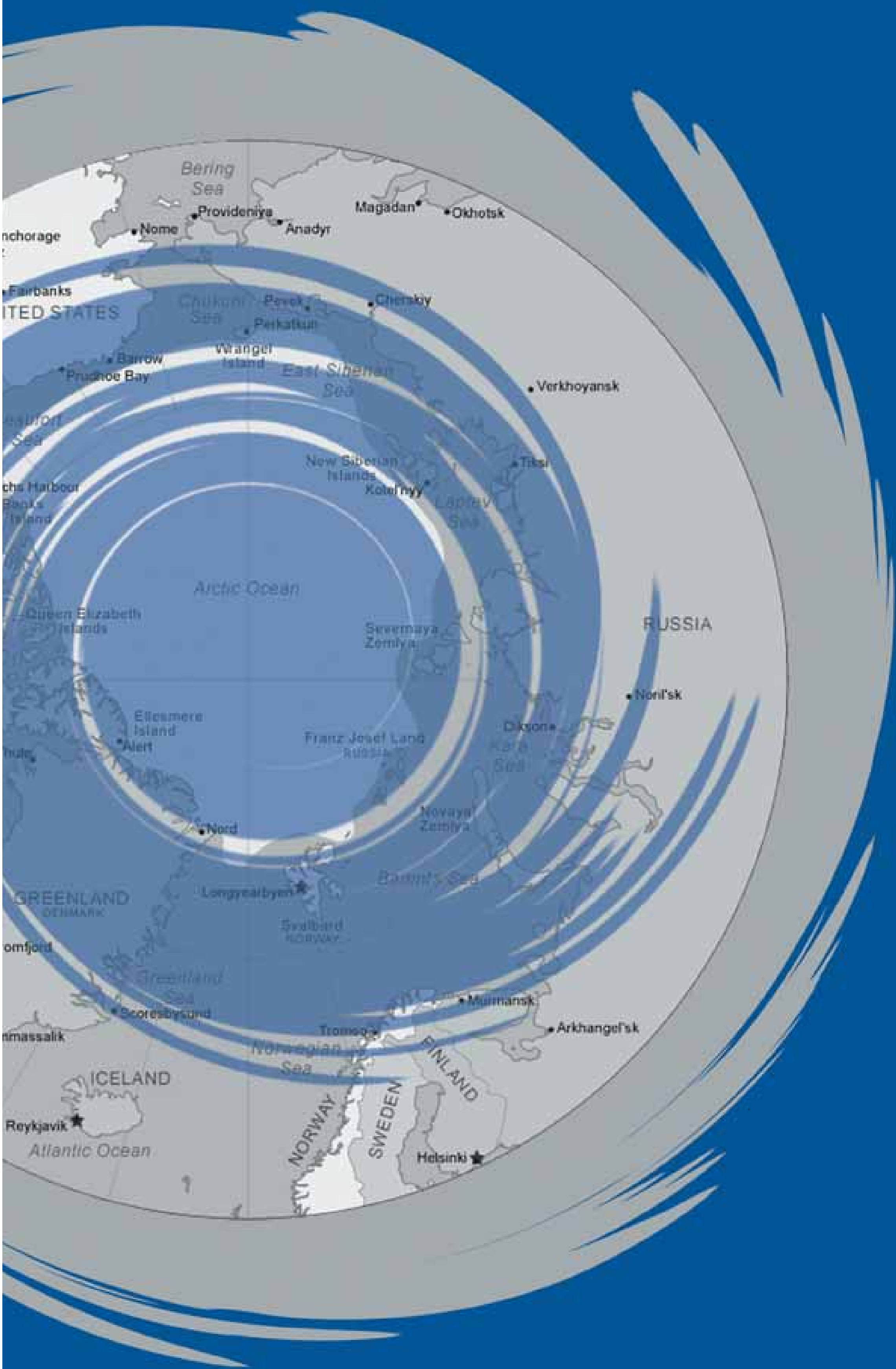

Climate Change Impact on Public Health in the Russian Arctic

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CONTENT

INTRODUCTION

Climate change and its social implications are among the most important challenges of the twenty-first century. The fourth report of the Intergovernmental Panel on Climate Change (IPCC) argues unequivocally that persistent climate change is taking place throughout the world [Climate Change..., 2007]. The Report emphasizes the human health implications of climate change, which are already observed everywhere. The IPCC's data on global warming according to the United Nations Secretary-General Ban Ki-moon sound as a call for action. The UNDP Human Development Report 2007/2008 *Fighting Climate Change: Human Solidarity in a Divided World* is dedicated to addressing this challenge [UNDP Human Development Report..., 2008].

Climate change is also affecting Russia. The average annual temperature for 2007 was 2.1C higher than the historical average since 1886 [Report on the Peculiarities of Climate in Russia..., 2008]. Some of the fastest and most significant climate changes are taking place in the Arctic, resulting in melting sea ice, thawing permafrost and thinning snow cover. Warming is especially clear in the Arctic during the winter, while record high temperatures are also becoming common.

