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*Anastasia Emelyanova*

# CROSS-REGIONAL ANALYSIS OF POPULATION AGING IN THE ARCTIC

UNIVERSITY OF OULU GRADUATE SCHOOL;  
UNIVERSITY OF OULU,  
FACULTY OF MEDICINE;  
THULE INSTITUTE,  
CENTRE FOR ARCTIC MEDICINE, AURORA DP





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**ANASTASIA EMELYANOVA**

**CROSS-REGIONAL ANALYSIS OF  
POPULATION AGING IN THE  
ARCTIC**

Academic dissertation to be presented with the assent of the Doctoral Training Committee of Health and Biosciences of the University of Oulu for public defence in Kuusamonsali (YB210), Linnanmaa, on 26 November 2015, at 12 noon

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Supervised by  
Professor Arja Rautio

Reviewed by  
Professor Warren C. Sanderson  
Professor Bernd Marin

Opponent  
Professor Reijo Tilvis

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University of Oulu, P.O. Box 8000, FI-90014 University of Oulu, Finland

***Abstract***

Despite the greater strategic importance and increasing activities in the Arctic as well as the increased attention paid by national governments, few attempts have been made to understand the on-going demographic changes from a pan-Arctic perspective. In particular, population aging or “silverization” is a demographic megatrend affecting regional societies and the economy which can exert profound social consequences in this most desolate and least populated region in the world. Although there are a few studies investigating aging in the Arctic countries, none have extended their research to the sub-national level. This thesis consists of an analysis of aging and possible rejuvenation trends in 23 Arctic sub-regions, and compares these trends to the national average of their eight respective countries. Two groups of indicators have been used to measure aging; these are based on “chronological” and “prospective” ages, the latter considers changes in life expectancy and improvements in population health.

The study generated a large set of aging data for the period 1980/1990 to 2010 as well as the present day, utilizing the available baseline data. The discussion examined major trends in aging elucidating the interactions of conventional and prospective indicators, revealed the oldest and youngest territories, linkages between the Arctic and nationwide rates, the fastest and slowest regions that are aging (or in contrast, rejuvenating), sex and ethnic differences, and whether Northern Canada and Alaska, North Atlantic, Arctic Russia and Northern Fennoscandia are converging or diverging in terms of aging development. In addition, the interplay of causes of aging and other demographic conditions of Arctic territories was examined as well as the gaps in knowledge and prospects for future research. The international comparative evidence of the thesis can help the northern communities’ policy makers in planning changes that have to be made in order to adjust to an aging transition. It is clear that sustainable population development is the key to a viable Arctic region.

***Keywords:*** Arctic demography, chronological and prospective measures on aging, population aging, the Arctic



## **Emelyanova, Anastasia, Vertailututkimus väestön ikääntymisestä arktisilla alueilla.**

Oulun yliopiston tutkijakoulu; Oulun yliopisto, Lääketieteellinen tiedekunta; Thule-instituutti, Arktisen lääketieteen keskus, Aurora DP

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Oulun yliopisto, PL 8000, 90014 Oulun yliopisto

### ***Tiivistelmä***

Arktisella alueella tapahtuvaa väestörakenteen muutosta ja sen syitä on tutkittu vähän, vaikka alueen merkitys ja aktiviteetit ovat korostuneet valtioiden strategioissa. Erityisesti väestön ikääntyminen tai ”harmaantuminen” on yleinen demografinen suuntaus, joka vaikuttaa pohjoisten alueiden väestöön ja talouteen ja voi johtaa syvällisiin yhteiskunnallisiin seurauksiin tällä maailman harvaan asutuimmalla alueella. Ikääntymistä on tutkittu jonkin verran yksittäisissä maissa, mutta ei näiden maiden pohjoisissa osissa. Tässä väitöskirjatyössä analysoidaan ikääntymistä ja mahdollista nuorentumista kahdeksan arktisen maan 23 pohjoisella alueella ja näitä verrataan saman maan kansalliseen keskiarvoon. Ikääntymisen mittareina on käytetty kahta mittaustapaa perustuen joko ”kronologiseen” tai ”prospektiiviseen” ikään, joista jälkimmäinen huomioi muutokset odotettavissa olevassa eliniässä sekä väestön terveydentilan kohentumisissa.

Tutkimuksen tuloksena syntyi laaja ikääntymistä käsittelevä tietoaaineisto vuosilta 1980/1990 vuoteen 2010/nykypäivään perustuen käytettävissä oleviin lähtöaineistoihin. Tässä työssä yksilöitiin ikääntymisen pääsuuntaukset ja vertailtiin perinteisten ja uusien indikaattoreiden tuottamia tuloksia. Lisäksi selvitettiin ikääntymisen kannalta väestöltään vanhimmat ja nuorimmat alueet, verrattiin arktisen alueen ja kansallisten lukujen välisiä yhteyksiä sekä esiteltiin nopeimmin ja hitaimmin ikääntyvät (tai nuorentuvat) alueet sekä sukupuoleen ja etnisyyteen liittyviä eroja. Tutkimus luo uutta tietoa Pohjois-Kanadan ja Alaskan, Pohjois-Atlantin alueen, Venäjän arktisen alueen sekä pohjoisen Fennoskandian väestöjen ikääntymiskehityksestä. Lisäksi väitöskirjatyö analysoi ikääntymiskehityksen ja muiden väestökehitykseen liittyvien olosuhteiden syitä arktisella alueella sekä tulevaisuuden tutkimustarpeita. Kansainvälinen vertailu voi auttaa valtioiden ja alueiden päättäjiä tekemään suunnitelmat, joilla pohjoiset yhteisöt voivat sopeutua ikääntymisen tuomiin haasteisiin. Kestävä väestökehitys on avain elinvoimaiseen arktiseen alueeseen.

*Asiasanat:* arktinen alue, arktisen alueen väestörakenne, ikääntymisen kronologiset ja prospektiiviset mittarit, väestön ikääntyminen





***To my father Sergey***

*For cherishing the curiosity and inquisitive way of thinking,  
being with me during the first 17 years of my life*



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2 August 2015

Anastasia Emelyanova

## Abbreviations

Age RLE 15	age at which remaining life expectancy is equal 15
AI	aging index
ASI	Arctic social indicators
CHMD	Canadian Human Mortality Database
CircHOB	Circumpolar Health Observatory
IIASA	International Institute for Applied Systems Analysis
LE	life expectancy
LE0	life expectancy at birth
MA	median age
NAA	North American Arctic (including Alaska of the US, Nunavut, Northwest Territories, and Yukon of the Canadian North)
NWT	Northwest Territories (Canada)
OADR	old-age dependency ratio
PAI	prospective aging index
PMA	prospective median age
POADR	prospective old-age dependency ratio
Prop 60+	proportion of the population aged 60 years and more
Prop RLE 15-	proportion of the population with remaining life expectancy of 15 years or less
RLE	remaining life expectancy
US	United States of America



## Original publications

This thesis is based on the following publications, which are referred throughout the text by their Roman numerals:

- I Emelyanova A & Rautio A (2012) Aging population in the Barents Euro-Arctic Region. *Eur Geriatr Med* 3(3): 167–173. doi: 10.1016/j.eurger.2012.03.005.
- II Emelyanova A & Rautio A (2013) Perspectives for population aging in the Russian North. *J Popul Aging* 6(3): 161–187. doi: 10.1007/s12062-013-9086-z.
- III Emelyanova A & Rautio A (2015) Demographic aging in Alaska and Northern Canada in the period 1980–2013. Manuscript.
- IV Emelyanova A & Rautio A (2015) Measuring aging in the North Atlantic region: the prospective approach. Manuscript.
- V Emelyanova A & Rautio A (2015) Policies of Arctic countries to promote volunteering in old age. In Naskali P, Seppänen M & Begum S (eds) *Aging, wellbeing and climate change in the Arctic: an interdisciplinary analysis*. To be published by Routledge, Taylor & Francis Group on 30 November 2015. Manuscript.

In addition, substantial unpublished data are presented in the thesis.





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# 1 Introduction

## 1.1 Topicality of the study

The aging of human populations is a phenomenon which has only appeared in the most recent stage of history. It refers to a demographic process which manifests itself in the growing number of older persons in society, attributable to the concurrent drop in fertility and mortality rates, growing life expectancies, and the generation of baby boomers (born during the post–World War II years) who have reached the top of the age pyramid. The magnitude and pace of aging changes can catch policy-makers by surprise especially in certain parts of the world where the trend may be accentuated.

The Arctic, which covers more than 10% of the planet's total land area but is one of the most desolate and least populated areas in the world, is not exempt from experiencing this aging phenomenon. The population living in the northern parts of countries extending into the Arctic is invariably only a tiny percentage of each country's total population i.e. from 0.1 to 3% (the lowest values refer to Alaska and Siberian Russia) although the land may actually be the lion's part of the country's total land mass. This region has its own drivers of population change, one of which is linked to global population growth. In 2013, there were only four million people living permanently in the area (4 053 055 according to Larsen & Fondahl 2014). This rather modest number will change in the coming decades, in fact, there has been a rather marked population growth occurring since World War II. For instance, in 1945 the population of Alaska was 100 000, and it has grown sevenfold by 2013, in Greenland, the increase has been more than fivefold, and a fourfold increase occurred in Iceland (Larsen & Fondahl 2014).

The growth in the Arctic has been, and will be in the foreseeable future, mostly driven by economical and geopolitical factors, first of all the anticipated climatic changes, economic growth (the wellbeing in Arctic regions largely depends on exploiting resources), exploration of untapped natural resources, opening of new shipping routes with their commercial prospects, and the needs for environmental protection as well as military factors. As a response to the strategic importance which has emerged since the start of the 21st century, Arctic strategy documents have been recently re-evaluated and published by all Arctic states (GeoPolitics in the High North 2015).

At present, only Alaska, Iceland, and the Canadian Arctic have continued to experience population growth; this is due to not only positive net migration but also to natural population increases (Larsen & Fondahl 2014). During the last ten years, the populations living in the northern parts of Sweden, Finland and Arctic Russia have declined by 5 to 10%. In particular, from the 1990s, the dramatic growth seen in Greenland and the Faroe Islands has reversed to a trend of “thinning out societies” (Aasbrenn 1989). Concerns have been raised about the balance between sexes: due to excessive death rates of Russian men, there has been a predominance of older and lonely women living in the Russian Arctic. In contrast, it is the young women from Greenland who have been most likely to leave (see e.g. Hansen *et al.* 2012).

An awareness of the age structure of a population contains relatively older or younger people is necessary if one wishes to forecast how the natural increase will occur i.e. will the population grow or decline in the studied areas. In the existing scenarios, the population of the Arctic will grow slowly by only 4% over the next two decades, at the same time when the world’s population is predicted to increase by 29% (Larsen & Fondahl 2014). However, new commercial considerations and related potential influx of migrants can rapidly alter its population growth.

Scientists have echoed the interests often expressed by politicians with respect to the increases in human activity in the region. They have broadly recognized the contrasts between the northern and southern populations of the eight Arctic states that make up the Arctic (Russia, Norway, Sweden, Finland, Canada, the United States, Iceland, and Denmark), first of all in grand regional publications (Arctic Human Development Report 2004, Arctic Social Indicators 2010, Megatrends 2011, Young *et al.* 2012, Hansen *et al.* 2012, Larsen & Fondahl 2014). The research reports have described a fact not yet clearly stated in governmental strategies: support of a balanced population development is a key element to meeting the stated goals. The reported analyses have taken a long-term perspective on how best to achieve sustainable development of the Arctic, and that this must include the human dimension. There is comparatively little data for these northern and historically small populations, even less is available for these regions at the national level. Fortunately new statistical sources, such as the ArcticStat and Circumpolar Health Observatory (CircHOB), have started to accumulate data on populations in the Circumpolar Arctic with the goal being to facilitate comparative research on the conditions of the peoples of the Arctic by merging together already existing metadata that are all too frequently in a diffuse form and often hard to find (ArcticStat 2015, CircHOB 2015).

In conjunction with the process of accumulating the data and understanding human development in the Arctic, one question to be answered is *whether there is a demographic reason why one should study the Arctic as a region as such. Is the Arctic more than a collection of different places with many common problems, a few of which are demographic?* The majority of northern communities have common features in their existence that justify taking a demographic approach to analyze the Arctic as a separate region. Firstly there are the climatic features, which although not of a direct demographic nature, are very important to understanding human existence in sparsely settled, remote geographical locations with a harsh physical environment, such as the cold weather and long winters, extreme seasonal variations in the amount of light and the close proximity to the wilderness. Most of the northern populations exhibit similar demographic features such as low population densities, with more men than women, higher mobility than in the south of these countries (local young people leave while migrants from abroad arrive e.g. the Polish workforce in Iceland, Asian migrants in Alaska and the Canadian North, etc.), increasing touristic activity, and rapid urbanization and concentration of the populations of nearly all Arctic regions to live in the capitals and regional centers (2.1 Literature on population aging). Infant mortality is comparatively low in the whole Arctic if judged by international standards, in fact some territories enjoy the lowest rates in the world (Larsen & Fondahl 2014: 102). However if one only examines the national birth rates of the Arctic countries then one will be totally unable to understand of the demographic processes on-going in these northern populations.

As elaborated on the causes of aging (in 4. Discussion and concluding remarks), the rates of all-ages mortality and fertility have been clearly different from the national rates. One explanation is that the Arctic is rich in Indigenous Peoples and the ethnic composition in the North makes a substantial contribution to natural balance, median ages, and other demographic patterns. The North American Arctic (NAA) is home to three major aboriginal groups i.e. Inuit, First Nations or Indians, and Métis in Canada as well as American Indians and Alaska Natives in the United States. There are Native Greenlanders or Inuit; the Nordic countries are homes to the Sami people. In Russia, numerically small Native Peoples live in the North, the largest of which are the Yakuts, Komi, and Karelians. The percentage of the total population made up by the Indigenous populations ranges widely, from more than 80% in Greenland and Nunavut, 50% in Northwest Territories (NWT), 20% in Alaska and Yukon, 15% in Arctic Norway and as little as 3-5% in the Russian Arctic (except for 30% in Chukotka). It is important to note that ethnically sub-divided

demographic data is scarce and incomplete (more in 2.2.1 Aging data of Arctic populations) which makes it very difficult to restrict the aging analysis to only the minorities living in the North.

If one agrees that it is reasonable to study the Arctic as a single region whose populations face many similar problems, the following research question is *whether one should better consider the Arctic as a homogenous or as a heterogeneous region in terms of population development and, in particular, with respect to population aging?* In addition to the above mentioned similarities of living in the North, the impacts of migration, birth choices, mortality and morbidity rates, gender composition, globalization and environmental shifts display unique characteristics, differing within and among the regions of the Arctic, between Indigenous and non-Indigenous northerners, rural and urban residents, between sexes and also in many other aspects. Thus, it can also prove difficult to make generalizations about Arctic population development. This thesis has developed hypotheses about both the similarities but also the major diversities and large contrasts that characterize population changes and the aging of different populations in various parts of the Arctic.

Societal aging has been recognized as a powerful megatrend in Arctic settlements (see 2.1 Literature on population aging), however, as stated above, previously it has not been possible to answer these questions, since there is a paucity of data on population dynamics at the sub-national level. The process has lacked substance despite its potentially high impact for community wellbeing, since it has the power to transform all tiers of these small communities and profoundly distort the age composition of regional populations. The most recent updated edition of the Arctic Human Development Report has highlighted the need to understand better the social, cultural, economic and political roles that older adults play in regional development, and raises questions about aging-driven complexities. “How will Arctic societies adapt to the aging population, and how can the elderly be better integrated into societal life? What role might elderly citizens make to economic, cultural, and political development? How can increased old-age dependency rates be addressed? What roles can the elderly play in contributing to community cohesion and viability, in connection with Arctic “diasporas” abroad, and how does this differ across Arctic regions and settlement types?” (Larsen & Fondahl 2014: 489).

The extensive scientific, political, and public interest now being focused on the Arctic and its surprisingly sparse database only emphasizes the importance of

elucidating the regional demography and the aging of local populations, also as a part of the global aging discourse and policy development.

The focus area of the thesis is on aging in different regions of the Arctic, and the thesis introduces new data that reveal similarities and diversities in aging development for the Arctic, the borders of which are categorized according to the CircHOB system, located to the north of 60° N. (Fig. 1). The Arctic can be broadly divided into four regions:

1. The northern Fennoscandia. This includes three Finnish territories (Kainuu, Oulu, and Lapland), three Norwegian counties (Finnmark, Troms, and Nordland), and two of the northernmost areas of Sweden (Vesterbotten and Norrbotten).
2. The Russian Arctic, including various northern republics, oblasts, and autonomous regions: Karelia, Komi, Arkhangelsk, Murmansk in European Russia, as well as the Siberian regions of Sakha (Yakutia), Kamchatka, Magadan, and Chukotka.
3. The North American Arctic, which consists of Alaska of the United States of America (US) and three Canadian territories, the westernmost Yukon, the most populous Northwest Territories, and Nunavut, the largest, least populated, northernmost and newest territory of Canada.
4. The island-states in the North Atlantic region, including Iceland and two Danish self-governing and autonomous territories, the Faroe Islands and Greenland.



**Fig. 1. Coverage of the Arctic (Published by permission of Circumpolar Health Observatory).**

## **1.2 Aims of the study**

The aim of the thesis is to identify the rates of demographic aging within the different territories of the studied region: to identify the oldest and youngest territories, the fastest and slowest regions in terms of aging (or in contrast, rejuvenating), to compare Arctic sub-regions to the national average of Arctic countries; and finally to examine whether the aging trends in the different parts of this region are converging or diverging. Furthermore, male and female rates of aging are studied separately as there are known to be major sex differences in determinants of longevity (Gavrilov & Gavrilova 2015). As data on Indigenous Peoples are not consistently available across all Arctic regions, ethnic origin is



referred to only to a limited extent. All this will help in understanding whether the Arctic has been aging in a common way, or are there major differences across the region.

In this thesis, aging has been measured with different methodological techniques (2.1.2 Methodological approaches) that trigger many more new research questions, such as what is the reason for the differences observed in aging rates, when measuring the process with different tools. One overarching aim of this research is to produce a full set of data on the aging of Arctic and respective national populations for the period 1980–1990 to 2010 and the present, based upon available baseline data (2.2.1 Aging data of Arctic populations and 2.2.3 Limitations of data).

Chapter 3 – Results - describes the findings on the rates of population aging and the subsequent Chapter 4 – Discussion and concluding remarks - consists of a review of causes driving aging in the Arctic, touching also on migration patterns, shifts in age distribution, fertility and mortality, life expectancy (LE), patterns of sex composition, and other parameters that can help explain aging development in the studied region. Furthermore, it presents a summary of results, interpreting the interactions between aging indicators. Lastly, it proposes how the data gathered in this thesis can best be utilized as well as identifying gaps in knowledge and prospects for the future.

