	62.52	66.11	66.83	67.12	69.76	71.57	72.31	73.04
Prop 60+	7.69	6.19	5.55	5.75	6.86	9.80	14.75	23.57	28.93	31.77	33.65
Prop 65+	5.82	4.29	3.21	3.50	4.01	6.04	8.71	15.38	23.19	25.21	27.15
Prop RLE 15-	7.12	3.85	4.64	4.55	3.51	5.00	6.72	9.17	14.14	16.85	16.91
OADR 60+	11.51	10.40	8.91	8.41	9.99	14.09	21.66	39.64	51.86	58.77	65.38
OADR 65+	8.47	6.98	4.96	4.96	5.60	8.24	11.75	22.73	37.69	41.58	46.85
POADR	9.56	5.85	6.84	6.14	4.65	6.30	8.11	11.05	16.69	19.63	19.86
AI 60+	30.23	18.07	17.29	22.26	28.12	47.57	86.09	138.82	189.30	224.39	225.98
AI 65+	22.88	12.51	9.99	13.54	16.42	29.31	50.86	90.57	151.72	178.03	182.36
PAI	27.99	11.23	14.44	17.61	14.39	24.28	39.20	54.03	92.52	119.01	113.54
FEMALES											
MA	25.25	22.24	22.73	26.20	30.71	35.37	38.39	41.80	45.95	48.41	48.61
PMA	42.87	27.01	27.97	33.32	35.10	38.21	39.89	43.92	46.67	48.39	47.81
LE at 0	59.54	74.12	75.27	74.05	78.03	80.07	81.17	80.70	82.17	83.03	83.89

Year	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*	*2010*	*2020*	*2030*	*2040*	*2050*
LE at 60	9.25	21.33	23.38	21.19	21.63	22.89	23.86	23.68	24.72	25.35	26.00
Age RLE 15-	53.65	68.73	71.38	68.28	68.09	70.69	70.93	70.93	72.11	72.78	73.45
Prop 60+	4.51	4.91	4.16	5.21	6.15	8.93	13.76	22.59	29.48	34.74	36.89
Prop 65+	1.67	3.26	2.46	3.11	4.02	5.90	8.22	15.52	23.06	27.73	30.65
Prop RLE 15-	8.00	2.23	1.29	2.16	3.03	3.56	4.61	8.03	13.68	17.57	19.51
OADR 60+	7.41	9.08	6.88	7.65	8.91	12.62	19.79	37.35	53.08	67.42	75.74
OADR 65+	2.63	5.85	3.95	4.42	5.65	7.99	10.95	22.98	37.21	47.37	55.79
POADR	12.24	3.77	2.00	2.95	4.02	4.46	5.54	9.67	16.08	20.37	22.79
AI 60+	13.02	11.99	11.76	19.51	24.88	44.01	82.23	133.56	196.97	253.09	255.89
AI 65+	4.83	7.97	6.95	11.63	16.27	29.06	49.13	91.75	154.04	202.02	212.62
PAI	23.10	5.43	3.65	8.10	12.23	17.52	27.57	47.48	91.36	128.02	135.32
3. NUNAVUT and NORTHWEST TERRITORIES											
MALES											
MA	23.45	23.03	20.53	23.07	25.63	27.45	28.83	31.48	33.61	33.42	34.03
PMA	43.98	35.94	35.26	35.36	36.29	36.80	36.25	38.05	38.33	37.41	37.26
LE at 0	44.42	58.16	62.54	67.49	69.84	70.93	72.82	74.83	77.00	77.89	78.78
LE at 60	15.00	17.95	16.39	17.73	17.61	18.27	20.23	20.58	21.76	22.27	22.81
Age RLE 15-	60.00	65.65	62.49	64.22	63.73	64.57	66.91	67.48	68.84	69.39	69.94
Prop 60+	5.06	4.59	4.18	4.59	4.61	5.60	7.74	12.42	16.81	18.75	20.62
Prop 65+	2.93	2.92	2.31	2.87	2.79	3.47	4.25	7.14	12.34	13.92	15.39
Prop RLE 15-	5.06	2.74	3.18	3.11	3.19	3.62	3.36	5.49	8.65	10.40	10.67
OADR 60+	8.17	7.83	7.52	7.39	7.20	8.63	11.62	20.20	28.52	32.51	37.06
OADR 65+	4.58	4.84	4.03	4.50	4.23	5.17	6.06	10.68	19.45	22.27	25.30
POADR	7.55	4.34	5.33	4.66	4.64	5.13	4.52	7.43	11.41	13.61	13.99
AI 60+	15.34	12.47	10.38	13.84	14.74	19.01	30.23	47.67	69.31	79.52	86.80
AI 65+	8.90	7.93	5.75	8.66	8.91	11.76	16.59	27.38	50.87	59.03	64.81
PAI	15.34	7.44	7.91	9.37	10.18	12.27	13.13	21.08	35.65	44.11	44.91
FEMALES											
MA	20.24	17.88	18.76	21.82	24.43	26.67	28.40	31.20	34.25	34.85	36.09
PMA	47.21	30.12	28.92	29.65	30.47	32.78	32.49	36.52	38.25	38.12	38.63
LE at 0	43.39	62.02	69.27	73.66	75.78	75.92	77.89	77.20	78.60	79.42	80.25
LE at 60	11.38	18.65	20.22	20.85	20.86	20.22	22.00	21.03	21.92	22.46	23.02
Age RLE 15-	55.00	67.24	67.32	68.89	68.29	66.92	68.95	67.66	68.61	69.17	69.73
Prop 60+	4.65	4.13	3.74	4.18	4.27	5.23	7.38	11.98	17.32	20.53	23.53
Prop 65+	3.27	2.76	2.36	2.73	2.72	3.25	4.46	7.54	12.75	15.41	18.18
Prop RLE 15-	7.37	2.25	1.86	1.90	1.99	2.70	3.08	5.85	9.24	12.06	13.44
OADR 60+	8.46	8.09	7.02	6.88	6.79	8.14	11.11	19.31	29.37	36.10	43.62
OADR 65+	5.80	5.25	4.32	4.40	4.22	4.91	6.43	11.34	20.06	24.87	30.64
POADR	12.37	4.07	3.26	2.92	2.96	3.89	4.17	7.91	12.12	15.59	17.34
AI 60+	11.52	9.23	8.71	11.89	13.04	17.17	28.13	46.03	73.08	90.75	104.55
AI 65+	8.09	6.15	5.50	7.78	8.30	10.67	17.00	28.97	53.79	68.13	80.74
PAI	18.26	5.02	4.32	5.39	6.07	8.87	11.74	22.50	39.01	53.34	59.68

Notes: 1. The appendix depicts only decade divided rates. Rates for the middle-decade years 1955, 1965 etc. can be requested from the authors.

2. Historical mortality and population data (1950−2010) is based on the Canadian Human Mortality Database), projected data (2015−2050) is based on assumptions setting to United Nations 2030/2050 medium scenario for Canada, more details in the article.

3. MA = median age, PMA = prospective median age standardised to a reference year Canada 2005; LE at 0 = life expectancy at birth; LE at 60 = life expectancy at the age 60; Age RLE 15 = an age at which remaining life expectancy is equal 15 years; Prop 60+/65+ = a share of people aged 60/65 years and older; Prop RLE 15- = a share of people with remaining life expectancy 15 years and less; OADR 60+/65+ = old-age dependency ratio given a share of people older than the age 60/65; POADR = prospective old-age dependency ratio; AI 60+/65+ = ageing index given a share of people older than the age 60/65; PAI = prospective ageing index.