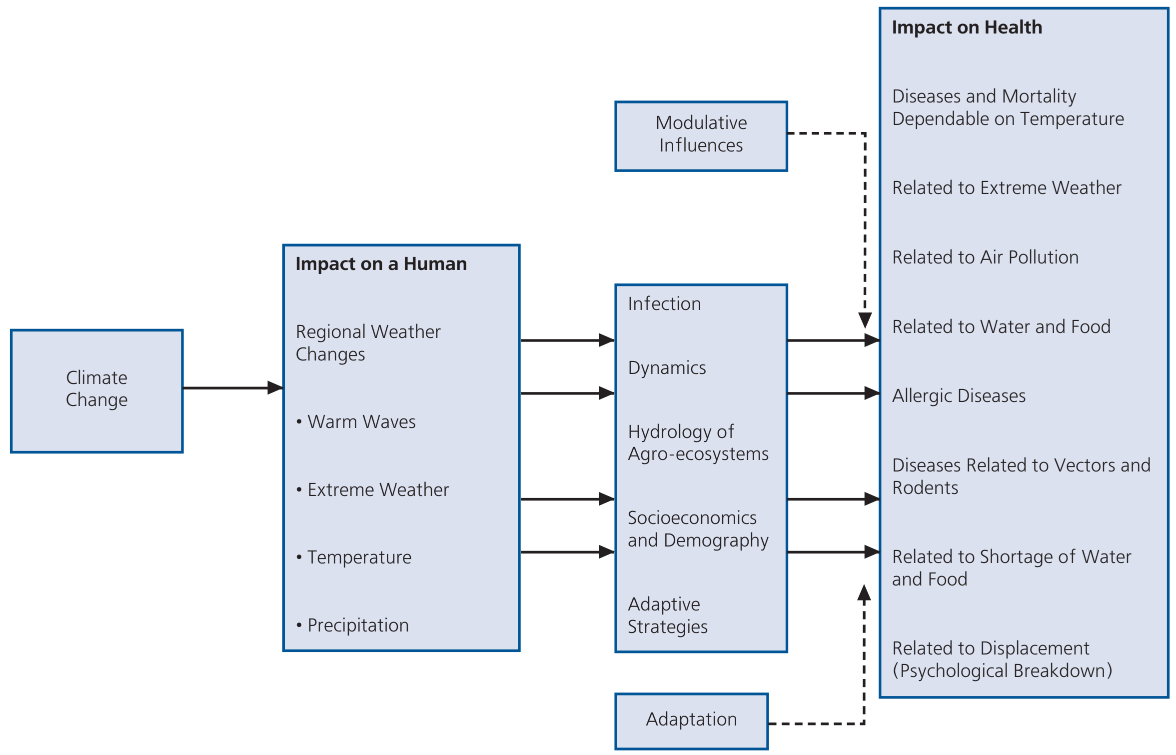
Climate change affects human health in a number of ways. In recent years, climate change has become one of the leading negative factors to human health alongside traditional risk factors such as air pollution, drinking water pollution, smoking and drug abuse. Climate change increases health risks and mortality on days with unusually high or low temperatures. It also increases mortality and injuries resulting from floods, storms and other weather events. Weather events also indirectly affect health through worsened living conditions, including loss of housing to coastal erosion, lack of safe drinking water, damaged roads, disrupted urban and rural infrastructure due to floods, thawed permafrost and increased air pollution in industrial cities.

Climate change also increases the spread of infectious and parasitic diseases. Rising temperatures change the traditional geography of the agents and carriers of disease. In addition, traditional food storage methods used by northern indigenous peoples are also compromised by higher temperatures (Figure 1).

According to the World Health Organization (WHO) estimates, climate change is a cause of approximately 150,000 premature deaths worldwide (0.3% of total deaths). By the year 2050, climate change is expected to further increase mortality by 1.0-1.5% [Climate Change and Human Health..., 2004]. WHO suggests that public health systems in all countries should be adapted to ongoing climate change. WHO announced the year 2007 to be dedicated to the protection of human health against climate change, which was the theme of the World Health Day on April 7th.

The social impact of climate change, including its effects on human health, is especially severe in the

Figure 1. Major Human-Health Implications of Climate Change



Arctic region. Indigenous minorities in the Arctic often remain engaged in traditional occupations that are vulnerable to climate change. Residents in the Arctic face significant challenges in accessing health care services. At the same time, the Arctic region is being exposed to new infectious diseases that are able to move northwards with the warming climate.

The Russian Arctic has a significantly larger population than Arctic regions in Alaska, Canada, Greenland and Scandinavian countries. The Russian Arctic is home to 46 cities and towns, with 5,000 and over residents. Heavy industrial facilities are also located in the region, including some of the world's largest metallurgical works, quarries, mining and processing enterprises, coalmines, nuclear weapons test sites, radioactive waste storages and other environmentally hazardous facilities.

In order to study this challenge, the first international workshop *Climate Change Impact on Public Health in the Russian Arctic* was organized in May 2008 by the UN in Russia Arctic Initiative under the aegis of the UN Resident Coordinator in the Russian Federation and with participation of the United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), World Health Organization (WHO), as well as the Arctic Monitoring and Assessment Programme (AMAP). This publication draws on materials presented at that meeting.