Summarizing the contributions to the work done with this thesis: (1) a new dataset of aging data and life tables has been devised at the national and sub-national levels; (2) computations of prospective measures have been done; this was a particularly innovative part of this work (since this required collection and reconstruction of specific population data and demographic knowledge); and (3) an analysis of the results was undertaken.



## **2 Literature, methodology, and data aspects**

### **2.1 Literature on population aging and methodology**

This chapter provides an overview of the main scientific and more focused methodological literature referred to in various parts of the thesis. (1) In the analytical part of this work, a global approach was utilized to understanding the aging process, with a greater emphasis placed on the regional Arctic studies which could create a foundation for the present research. The analytical approach is complemented by reviewing important international policy documents on the topic of aging research. (2) Another prominent aspect of the literature review was to apply conventional and novel approaches which were elaborated and profiled from the perspective of how population aging should best be methodologically assessed.

#### **2.1.1 Arctic aging megatrends**

The consequences of population aging are relatively new in human history but they are multifaceted and now recognized as a global phenomenon (Global aging 2000, Coleman 2001, Lutz *et al.* 2008, Crampton 2009, Bloom *et al.* 2011, Aging in the twenty-first century 2012, World population aging 2013, Marin 2013, Zaidi & Stanton 2014). The above publications have applied a range of approaches to understanding aging, mostly from the point of view of changing age structures, economical and historical conditions, and societal consequences. They share the data on the global rates of aging, which is important when one wishes to view the Arctic from a larger international perspective. Many sources refer to the need for standardization of policy responses in various sectors such as public expenditures, and other policies concerned with demographics, social issues, economic development and labor-related factors. There are some very important documents on these issues e.g. the Political declaration and Madrid international plan of actions on aging (2003) and its follow-up reports and regional strategies as well as the most recent Vienna Ministerial document “Ensuring a society for all ages: Promoting quality of life and active aging” (The 2012 Vienna Ministerial Declaration 2012).

Unfortunately not much research has been conducted on aging at the regional level of the Arctic. There are some sources which could be referred to on the topics of age structures and aspects of population health of the Arctic populations i.e. the

Arctic Human Development Report (2004), its second edition (Larsen & Fondahl 2014), Health Transitions in Arctic Populations (Young & Bjerregaard 2008), and the Circumpolar Health Atlas (Young *et al.* 2012). Some key questions about the Arctic populations have been examined including factors related to childbearing and births, mortality levels, changes in the sex, age, and ethnic composition of Arctic populations, their spatial distribution and age-differentiated net migration, some projections for the future of population development as well as overarching and multidisciplinary understanding of northern conditions, status and determinants of population health in the region. A cursory examination reveals that it will likely be impossible to identify any uniform pattern of aging within the region due to the huge variations in the basic demographic data.

There are some other academic publications which have specific details about population aging at the territorial level of the Arctic e.g. those predominantly released by Nordregio which concentrate on the Nordic countries (Foss & Juvkam 2005, Hansen *et al.* 2011, Martel *et al.* 2011, Nordic Population Aging 2013). Their main findings have been concerned with the rapidly aging population, even though the Nordic countries (and its North Atlantic counterpart) still enjoy relatively high fertility rates compared with central and southern European countries. Although a generally older age structure can be found in northern Sweden and Lapland, the relatively greatest increase in the older population has occurred in Iceland and Greenland where the age structures are young at the moment but for several reasons there have been significant outflows of people of child-bearing age.

One major aspect of Nordic research into aging has been its highlighting of territorial and urban-rural differences, and the sub-national scale of research. For instance, several studies have emphasized the trends that occur when migration heavily distorts the birth-death balance causing societal aging to be particularly intense in rural and remote areas. In this instance, there is pronounced out-migration of youths and young adults (notably young women) from the periphery to metropolitan areas or elsewhere away from the northern region. In contrast, due to the extensive in-migration of young people into the larger cities of the Nordic region, in their capitals and other larger cities, the impact of aging is much less significant (although rising in these locations as well).

Before starting this thesis work, population aging in the Russian North and Barents Euro-Arctic region was investigated by the author in collaboration with Danilova and Golubeva (Danilova *et al.* 2011). The discussion in this article revealed the sharp differences between northern Russia and the rest of the country but also identified exceptions from the wider Arctic in most demographic aspects.

The authors examined the vast cross-territorial differences on aging, for example, between European areas of northern Russia and Fennoscandia, and the contrasts between all Barents areas e.g. young developing and birth-promoting region of Oulu and the dramatically aging neighboring region of Lapland in the Finnish North. Migration is often the reason behind such extreme differences: more people leave from Siberia and from the northernmost Finnish region (Lapland) to seek education and employment in economically advantaged cities, usually in the capital region of their countries.

Moore and Pacey (2004) had conducted informative research on aging in the NAA in which the dynamics of population change were graphically presented and policies on aging for the NAA territories were discussed. Several reports have commented on the absence of any comprehensive policy on aging in Yukon and Nunavut (Hamilton 2008, Hamilton & Mitiguy 2009, Wilson *et al.* 2012, Lewis 2013), and emphasized the need for valid, research-based evidence to be the foundation of any policy response on aging in Northern Canada. It is clear that an effective policy is essential, since there was a large migration of individuals who came to the region attracted by the opportunities offered through regional development in the period 1950–1970. By the 2000s, these individuals have gradually aged, and now represent a cohort of older adults. Thus the NAA hosts a larger share of baby boomers than are encountered in the other states of the US or in the territories of Canada, even though these regions overall are still one of the youngest in their respective countries.

As stated in several of these sources, the Arctic countries have been challenged to produce either a regional action plan on aging or nationwide plans that should explicitly cover all public sectors. In fact, there is no similarity in approaches being adopted in the Arctic, simply because political priorities and welfare models differ so much across the region, and also given the social heterogeneity of older people as one of the main challenges facing all modern societies (Naegele *et al.* 2010). Health care is considerably more expensive in this sparsely populated region and it may even be unique in terms of its exploitation of innovative e-health technologies, culturally rich practices on healing and traditional indigenous medicine, extended roles of medical personnel (i.e. performing duties beyond what is expected) (Chatwood *et al.* 2012). These are all important aspects to be taken into account when devising regional policies on aging. Collaborative international efforts, comprehensive research evidence on aging (as conducted in this thesis) and cross-border knowledge sharing can all help to address societal aging, since its implications do not often end at the national borders of the Arctic countries.

### **2.1.2 Methodological approaches**

Another central element of the literature analysis is the methodological evaluation that have examined the main techniques which can be applied to measure aging from a demographic point of view. As stated in Articles II–IV, this study utilizes two recognized approaches with which to assess population aging as in this way it is possible to gain a better perspective of the different aspects of this complex process. In the literature, the first group of indicators is referred to in several ways e.g. as “chronological”, “standard”, “conventional” or “retrospective” methods on aging. The second measurement group has been given the name “prospective” (Sanderson & Scherbov 2007).

The main difference between these two approaches is on the age on which these measures are founded. The conventional approach is based on the characteristic of chronological age that is the number of years already lived by an individual and/or a population (see the list of the indicators in World population aging 2013). In this type of research, five standard indicators of population aging are calculated: Life Expectancy at Birth (LE0), Median Age (MA), Proportion of People Aged 60 Years and Over (Prop 60+), Old-Age Dependency Ratio (OADR), and Aging Index (AI). MA represents the line which would be drawn to divide the numbers in the population into two, those older than the age at the line and those younger. Prop 60+ is related to the population aged 60 and over divided by the total number of the population of all age groups. OADR relates the numbers of people 60 years and older to the numbers of people aged between 15 and 59. AI refers to the percentage of people 60 years or older divided by the number of children aged 0 to 14. Chronological measures have a range of advantages such as comparatively easy computation based on readily available and simple statistics of population accounts subdivided by age and sex. They have often been applied in demography and the results can be compared across most countries and regions of the world.

However, an alternative way of looking at aging emerged in the early 2000s e.g. as proposed by Denton and Spenser (2000) which argued against the traditional way of assessing aging. Sanderson and Scherbov continued this argument such that it represented a marked conceptual shift and novel understanding of population aging. They proposed new measures of assessing age and aging in demographic research that no longer simply counted the number of years lived, but instead considered remaining life expectancy or years left to live in the future. With this concept, it was appreciated that many age-specific characteristics of people were changing simply because today LE at the older ages is increasing. These authors

provided an example of a person aged 60 in 1900 had a much lower LE and was considered as fairly old, whereas today, a person who is 60 can better be thought of as middle-aged, still able to enjoy a long duration of healthy life (Sanderson & Scherbov 2007, Sanderson & Scherbov 2008, Sanderson & Scherbov 2013, Sanderson & Scherbov 2015). Historical demography has revealed that indeed many important human characteristics have changed and they will not remain the same over time. Ignoring age-specific changes and referring only to fixed chronological age creates a misleading picture of aging that erroneously identifies aging rates as increasing too rapidly, according to the cited authors.

There are numerous publications and public discussions on the aging workforce i.e. those claiming that the “silver tsunami” is threatening to bankrupt pension systems, posing unbearable costs of long-term care, poverty among older adults, and creating many other huge social and economic challenges; often these arguments have been based on aging rates measured with the conventional approach (e.g. Perry 2009, Bucher 2014). On the other hand, there are five prospective metrics which look at this trend from the opposite direction, i.e. Age at which Remaining Life Expectancy is equal to 15 (Age RLE 15), the Share of People with a Remaining Life Expectancy of 15 Years or Less (Prop RLE 15-), Prospective Median Age (PMA), Prospective Aging Index (PAI), and Prospective Old-Age Dependency Ratio (POADR), make it possible to adopt to dynamic changes in longevity and reflect a more up-to-date understanding of on-going changes in aging (Prospective measures of population aging: version 1.0 2014). In this case, PMA is derived from the life table where the remaining LE is the same as it is at the MA in the reference year, “Iceland 2005” in this case. Prop RLE 15- is calculated as the number of people in age groups where RLE is 15 years and less divided by the total population. POADR puts the share of people older than the RLE 15- old-age threshold in the numerator to be divided by the number of people aged between 15 and the old-age threshold. PAI relates the number of people older than RLE 15- to the number of children aged between 0 and 14 (more on methodological insights and how to compute prospective indicators in the publication of Sanderson and Scherbov between the years 2007 and 2015).

There can be a profound conceptual advantages using the novel prospective approach, e.g. in the case of this study, since they make it possible to reveal actual “rejuvenation” trends happening in many places of the vast Arctic region. These phenomena have not been anticipated before as standard measures mostly indicated that the regions were experiencing a stable growth in their aging rates (see Results and Discussion). At the same time, the prospective concept involves a number of

associated and complex data aspects. This approach has started to be applied only recently, and this means that there are relatively limited possibilities for comparisons and these are mostly to national rates which are available in European Demographic Data Sheets of the Vienna Institute of Demography from 2008 onwards (VID 2015). The prospective approach not only requires access to population accounts as baseline data, but also one needs to calculate mortality rates by age and sex in order to compute life tables, and these are rarely available at the sub-national and local levels. The investigator needs to possess specific technical skills on how these measures should be computed, given that baseline data has to be found or even reconstructed.

## **2.2 Characteristics and limitations of data**

### **2.2.1 Aging data of Arctic populations**

Demographic and socio-economic publications released by national and territorial statistical bureaus of Arctic countries are used. In general, the study has had to resort to accessing national statistical banks that contain tables on various national and regional population data.

With respect to the Russian North, the Federal State Statistics Service and the Centre for Demographic Research at the New Economic School have been the main sources of mortality and population numbers (Centre for Demographic Research 2015, The Russian Federation Federal State Statistics Service 2015). For the Scandinavian territories, Statistics Finland, Statistics Sweden, and Statistics Norway (2015) share tables with time series on population and mortality accounts. However, there was a need to reconstruct life tables for the Arctic regions of Finland, Sweden, Norway, and Russia, where life tables at the sub-national level were not available, using the methodology suggested by Preston *at al.* (2001). It is hoped that the life tables constructed for these regions in this thesis will be useful for others working in demographics. They are innovative and have scientific and practical applications beyond the pure prospective measurement of aging. In the case of the North Atlantic, life tables were requested by the Centre for Arctic Medicine (University of Oulu, Finland) from the official authorities of the Statistics Denmark, Statistics Greenland, Statistics Iceland, and Statistics of the Faroe Islands (2015). Furthermore, the search engine of the ArcticStat was very useful in accessing metadata sources for the Arctic (ArcticStat 2015).



Canada's national statistical agency and the Canadian Human Mortality Database (CHMD) are the two other main sources of regional and national population data (CHMD 2015, Statistics Canada 2015). However, they use different methodologies and their demographic estimates may differ from those used in the other Arctic countries. The Canadian Socioeconomic Information Management database of Statistics Canada publishes abridged life tables, with the latest available for the period 1995–2011. In view of the fact that the CHMD provides life tables for a longer period and allows better comparability, it was chosen as the main data source for this thesis and Article III. The CHMD life tables are available for the whole study period, starting from 1980 and are subdivided by sex. However, they are not available for all three Canadian Arctic provinces separately: it publishes data for Yukon and joint NWT/Nunavut.

When studying the US and Alaska, chronological indicators have been computed on the basis of population estimates from the Alaska Department of Labor and Workforce Development (2015) and US Census Bureau (2015). The population data in Alaska included both intercensal 1980–1990 and vintages up to 2013 estimates. All other numbers were based on the 1990 Census. Population numbers may slightly differ from other vintages. For prospective analysis, only decennial life tables were available from limited census releases of 1979–1981, 1989–1991, and 1999–2001. Additional computations of the US national indices for 2005 and 2010 became possible via access to the Human Mortality Database (2015).

### **2.2.2 Age thresholds**

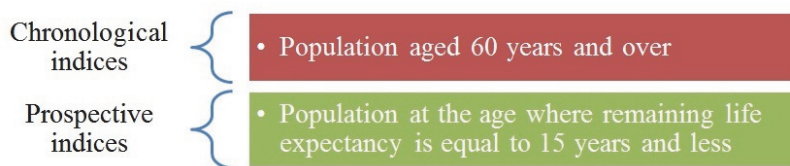
Depending on the methodological approach, different age thresholds for measuring aging have been used in this thesis. With chronological methods, the age of 60 years divides the line between “young” and “old”, mostly this is due to the complicated retirement schemes in the specific northern setting of the Arctic (Fig. 2, Table 1).

Alaska's government developed the Tier I–IV public employees' retirement system in which retirement is possible between the ages 50 to 60, earlier than usual in the US, where the age of retirement is above 62 years (Alaska Division of Retirement and Benefits 2015). The Canada Pension Plan and Old Age Security programs provide a retirement pension to eligible Canadians at the age of 65. However, individuals can apply to different schemes according to their labor history (Pensions in Canada and related benefits 2015). In the North Atlantic, old age is officially defined as 67 years, however, there are various early retirement

arrangements. “Due to the relations between legal arrangements in Denmark and the Faroe Islands and Greenland, in Greenland it is possible to retire at the age of 60 years, and special arrangements for women means that it can even be possible to retire at the age of 55. In the case of Iceland, the general retirement age is 67, but seamen may retire at the age of 60 years. The same is true in Greenland and the Faroe Islands, where the Danish system of early retirement from the labor market at the age of 62 can be applied” (Hansen *et al.* 2012: 18).

The retirement age also varies within a wide range of programs in the Russian North and Fennoscandia. This meant that some uniform threshold had to be set in order that the calculations would be comparable, and the threshold was a 60 year-old cut in this study and included articles. This should not be interpreted to mean that the population over the age 60 is old and a burden, out of the labor market, unhealthy, or non-active in society. In fact, the older population group is increasingly heterogeneous and contributes to society in a great number of ways (Global aging 2000, Larsen & Fondahl 2014).

On the other hand, prospective measures are based on the threshold age at which RLE is 15 years and less. This replaces the 60-year age cut-off point of a fixed chronological age from birth by an empirically determined biometrical measure of years remaining to be lived. This refers to a floating number of prospective years to live. The concept of prospective age refers to “the age not chronologically from birth, but biometrically from the end of life”, i.e. measured from the remaining lifetime or years left until death (Sanderson & Scherbov 2008: 15).



**Fig. 2. Threshold ages applied in the denominators of the aging indicators.**

**Table 1. The standard statutory retirement ages in Arctic countries, circa 2015.**

Country	General national retirement age (Men / Women)	Early retirement age (can be national or earning-related schemes)	Arctic areas' retirement age (if specific)
Canada	65	60	-
Denmark	65 / 67	60	Greenland: 60 / 55 Faroe Islands – 67, 62 years for early retirement
Finland	65	63	-
Iceland	67	60 (seamen)	-
Norway	67	62	-
Russia	60 / 55	55 / 50	55 / 50 for all the studied Arctic regions 50 / 45 (reindeer herders, employed in fishing, trade hunter in the Far North)
Sweden	65	55–61	-
USA	66	62	The Tier I–IV public employees' retirement system in Alaska allows retirement between the ages 50 to 60

### **2.2.3 Limitations of research data**

Four other factors should be emphasized about the data quality. First, it is worthwhile noting that the size of the population and annual death counts are so small in Yukon, NWT/Nunavut, and Greenland that standard methods could not be applied and therefore life tables for every single calendar year were not computed and instead life tables were calculated for a 5-year period. In Northern Canada, these are the periods from 1980–1984 onwards. The Greenland's table indicators refer to the periods of 1977–1981, 1987–1991, 1997–2001, and 2007–2011. This can even be considered as an advantage: Scherbov and Ediev (2011) have argued that 5-year estimation mitigates the upward bias in life expectancy that can happen for those territories with a small population size.

Second, recent territorial division and boundary changes for some of the Russian and Canadian provinces complicate the definition of “the Far North”. The Canadian region, Northwest Territories consists of several districts, one of which had a unique status resulting in the creation of Nunavut in 1999. In the earlier period from 1991 to 1999, population estimates for NWT and Nunavut had been already divided but earlier data for the period 1980–1990 was only available for NWT and Nunavut combined. Therefore, the chronological measures on aging were

calculated separately for three Canadian provinces starting from 1991. However, a prospective analysis could only be done for two: Yukon and the combined NWT and Nunavut, since this was the only way to handle the data in the CHMD life tables. In Russia, there were boundary changes in the early millennium decade (2002–2007) causing transformations in the official statistical databases. In 2007, the territories of the former Krasnoyarsk regions, Evenk and Taymyr Dolgano-Nenets autonomous areas were merged into the Krasnoyarsk region. The northern Khanty-Mansi autonomous area became a part of the larger Tumen region in the statistics, and the Koryak autonomous area joined an administrative division of Kamchatka. These administrative changes mean that although general, vital data for some Arctic areas were available, however the specific age-sex mortality statistics in the regions' parent units, needed for this doctoral study, were not. For these reasons, only the eight Russian northern regions where boundaries did not undergo any change were included here.

Third, as mentioned earlier in Chapter 1.2 Aims and background studies, aging analysis has been conducted separately for male and female populations. The ethnic composition is only referred to when explaining the regional context as the ethnic patterns of morbidity, mortality, longevity, fertility etc. are largely not separately counted in the statistics (except for the NAA); they are often incomplete, and unreliable. For this reason, it was decided not to try to reconstruct life tables for distinct ethnic groups, and thus the aging analysis was conducted on “all-inclusive” populations of the regions without ethnic distinctions.

Finally in order to have better comparability, it was decided to refer generally to the range of years 1990 to 2010 in the Results and Discussion. However, indicators were calculated for the years 1980 to 1990 for the North Atlantic and North American regions as the data permitted their estimation and these values can be found in Appendix 1. The data by sex, region, and the country in Appendix 1 had four cut-off points: 1980, 1990, 2000, ending with the year 2010. Since the countries publish population information only after a delay, in the calculations the latest rates ends in 2012–2014. These latest rates, as well as those for any single year of the studied period and also computed as life tables can be requested from the author.

## 3 Results

The Results are based on above described aging data; this is initially organized in so-called measures of location that consider longevity aspects (life expectancy at birth, at the age 60, and the age at which remaining life expectancy is equivalent to 15 years left, median age and prospective median age of population). The second group of indicators on aging is presented as the statistical head-count ratios that reveal the changing balance between age groups, and are also adjusted to prospective age. They interrelate the number of individuals from larger age categories. The classification to “measures of location” and “head-count ratios” follows the approach proposed by Gavrilov and Heuveline (2003). The chapter provides the findings for separate indices, whereas the unifying trends are interpreted in the Discussion and concluding remarks.

### 3.1 Longevity indicators

#### 3.1.1 *Life expectancies and remaining years to live*

Life expectancy at different ages is an effective tool to demonstrate how a population ages. In the Arctic, there is no uniform indication of life expectancies due to large differences in mortality. The rates are diverse between the territories and sexes, and were found to differ, first, in relation to nationwide rates; secondly, in the speed of growth; next, in comparisons of LE0 and Age RLE 15 indicators, which reflect the patterns of longevity at younger and older ages.

Based on data for 2010, LE at birth in the Arctic parts of the studied countries differs from that of their respective nations (Table 2, Articles I–V). Three main groups could be identified. First, the populations of both sexes of the Faroe Islands and Iceland enjoyed two to five years more life expectancy than the Danish population and the same was true for women in northern Finland and men of Troms, - these are the Arctic lands where LE is registered to be longer than that of the whole country. Second, there are those populations where life expectancies did not differ dramatically from the average rates of their nation states, including Alaska, Yukon, and the majority of the Scandinavian and European regions of the Russian Arctic. Thirdly, there were those northern territories where life expectancy has been substantially below the national average, such as Canadian North (except Yukon), Greenland as well as Chukotka of Russia. Chukotka had the lowest life expectancy

values i.e. 52.7 years for men and 63.6 years for women, almost 10 years less than Russia's all-population rate.

The regions with the lowest-low life expectancy are settled predominantly by the Arctic Indigenous Peoples and they are characterized by relatively poor population health and impoverished economic status. The better the health of a population, the higher LE one would expect would be achieved. To address health inequalities, policy planning needs to take into account the fact that health care will inevitably be expensive in these remote communities. For instance, Nunavut in Canada has the highest per capita health expenditure in the world at just under 26% of the territory's GDP (Ellsworth & O'Keeffe 2013). However, high expenditures have not been translated into higher life expectancies, they simply reflect the expense of delivering services in remote and sparsely populated regions. In Greenland, land roads may be absent and many communities can be accessed only by helicopter. Thus, the improved availability and quality of services for Indigenous communities is a key policy task.

For the three classified groups and within the research period, LE0 improved and reached the highest values i.e. the 80-year rate in men of Troms and Iceland, and 84 years for women of the north of Finland in 2010 (Table 2). These same territories led the indicator in the 1980s. However, marked changes throughout the examined period have been occurred with respect to the sex gap in life expectancies. Although this widened for the Russian regions, in contrast, it has tended to decline for the rest of the Arctic, ranging from four to five years in favor of women in the NAA and North Atlantic, seven to eight years in northern Finland, to a significant gap of 11 to 12 years between sexes in the northernmost Russia. The large gap remained between the Russian North and the rest of the Arctic, despite the recent increase of LE in Russia after the 2000s, mostly attributable to a reduction in the numbers of Russians dying from cardiovascular disease, alcohol-related conditions, and violence (Shkolnikov *et al.* 2013).

In addition to these standard longevity indications such as LE0, it is relevant to look at longevity patterns in the older ages. Life expectancies after retirement can be a good way of assessing old age mortality. The trend towards growing LE in older ages is usually observed but in this indicator, growth tends to be slower than for the same indicator at birth. An obstacle hindering demographic studies of the Arctic is that official statistics are provided to only a limited extent, not always available at the sub-national level and there are usually different thresholds such as the LE at the age 50 or 60 or 65, all of which compromise comparability. One solution is to identify the age with exact number of remaining years to live, as

proposed by Sanderson and Scherbov (2008). This age can be adjusted to increased LE and be shifted towards the oldest edge, in the thesis's case, it was chosen as the value where there were 15 remaining years left to live.

The indicator Age RLE 15 has undergone a much slower increase than the LE0, reaching the highest 72.1 years for Vesterbotten man and 74.5 years for the Faroese women in 2010. Moreover, the results revealed several cases of no Age RLE 15's growth when comparing the values from 1980 and 2010 e.g. for women living in Greenland, NWT, Nunavut, and men of Yukon. From the pan-Arctic perspective, male Age RLE 15 increased faster than the equivalent value for females, which is different from the global trend. The Age RLE 15 index also revealed clear setbacks for the male population of the Russian Arctic except Sakha, and for the female populations of Chukotka and Greenland. In total, the Russian Arctic has the lowest Age RLE 15 (and LE0 as well). Greenland and Nunavut are the closest to Russia, this is explained partly by its colonial history but perhaps also by the earlier stages of demographic and epidemiological transitions of their populations. For example, it was observed that there was negative growth registered for women of Vesterbotten, whereas the corresponding index for males in this region underwent the highest gains in this index over two decades. Vesterbotten has not experienced a colonial history and furthermore the share of Swedish Sami in the regional population is relatively low, therefore the reason why it shows a reversed trend may be different and in fact it emphasizes the difficulties of attempting to find generalizing patterns which would encompass the entire Arctic.

With respect to the female-male gap, LE in older ages had less clear difference between sexes than in case of LE0 with exception of Iceland and Yukon in 2010. By that year, Vesterbotten displayed a unique case of the Age RLE 15, the rate for the male population (72.1) exceeded that of their female counterparts (68.8). Even with better positioning to LE0, the sex gap showed a tendency to accelerate over time in the Russian Arctic and Canadian Yukon, but almost halved in all other territories, bringing men and women to a position of equality, with both sexes enjoying almost equal remaining lifetime values. One could state that achieving a more balanced sex ratio would be an advisable target of regional policies.

**Table 2. Life expectancy at birth<sup>1</sup> throughout the Arctic regions, subdivided by sex, 1990–2010. Summary table from the updated results of Articles I–IV.**

Regions and countries <sup>2</sup>	1990		2000		2010	
	Men	Women	Men	Women	Men	Women
Nationwide rates for Arctic countries						
Canada	74.2	80.6	76.6	81.8	79.2	83.5
Denmark	72.2	77.8	74.5	79.1	77.3	81.6
Iceland	75.4	80.5	77.8	81.5	79.7	83.8
Finland	70.9	78.9	74.1	81.0	76.7	83.2
Norway	73.4	79.8	76.0	81.4	78.8	83.1
Russia	63.8	74.3	59.0	72.2	62.9	74.8
Sweden	74.8	80.4	77.4	82.0	79.5	83.5
The US	71.8	78.8	74.1	79.5	76.4	81.2
The regions of the Arctic						
Alaska	71.6	78.6	74.2	79.4	76.8	79.4
Arkhangelsk	63.7	74.3	56.3	70.6	61.7	74.5
Chukotka	64.4	72.1	54.9	67.1	52.7	63.6
Faroe Isl.	73.9	79.9	77.6	83.7	79.7	86.1
Finnmark	71.0	78.1	73.4	80.8	75.9	82.1
Greenland	62.0	68.5	65.5	71.0	69.1	73.6
Kainuu	70.0	78.3	72.0	80.6	75.0	83.8
Kamchatka	61.4	70.8	58.1	69.7	60.5	71.8
Karelia	63.3	73.8	56.4	70.2	59.8	73.4
Komi	62.8	73.5	57.8	70.1	60.7	73.3
Lapland	69.8	78.8	73.2	81.0	76.5	83.7
Magadan	61.6	71.1	55.7	70.0	59.8	71.1
Murmansk	65.7	74.1	58.5	71.0	62.7	73.9
Nordland	72.5	80.2	76.0	81.5	78.8	83.1
Norrbotten	71.4	78.4	73.8	80.4	76.3	81.8
NWT+Nu <sup>3</sup>	70.0	77.9	71.0	75.0	73.1	78.9
Oulu	71.3	79.3	74.2	81.1	77.8	84.3
Sakha	61.4	71.4	57.9	70.3	61.0	73.1
Troms	72.5	80.5	75.2	82.2	79.9	82.6
Vesterbotten	72.6	78.8	74.2	79.4	77.1	81.5
Yukon	74.2	76.7	73.5	78.9	75.4	80.1

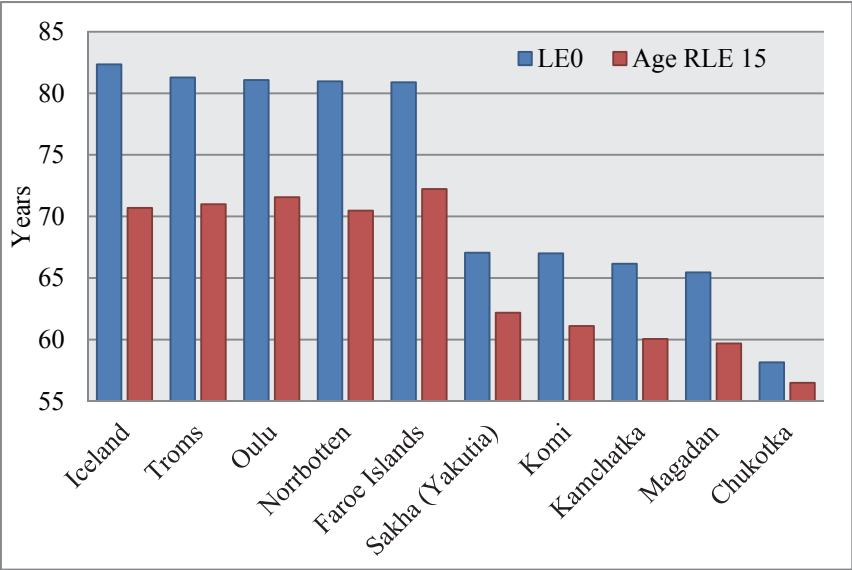
<sup>1</sup> Life expectancy at birth is the average number of years a newborn would live if current age-specific mortality rates were to continue (World population aging 2013)

<sup>2</sup> The data is collected from national and sub-national statistical databases of Arctic countries as well as Human Mortality Database and Canadian Human Mortality Database. Sub-regional data for Fennoscandia and Russian Arctic has been re-calculated by the author on the basis of age-sex specific mortality rates

<sup>3</sup> NWT = Northwest Territories, Nu = Nunavut, the rate is combined for these two regions of Canada



Comparing the North to national averages with respect to the Age RLE 15 (jointly for sexes), then one would expect the “catching up” trend over the period to be apparent for a major part of the Arctic. There are exceptions to this trend i.e. the US and its growing divergence with Alaska’s index, and the same is true for Danish autonomous regions and Canadian NWT and Nunavut. Fennoscandia displayed another distinct pattern: most of its territories have kept the Age RLE 15 as identical to national averages, although there is a slight growth which indicates that the North may surpass the nationwide value in the near future. In fact, the Faroe Islands and Oulu region of Finland already exceed the RLE 15 values of their respective countries national averages in 2010.



**Fig. 3. The highest and lowest Life expectancies at birth (LE0) and the Age at which remaining life expectancy is equal 15 years (Age RLE 15) for selected Arctic areas, sexes combined, 2010. Summary table is based on the updated results of Articles I–IV.**

Fig. 3 depicts data on LE and it reveals longevity differences for some Arctic populations. By the end of the studied period, a major 25-year difference is evident if one examines the values between Chukotka and populations of Troms, Iceland, and the Faroe Islands, all of which are on the top of the LE0 spectrum. A less, but still striking, difference is the 16-year gap found for the Age RLE 15 between

Chukotka and the Faroe Islands. Despite the fact that Russian life expectancies have consistently recovered since the 2000s, there is an alarming trend when differences between the regions with the highest and lowest indicators' values continue to polarize over the period, e.g. growing from eight years of Age RLE 15 difference in 1990 to 16 years in 2010, and from 13 (1990) to 24 years (2010) of difference between the highest and lowest LEO rates registered for these years.

In addition to the growing gap between the different Arctic territories, the actual difference with nationwide rates has been diminishing: the rates have become much closer to the national averages, even exceeding them, as in case of the Danish Faroe Islands and Finnish Oulu. This is a sign that over the few past decades, Arctic residents have moved to a more advanced stage in the demographic transition: although some populations are moving slower and some faster along that transition path. The northern regions are now more similar to the longevity rates of the southern communities in their countries. The new flows of immigrants, faster growth of non-Indigenous populations in relation to Native groups, relevant cultural changes towards western lifestyles and new foods have all contributed to this trend. However, Greenland, Nunavut, and a part of Siberian Arctic still exhibit appallingly lower population longevity rates and these are associated with the shrinking local economies and poor health status. A multi-domain policy needs to be implemented to prevent intensive out-migration of the best educated and healthy residents of young and working age.

### ***3.1.2 Median ages and prospective co-indication***

If one considers the Arctic regions, then the Fennoscandia area shows the highest MAs which ranged from 40 to 50 years in 2013. These are the regions in demographically advanced countries where adjustments to an aging society have been part of government policy for a number of years (Megatrends 2011). By comparison, the value of the global MA was 29 years in 2010, 27 years in less developed countries, and 40 in more developed ones (Larsen & Fondahl 2014). Thus if we consider these values, then it is apparent that the Arctic possesses higher median ages which is a sign of its more pronounced population aging than the corresponding global values.

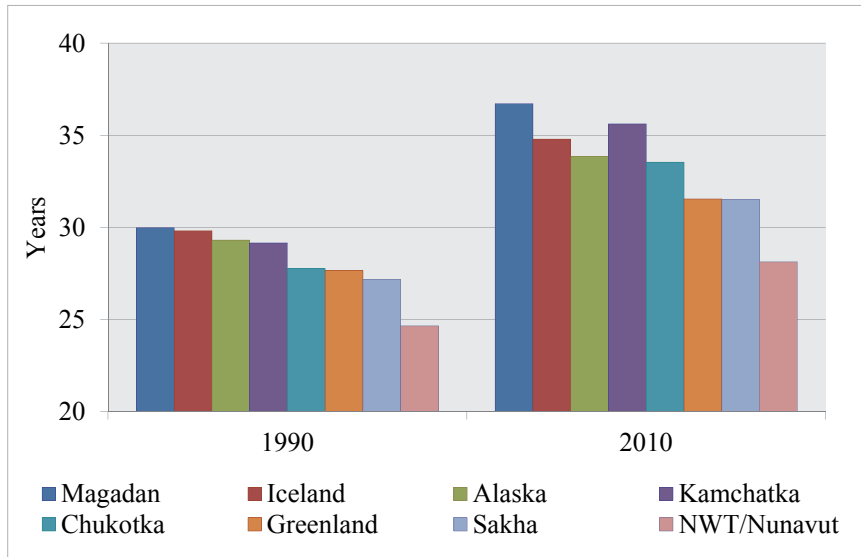
Over the examined period, there has been an evident increase in MAs throughout the Arctic. The male population of Swedish Norrbotten was the only one in the Arctic that had an MA higher than 40 years in 1990 (40.3), but a mere two decades later, already six territories exceeded the 40-year border. For women,

the growth of the indicator occurred at a more advanced speed: in 2010 half of Arctic provinces not only crossed “the 40 line” but now some are even approaching the 50 year old threshold with the maximum MA being found for women living in Lapland (49.6).

Before discussing the distinctions between the territories with the lowest MA values (Fig. 4), one should note the clear differences between Indigenous and non-Indigenous Arctic populations in median age values. All Native groups are largely younger than their non-Native counterparts and in fact there is a correlation which can be found: the more Indigenous Peoples within the percentage of the regional population, the younger will be the MA of that region, on average it will be 10 years less than the MA of a population of non-Indigenous origin. For instance, in 2013, the Inuit of Nunavut accounted for 86% of the population, resulting in MA of the province of 25.4 years for both sexes combined, in comparison to 41 years for the entire Canadian population. In that same year in Canadian NWT, half of the population was non-Indigenous (52%), and they had an MA of 32 years. Yukon’s population has the lowest proportion of Native Peoples (23%) and the MA was reported to be 39 years in 2013, almost identical with Canada’s total MA value of 40 years. In the Nordic countries and Russia, ethnicity is not recorded in registers.

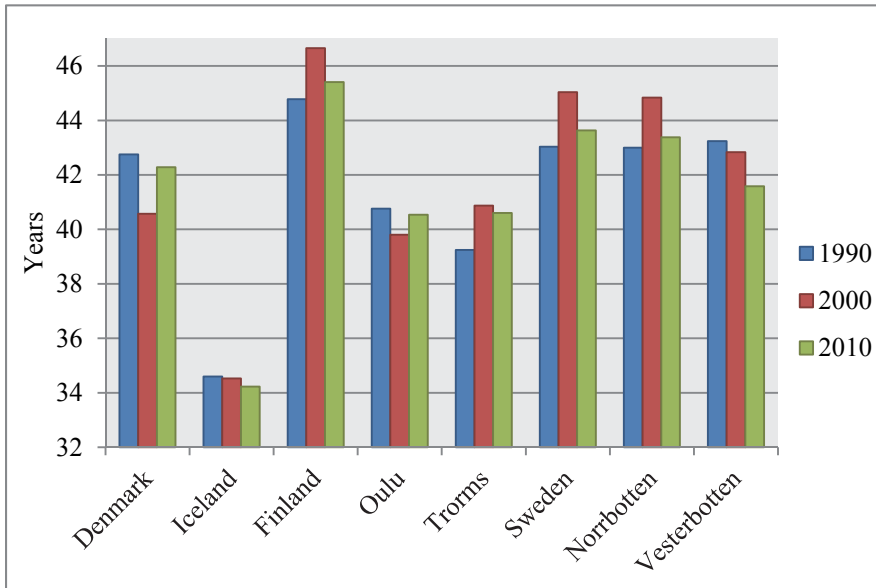
Fig. 4 demonstrates the lowest end of the spectrum but even in these regions there has been a clear growth in MA over the last 20 years. In 1990, eight regions of the Arctic had populations with MA below the age 30. In 2010, only one area was left with this status – joint region of Nunavut and NWT. The other lowest MA values have been found in Greenland, Siberian Sakha and Chukotka, where this may be due to the low percentage of healthy residents.