1. The Socio-Economic Situation in the Regions of the Russian Arctic

The regions of the Russian Arctic have different indicators of socio-economic development that is mainly related to the availability of hydrocarbon deposits and other natural resources. The leading extracting regions of the Russian Arctic are Khanty-Mansiysk and Yamalo-Nenets Autonomous Okrugs, followed by the Republic of Sakha (Yakutia) and Komi with their coal deposits, Arkhalgelsk Oblast and Nenets Autonomous Okrug, Murmansk and Magadan Oblasts. The arctic territories have similar position in their income per capita. For this indicator Nenets, Yamalo-Nenets, Khanty-Mansiysk and Chukot Autonomous Okrugs follow after the position of Moscow. The average income indicators are favorable in most arctic territories (with exception of Arkhalgelsk Oblast with the average income per capita below the national average). However the share of population with income below the cost of living exceeds 20% in the Taimyr, Evenk and Koryak Autonomous Okrug, as well as in the Republic of Sakha (Yakutia). This reflects a significant disparity in the income level in the arctic territories. While the unemployment rate could not be considers as a determinant of the living standard for the Russian Arctic population, in the Republics of Komi and Sakha (Yakutia) it is higher than in other arctic territories [Russian Regions..., 2006, 2008; Social Situation and the Living Standard among the Population of Russia, 2007]. The socio-economic situation of the indigenous peoples in the Russian Arctic is more sensitive. The surveys of household budgets for this group have demonstrated that the monthly GDP per capita is 4.1 times below the average regional indicator. In particular in 2006 the difference of GDP in relation to the regional average was in the Taimyr Autonomous Okrug 4.1 (RUB 3,4 and 13,8 thousand respectively), the Evenk Autonomous Okrug - 3.4 (RUB 3,8 and 12,9 thousand respectively), the Republic of Sakha (Yakutia) - 2.6 (RUB 5,2 and 13,6 thousand respectively). However, this difference is most evident in relation to the economically stable Khanty-Mansiysk Autonomous Okrug and amounts to 4.6 times (RUB 4,9 and 22,4 thousand respectively) [Statistical bulletin *Economic and Social Indicators in the Settlements of the Indigenous Populations of the North*, 2007]. A significant problem in the living conditions of the ingenious peoples is poor water supply and sewage systems. There is no access to this infrastructure in the majority of the buildings in the Republic of Komi and the Evenk Autonomous Okrug, while in the Republic of Sakha (Yakutia) only 26% of housing has sewage system.

There is much disparity in the annual budgets of the public health systems per capita among the Arctic territories. The number of doctors and medical personnel, hospitals and ambulatory clinical institutions, as well as obstetrical facilities have been decreasing and there is a shortage of women's and children's medical services and facilities in the areas inhabited by indigenous peoples. A large share of the medical service facilities are in need of substantial repair work, basic pharmaceuticals and modern medical equipment. The qualified medical providers face difficulties in accessing small remote areas by transport. The accessibility indicator related to availability of transportation is 7 hours per week for the Taimyr Autonomous Okrug, 62 hours per week for the Evenk Autonomous Okrug, 28 hours per week for the Chukot Autonomous Okrug, 25 hours per week for the Republic of Sakha (Yakutia) and 18 hours per week for the Yamalo-Nenets Autonomous Okrug [Bugromenko, 2008].

The Federal target programme *Economic and Social Development of the Indigenous Peoples of the North up to the Year 2011* emphasizes the central importance of effective public health system for sanitation and epidemiological services though improvement of equipped expeditionary field ambulances. However, such medical services are maintained at the expense of the local budgets.

Today, their effectiveness to a large extent depends not only on the efforts of the public health service, but mainly on the financial capacity to cover transportation rates that could amount to 80% of the total field medical services costs [www.severcom.ru\files\upload\analytics].

2. The Russian Arctic Environment and Human Health

The development of the Russian Arctic has led to the emergence of some of the world's largest industrial complexes and energy reserves. Gas deposits are being developed on the Yamal peninsula and in Nenetz Autonomous Okrug. Major oil deposits are located on the territory of Khanty-Mansiysk Autonomous Okrug. Coal mining is also taking place in Komi Republic and Sakha (Yakutia). Beyond the Arctic Circle, the Arctic's largest city of Norilsk hosts a large-scale metallurgical industry.

These heavy industries cause significant air pollution in the Kola Peninsula, in Vorkuta, Yakutsk, and other territories. Areas that host the extraction and transportation of oil face the risk of polluted drinking water sources from damaged energy pipelines. There is an average of 1,900 accidents per year related to the oil deposits of Khanty-Mansiysk Autonomous Okrug [Collection of Statistical and Analytical Information..., 2004]. Leaks cause pollution in areas with major oil resources [Kochina, Kushnikova, 2008].

The entire Arctic region also faces the prospect of further pollution from accumulated stable organic compounds and other substances. As temperatures rise, these substances may affect human health as they are released from snow, ice and permafrost.

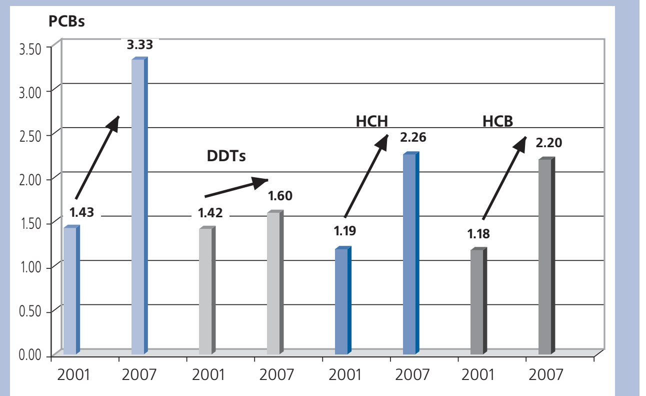
As the climate warms and permafrost melts, there is a growing risk that toxic substances from chemical and radioactive waste storage sites may pollute the environment. Radioactive waste storage facilities in Novaya Zemlya [Russia and Neighbouring Countries..., 2008] and waste accumulators of Norilsk Combine containing sulphates, chlorides, copper, nickel and other toxic substances

BOX 1: Climate Change and the Risk from Toxic Substances on Human Health in the Russian Arctic

While the accumulation of persistent toxic substances (PTS) in Arctic ecosystems has long been observed, its implications for human health with Arctic climate change remain largely unstudied. Research on indigenous peoples living in the Russian Arctic revealed highly toxic substances such as polychlorinated biphenol (PCB), lead and hexachlorobenzene (HCB) in the umbilical cords of newborn children and in adult men and women, among the highest rates in northern countries. In some cases, the level of toxic substances exceeded levels detected in people residing in the ecologically damaged coast of the Aral Sea. These toxic substances have serious effects on human health, including a higher frequency of reproductive mortality, malignant tumours and immune system disorders. Approximately 85% of persistent toxic substances reach the human body from local pollution sources, including over 15 million barrels of industrial waste accumulated during the intensive development of the Russian Arctic.