The Russian Arctic shows on average 10-year values below those of Scandinavia, although they are similar to the North Atlantic and North American counterparts. At the same time, national totals exceeded the median ages everywhere except the Nordic countries. In contrast to the north of Russia, which has an asymmetric imbalance between the sexes of up to six years in favour of women, there are no significant differences detectable between male and female median ages in the North American Arctic. Male MAs have even risen in Northern Canada and Greenland, while female MAs are rather similar to the rest of the NAA, North Atlantic, and Norwegian Finnmark, between 1980 and 2010.



**Fig. 4. The lowest Median Ages among Arctic territories at a cross-cut of “30 years old”, sexes combined, 1990 vs. 2010 years. Information based on the updated results from Articles I–IV.**

Depending on which indicator is being used, the territories with the highest MA changed. In the North America, from 1980 to 2010, the MA leader changed from the US to Canada. PMA has been derived from the life table where the remaining LE is the same as it is at the median age in the reference year (Sanderson & Scherbov 2008), in this case according to the standardized to the life tables of Iceland 2005. Canada as a country continued to have the highest PMA rate for females, whereas male PMA became the leader in the northern region, Yukon. Indeed, Yukon and Alaska reached the values near to that of the national level of Canada and the US in 2013, due to aging of the relatively large baby boomer populations, whereas the gap to the national rate widened in NWT and Nunavut. The Nunavut population experienced dramatic growth of inequality, especially with regard to women. As stated above, female MA was 16 years lower than in Canada as a whole in 2013, having risen from an earlier gap of eight years in 1980 when Nunavut was still part of NWT. The gap in MA of women of the North America is larger than that of men when compared to the national average rates, which was similar in another population of the Arctic, Greenlandic Inuit.



**Fig. 5. Arctic countries and territories with reversals of Prospective Median Ages, sexes combined, 1990–2010. Information based on the updated results of Articles I–IV.**

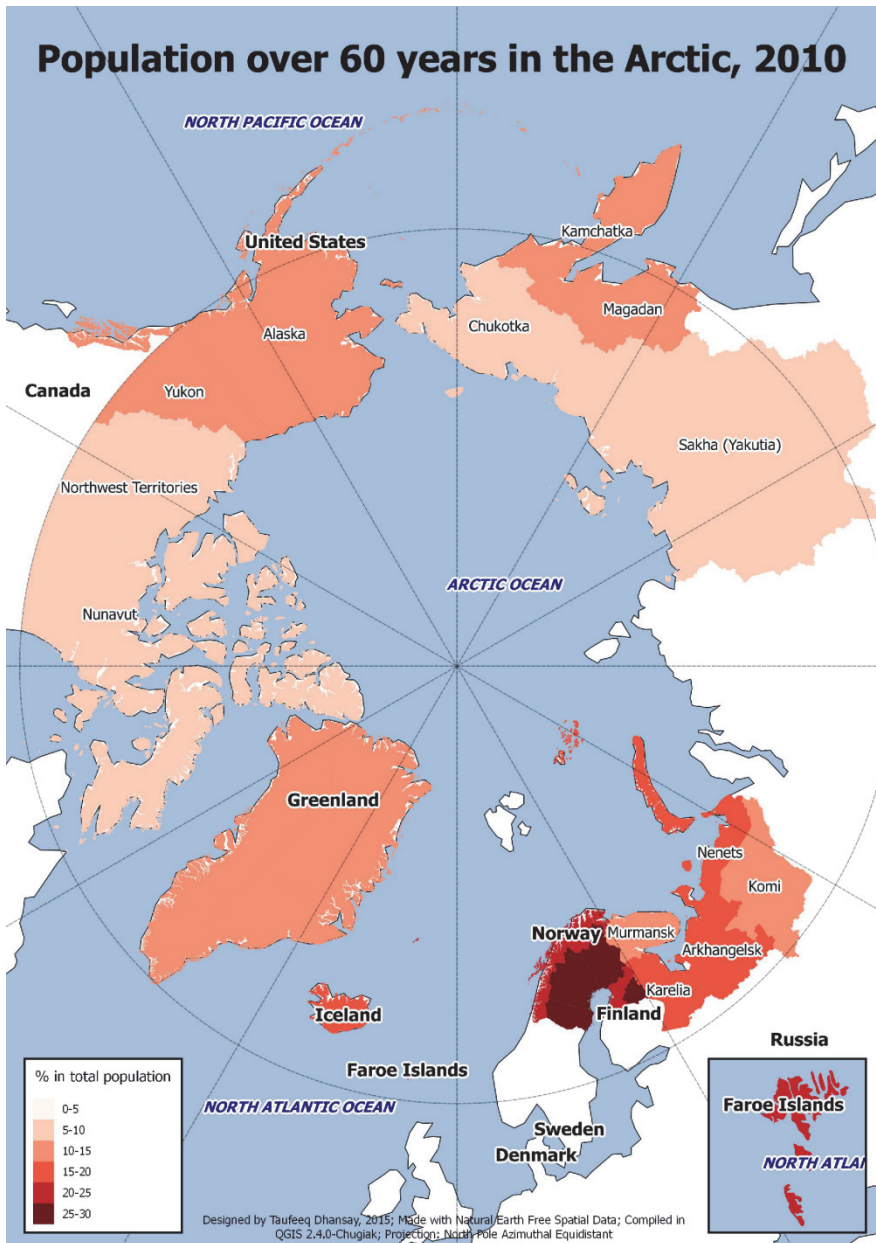
The temporal trends of PMA increases are several fold slower than if they are estimated by traditional MAs. Within the Arctic Circle, most of the PMAs displayed values which exceeded the retrospective MAs. In the latest values from 2010, the difference between 2010-year rates of standard and PMAs narrowed, and MA became slightly higher for the Faroe Islands and Iceland, and Scandinavian Arctic, excluding Norwegian Finnmark. The reason for this phenomenon is illustrated in Fig. 5, PMAs have reversed for the Nordic part of the Arctic after the 2000s due to extensive increases in life expectancy. In contrast to the situation in Russia, the growth of prospective MAs has been striking and faster than the growth of traditional MA values. The PMA for the combined Nunavut and NWT has remained the lowest during the period, in 2010, showing an almost a 10-year difference with its neighbouring Yukon. This is important for policy-makers since it means that measuring median ages prospectively e.g. taking into account major increases in life expectancy, can lead to a different perspective i.e. that there is a slower increase in actual aging. The policy adjustments in this case can be planned appropriately, avoiding unjustified fear of excessively rapid aging.

## **3.2 Head-count intergenerational indicators**

### **3.2.1 Proportions of older adults**

In this sub-chapter, the results are presented as they relate to a particular group in the age structure, older adults. The background information about age structure patterns can be found in Articles I–IV and this can be very useful to interested parties such as policy-makers. Devising local or national demographic strategies requires verified information on how large the actual proportion of older people is in any given society, in particular in the light of new activities in the Arctic and the potential new cohort of incoming workers moving into the North.

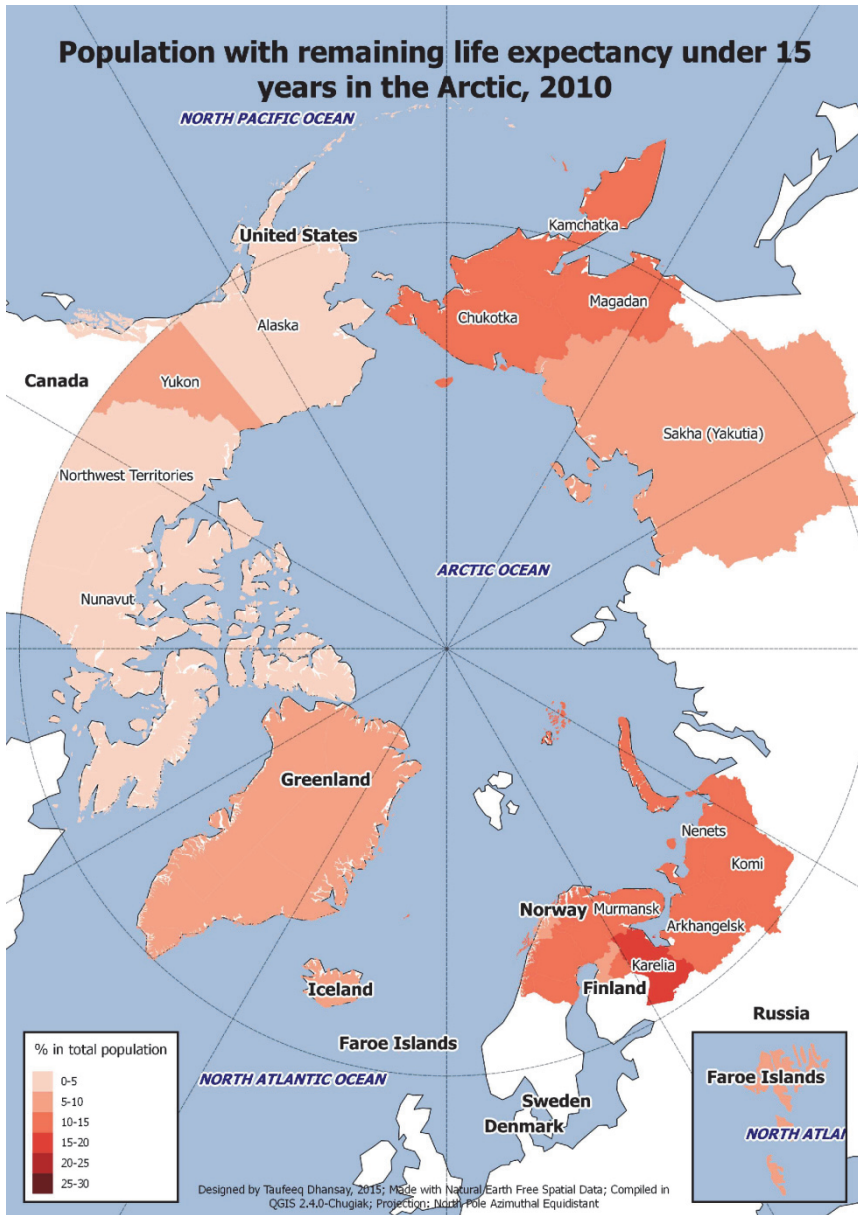
As with most of the studied demographic indicators, there are significant variations among Arctic territories in terms of share of older persons. The maps below provide the first glimpse of the 2010 situation, comparing the proportion of people over the age 60 (Fig. 6) to the proportion of people with remaining life expectancy 15 years and less (Fig. 7), as a per cent of the total population. By 2010, the Arctic Prop 60+ rates rose to a rate of 17% as the average for the region, much higher than measured with Prop RLE 15- which gives a value of 11%. In view of this large difference i.e. between 11 and 17 percentage points, our understanding of how fast the Arctic is actually aging can be significantly altered by adopting the prospective method.



**Fig. 6. The Arctic's proportions of population aged 60 years and over, sexes combined, 2010, % of total population.**

As seen from Fig. 6, Chukotka, Sakha, NWT and Nunavut have the lowest shares of Prop 60+. The graph highlights the changes in these youngest territories to the NAA. At the same time, there has been no change among the oldest territories when applying either the conventional or the prospective approaches: the Swedish and Finnish Arctic, except for the Oulu region of Finland which has the highest share of children and youth in its age structure due to high birth rates, a thriving educational sector, and innovation oriented economic sectors that attract young and middle-aged professionals.





**Fig. 7. The Arctic's proportions of people with remaining life expectancy 15 years and less, sexes combined, 2010, % of total population.**

In addition, Table 3 reveals that the 2010 Arctic values have been on a clear uptrend since 1990: Prop 60+ increased from 11.8% to 17.1% while Prop RLE 15- increased from 8.3% to 10.7%, the latter representing dynamics of change that are twice as slow. In the prospective calculation, the Faroe Islands, all Nordic areas, and most country-wide values (except Russia) have revealed the “de-aging” trends over the period. With respect to Russia, the situation is that before 2000, the female Prop RLE 15- increased for half of the region (Karelia, Arkhangelsk, Komi, and Sakha) and after that declined, which reflects the sharp change in demographic situation between the “transitional” period of the 1990s and the following 2000s. Both methodological approaches, however, reveal that the Arctic has been below the national averages. At the same time, the analysis indicates that Arctic populations are tending to catch up to national rates, especially for Prop RLE 15- as the nationwide rates were only declining (Table 3).

**Table 3. Share of older persons<sup>1</sup> in the Arctic vs. nationwide average of Arctic countries, % of total population, 1990–2010. Summary of the updated results originating from Articles I–IV.**

Sex	Year	Arctic territories		National rates for Arctic countries (nation-wide average)	
		Prop 60+	Prop RLE 15-	Prop 60+	Prop RLE 15-
<b>Total</b>					
	1990	11.76	8.28	18.60	12.78
	2010	17.11	10.66	21.39	11.14
<b>Male</b>					
	1990	9.76	8.42	15.66	12.23
	2010	15.11	11.27	19.16	10.71
<b>Female</b>					
	1990	13.76	8.14	21.53	13.32
	2010	19.11	10.04	23.61	11.56

<sup>1</sup> Share of older persons is shown with two indicators: Prop 60+ = Population aged 60 and over divided by the population total of all age groups, Prop RLE 15- = Population in age groups where remaining life expectancy is 15 years or less divided by the total population

The 60+ aged group of the NAA and Greenland is proportionally divided between the sexes. In the total age structure of these areas, there is a slightly higher number of men than women. In the total US and Canada, however, there are more women than men. From the broader Arctic perspective, male and female older populations in many areas have changed from having a negligible to significant sex gap. The Nordic Arctic territories (except Finland) show 2–3% higher rates in favor of

women; in Siberian Russia and Finnish North, women outnumber men by 5%, when this is assessed by Prop 60+ with the largest difference found in the European North of Russia, 10% higher female proportions. The Prop RLE 15- demonstrates the opposite: less difference between the sexes in 2010, and even a slight predominance of males in Yukon, Lapland, Kainuu, Karelia, and Murmansk, among those who survived the threshold of 15 years remaining to live.

This sub-chapter clearly shows how chronological and prospective methods often reveal not only complementary, but in fact contrasting evidence that may require different policy solutions for these societies. For instance, prospective evidence suggests that the policy focus needs distinctive adjustments for the Arctic sub-regions since these areas differ from the country-wide trend i.e. most of the national values of aging “rejuvenate” while the values in the North continue to grow. Moreover, the fact that there are more older women than men requires that this imbalance must be reflected in the provision of female-emphasized care and other services targeted to older female customers, but efforts need to be expended towards achieving better survival rates for men into old age.

### **3.2.2 Elder-child ratios**

In aging studies, it is important to examine ratios that take into account both the numbers of older people and those of the young, as it shows how the latter group subsequently replaces the older generation. In this thesis, two indicators were used to measure elder-child ratios i.e. the Aging Index and Prospective Aging Index. The AI shows interplay between the populations older than the age of 60 and the youngest cohort below 15, meanwhile the PAI considers its older group as the population with remaining lifespan of 15 years and less. This thesis is the first publication that has compiled a comprehensive dataset on AI and PAI for the Arctic territories and countries, not yet computed by other researchers or statistical agencies.

Population aging according to the AI is constant and the index is rapidly growing in most of the places worldwide (Gavrilov & Heuveline 2003, Bucher 2014). In the Arctic, some regions have experienced a striking increase in only a few decades, e.g. the value of the AI ratio has grown for male population of Yukon from 21 in 1980 to 101 in 2013, for females in the Magadan region, the change in AI ratio is from 18 to 108 for the same years. The growth reflects a rapid societal change among fertile-age women who have started to make childbearing choices. This invariably leads to a re-distribution of children and older adults in the age

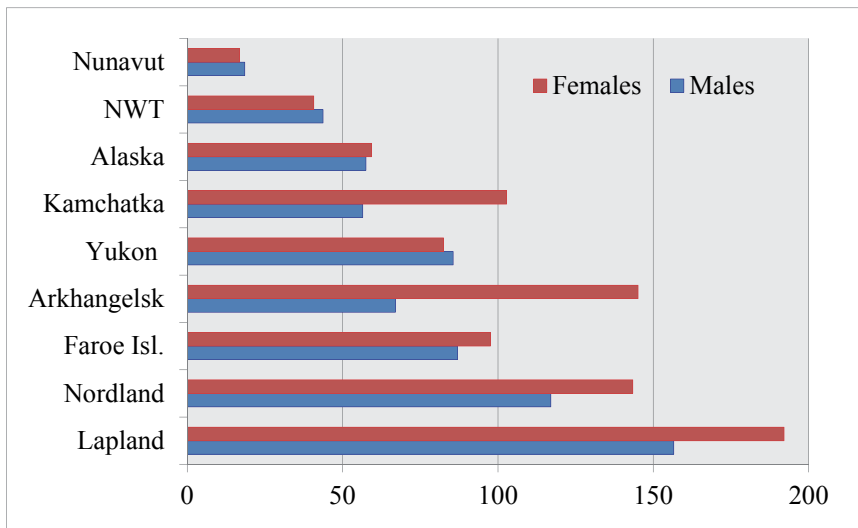
structures. Therefore, the context behind Aging Index is built upon regional fertility rates. The regions with the highest AIs, almost a third higher than the nationwide rates, have experienced a sharp decline in local birth rates. All other Scandinavian territories of the North (except Oulu) as well as the neighbouring Russian Karelia (female population) show the same pattern – being more than the national averages (Articles I–II). At the other end of the spectrum, there is a large gap between Arctic AIs and the averages of their respective countries, displaying a sevenfold difference in the case of Nunavut and Canada (20 vs. 132, 2013) due to increasing numbers of births in the predominantly Indigenous Arctic region.

Following the finding that the AI rates have been growing, the second observation is there are vast AI differences between the territories of the Arctic. In 2013, the highest AIs crossed the 200-rate, which is a very high bordering value from a global perspective; this was found in Finnish Kainuu (200 for men and 244 for women) and Swedish Norrbotten (181 and 210 respectively for sexes). This is a reflection of a rather unbalanced age structure i.e. it means that there are 244 older women for every 100 girls no older than 15. The implications can be positive, such as a high availability of carers for grandchildren, better financial security for the children as their grandparents need to support fewer descendants. On the other hand, this demographic condition can certainly influence and often stagnate future development of the area from the point of view that there are simply not enough young people. Nonetheless with this evidence, the policy-makers may be obliged to redistribute public funds toward pensions and elder care spending, so that less is available for services aimed at children.