Data shows that the observed trends of increasing annual temperatures in the lower atmosphere of the northern hemisphere coincide with the rapid shift of maximum condensation and fallout of the aerosol components of chororganic pesticides to 65-70 degrees north. These aerosol components are often transmitted through the atmosphere from regions that intensively use these substances in agriculture. Increasing temperature of permafrost soils in the Arctic also corrodes metal containers and accelerates pollution from stored industrial waste. It is likely that these processes significantly increase the prevalence of toxic substances (PCB, HCB, DDT, lead) in indigenous children tested from 2001-2007, despite the fact that the use of those toxic substances in tested areas ceased in the 1990s (Figure 2).

Figure 2. Temporal Trends in Human Exposure to POPs (as Measures for Serum Concentrations, μg/L). A Cohort of Indigenous Children 6 Years Old of Arctic Russia



Thus, climate change is a significant risk factor in the increasingly harmful effects of persistent toxic substances on public health in the Russian Arctic, which demands urgent measures to prevent climate change.

[Grebenets, 2006] are particular causes for concern. Coastal erosion in the Arctic territories also threatens ports, tanker terminals and other industrial facilities. A real threat exists for petroleum storage facilities in Varandey, located on the coasts of Pechora Sea [ACIA..., 2004].

High temperatures in Arctic cities exacerbate the decline in air quality caused by pollution. A study of air quality in Moscow found that the concentration of fine particles PM10 increases with rising temperatures in summer and with declining temperatures in winter [Revich, 2008]. Similar studies have yet to be conducted for cities in the Russian Arctic.

The highest levels of air pollution in the Arctic region are found in Norilsk and the towns on the Kola Peninsula (Monchegorsk, Nikel, Zapolyarniy, Kirovsk, Apatity). In Monchegorsk (population 55,000), the world's largest nickel works Severonikel emits sulphur dioxide as well as compounds of nickel, copper, lead, cobalt, platinum, chlorine, benzo(a)pyrene and other substances. Metallurgical facility emissions also pollute the air in Nikel (population 16,000) and Zapolyarniy (population 18,000). Average annual concentrations of sulphur dioxide and insoluble compounds of nickel in the air exceed the maximum allowable concentration by 12-20 times in Nikel and by 5 times in Zapolyarniy [Talykova, 1996]. Pollutant concentrations were even higher when there was no air movement. The emission of nickel into the environment has led to increased nickel accumulation in the bodies of residents in Nikel and Zapolyarniy [Bykov, 1997].

The enterprise *Apatit* extracts and processes apatite-nephelinic phosphate ores, which affects other small towns in Murmansk Oblast, Kirovsk (population 34,000) and Apatity (population 64,000) with the emission of phosphorus, aluminum compounds, and other substances [Talykova, 1996; Bykov, 1998]. Kandalaksha (population 60,000) hosts an aluminium smelter, whose emissions treatment, waste stockpiling and storage processes are not enough to protect the environment from chemical pollution. Kandalaksha's air shows excessive concentrations of hydrogen fluoride, salts of hydrofluoric acid and benzo(a)pyrene [Chashchin, 2006].

Norilsk (population 221,000) located in southwest of Taymyr Peninsula north of the Arctic Circle leads among the Russian cities in pollutant emissions. The city has a metallurgical facility that produces nickel, cobalt, copper and other metals. In 2005, emissions from the Zapolyarniy division of Norilsk Nickel totaled 2.1 million tones, of which sulphur dioxide accounted for 2.0 million tonnes. Only about 41% of sulphur dioxide was captured and neutralized.

The climate north of the Arctic Circle features extreme atmospheric phenomena and intensive cyclone activity. Temperature, air pressure and wind speed can fluctuate severely in short periods of time. In winter, the weather conditions are worst for emission accumulation as frequency of air stagnation can reach 9-19% and mist stagnation can reach 8-17%. In the recent years, there has been a gradual decrease in pollutant concentrations in the air from sulphur and nitrogen dioxides, nitrogen oxides, hydrogen sulphide, phenol, formaldehyde, and suspended particles. However, high concentrations of nickel, copper, sulphur dioxide, phenol, and suspended particles continue and worsen during periods of adverse weather conditions.

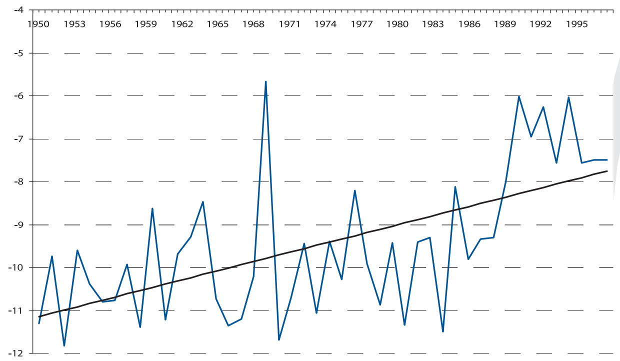
According to estimates for recent years, air pollution accounts for 37% of first-discovered incidence of a desease among children and 21.6% among adults. Norilsk residents have higher prevalences of health complications than elsewhere in Krasnoyarsk Krai, including respiratory, eye, ear, mastoid, bone and muscular diseases. In Norilsk, the incidence among children of a number of diseases is higher than the average for Krasnoyarsk Krai, including blood and hematopoietic organ disease (by 44%), nervous system disease (by 38%) and bone and muscular disease (by 28%) [Report..., 2006] In the Arctic and sub-Arctic region, there are many communities using coal for fuel, which further pollutes the air.

3. Climate Change in the Arctic and Emidemiological Challenges of the Permafrost Degradation and Floods

3.1. Climate Change

Climate change in the Arctic is more severe than in many other parts of the world. According to the survey *The Impact of Arctic Warming*, "the increasingly rapid rate of recent climate change poses new challenges to the resilience of Arctic life" [ACIA..., 2004]. These changes have decreased the area and thickness of sea ice, eroded coastlines, thawed permafrost, moved the border of the forest zone northward or to higher altitudes, increased risks of flooding in littoral areas and increased risks of forest fires. Changes have also occurred within ecosystems. A specific velocity of decrease of expansion for September ice in Siberian seas for 1996-2007 in accordance with trends was 7.7% annually. It was 3.2% annual decrease for the northern hemisphere [Report on the Peculiarities of Climate ..., 2008]. Temperatures in this region are expected to continue to increase. A constant rise in annual average temperature is also observed in settled areas (Figure 3).

Figure 3. Average Annual Temperature Trends in Yakutsk



According to various forecasting models, summer temperature changes in Yakutsk, Tura and Zhigansk are estimated to change between -3.8 and +2.7° C by 2020. This could be accompanied by a rise in the temperature of frozen ground. Towards the middle of the twenty-first century, the surface temperature of permafrost could grow by 1.5-2.0°C in Western Siberia and Yakutia, and by 1.0-2.0°C in Chukotka and northern regions of the Far East [Izrael et al., 2006]. The western part of the Russian Arctic is also experiencing rising temperatures, although not as markedly as in the east. In 2006, the average annual temperature in Murmansk Oblast was 0.7-1.7°C above average. Over the winter season, the average air temperature was –5 to -7°C on the coast and –8 to –10°C in central and southern areas, which is 1-2°C higher than usual. In November 2006, abnormally warm weather occurred as average monthly temperatures floated between -2 and +2°C, which is 4-7°C higher than usual. The last instance of such warm November weather was in 1967. Climate change was also associated with periods of very low temperatures, which is characteristic of climate change elsewhere [Report on Environmental Protection and Sustainable Natural Resources Management in Murmansk Oblast in 2006, 2007].

3.2. Degradation of Permafrost

Climate change in the Russian Arctic also degrades permafrost, such that vast territories of tundra may be replaced by taiga. From epidemiological point of view these changes could expand the habitat of rodent species that carry infections. Changes in water circulation and rising water temperatures could also increase diseases in marine mammals and fish. Changes in permafrost also damage the foundations of buildings and disrupt the operation of vital infrastructure in human settlements, resulting in an additional risk of disease. Studies forecast that the total area of permafrost may shrink by 10-12% in 20-25 years, with permafrost borders moving 150-200 km northeast [Anisimov et al., 2004].

One survey of the impacts of climate change in Russia and neighbouring countries cites several examples of such situations [Russia and Neighbouring Countries..., 2008]. An apartment building collapsed following melting permafrost in the upper stream of the Kolyma river, and over 300 buildings were severely damaged in Yakutsk as a result of retreating permafrost. More than 50% of buildings in Pevek, Anderm, Magadan, and Vorkuta have also been damaged [Anisimov, Belolutskaya, 2002, Anisimov, Lavrov, 2004]. Approximately 250 buildings in Norilsk industrial district had significant damage caused by deteriorating permafrost and approximately 40 apartment buildings have been torn down or slated for demolition [Grebenets, 2006].

The geocryological hazard index is used to assess the risk of damage to structures built on permafrost. Ratings are especially high in Chukotka, on the coast of the Kara Sea, in Novaya Zemlya and the north of the European part of Russia. Permafrost degradation along the coast of the Kara Sea may lead to intensified coastal erosion, which moves the coastline back by 2-4 meters per year [Anisimov, Lavrov, 2004]. This coastline retreat poses considerable risks for coastal population centres in Yamal and Taymyr and on other littoral lowland areas. Climate refugees may emerge if climate change significantly damages housing. Refugees from climate change have already appeared in Arctic territories of the United States (Shishmaref) and Canada (Tuktyaktuk). Coastal destruction has also become a problem for residents of Inupiat and on the island of Sarichev.

3.3. Floods and Disease

Risks to human health in the Arctic are posed mainly by natural phenomena such as snowstorms, frost, avalanches, high waters, and floods. These events are becoming increasingly frequent, resulting in higher rates of death, trauma and post-traumatic shock. People who live through extreme weather conditions can develop mental disorders from the traumatic experience. Low-income people are especially hard-hit by floods, which pose a significant threat for vital infrastructure in communities and threaten public health.

Natural disasters may have indirect consequences for public health, including increased mosquito populations after flooding, the activation of ticks and other infection carriers, increases in the period of potential infection carriers and disruptions in the operation of water supply and sewage facilities, which aggravates the risk of intestinal infections.