In contrast to these over 200% rates, the North Atlantic had a ratio at 80 in 2013, 60 in the Arctic of the North America, and in the Russian North the ratio was 50 for men and 100 for women. These kinds of index's values indicate that the younger age structures are greater than the older ones, but unfortunately a lack of child care services and not enough activities for youth can be found in these regions. Thus, policy-makers may consider initiating more programs to support the very young from both the short and mid-term perspectives.

The third observation is that Aging Indices have only been higher (marginally) among men in the Canadian North and only recently in Greenland. Both the Greenlandic and Canadian populations have shown a larger share of boys than girls in the age range of 0–15. In all of the other regions and Arctic countries, the AIs have remained higher for women (Fig. 8).

**Fig. 8. The Arctic's Aging Index for male and female populations, selected regions, 2010, %, based on the updated results detailed in Articles I–IV.**



In further observations for AIs, all territories' shares grew, but when assessed with prospective indices, then clear declines were registered, especially for the female population. The Faroe Islands, Oulu, Norwegian and Swedish Arctic have been getting younger, as revealed by the PAI. This means that these regions have a better potential to enjoy balanced future age structures, and this conclusion is opposite to the evidence estimated by a simple chronological indicator. These areas are also following the trend of nationwide decreases in the PAIs, which is the case in all Arctic countries except Finland and Russia.

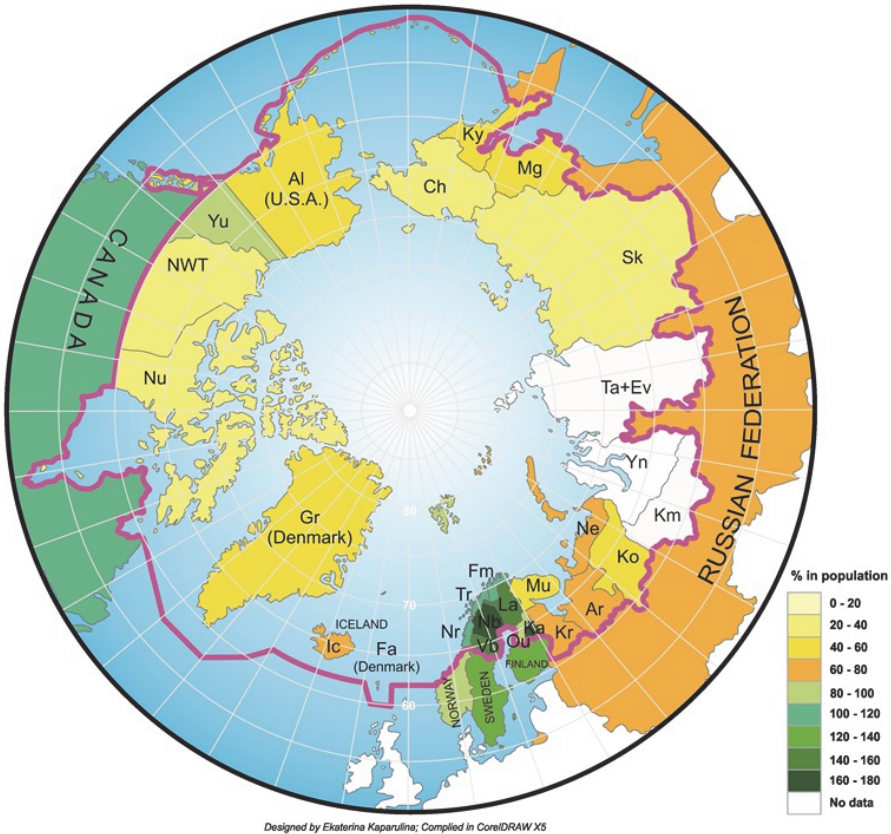
When considering increases in life expectancy with the methodology used, PAI also demonstrates different speeds at which the regions have been getting older (Articles II–IV). In 1990, NWT and Chukotka were both the lowest, but in 2010 the PAI value of NWT had increased only very slightly whereas Chukotka's rate underwent extreme growth, 13-fold increase in the female rate (from 6 to 78) and a sevenfold increase for male PAI value (from 5 to 31). The growth of the index in the Russian Arctic is the steepest in comparison to other areas, exceeding the values of conventional AIs. The reason was a sharp change in the proportions of children and the oldest people who had less than 15 remaining years of life. In that region, the PAI is widening against a background in which fertility in the Russian northern territories experienced a major decline. The crude birth rate (per 1000 population)

has decreased, especially in Karelia and Siberian Arctic, and it is now below the total national rate for the first time in the observation time period. As another example, the 1970 rate in the Russian Arctic (studied regions) was 17 births per 1000, higher than national average of 14.6. In 2013, the national average (13.2) now slightly exceeded that of Russia's Arctic regions (13.0) (The Russian Federation Federal State Statistics Service 2015). However, Komi and Sakha still have birth rates which are above the national average.

In almost every territory, the difference between the North and the all-national PAI rate was larger in the 1980s, for instance, the US and Alaska, Canadian North and Canada were divided by a near triple PAI-difference, and this has undergone a significant convergence in three decades. With respect to the gap within the Arctic, it varies from region to region, worsening in the North America, but showing a convergence in the North Atlantic. Fig. 9 and Fig. 10 show a visual representation of 2010-year AI vs. PAI elder-child ratios in the Arctic.

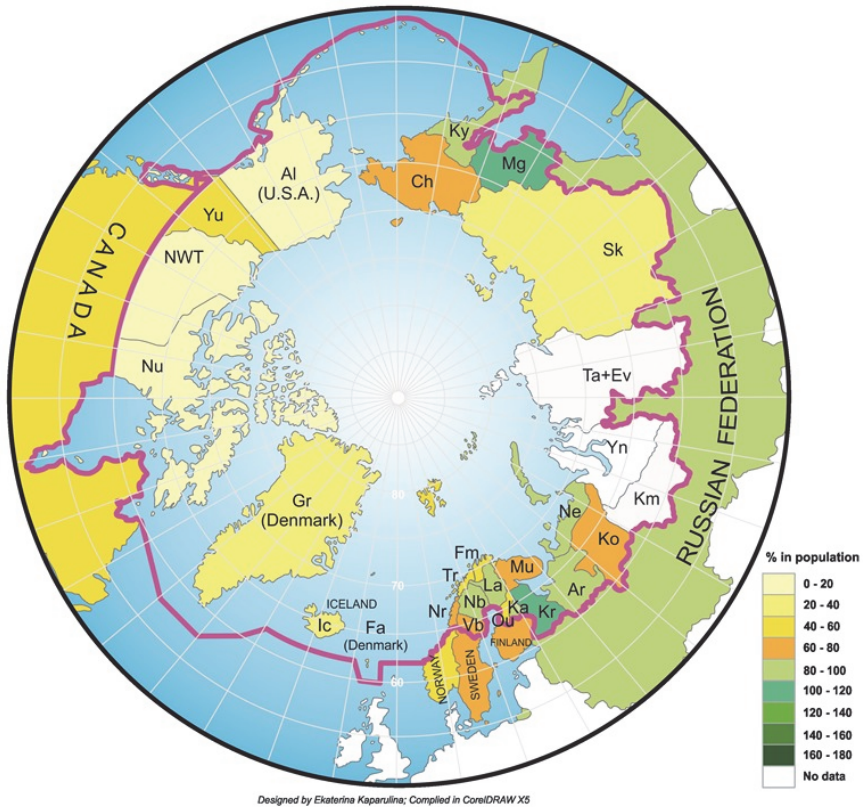
Finally it is worthwhile noting that sex variations have diminished if one applies the prospective calculation. If the traditional way of assessing AI is used, then Iceland and the Faroe Islands have much older female populations. However, if one utilizes PAI, then the difference between the sexes almost totally disappears. It is clear that depending on which methodological approach is used it can have significant implications, for example affecting important policy decisions, i.e. a more female oriented emphasis in the case of the reference to the AIs, and a more gender-equal approach if conclusions have been based on the PAI evidence.

## Aging Index in the Arctic, 2010



**Fig. 9.** The Arctic's elder-child ratio as measured with chronological Aging Index, sexes combined, 2010, % in the total population, based on the updated results from Articles I-IV.

## Prospective Aging Index in the Arctic, 2010



**Fig. 10.** The Arctic's elder-child ratio as measured with Prospective Aging Index, sexes combined, 2010, % in total population based on the updated results from Articles I–IV.

### 3.2.3 Old age dependency relations

A relevant common measure of population aging is the old-age dependency ratio, which is the number of individuals of retirement age, the age when this population group can become economically inactive – 60 years and older – compared to the number of those of working age. This demographic/societal value may help in assessing wealth and assets transfers between generations, taxation policies, and saving behavior (Gavrilov & Heuveline 2003). On the grounds of the OADR



calculations, it was conceptualized how aged people are dependent on the middle-aged population in the different parts of the Arctic (Articles I–IV).

The context forming the current OADRs in the North Atlantic reveals the fact that the young-age dependency ratio is highest in Iceland, Greenland, and the Faroe Islands compared with other Nordic countries. Indeed, the latest data from the year 2013 reveal that the Scandinavian Arctic has the highest old-age dependencies (Kainuu, Lapland, and Norrbotten), and on average, a 10% higher OADR than in the North Atlantic. However, there is a serious imbalance between the sexes in the Finnish, Swedish, and Norwegian Arctic (42% of male index vs. 51% of female OADR). This is not seen in the North Atlantic where there has been a serious, unfavorable and still upward trend of migration of young women to other economically prosperous areas and countries. This led to the index equalization, an OADR average of 36 for either sex in 2013 while in 1980, the number of female pensioners dominated and the index was equivalent to 21% of its labor force vs. 17% of male OADR.

The 2013-year picture differs from that of the beginning of the studied period in some parts of the Arctic (Articles I–IV). Alaska and Yukon reached the fastest OADR growth. In the Russian North, the fastest OADR growth is evident in Siberian areas, which are rapidly catching up with the European Arctic of Russia. The three highest and lowest old age dependency rates can be examined in Table 4.

**Table 4. The highest and lowest chronological and prospective old-age dependency ratios in 1990 and 2010, % in total population among Arctic territories and countries based on the updated results of Articles I–IV.**

Sex	The rate's position	Territories/Countries with the highest rate		Territories/Countries with the lowest rate	
		1990	2010	1990	2010
Total	OADR <sup>1</sup>				
	1 <sup>st</sup> place	<b>38.4 Sweden<sup>2</sup></b>	53.4 Kainuu	2.2 Chukotka	9.3 Chukotka
	2 <sup>nd</sup> place	37.5 Vesterbotten	50.7 Norrbotten	5.2 Magadan	11.0 NWT/Nu <sup>3</sup>
	3 <sup>rd</sup> place	36.3 Nordland	47.1 Lapland	6.2 Kamchatka	13.3 Sakha (Yakutia)
Total	POADR				
	1 <sup>st</sup> place	22.6 Vesterbotten	23.8 Karelia	2.2 Chukotka	4.6 NWT/Nu
	2 <sup>nd</sup> place	<b>22.0 Sweden</b>	<b>21.7 Russia</b>	3.9 NWT/Nu	7.5 Yukon
	3 <sup>rd</sup> place	21.1 Nordland	21.3 Arkhangelsk	4.4 Yukon	10.9 Sakha (Yakutia)
Male	OADR				
	1 <sup>st</sup> place	33.1 Vesterbotten	45.7 Norrbotten	1.6 Chukotka	8.1 Chukotka
	2 <sup>nd</sup> place	<b>32.9 Sweden</b>	45.6 Kainuu	3.3 Magadan	10.3 Murmansk
	3 <sup>rd</sup> place	30.7 Norrbotten	42.0 Lapland	3.5 Kamchatka	10.4 Sakha (Yakutia)
Male	POADR				
	1 <sup>st</sup> place	24.5 Vesterbotten	27.0 Magadan	2.4 Chukotka	4.8 NWT/Nu
	2 <sup>nd</sup> place	<b>22.4 Sweden</b>	26.1 Chukotka	4.8 Yukon	9.0 Yukon
	3 <sup>rd</sup> place	22.2 Nordland	25.6 Karelia	4.9 NWT/Nu	<b>11.3 Canada</b>
Female	OADR				
	1 <sup>st</sup> place	<b>43.9 Sweden</b>	61.2 Kainuu	2.8 Chukotka	10.4 Chukotka
	2 <sup>nd</sup> place	42.0 Nordland	55.7 Norrbotten	6.6 NWT/Nu	10.7 NWT/Nu
	3 <sup>rd</sup> place	42.0 Vesterbotten	52.3 Lapland	7.1 Magadan	16.1 Greenland
Female	POADR				
	1 <sup>st</sup> place	<b>21.6 Sweden</b>	<b>22.2 Russia</b>	1.9 Chukotka	4.4 NWT/Nu
	2 <sup>nd</sup> place	21.3 Nordland	22.0 Karelia	3.0 NWT/Nu	5.9 Yukon
	3 <sup>rd</sup> place	20.8 Vesterbotten	21.1 Arkhangelsk	4.0 Alaska	8.7 Chukotka

<sup>1</sup> Old-age dependency is shown with two indicators: OADR = Old-age dependency ratio as the number of people 60 years or older divided by the number of people aged between 15 to 59, POADR = Prospective old-age dependency ratio as the number of people older than the old-age threshold (remaining life expectancy of 15 years or less divided by the number of people with ages from 15 to the old-age threshold)

<sup>2</sup> Nationwide values are shown in bold

<sup>3</sup> NWT = Northwest Territories, Nu = Nunavut, the rate is combined for these two regions of Canada

At the same time, the increasing LE in a population that is healthy and disability-free leads to a scenario in which the majority of individuals over the age 60 are less dependent. The problem with the standard OADR is that it does not consider the possibility that the 60+ population is not always dependent: a large proportion of them are still working while other individuals of “working age” do

not necessarily possess a tax-paying job. Therefore, a more reliable estimation of age dependency is made when the age with a remaining life expectancy of 15 years is substituted for the 60-year cut-off in the denominator. The prospective index POADR is this kind of measure since it is based on the group of individuals with RLE 15 years left.

In fact, this study reveals that there are significantly different patterns of aging depending on whether a chronological or a prospective OADR-index is utilized. The gap between conventional and prospective OADRs amplified significantly over the period, as their values were notably closer in the 1980s. The reason is the slower rate of POADR growth. By 2010, the POADR rates have been estimated to be two to three times lower than the conventional OADRs except for Russian males whose rates are higher and have continued to rise.

The 2010-year national POADR rates generally have leveled out except for Russia. This reversing trend contradicts the rates of standard OADRs that have only been increasing rapidly. The Russian exception is attributable to the gap which develops between men and women after their 60<sup>th</sup> birthday. The Russian Arctic is also characterized by the fact that the growth of this index displays much greater dynamism than the nationwide value. In a further comparison to the situation in 2010, national values mostly exceeded the values of northern regions in the North America and North Atlantic, with the exception of the Russian Arctic. The national POADRs appeared below of the 1980/1990 rates. The same down-aging happened in the Faroe Islands, Norwegian and Swedish Arctic, and this is the opposite of what would be expected of these populations which would be considered as very aged with conventional OADRs.

Table 4 confirms that many territories from the top of the POADR table were replaced with Russian areas. The Greenlandic index, measured prospectively, has been only growing consistently. A high dependency ratio adjusted to prospective age can cause challenging problems for a region if a large proportion of total governmental expenditure is devoted to health care and old age social security, which are most used by the oldest citizens in the Russian and Greenlandic communities of the North. The same is similar for the corner of Fennoscandia. Traditionally the oldest territories Lapland and Kainuu have suffered an increase in the POADRs.

The cases of Russian and Nordic Arctic reveal specific patterns of sex-specific POADRs. Siberian Chukotka and Magadan reached highest dependency for the male index in 2010, but have one of the lowest values of this index for females. Meanwhile, Arkhangelsk and Karelia from the European part of Russia are near the

top of the female POADR table (Table 4). This emphasizes the fact that there are major sex-related and geographical differences and it is essential to estimate dependencies separately for men and women. Other examples of sex-related differences can be found in Iceland, Finnmark, and Norrbotten where male POADRs have more frequently decreased, while the female populations of the same regions have undergone index increases.

With regard to sex related patterns, chronological vs. prospective analysis revealed a change in aging “leader” among sexes in 2010. With chronological OADR, the female population has shown higher dependency in total Canada, Alaska, and the US, while the three northern provinces of Canada indicate higher dependency for males over the age 60. However, if one utilizes the POADR approach, then men dominate in every territory with women taking the lead only in the 2000s, and only in the all-national rate. In relation to sex-divided findings, the Arctic regions may best benefit from the types of policies that balance intergenerational ratios, but this will mean planning the actions separately for men and women since sex-specific dependency rates have been so different.

Similarly, many changes happened in this relatively brief 20–30-year period, signifying the rapidly evolving nature of dependencies on age; these need to be considered in planning long-term social programs. An aging population increases the demand for the provision of certain public services and these may entail structural changes e.g. the recruitment of qualified gerontology specialists, although this can be a major challenge for small island communities in the High North, especially those in the North Atlantic and Canadian Arctic.

## **4 Discussion and concluding remarks**

In this chapter, the context of demographic conditions of Arctic territories is broadly reviewed, in an attempt to answer the research question of whether the Arctic is distinct in its demographic development. The driving causes of aging are considered for the four larger regions: Fennoscandia, Russian Arctic, North American and North Atlantic Arctic. The second research question was “is the Arctic distinct in many regards but rarely in its aging patterns” is answered by presenting major trends in aging and looking at the interactions of five chronological and five prospective indicators. The interpretations concentrate on what they have in common and how differently they estimate the population aging development.

Particular attention is paid to identifying the oldest and youngest territories, linkages between the Arctic and nationwide rates, the fastest and slowest regions that are aging (or in contrast, rejuvenating), sex differences, and whether the territories of the Arctic are converging or diverging in terms of their aging development. The overall results emphasize that the Arctic is not a homogenous region in its aging development. However, the Arctic’s aging is distinctive with regard to the corresponding national patterns. The final part is a summary with recommendations on how this thesis data can be applied in policy and statistics, as well as identifying the gaps in knowledge and prospects for future research.

### **4.1 Variety of driving forces behind population aging in the Arctic**

Significant differences in the background causes of aging are apparent among and within the larger regions of the Arctic (Table 5) as the conditions in which these four groups of northern populations have grown older vary extensively. In many respects, their only common characteristics are harsh climates and low population densities, inhabited by more men than women, with higher than normal population mobility. It was addressed in Articles I–V that “not only does the degree of population aging vary considerably between areas, the relative importance of different components of change also tends to shift” (Moore & Pacey 2004: 10). There are also a few general trends, for instance the major impact of migration.