The impact of floods on human health is so great that the WHO European Office has published materials of a special international meeting on this issue:

Floods, Climate Change and Adaptation Strategies for Human Health. The social impact of floods includes the destruction of housing, infrastructure, industrial facilities and energy networks. Floods can also lead to the pollution of drinking water with hazardous chemicals from storage facilities containing poisonous chemicals, POL, or petroleum.

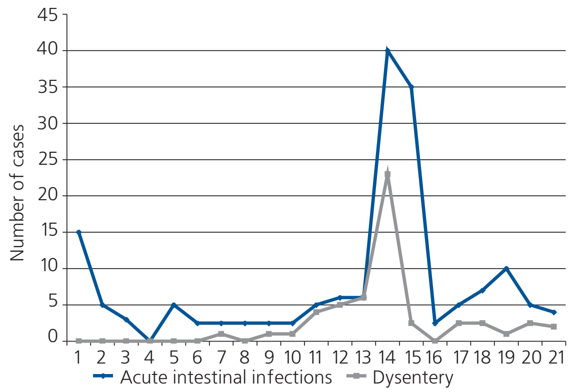
In the recent years, floods have affected Yakutia more than any other region. One of the worst floods occurred in the city of Lensk in 2001, when an extremely cold winter caused an unprecedented spring thaw flood. Large quantities of ice combined with a warm spring caused rapid melting of glaciers in the upper stream of the Lena river, aggravated by heavy rains. As a result, the water level rose to the highest level in the history of Lensk by 2.0–2.5 meters. Broken ice floated through the city, destroying houses, roads and power lines along the way.

As a result, water levels rose to historic levels and flooded the city. Ninety-two evacuation posts were quickly set up in the face of the expected spring thaw flooding. Food reserves were prepared, temporary storage for agricultural animals was arranged, feed reserves were created, and people and cattle were evacuated [Eco-Epidemiological Assessment of the Quality of Water in the Lena River, 2006].

The Lena flood endangered the delivery of vital services for sanitation and health for over 38,000 residents in Yakutia between spring and August 2001. City infrastructure was ruined, water sources for industrial and domestic needs were damaged, and drinking water sources were threatened with total pollution. As well, petroleum reserves were destroyed in the city, and 9,000 tons of petroleum products were dumped into the Lena river. Eighty percent of housing in Lensk was fully destroyed or damaged and 95% of the city was flooded. Water reached the very centre of the city. To prevent intestinal infections, officials suspended the operation of water pipes and left just one water pipeline in operation that was equipped with a system of hyperchlorination. Sewage pumping stations and urban wastewater treatment facilities were flooded. The pollution of drinking water led to an increase in the incidence of dysentery and acute intestinal infections (Figure 4).

The 2001 flood in Yakutia significantly increased the incidence of hepatitis A. After many years in decline, hepatitis A levels sharply increased by 30 times. In 2001, 39,000 people in Yakutia living in 59 communities were affected with hepatitis A. Nearly 8,500 residential buildings and 304 utility facilities were destroyed, cattle and poultry were killed, arable and grazing lands were flooded, and agricultural assets were damaged. Total damages amounted to over 7 billion roubles.

Figure 4. Incidence of Dysentery and Acute Intestinal Diseases of Unidentified Aetiology in Lensk in 2001 (average for 5 days) [Protodyakonov, 2007]



Such disastrous consequences from floods and other phenomena caused by climate change could happen again. Only 40% of Yakutia's population is supplied with running water from centralized sources and 140 operational water pipes fail to meet sanitary standards. The republic adopted urgent measures to address these threats to public health. Emergency maintenance and rehabilitation of sewage and wastewater treatment facilities prevented dumping of more wastewater into the environment, old artesian wells were put back into operation, and water was chlorinated [Protodyakonov, 2007]. After the flood, the region proposed to build a single water supply station, improve sewage facilities and build new infrastructure.

Climate change also leads to increased frequency and intensity of coastal floods at sea. As a result, sources of drinking water may be flooded with seawater, which, in turn, can threaten water quality.

4. The Russian Arctic Human Settlement and Health

4.1. Human Settlements

The Russian legislation (Presidential Decree No. 46 of 24 January 1992) defines territories of the "Extreme North" and territories with equal entitlements. According to official data, territories of the Extreme North include Murmansk Oblast, Nenets Autonomous Okrug, the town of Kostomuksha, and four districts in Karelia, towns of Vorkuta and Inta and four districts in Komi Republic, Yamalo-Nenets Autonomous Okrug, Taymyr Autonomous Okrug (cities of Norilsk and Igarka), Sakha Republic (Yakutia), Magadan Oblast, Chukotka Autonomous Okrug, two districts in Khabarovsk Krai, five northern districts of Sakhalin Oblast, and two districts in Tyva Republic. Territories with entitlements equal to those of the Extreme North include the town of Kandalaksha in Murmansk Oblast, individual districts in Arkhangelsk Oblast, Komi Republic, Karelia, Khanty-Mansiysk Autonomous Okrug, some districts in Tomsk and Irkutsk Oblasts, Krasnoyarsk, Primorye and Khabarovsk Krais, and the republics of Buryatia and Tyva.

The Sub-Arctic region situated near the Arctic includes Arkhangelsk Oblast (except Nenets Autonomous Okrug), Komi Republic (except Vorkuta), Khanty-Mansiysk Autonomous Okrug, city of Yeniseysk, Yeniseysk District, Severo-Yeniseysk District and Turukhan District in Krasnoyarsk Krai, Evenkia Autonomous Okrug, southern districts of Sakha Republic (Yakutia), and Okhotsk District of Khabarovsk Krai.