Regional migration has proved to be a significant driver of population change and the aging process during the last century for the Arctic, although this migration was associated mainly with the character of the labor market in its different territories, usually as waves of industry-based booms, rapid expansion of natural

resource exploitation, as well as military and defence projects in the area (Southcott & Huskey 2010, Heleniak 2014, Heleniak & Bogoyavlensky 2014). The drivers of mobility have differed in the 1980s, 1990s, 2000s, and in the present day. Indeed, before the studied period began, the North had served as a military base during the Cold War, the Korean and Vietnam Wars. In the 1970–1980s, huge national projects such as the building of oil pipelines and extensive drilling attracted another large cohort of young workers into the Arctic. This brought a mass inflow of male workers into the region, in particular to the Canadian North and Alaska, Russian North and more recently to the North Atlantic area. Later in the 1980–1990s, the energy and industrial forestry and fishing sectors suffered slow-downs and many inhabitants of productive age moved away from the region. At the same time, despite the often shifting and temporary nature of the work in the Arctic, a large number of migrants settled down in these northern communities. Furthermore, higher education in the North flourished (1990s) and encouraged young people to stay and move within the region.

There has been a major trend of female out-migration from the North Atlantic as these women sought higher education and better employment opportunities (Article IV), together with the generation of baby-boomer arrivals that reached their pension age in the 2000s. These factors have accelerated population aging and provided often a slightly dominating “male” face of aging in the studied areas. At the same time, out-migration of people of child-bearing age combined with the excessive mortality of men in pre-retirement and early old age in the Russian Arctic caused a significant anomaly such that there is a dominance of older women in its demographic portrait (Article II).

Thus, increasing regional activities and more opportunities for travel, education, employment and social inclusion (Article V) have meant that the northern populations which for centuries have been small in numbers and sparsely settled, were dramatically affected by migration inflows. The migration and accompanying globalization to a varying degree led to non-traditional lifestyles that altered birth and family choices as well as altered causes of morbidity and mortality: this represents the world of combined demographic and epidemiological transitions. It is not clear if the migration will remain positive or negative in the different parts of the Arctic, as migration can be highly sensitive to international collaboration and financial crises. For instance, in-migration was quite significant into Iceland until the financial crisis of 2008 which was accompanied by challenges to the fishery industry (Hansen *et al.* 2011). Most recently, financial constraints, regulatory changes, and political conditions, such as the sanctions against Russia and

environmental campaigns, have caused a number of the largest commercial companies to back away from plans to explore and exploit the natural resources in the Arctic. This may reduce the impact of the incoming work force on population aging.

**Table 5. Drivers of aging in four larger sub-regions of the Arctic, 2010.**

	Northern Fennoscandia	Russian Arctic	North American Arctic	North Atlantic Arctic
Fertility	Lower fertility, above national average except in Norrbotten (the highest in Oulu and Lapland around 2.0 children per woman)	Lower fertility, above national average except in Murmansk, Magadan (the highest in Yakutia, 2.0 children per woman)	Higher fertility around replacement level, above the national average (the highest in Nunavut, 3.0 children per woman)	Higher fertility around the replacement level, above national average (the highest in the Faroe Islands, 2.5 children per woman)
Migration	Largest migration to Norwegian Arctic, outmigration from Norrbotten	Out-migration from all Arctic regions	Positive migration to Alaska, Yukon	Profound out-migration of females, in-migration has been high before the 2008-fishery/banking crisis
Life expectancy at birth	Among the highest in the world, 1 year below national average except for Oulu, Lapland, Troms	Closer to less developed countries, 3 years below national average (lowest in Chukotka)	5 to 7 years below national average except for Alaska (similar to nationwide) (10-year difference with Nunavut)	Among the highest in the world in Iceland, Faroe Islands is 2 years above but Greenland is 8 years below their national average

In addition to net migration, the mortality-fertility balance is another driver of aging in the Arctic but this is less affected by global economy and political events. Most Arctic territories have now transitioned to a later stage in demographic development, with low birth and death rates, meaning that the difference between births and deaths is rather low and sometimes negative. Nonetheless, these rates are comparatively higher than national averages, especially in the areas with large Indigenous populations. Most recently, the fertility rate in the Arctic has ranged

from 3.0 children per woman in Nunavut, with Alaska and the Faroe Islands also above replacement level, to the lowest values of 1.7 in Yukon, Norrbotten, and 1.3 in Murmansk.

The index of fertility at a replacement level (roughly 2.1 children per woman) seems to be encountered only in two North American regions, Nunavut and Alaska as well as in North Atlantic Faroe Islands and Greenland, and the Russian republic of Sakha. All in all, at the turn of the century, fertility rates have undergone a decline throughout the Arctic. In Yukon, NWT, and Norwegian Arctic - fertility is at a level which is below replacement but above the national average. Iceland has also one of the highest fertility rates in Europe. There are also the areas below both replacement and national levels, namely Norrbotten in Sweden. The lowest-low fertility, as already stated, was found in the Murmansk region of Russia. It is clear that fertility is a strong determinant of future population growth, often associated with prosperity when it remains high, but the opposite if it is low since this leads to population decline and population aging. In the Arctic, in general, the fertility rates will cause a slight decline of its population but this will occur relatively slowly (Larsen & Fondahl 2014).

Mortality trends for the Arctic populations have been widely examined in the thesis through the prism of LEs at birth and at older ages. The inclusion of gender and ethnic patterns of mortality revealed a rich diversity in life expectancies. Most of the countries have exhibited progressive growth of LE during the past three decades due to improvements in population health (Caldwell 2001) and the Arctic territories are not an exception. During the previous century, there were huge improvements in health due to vaccination and drugs to combat infectious diseases and other causes of mortality, improved sanitary conditions, better food hygiene, and overall improved public health. In addition to this general trend, the Arctic exhibits specific patterns of longevity e.g. in comparison to their respective countries. For example, mortality and life expectancies in several regions of the Russian Arctic (Murmansk, Kamchatka, Magadan, Chukotka) and Greenland are about the level of the less developed countries, whereas due to low mortality, the LEs in Iceland, the Faroe Islands, and Arctic regions in Fennoscandia are among the highest in the world (Larsen & Fondahl 2014). The variety of such drivers determined the interaction of aging indicators examined further below.



## **4.2 Aging indicators and their interactions**

Given the growth rate of the senior population and the fact that many Arctic territories have previously been one of their countries' youngest provinces, aging change has developed faster in northern territories of Arctic countries than in middle and southern latitudes of the same countries. But at the same time, population aging cannot be considered as uniform in the Arctic, - substantial diversity was detected among the 23 Arctic territories, underpinned by both regional factors and the methods applied. There are territories that lag considerably behind nationwide rates or have quickly approached and even exceeded national averages in some parameters of aging.

According to the aims of the study, key conclusions can be drawn for the following five sub-topics: regions "leading" and "lagging" in aging; dynamics of aging change; variation between the sexes; the Arctic and the national averages; and cross-territorial gaps.

### ***4.2.1 Regions "leading" and "lagging" in aging***

In a nutshell: Chukotka and Nunavut have been found to be the absolutely youngest populations in the Arctic, perhaps as a consequence of their Indigenous age structure at an earlier stage of demographic transition and heavy out-migration of population of all ages; in this parameter, these two regions are followed by Siberian Sakha and Magadan as well as Greenland and Alaska. The oldest regions have been Kainuu and Lapland of Finland as well as Swedish Norrbotten and Vesterbotten.

Changes have occurred in the rank order of leading and lagging regions over three decades, once the traditional method of aging is replaced with the prospective approach. If it is measured in the traditional manner, then the leading or oldest territories of 2010 are found in Fennoscandia: Kainuu and Lapland of Finland as well as Swedish Norrbotten and Vesterbotten, having the lowest fertility rates. However, if one compares the rates of 1990 and 2010, then Kainuu, Lapland, Norrbotten, and Nordland, as well as Canadian Yukon show the largest gains in the conventionally measured rates. Noticeably, all conventional indicators are unanimous in the distribution of the top leading and lagging regions, with minor variations in the middle of the range.

If one considers the year 2010 aging lagging areas, then Chukotka and Nunavut are the absolute youngest in the Arctic as a possible consequence of their Indigenous dominated age structure and pronounced out-migration of the residents.

These regions are followed by Siberian Sakha and Magadan, Greenland and Alaska which also are in the group with the youngest populations. They show the aging rates three to five times lower than that of the oldest territories. There are minor shifts from the situation of the 1980–1990s: the Finnish North was much younger and instead, Norwegian Nordland as well as Swedish Arctic territories were in the top “oldest” five. However, the youngest regions were the same, although also Kamchatka was found in this index. The gap between the oldest and youngest areas was more significant at the beginning of the period; the differences which ranged from six to eight fold between the lowest and highest rates of standard indices have diminished over time.

If one compares the averages (chronological rates) of the four larger regions of the Arctic, the range from the oldest to the youngest has remained the same throughout the period: the Scandinavian part of the Arctic continues to be the oldest, followed by the North Atlantic, then the Russian North, with the NAA being the youngest. The Russian North is only the youngest in life expectancy related measures (LE0 and Age RLE 15). In the comparison between the older Russian European and younger Siberian Arctic, the latter would be awarded the lowest positions in Prop 60+, AI, and OADR.

Measuring the regional aging with prospective indices, a striking difference emerges from the PMA calculations. Northern regions of Russia occupied the top of the oldest rank order in 2010, even exceeding the all-Russia rate, which was not the case in 1990. In addition, when comparing 1990 and 2010, the Russian regions gained the most in the prospective rates. When one uses conventional measurements, values of Scandinavian areas gained the most. Additionally, the North Atlantic, Iceland and the Faroe Islands as well as North American Arctic (except Yukon) had the lowest PMA in 1990, and remained in this position in 2010. PMA is the only prospective indicator the values of which most of the time exceed the standard indicator both for the Arctic and the studied countries. The Age RLE 15 also shows that populations of the Faroe Islands, Oulu, and Lapland enjoy the highest age at which their remaining LE is equivalent to 15, i.e. they can expect to live to ripe old ages, while all Russian regions expect to live for the shortest time. In the comparisons of larger regions, the situation changes accordingly. In the standard way of appraisal, the Siberian Arctic is the youngest, but with the prospective approach, the NAA is the youngest. In fact, when assessed prospectively the Russian European Arctic was the second oldest in 1990, and already the top-oldest in 2010.

#### **4.2.2 Dynamics of aging change**

To sum up: Chronological rates of 2010 appeared to be higher than in the 1990s, signifying population aging. Nonetheless in many regions, the prospective indices of 2010 became modestly lower than those encountered in 1990, especially in Vesterbotten, Troms, Nordland, Oulu, and the Faroe Islands and Iceland. The European Arctic has experienced a faster aging transformation than the American Arctic.

Profound variations are found in the speed and dynamics in which the regions are becoming older during the studied period, but this is subject to the methodological approach in the measurement. Chronological rates of 2010 appear to be increasing if based on values from the 1990s, i.e. there is population aging occurring in the Arctic and corresponding countries. On the other hand, in many regions, prospective indices of 2010 became modestly lower than the level found in 1990, especially in the prospective indices for Vesterbotten, Troms and Nordland, Oulu, and the North Atlantic Faroe Islands and Iceland.

During this period, small decreases for most of the indicators occur, mostly of a prospective nature but also some of which are chronological. Table 6, “Rejuvenation shifts during 1990–2000 and 2000–2010 by indices and sex”, reports in detail the regions in which some of the indices declined, in other words, population rejuvenation. These reversals, however, should be regarded as rather insignificant due to the small decreases in the actual rates (see Appendix 1). The more that indices reverse for a particular territory, the greater confidence one can have in the claim that the population aging process has undergone a setback. For example, the decreases in many indices happened both before and after the 2000s. In the regions of Fennoscandia, rejuvenation trends could be confirmed, more of the indices showed a declining trend from 1990–2000. For the Russian North, aging did not reverse in the 1990s but it did reverse more evidently in the new millennium decade 2000–2010. For a few territories, Greenland, Alaska, Yukon, Lapland, and females of Magadan (cells “x” of Table 6), none of the indices decreased, therefore aging can be regarded as constantly accelerating and as an irreversible process. If one examines the prospectively measured aging rates, then only Age RLE 15 (except for Russia in the 1990s) increased linearly in all of these Arctic regions.

In the standard estimation, the European part of the Arctic has experienced a faster aging change than the American Arctic. Yukon is the fastest aging region in the NAA, as are the Faroe Islands in the North Atlantic, Finnish Kainuu, Lapland, and Norrbotten of Sweden in the Nordic regions, and finally Karelia, Kamchatka,

and Magadan are showing the greatest gains in chronological rates in Russia's Arctic. Chronological AI is the index that displays the steepest increases. At the same time, prospective indicators depict much slower growth in comparison to the corresponding chronological indicators, in some cases converting to a trend towards rejuvenation or "de-aging" (Table 6). The regions that are undergoing the fastest aging transition with the prospective approach are located in the North of Russia.

#### **4.2.3 Variation between the sexes**

In summary: The North American and North Atlantic Arctic have shown higher aging rates for the male population, which is a rare situation in global terms. The possible explanations relate to two facts (1) these regional economies tend to favor male occupations (natural resources, forestry, fishing) and (2) more females migrate permanently away from the Arctic regions (in particular, from the Danish North). The rates of aging have been higher for women in the Russian North and Fennoscandia.

When sex is taken into account, variations between the regions in aging patterns become much more complex. In global terms, women have a higher life expectancy than men and a higher percentage of older females can be found in most countries, especially where there are greater sex differentials in life expectancy. This is not the case throughout the Arctic overall. Regional economies tend to favor more male occupations, therefore higher male–female sex ratios can be encountered in the region (Heleniak 2014). Throughout the 20th century, the region's history was replete in military and industrial build-ups, and booms of mining, exploitation of natural resources, forestry and fishing, described in more detail in this thesis's Articles. Alaska and the Canadian North, have experienced massive arrivals of men who have aged gradually and therefore these show slightly higher aging rates for males. The same situation is found for the North Atlantic, but the reason is not only because the leading employment sector, fishing, is predominantly occupied by men, but also due to a recent considerable mismatch between the numbers of young women leaving and men staying in their North Atlantic homes. More females have migrated permanently away from their island home communities and the region itself (Rasmussen 2005) to pursue education and career, taking away labor skills and potential offspring. More women from Greenland, and to a lesser degree from the Faroe Islands, have moved to Denmark also due to the relatively large number of interethnic marriages between Danish

men and women from the islands, consequentially contributing to the “male” type of aging in the self-governing Danish North (Article IV).

In two of the larger parts of the region, the Russian and Fennoscandia’s Arctic, aging still has a female face, according to the chronological indices. The Russian subarctic regions were also a location which experienced a massive population inflow to the so-called areas of new (industrial) development in the 20th century, but at that time, both men and women arrived. Later, the phenomenon in mortality and life expectancy gaps over the last 20 years has been widely investigated (e.g. Eberstadt 2010, Grigoriev *et al.* 2014) as from age thirty and over, there was a pronounced excess of women over men in the northern population of Russia (Young & Bjerregaard 2008). Not surprisingly, the female population of the Russian Arctic is considerably older than the male one. The most significant sex difference is observed in Arkhangelsk and Karelia. Sex differences became accentuated in the 1990s, requiring long-term policy changes to balance the aging groups, even though the gap has started to diminish in the 2000s. The observation that difference between the sexes was larger in the earlier part of the period is confirmed for the whole Arctic: the sex-related gaps for 2010 are smaller than they were in 1990, with minor exceptions in MAs in Russia.

The situation does change somewhat if one uses a prospective approach. There are more regions where the gap in male/female prospective values did not decrease, but rose towards higher male predominance. As an outcome result, in 2010 many male indices slightly exceeded those of female populations or there tended to be only a minimal difference, with the exception of Siberian Russia where there is still a huge male predominance, even when using the prospective approach. For example, the POADR value of Chukotka was similar for men and women at 2% in 1990, but within two decades it became 26% for men and three times lower at 9% for women. If one examines the PAI parameter, then the 1990-year value for male and females natives of Magadan was 16%, which changed to 107% for men and 58% for women in 2010. Therefore, when prospective methods of estimating population aging are applied, it seems that the aging is more intense for the older male populations of the North, and therefore a different gender policy can be needed and in fact one opposite to that indicated if one utilizes the traditional method of analyzing aging.

#### **4.2.4 The Arctic and the national averages**

In a nutshell: The Arctic has been achieving rates similar to, and in some cases slightly exceeding, the nationwide level of population aging, partly due to the fact that many countrywide rates are undergoing a backwards development (i.e. in the Arctic countries we have a phenomenon of relative population “rejuvenation”), and also with regard to faster aging of northern populations.

The totals of Sweden and Finland are the only countries that keep the “oldest” positions in 2010 from the viewpoint of chronological head-count ratios. Norway and Denmark accompanied them earlier in 1990, but moved to the middle of the range in just two decades and were replaced by their Arctic counterparts. If one uses the MA estimations, then the previously leading Scandinavian countries were displaced by the US and Denmark, whose total populations occupied the top five of the oldest in terms of MA in 2010 due to progressively fast growth of median ages, and these regions were accompanied by the North Atlantic trio. In the case of the latter regions, this finding is closely related to mobility. The turmoil in the fishery and financial sectors<sup>1</sup> as well as educational competition caused an effect of “thinning out societies” (Gløersen *et al.* 2005) and massive out-flow of young educated people to Scandinavia and elsewhere from the North Atlantic, aggravating population aging. The prospective measurement encounters less variation, replacing the oldest countries of Fennoscandia with Russia in 2010.

There is one country, Norway, which stands out as its population has not simply lost the aging “leadership”, but in fact its female population is becoming younger if one compares the situation in 2010 with that of 1990. This finding emerges with both prospective and chronological estimations (AI, OADR, Prop 60+). Table 2 provides a summary of which of the nationwide rates have declined in comparison to the Arctic separately over the two latest decades.

If one examines the national vs. Arctic aging development, then an interesting change can be noted in the “chronological” distribution in the middle of the regions’ range. We observe a general tendency of the Arctic to catch up and become older in relation to the national averages of Arctic countries, i.e. at the beginning of the period, the countries’ averages were much higher in the age table, e.g. not only

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<sup>1</sup> Fishing is a predominant source of income in the North Atlantic that experienced severe downturns in the studied period. Overfishing led to a collapse of fish stocks in the early 1990s and later the banking crisis in 2008–2010 caused the negative trend where young people left to seek work elsewhere in the world. Moreover, Iceland's latest financial crisis had its own specific pattern of migration, such as the departure of many working-aged migrants from Poland, the Philippines, and Thailand (Hansen *et al.* 2012).

Sweden and Finland took the leading positions, but also Denmark and Norway were among the oldest old in 1990. In 2010, the majority of the nationwide values had changed their positions and moved to the right towards “the youngest” end of the spectrum (except Russia). For example, if one examines the MA estimations, Sweden was in 1st place in 1990, but 18th among the 23 studied regions in 2010. Chronological indicators measured as mean values<sup>2</sup> firstly for the Arctic and, secondly, jointly for seven countries (with Iceland included in the Arctic), showed that indeed, the difference had become minimized: earlier the nationwide conventional aging rates were higher by between 33% to 40%, but in the latter part of the study period, they exceeded the Arctic by only 10 to 20%.

This observation is in agreement with the results of prospective analysis, i.e. it does seem that the Arctic is no longer a region with much younger age structures than their respective countries’ average. In 2010, the mean of Arctic PMA even slightly exceeded the means calculated for seven countries, i.e. PMA values of 43.8 (Arctic) vs. 42.7 (country-wide), while the other prospective rates were also slightly higher than the national averages. In 1990, the Arctic was indeed much younger, for instance the PAI value was 37.3, almost half the countrywide mean PAI value of 63.8. The case of Russia is a clear confirmation of this proposition: if one measures age prospectively, then Karelia achieved a stage of population aging, surpassing the countrywide rates in 2010, with Arkhangelsk reaching the same rates as Russia for both sexes. Earlier in 1990, these regions had been well below the national average. This trend of the Arctic achieving rates similar to the nationwide level of population aging is partly due to the fact that many country-wide rates have undergone a development change, towards population rejuvenation, and also attributable to the faster aging patterns of Arctic populations (see above 4.2.2 Dynamics of aging change).

#### **4.2.5 Cross-territorial gaps**

To sum up: The inter-territorial gap widened robustly between Canadian North and Alaska, and within Fennoscandia. In Arctic Russia, the Siberian Arctic significantly gained on their aging rates, leading to a convergence with the European part of the Russian North. Greenland became closer to the demographically advanced regions

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<sup>2</sup> By “mean” values, one simply adds up all the values, then divides them by the total number of territories.

of the Faroe Islands and Iceland, however the gap has widened between the Faroe Islands and Iceland, i.e. there is more intense aging occurring in the Faroe Islands.

Analysis of population aging reveals whether the region's territories converge or diverge in their rates of aging, both within and between the four larger areas of the Arctic – the NAA, North Atlantic, Arctic Russia, and Northern Fennoscandia. According to all conventional and prospective measures, the inter-territorial gap clearly widened between Canadian North and Alaska, which are undergoing a growing divergence in terms of aging. In Arctic Russia, 1990-year values were several times lower for the regions of the Siberian North. Chukotka and Kamchatka made significant gains in their aging rates, leading to a convergence with European part of the Russian North. The gap between the Siberian rates and the oldest areas, Karelia and Arkhangelsk, diminished to become only a twofold difference. In the North Atlantic, the Greenlandic rates got closer to the other two regions, which were demographically more advanced. Meanwhile, the Faroe Islands and Iceland had similar aging rates in 1980, but the age of the Faroese population has advanced more intensely in the last three decades so the gap between the Faroe Islands and Iceland has widened. Lastly, a clear cross-territorial divergence is evident in the Fennoscandia as in every indicator the difference between the lowest and highest values grew when comparing the years 1990 and 2010. In 1990, the Swedish North was the oldest area, but this changed to the Finnish North in 2010.

Between the enlarged parts of the Arctic, chronological indices stay close to each other between the NAA and Siberian Arctic (the lowest). The North Atlantic and European Arctic of Russia have relatively similar rates, with Fennoscandia being always having the highest value. However, the interregional gap has increased for MA, AI, and OADR and especially for life expectancy at birth, since the latter indicator grew for the Arctic but decreased for its Russian population when comparing the 1990 and 2010 rates. A major divergence is also apparent in prospective Age RLE 15, PMA, and PAI, where the gap between the lowest and highest values grew over the period but stayed the same with Prop RLE 15- and POADR. As in case of the conventional indices, the NAA and Siberian Arctic show similarly low values, but only in the 1990s. Subsequently, prospective indices on aging rapidly increased in the Russian Siberia reaching the rates of aging observed in the Scandinavian area, even surpassing them in the European Arctic part of Russia. In summary, this means that the territory-to-territory differences in aging development in the Arctic are becoming even more evident, and most probably one cannot expect that there will be any uniformity in this process in the region's future.



To conclude the 4.2 sub-chapter, it is argued that in conjunction with the clear aging transition the Arctic, certain de-aging patterns have been detected, although these not be very large or generalizable to all regions, they do tend to be apparent in most of the calculated indicators (Table 6). With both retrospective and chronological indices, there is evidence for rejuvenation to be found at some national levels; with the prospective indices, down-aging is present over a more geographically widespread scale. This apparent discrepancy between these approaches is associated with the prolongation in LE which has occurred during this period. It is evident that in policy making, decisions may be sensitive to which indicator is employed, and therefore there is a need to evaluate carefully which of the many indicators is the most appropriate; the option which is most suitable for one region may prove sub-optimal for other territories.

**Table 6. Rejuvenation shifts 1990–2010 revealed by indices and subdivided according to sex.**

Territory	1990–2000		2000–2010	
	Men	Women	Men	Women
North Atlantic Arctic				
Denmark	<b>Prop 60+, OADR<sup>12</sup></b> PMA, POADR	<b>Prop 60+, OADR</b> PMA, POADR	PMA, Prop RLE15- POADR	PMA, Prop RLE15- POADR
Greenland	x	x	x	PMA, POADR
The Faroe Islands	Prop RLE15-, POADR	PMA, POADR	PMA, Prop RLE15-	PMA, Prop RLE15- POADR
Iceland	PMA, Prop RLE15- POADR	x	PMA, Prop RLE15- POADR	PMA, Prop RLE15- POADR
North American Arctic				
The USA	<b>OADR, PMA, PAI</b> Prop RLE15-, POADR	<b>Prop 60+, OADR</b> <b>AI</b>	PMA, Prop RLE15- POADR, PAI	Prop RLE15-, POADR
Alaska	x	x	x	x
Canada	Prop RLE15-, POADR	Prop RLE15-, POADR	Prop RLE15-, POADR	
Yukon	x	x	x	x
Northwest Territories and Nunavut	x	x	Prop RLE15-	PMA
Scandinavian Arctic				
Finland	Prop RLE15- POADR	<b>MA</b> , Prop RLE15- POADR	POADR	Prop RLE15- POADR
Lapland	x	x	x	POADR

Territory	1990–2000		2000–2010	
	Men	Women	Men	Women
Oulu	Prop RLE15- POADR	x	Prop RLE15- POADR, PAI	Prop RLE15- POADR, PAI
Kainuu	x	PMA	POADR	POADR
Norway	<b>Prop 60+, OADR</b> <b>AI</b> , Prop RLE15- POADR, PAI	<b>Prop 60+, OADR</b> <b>AI</b> , Prop RLE15- POADR, PAI	Prop RLE15-, POADR, PAI	<b>MA</b> , PMA Prop RLE15- POADR, PAI
Troms	<b>Prop 60+, OADR</b> <b>AI</b> , PMA, PAI Prop RLE15- POADR	<b>Prop 60+, OADR</b> <b>AI</b> , PAI Prop RLE15-	PMA, Prop RLE15- POADR, PAI	Prop RLE15- POADR, PAI
Finmark	<b>AI</b> , Prop RLE15- POADR, PAI	<b>AI</b> , PMA	Prop RLE15-, POADR, PAI	x
Nordland	<b>Prop 60+, OADR</b> <b>AI</b> , Prop RLE15- POADR, PAI	<b>Prop 60+, OADR</b> <b>AI</b> , Prop RLE15- POADR, PAI	Prop RLE15- POADR	Prop RLE15- POADR
Sweden	<b>Prop 60+, OADR</b> <b>AI</b> , Prop RLE 15- POADR, PAI	<b>Prop 60+, OADR</b> <b>AI</b> , PMA, Prop RLE 15-, POADR, PAI	Prop RLE 15- POADR	PMA, POADR, Prop RLE 15-, PAI
Norbotten	PMA, POADR	Prop RLE 15-	POADR	PMA
Vesterbotten	<b>OADR</b> , POADR, Prop RLE 15-, PAI	PMA, Prop RLE 15- POADR	Prop RLE 15- POADR	PMA, Prop RLE 15-, POADR Age RLE15-
		Russian Arctic		
Russia	Age RLE15-	Age RLE15-	<b>Prop 60+, OADR</b> PMA, Prop RLE 15- POADR	<b>Prop 60+, OADR</b> Prop RLE 15- POADR
Karelia	Age RLE15-	Age RLE15-	<b>Prop 60+, OADR</b> PMA, Prop RLE 15- POADR	<b>OADR</b> , PMA Prop RLE 15-
Murmansk	Age RLE15-	Age RLE15-	PMA	PMA
Arkhangelsk	Age RLE15-	Age RLE15-	PMA, Prop RLE 15-, POADR	PMA, Prop RLE 15-, POADR
Komi	Age RLE15-	Age RLE15-	PMA	PMA, POADR Prop RLE 15-
Sakha (Yakutia)	Age RLE15-	Age RLE15-	POADR	Prop RLE 15- POADR
Chukotka	Age RLE15-	Age RLE15-	Age RLE15-	Age RLE15-
Kamchatka	Age RLE15-	Age RLE15-	x	x
Magadan	Age RLE15-	x	PMA	x

<sup>1</sup> Chronological indicators are shown in bold, "x" means that none of the indicators find any evidence of reversals in the comparison between the beginning and the end of the period

<sup>2</sup> MA = median age; PMA = prospective median age; Prop 60+ = a share of people aged 60+ years; Prop RLE 15- = a share of people with remaining life expectancy 15 years and less; OADR/POADR = (prospective) old-age dependency ratio; AI/PAI = (prospective) aging index; Age RLE 15 = an age at which remaining life expectancy is equal 15 years

### **4.3 Use of thesis data, gaps in knowledge and prospects for the future**

The data collected in this thesis and included articles can be of use to demographers, statisticians and social scientists that would like to specialize in the Arctic regions and countries; it will hopefully guide decision makers for formulating the policy priorities for Arctic populations, primarily in adapting to an aging transition (more policy discussion in Article V).

As mentioned in the Introduction, the new pan-Arctic statistical databases on the peoples of the North, the ArcticStat and Circumpolar Health Observatory are the first sources make use of the thesis data. Given that the aging is recognized as a megatrend in the Arctic (research reports of Nordregio), a step towards aging monitoring can be made by utilizing these information systems. For instance, it would be highly informative to publish intra-regional life tables that provide an overview of survival rates and the probabilities of dying at different ages as well as other useful demographic data, not often available at the sub-national level. Furthermore, publishing and monitoring the head-count ratios on aging may allow a convenient reference point from which to determine the population group that should be prioritized when planning a new policy program. Prospective rates on aging would additionally provide an informative perspective on how the age structure of a population is changing in comparison to earlier periods, given the rapid prolongation in LE and improving (or deteriorating) population health. Assuming a limited flexibility of such larger data platforms to introduce new indicators, the Prop RLE 15- is recommended to be a starting point, as it revises the very definition of “older adults” and how aged a certain community is in reality, in relation to the standard 60/65+ share of older persons.

Second, aging indicators can be used in the future work of the project “Arctic Social Indicators” (ASI) in its domain “Health and Population” and related ones. The goal of the project is to follow-up to the Arctic human development report and to devise Arctic social indicators which will help to facilitate the tracking and monitoring of human development in the Arctic (Arctic Social Indicators 2010, Larsen *et al.* 2015). A number of regional case studies from the thesis can illustrate major social problems e.g. how changing median age or the child-elder ratios have significantly affected the population development in a given region. It is important to establish the connections between demographic factors, changes in livelihoods, climate, the impact of the arrival of newcomers and other patterns in different regions in the Arctic as the basis for formulating relevant policies; this is also the

aim of the ASI indicators. Since it is anticipated that there will be a need to help these societies to cope with a more mature structure, the complete aging dataset developed for the Arctic in this thesis can serve as a primary source for the adoption of appropriate policies.

There is an emerging understanding that the Arctic is undergoing rapid changes in its climate as well in its exploitation of natural and human resources. This has a potential to impact on the rest of the world, and it is not surprising that many national governments as well as global think-tanks have recently launched flagship programs on the Arctic (e.g. the IIASA Arctic Future Initiatives, the National Research Council Arctic Program in Canada). Such programs are intended to take a holistic analytical perspective of the future of the Arctic. This aging discourse and thesis data can be integrated into some of these programs and benefit these initiatives to the extent that they impact on population and socio-economic development in the region.

The above Results and Discussion help to fill a gap in knowledge about the aging of populations in northernmost America and Eurasia; until now there has been a lack of comprehensive, comparative aging studies for the Arctic region. Given the sensitivity of these sparsely settled Arctic regions to migration and mortality-fertility changes, the reliability of previous population and aging forecasts for the Circumpolar North is strongly called into question. It would be important that future research on aging in the Arctic also considers the following points:

1. To include the rest of the Arctic, as this study covered only 23 northern regions out of 28, due to difficulties to extract reliable population data after some provincial and boundary changes.
2. To devise additional indices and sophisticated methodological approaches on age and aging since these can provide new insights into the scientific understanding of the studied megatrends. The list of novel informative indices could include various biomarkers; morbidity, disability, and cognition adjusted old-age ratios; measures based on subjective life expectancy, survival probabilities, and self-reported physical conditions; indices of active and healthy aging; National Transfer Accounts or employment based dependency ratios; the AgeWatch Index etc.
3. It is an important task for the future to understand interactions between new and multidisciplinary approaches on aging and conventional ones, since the inclusion of only one prospective approach in the present case already led to

striking differences in the population aging rates from the results estimated with one-parameter (chronological age) indicators. In addition, it is important to consider which indicators appear to be more suitable for one geographical location and which are better for some others, – i.e. an indicator which works well for the aging situation in Russia may not be at all informative for Greenland or Finland; it is important to determine how well and reliably each indicator reveals the future short/medium/long-term trends.

4. There are differences between Indigenous vs. non-Indigenous patterns and these can significantly modify the aging status of a region. One finding that emerged from this thesis is that the aging of Arctic nomadic populations is different from that experienced by the “outsiders” i.e. Indigenous peoples are at an earlier stage of the demographic and health transition and have much younger populations, this is attributable to their higher birth and death rates. In the thesis and Articles II–IV, examples of these differences have been outlined for Alaska Natives, Canadian Indigenous Peoples, Greenlandic Inuit, and the numerically small peoples of the Russian North. However, it would be interesting for future research to assess the aging among the Arctic minorities with prospective measures on aging but unfortunately the statistics available for use have not yet been divided by ethnicity.
5. The urban-rural context is crucial. “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 2014: 102). In addition, the indigenous northerners live predominantly in rural areas, and together with their younger age structures, this will require changes in the delivery of services as these populations age. It would be important that publicly-open regional mortality statistics should be categorized into a rural/urban subdivision since this type of data for conducting analytical predictions of future needs.
6. At present, there is virtually no policy oriented research on aging being conducted at the provincial/regional level of Arctic countries; it is hoped that research into of this topic will benefit from the discussion in Article V focused on social inclusion of older Arctic residents. Future studies should include qualitative and longitudinal investigations aimed to clarify the policy making process, taking into account the needs of the Arctic’s older population, and understanding and measuring the roles that older adults can play in regional development.

7. Further explorations of the linkages between population aging and social, economic, political, and environmental factors could clarify the understanding of Arctic demographical processes.

Sound scientific evidence is a good foundation from which to develop effective action plans on aging in member states and regions of the Arctic. However, in view of the main conclusion of this thesis, – i.e. aging patterns greatly differ across in the Arctic, instead of a one-size-fits-all demographic and aging policy for the Arctic countries, it will be necessary that policies are tailor-made to accommodate regional patterns. In this respect, responses to aging differs from many other regional policy domains, e.g. joint cross-regional actions on climate change and environmental protection of the Arctic or the Arctic governance which may benefit from being planned and implemented in a unified pan-Arctic manner.

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# Appendix

**Appendix 1 Population aging indicators in the Arctic regions and national total rates by sex, 1980–2010.**

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
The North Atlantic Arctic										
Denmark total										
1980	Males	33.00	43.51	17.16	14.12	28.14	21.89	78.40	66.17	63.12
1990		35.71	45.64	17.74	14.28	27.51	21.02	99.65	80.21	63.69
2000		37.23	45.23	17.34	12.29	27.29	17.91	90.76	64.29	65.25
2010		39.60	45.09	21.33	11.19	35.57	15.96	114.07	59.84	67.89
1980	Females	35.26	36.89	21.48	11.75	36.94	19.05	105.50	59.18	68.65
1990		38.42	39.86	22.97	14.04	37.97	20.21	139.12	85.01	68.97
2000		39.39	39.78	22.03	13.25	36.56	19.19	124.28	74.75	69.50
2010		41.28	39.47	24.73	11.54	42.80	16.27	141.38	66.00	71.14
Greenland										
1980	Males	24.72	37.13	4.51	4.17	6.76	6.14	15.67	13.32	61.02
1990		28.53	40.49	5.45	5.81	7.74	8.26	22.60	24.42	59.23
2000		32.56	42.53	7.34	7.40	10.96	11.09	28.52	28.54	59.74
2010		35.08	42.84	10.85	8.80	16.12	12.78	49.71	39.45	61.90
1980	Females	22.52	33.51	6.54	4.50	10.55	7.22	20.74	13.55	64.63
1990		26.81	36.97	7.54	4.78	11.59	7.00	27.59	17.83	64.73
2000		30.82	41.69	8.66	7.10	13.84	11.09	30.13	24.64	62.54
2010		32.01	40.52	10.59	7.23	16.12	10.57	44.61	29.73	64.68

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
The Faroe Islands										
1985	Males	28.39	34.54	13.70	10.50	23.48	16.40	49.05	41.32	64.51
1990		30.39	35.46	14.04	10.78	22.76	16.60	57.75	44.34	64.24
2000		33.96	35.34	15.73	9.18	25.88	13.63	67.05	39.13	68.17
2010		36.71	36.63	18.85	8.50	31.70	12.18	87.02	39.25	70.00
1985	Females	28.30	33.02	15.74	9.23	28.28	14.17	54.97	35.94	68.74
1990		31.06	33.74	17.53	9.71	30.21	14.75	71.76	39.75	69.22
2000		35.64	35.41	19.58	10.09	34.84	15.37	80.85	41.68	72.14
2010		38.18	35.34	21.58	8.68	38.32	12.55	97.58	39.26	74.46
Iceland										
1980	Males	26.30	31.95	12.24	8.25	20.53	12.98	43.51	29.34	65.80
1990		29.38	35.46	13.26	8.08	21.63	12.16	52.11	31.77	66.89
2000		32.13	33.12	13.83	7.83	22.16	11.45	58.12	32.90	68.84
2010		34.27	33.92	15.73	8.07	24.94	11.41	74.12	38.03	68.99
1980	Females	27.34	30.94	14.63	7.36	25.17	11.25	53.74	27.03	70.41
1990		30.25	33.74	15.74	7.70	26.36	11.37	64.09	31.37	70.85
2000		33.27	34.97	16.27	8.41	26.73	12.23	71.20	36.78	71.06
2010		35.31	34.54	17.78	8.15	28.87	11.45	86.12	39.50	72.39