Based on this classification, the population of the Russian Arctic and sub-Arctic is estimated at 6.7 million, or 4.7% of the national population. Up to 87% of the Arctic residents and 80% the Sub-Arctic residents live in cities and urban settlements (Table 1).

Table 1

Population of the Russian Arctic and Sub-Arctic Region (as of 1 January 2007), in Thousands

Region	Urban	Rural	Total
Arctic	1695,8	245,7	1 941,5
Sub-Arctic	3676,2	1068,4	4 744,6
TOTAL	5372,0	1314,1	6 686,1

There are 46 towns and urban settlements with a population of over 5,000 located in extreme climate conditions (Table 2).

4.2. The Main Health Trends in the Russian Arctic

The extreme climatic conditions of the Arctic territories affects demography and public health. The temperature in the Arctic reaches -20 to -30°C between December and February. Temperatures are even lower on colder days, especially with strong arctic winds. In many communities, the poor condition of power units and electricity networks results in frequent accidents and heating outages that can last days or even weeks.

Large medical research centres specializing in studying and preventing the impact of climate on health were established in the Arctic and sub-Arctic given the large number of towns, intensive economic development and indigenous minority peoples.

Table 2

Urban Population of the Russian Arctic (5,000 or More Residents)

Number of Residents (in thousands)	Cities
> 100 N=4	Murmansk (317), Norilsk (209), Noviy Urengoy (177), Noyabrsk (110)
40-100 N=6	Vorkuta (77), Apatity (62), Severomorsk (54), Monchegorsk (49), Nadym (48), Salekhard (40)
20-40 N=8	Kandalaksha (38), Muravlenko (37), Kirovsk (31), Labytnangi (27), Dudinka (23), Olenegorsk (23), Gubkinskiy (22), Tarko-Sale (20)
From 5 to 20 thousand	28 communities

These research centres created a new field, arctic medicine, with important epidemiological studies carried out by the Institutes of Clinical and Experimental Medicine and Physiology (Novosibirsk), Institute of Medical Problems of the North and Extreme North (Krasnoyarsk, Nadym), other research organizations of the Siberian Division of the Russian Academy of Sciences, medical institutes and universities. The findings of those projects were presented at the 13th Arctic Medicine Congress [Circumpolar Health..., 2006].

The Arctic and Sub-Arctic residents often endure chronic polar tension, caused by lowered immune system resistance from the harsh Arctic climate. Further north, the adaptive capacity of the body becomes exhausted, numerous diseases develop at a young age, and premature ageing is common. Arctic stress syndrome is a biological phenomenon in the North, causing metabolism and endocrine system disorders, immune system deficiency, psychological stress, and other health disorders [Trufakin, Khasnullin, 1998; Khasnullin, 1998].

The Russian Arctic faces the same demographic challenges as Russia as a whole, but in some of the Arctic territories negative trends are especially pronounced. These trends include population decline caused by high mortality, especially in employable age groups, a low birth rate, outbound migration, and an ageing population. Murmansk Oblast, for example, has the fastest shrinking population of all the regions of the European north. From 1989-2002, Murmansk Oblast lost almost a quarter of its population, decreasing from 1,147,000 to 893,000 residents. Mortality increased to double the birth rate in

Climate Change Impact on Public Health in the Russian Arctic

the towns of Kirovsk and Kandalaksha, and the proportion of elderly people grew by 1.5 times. As the elderly are one of the major groups at risk from climate change, the Russian Arctic's ageing population is of special concern.

Russia's high mortality rate is one of the country's most pressing social problems. The World Bank report on this issue, *Dying Too Young* (2005), notes that the most common reasons for mortality, disease and disability are non-infectious diseases and traumatism.

BOX 2: Mortality and Life Expectancy Profile of the Russian Arctic

Life expectancy at birth or at a certain age is the most adequate indicator for reflecting mortality rates. The trends of life expectancy in the Russian Arctic regions generally follows national trends, although in some short periods there are opposite movements (Figure 5.1).

In 1989-2006, life expectancy at birth was lower than the national average in most Arctic regions except in Khanty-Mansiysk and Yamalo-Nenets Autonomous Okrugs. Life expectancy was higher in 2006 for both men and women in Koryak Autonomous Okrug, for men in Chukotka, and for women in Nenets Autonomous Okrug.

In Khanty-Mansiysk and Yamalo-Nenets Autonomous Okrugs that are more economically developed regions, life expectancy was increasing after the late 1990's for both men and women. During the same period, national life expectancy rates were decreasing, except in 2006. Consequently, life expectancy at birth in the late 1990s in Khanty-Mansiysk and Yamalo-Nenets Autonomous Okrugs was 2.88-4.35 years higher than the national average for men and 0.06-1.44 years higher for women in 2006. Mortality rates in Evenkia and Taymyr Autonomous Okrugs are not as stable, due to their small populations.