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
The North American Arctic										
The United States total										
1980	Males	28.80	36.53	13.64	10.44	21.79	15.86	57.45	43.98	63.73
1990		31.60	37.83	14.39	10.17	22.90	15.18	63.19	44.66	65.19
2000		34.10	36.92	14.17	9.37	22.31	13.71	63.57	42.05	66.61
2010		35.90	36.52	16.85	8.20	26.93	11.51	81.95	39.86	69.12
1980	Females	31.30	35.66	17.79	9.24	29.29	13.31	82.92	43.00	69.77
1990		34.00	37.48	19.04	9.83	31.58	14.15	92.17	47.58	70.55
2000		36.60	39.60	18.31	10.37	29.90	15.00	89.45	40.71	70.56
2010		38.50	39.81	20.25	8.89	33.35	12.34	106.38	46.72	72.23
Canada total										
1980	Males	28.50	35.19	11.81	8.64	18.24	12.59	50.45	38.00	64.54
1990		32.10	36.95	13.70	9.08	21.11	13.05	63.99	42.47	65.97
2000		36.00	38.18	14.88	8.98	22.79	12.51	75.03	46.73	67.86
2010		38.90	38.67	18.40	8.41	28.55	11.28	107.43	49.30	70.10
1980	Females	29.80	33.64	14.75	7.19	23.34	10.06	66.89	33.66	70.38
1990		33.60	36.26	17.37	14.85	27.74	20.69	86.94	74.37	71.21
2000		37.70	39.20	18.31	9.11	28.99	12.49	98.77	50.66	72.01
2010		40.60	39.91	21.43	9.44	34.23	12.52	134.29	59.40	73.44

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Alaska										
1980	Males	26.31	34.86	4.72	3.35	6.83	4.75	18.06	12.79	63.05
1990		29.36	35.25	5.94	3.61	8.83	5.19	22.20	13.49	65.09
2000		32.36	36.00	8.00	4.17	11.94	5.88	32.01	16.75	67.35
2010		33.63	x <sup>3</sup>	12.45	x	18.91	x	57.49	x	x
1980	Females	25.74	30.77	5.07	1.87	7.56	2.66	18.22	6.71	69.45
1990		29.26	33.04	6.79	2.75	10.42	3.98	24.27	9.84	69.76
2000		32.52	35.37	8.95	3.82	13.64	5.40	35.18	15.06	71.06
2010		34.07	x	13.16	x	20.37	x	59.30	x	x
Yukon										
1980	Males	27.20	36.79	5.55	4.47	8.10	6.38	21.36	17.60	62.56
1990		31.00	39.00	6.63	3.44	9.58	4.77	27.37	14.05	66.13
2000		35.30	40.16	8.97	5.15	12.88	6.90	42.01	25.40	66.82
2010		38.70	41.72	14.68	6.87	21.54	9.03	85.56	40.39	67.12
1980	Females	25.60	33.30	4.92	2.19	7.23	3.07	18.16	8.30	68.27
1990		30.10	35.04	5.94	2.95	8.60	4.07	23.79	12.00	68.10
2000		34.80	37.57	8.25	3.56	11.70	4.65	38.98	17.91	70.70
2010		38.40	39.83	13.73	4.67	19.71	5.94	82.55	28.06	74.13
Northwest Territories and Nunavut										
1980	Males	22.50	31.97	4.67	3.15	7.63	4.90	13.71	9.62	64.28
1990		25.20	31.96	4.66	3.18	7.28	4.86	14.91	10.11	63.73
2000		26.35	32.81	5.27	3.67	8.26	5.49	17.70	12.50	64.59
2010		28.35	32.07	7.52	3.43	11.26	4.82	31.11	13.45	66.91
1980	Females	21.30	29.85	4.16	2.01	6.95	3.07	11.52	5.80	68.87
1990		24.10	29.66	4.17	1.97	6.61	3.03	12.73	5.96	68.31
2000		25.70	32.18	4.83	2.74	7.60	4.09	15.78	9.02	66.92
2010		27.90	32.10	7.13	3.12	10.70	5.94	28.78	11.94	68.95

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Northwest Territories										
2000	Males	30.00	x	6.29	x	9.35	x	23.81	x	x
2010		32.10	x	9.22	x	13.23	x	43.69	x	x
2000	Females	29.40	x	5.99	x	9.00	x	21.76	x	x
2010		31.70	x	8.86	x	12.77	x	40.73	x	x
Nunavut										
2000	Males	22.70	x	4.24	x	7.16	x	11.58	x	x
2010		24.60	x	5.82	x	9.28	x	18.53	x	x
2000	Females	22.00	x	3.66	x	6.20	x	9.79	x	x
2010		24.10	x	5.39	x	8.62	x	16.82	x	x
The Scandinavian Arctic										
Finland total										
1990	Males	35.18	42.82	14.71	11.66	22.64	17.14	72.41	57.40	63.03
2000		38.09	42.82	16.70	11.23	25.92	16.08	88.34	59.43	65.67
2010		42.35	44.57	22.31	11.42	36.89	15.99	129.78	66.40	68.22
1990	Females	43.07	46.74	22.19	13.35	37.30	19.54	121.08	72.84	68.41
2000		41.38	43.14	23.07	13.13	38.68	18.87	133.50	75.97	70.32
2010		46.57	46.25	27.55	12.44	48.68	17.35	173.72	78.45	72.44
Lapland										
1990	Males	34.78	43.03	13.90	11.13	21.50	16.51	64.87	51.95	62.61
2000		42.39	47.40	17.79	11.76	27.97	16.90	95.51	63.17	65.65
2010		46.70	48.46	24.87	12.73	41.99	17.84	156.57	80.14	68.74
1990	Females	38.00	41.54	18.99	10.63	31.66	15.55	90.32	50.55	68.19
2000		43.23	44.70	23.00	11.98	39.15	17.18	126.07	65.68	70.51
2010		49.64	48.26	29.14	12.39	52.32	17.11	192.07	81.69	73.51

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Oulu										
1990	Males	36.00	43.67	12.65	10.08	20.13	15.41	51.66	41.16	62.83
2000		36.67	41.35	14.42	9.55	22.63	13.88	65.99	43.57	65.85
2010		39.68	40.59	18.91	8.68	31.41	12.33	90.48	41.54	69.67
1990	Females	34.56	37.85	18.46	10.20	31.63	15.30	79.72	44.02	68.99
2000		37.64	39.47	19.62	10.85	33.05	15.74	93.35	51.63	70.30
2010		41.76	40.49	23.19	9.61	40.83	13.65	115.77	47.97	73.45
Kainuu										
1990	Males	37.99	45.89	14.94	11.51	23.34	17.06	71.00	54.67	62.88
2000		44.59	50.14	19.25	14.40	30.52	21.21	108.70	81.34	64.45
2010		47.53	49.53	26.60	14.82	45.56	21.11	177.28	98.73	67.77
1990	Females	40.02	43.95	20.94	11.98	35.90	17.80	100.98	57.76	67.93
2000		44.04	45.41	25.60	13.82	44.86	20.07	147.60	79.66	70.55
2010		49.49	48.63	32.42	14.04	61.18	19.67	222.05	96.17	73.90
Norway total										
1990	Males	34.59	39.83	18.36	14.28	29.59	21.60	93.62	72.85	64.43
2000		38.35	41.17	16.81	11.74	26.92	17.38	81.17	56.66	66.49
2010		41.36	41.75	19.02	9.49	30.87	13.34	98.14	48.96	68.88
1990	Females	38.82	41.62	23.63	13.98	40.65	20.63	129.45	76.61	69.53
2000		41.24	42.68	21.78	13.10	36.93	19.36	113.09	68.01	70.82
2010		41.06	40.94	22.72	10.62	38.58	14.97	123.44	57.73	72.36



Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Troms										
1990	Males	33.06	39.43	16.23	13.26	25.32	19.78	82.45	67.39	63.38
2000		35.34	39.19	15.58	11.09	24.67	16.39	73.28	52.14	65.61
2010		39.15	38.73	19.38	8.59	31.52	11.89	101.35	44.93	69.78
1990	Females	36.65	39.06	20.63	11.90	34.24	17.24	108.05	62.30	69.56
2000		40.28	41.21	19.99	11.80	33.28	17.29	100.17	59.13	70.68
2010		42.68	42.47	22.57	10.22	38.18	14.29	123.31	55.82	72.20
Finnmark										
1990	Males	32.74	40.53	14.69	12.64	22.33	18.64	75.10	64.63	62.31
2000		37.50	42.25	15.14	11.08	23.88	16.43	70.62	51.69	64.76
2010		42.78	45.63	19.90	10.23	32.64	14.17	103.94	53.44	67.84
1990	Females	35.91	40.71	18.81	11.51	30.53	16.70	96.07	58.80	68.14
2000		37.07	39.17	19.04	11.66	31.88	17.37	89.79	54.99	69.49
2010		41.64	43.00	22.04	12.40	37.44	17.70	115.51	64.99	70.97
Nordland										
1990	Males	34.13	39.93	18.74	14.56	30.60	22.25	93.74	72.82	64.48
2000		37.76	40.66	17.97	12.97	29.39	19.62	85.91	62.03	65.81
2010		41.23	41.74	21.82	11.34	36.67	16.20	117.00	60.80	68.54
1990	Females	38.51	41.15	23.97	14.21	42.02	21.27	126.16	74.78	69.46
2000		40.94	42.16	23.20	13.81	40.62	20.78	117.78	70.14	70.99
2010		45.60	45.39	25.53	12.24	45.05	17.51	143.37	68.76	72.42

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Sweden total										
1990	Males	37.06	41.16	20.11	14.88	32.88	22.41	107.48	79.52	65.43
2000		38.85	40.76	19.78	12.90	32.34	18.95	103.88	67.72	67.25
2010		42.59	42.48	23.15	11.62	38.77	16.32	135.11	67.84	69.13
1990	Females	42.68	44.91	25.22	14.69	43.91	21.61	145.41	84.68	70.06
2000		43.88	44.88	24.59	14.08	42.61	20.63	139.05	79.59	71.28
2010		45.17	44.79	26.78	12.32	46.90	17.21	166.24	76.45	72.36
Norrbotten										
1990	Males	40.26	44.80	19.10	14.39	30.70	21.49	102.33	77.08	64.48
2000		40.73	43.24	21.31	14.47	35.20	21.47	117.50	79.79	66.29
2010		44.45	44.73	26.57	13.78	45.65	19.41	174.44	90.45	69.00
1990	Females	39.19	41.20	23.21	12.66	39.54	18.28	128.15	69.89	69.95
2000		45.51	46.56	25.91	14.07	45.83	20.57	147.57	80.13	70.78
2010		48.48	42.03	30.55	14.62	55.74	20.67	208.67	99.87	71.94
Vesterbotten										
1990	Males	38.05	43.06	19.91	15.76	33.08	24.49	100.13	79.25	64.25
2000		41.14	43.36	20.11	13.57	33.02	20.12	106.04	71.56	66.67
2010		41.49	41.14	23.89	12.63	39.69	17.68	149.94	79.30	72.06
1990	Females	40.26	43.42	23.95	13.92	42.02	20.76	125.73	73.05	69.37
2000		41.18	42.30	24.59	13.56	42.70	19.76	137.95	76.06	71.30
2010		42.25	42.03	27.54	13.25	48.30	18.58	178.40	85.82	68.76

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
The Russian Arctic										
Russia total										
1990	Males	30.83	44.14	10.62	11.28	16.51	17.70	42.43	45.04	59.43
2000		33.76	51.01	13.56	16.53	20.45	26.09	67.37	82.12	56.58
2010		34.81	49.19	13.04	14.61	18.56	21.28	78.05	87.21	58.89
1990	Females	35.48	42.69	20.27	12.52	34.69	18.92	98.18	58.79	65.99
2000		38.77	47.66	22.42	15.86	36.96	23.60	132.40	93.67	65.00
2010		40.87	47.70	21.80	15.66	33.78	22.17	159.38	114.22	66.92
Karelia republic										
1990	Males	30.19	44.40	8.41	11.28	12.76	17.92	32.65	43.83	57.43
2000		33.77	54.18	12.14	17.18	17.94	27.42	60.22	85.18	53.03
2010		34.37	52.31	11.63	16.95	16.20	25.55	70.35	101.41	56.61
1990	Females	34.26	42.42	17.44	11.93	29.10	18.23	77.08	52.72	64.41
2000		38.60	49.59	21.13	16.78	34.03	25.26	125.88	99.98	63.20
2010		41.14	49.39	21.25	15.62	32.42	21.99	160.94	117.33	67.05
Murmansk oblast										
1990	Males	28.09	40.46	3.82	4.37	5.40	6.23	15.01	17.16	59.13
2000		30.93	49.74	7.15	11.06	9.62	15.71	38.47	59.52	53.98
2010		32.62	48.49	7.85	12.31	10.28	17.25	49.81	75.51	56.93
1990	Females	32.00	39.87	9.73	6.00	14.87	8.68	39.22	24.19	64.72
2000		37.13	47.92	14.79	11.13	21.71	15.51	86.54	65.13	62.87
2010		39.60	47.55	16.87	11.92	24.37	16.08	121.44	85.65	66.08

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Arkhangelsk oblast										
1990	Males	29.74	43.49	7.75	9.44	11.71	14.65	29.66	36.14	58.24
2000		33.29	54.02	11.37	16.48	16.62	26.04	56.19	81.46	53.17
2010		34.08	50.48	11.46	14.66	16.05	21.46	66.94	86.24	57.84
1990	Females	33.64	41.31	17.82	11.98	30.68	18.73	73.98	49.72	65.03
2000		38.15	48.92	20.54	15.87	33.22	23.86	116.56	90.05	63.17
2010		40.57	47.71	20.66	14.93	31.74	21.05	145.09	105.24	66.87
Komi republic										
1990	Males	29.03	43.61	4.90	6.34	7.17	8.90	18.35	23.75	57.86
2000		32.07	51.47	8.55	12.80	12.18	19.40	33.56	31.63	53.43
2010		33.67	50.75	8.58	13.68	11.63	19.95	48.57	76.97	56.19
1990	Females	30.98	39.29	11.34	7.25	18.13	9.88	43.34	27.71	64.76
2000		35.79	46.95	15.38	11.94	23.43	17.28	68.40	63.00	62.95
2010		38.25	46.75	15.96	11.43	23.20	15.61	104.85	74.56	66.00
Sakha (Yakutia) republic										
1990	Males	27.22	42.45	3.70	5.04	5.67	7.89	11.94	16.25	57.30
2000		28.53	46.70	6.56	8.57	9.88	13.32	24.21	31.63	56.45
2010		29.94	46.78	7.24	8.58	10.37	12.50	31.60	37.72	58.38
1990	Females	27.12	38.05	6.67	4.56	10.60	7.02	21.88	14.97	63.78
2000		30.68	41.43	9.98	7.07	15.38	10.43	39.65	28.11	63.65
2010		33.09	41.82	11.08	6.80	16.21	9.38	53.80	32.79	65.98

Year	Sex	MA <sup>1</sup>	PMA <sup>2</sup>	Prop 60+	Prop RLE 15-	OADR x 100	POADR x 100	AI x 100	PAI x 100	Age RLE 15
Chukotka autonomous area										
1990	Males	25.73	38.47	1.10	1.72	1.55	2.44	3.96	6.16	57.78
2000		28.17	47.35	3.97	8.11	5.38	11.63	17.92	36.57	54.36
2010		28.38	50.88	5.95	16.34	8.12	26.10	28.73	77.58	52.32
1990	Females	29.81	39.07	1.93	1.32	2.80	1.90	6.64	4.54	62.79
2000		32.60	44.27	5.22	2.96	7.27	4.00	22.60	12.81	63.49
2010		34.71	49.79	7.46	6.35	10.41	8.70	35.71	30.74	60.66
Kamchatka kray										
1990	Males	28.22	44.00	2.55	4.50	3.54	6.43	10.00	17.69	55.68
2000		31.22	49.71	6.19	11.08	8.25	15.78	33.04	59.07	54.04
2010		33.39	50.64	9.06	15.30	12.09	22.50	56.49	91.56	55.66
1990	Females	30.09	41.12	6.00	4.85	8.93	7.10	22.35	18.06	61.96
2000		34.73	46.60	11.06	8.89	15.81	12.31	58.37	46.89	61.84
2010		37.84	47.88	15.88	10.58	23.13	14.32	102.80	67.98	64.43
Magadan oblast										
1990	Males	29.45	44.91	2.37	4.38	3.33	6.34	8.93	16.50	55.43
2000		33.08	53.89	5.71	14.22	7.65	21.51	29.05	72.32	51.62
2010		34.82	53.14	8.67	17.71	11.69	26.96	50.40	106.54	54.41
1990	Females	30.50	41.26	4.85	4.26	7.13	6.20	17.92	15.73	61.96
2000		35.65	47.49	9.74	7.64	13.60	10.36	52.41	41.11	62.06
2010		38.60	48.28	14.33	8.54	20.27	11.14	95.66	57.92	64.96

<sup>1</sup> MA = median age; PMA = prospective median age; Prop 60+ = a share of people aged 60+ years; Prop RLE 15- = a share of people with remaining life expectancy 15 years and less; OADR/POADR = (prospective) old-age dependency ratio; AI/PAI = (prospective) aging index; Age RLE 15 = an age at which remaining life expectancy is equal 15 years

<sup>2</sup> A reference year for PMA is Iceland 2005

<sup>3</sup> 'x' = no data available for the region



## Original publications

- I Emelyanova A & Rautio A (2012) Aging population in the Barents Euro-Arctic Region. *Eur Geriatr Med* 3(3): 167–173. doi: 10.1016/j.eurger.2012.03.005.
- II Emelyanova A & Rautio A (2013) Perspectives for population aging in the Russian North. *J Popul Aging* 6(3): 161–187. doi: 10.1007/s12062-013-9086-z.
- III Emelyanova A & Rautio A (2015) Demographic aging in Alaska and Northern Canada in the period 1980–2013. Manuscript.
- IV Emelyanova A & Rautio A (2015) Measuring aging in the North Atlantic region: the prospective approach. Manuscript.
- V Emelyanova A & Rautio A (2015) Policies of Arctic countries to promote volunteering in old age. In Naskali P, Seppänen M & Begum S (eds) *Aging, wellbeing and climate change in the Arctic: an interdisciplinary analysis*. To be published by Routledge, Taylor & Francis Group on 30 November 2015. Manuscript.

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