Figure 5.1. Life Expectancy at Birth in Russia and the Arctic Regions, 1989-2006

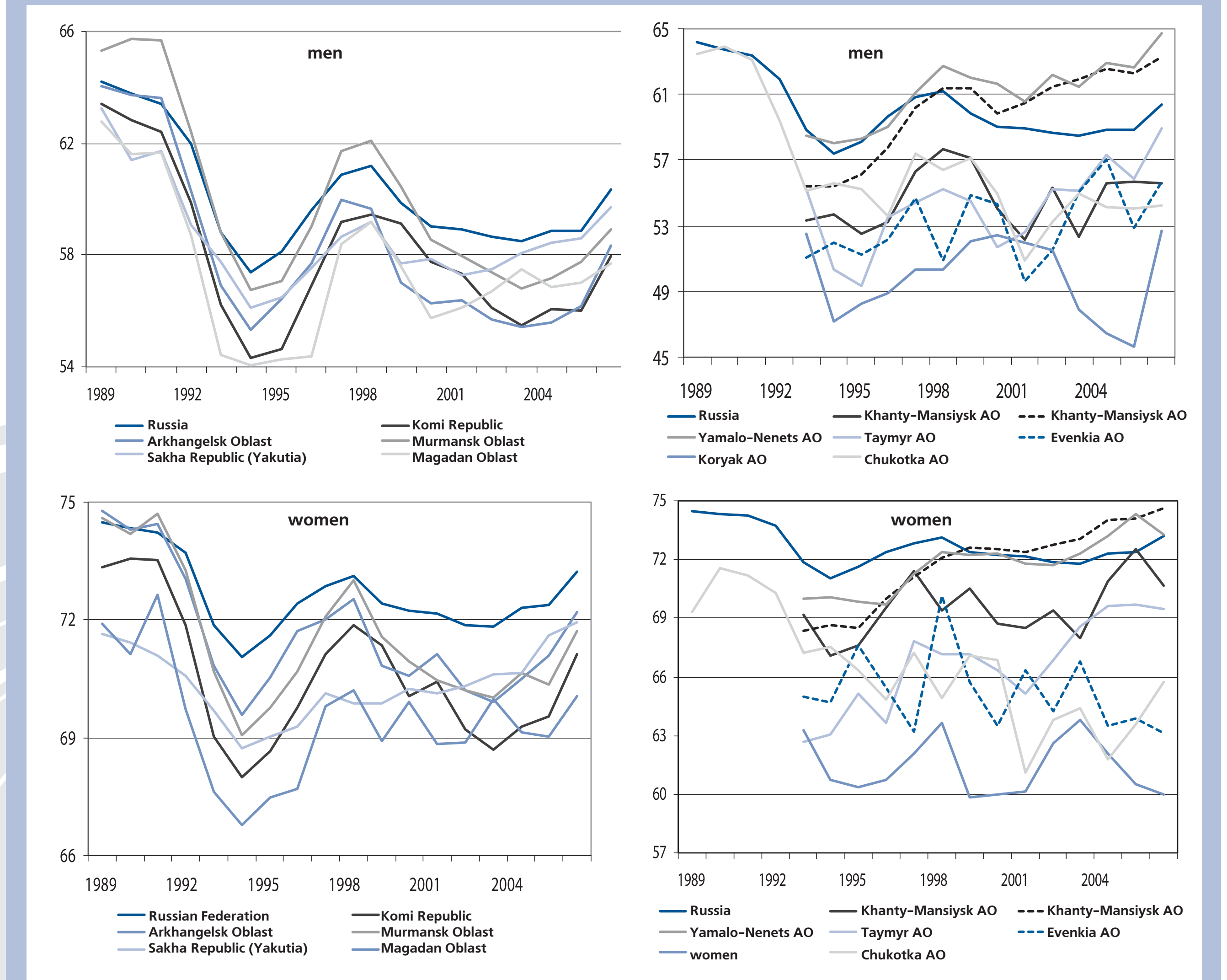
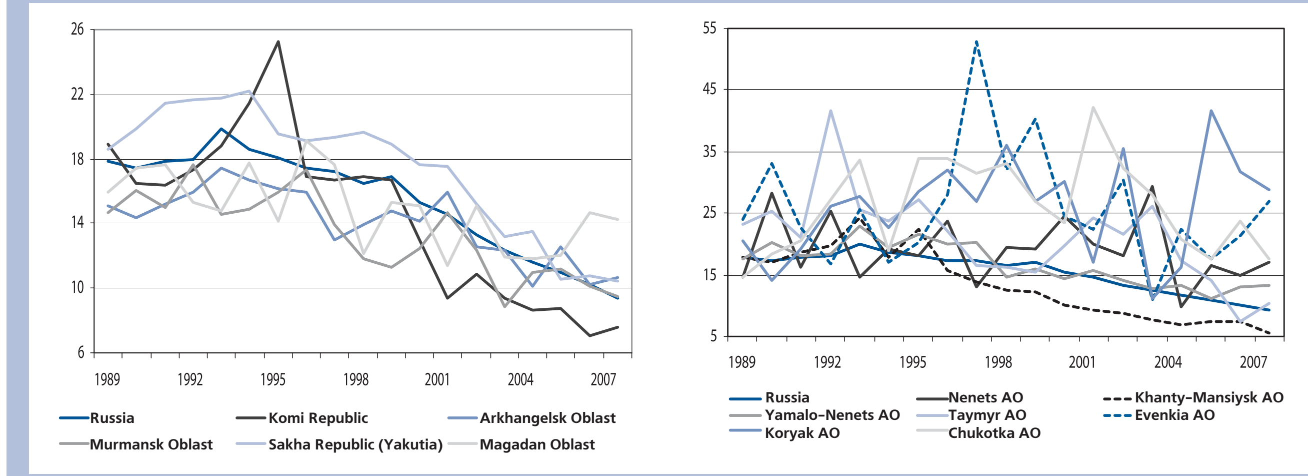


Figure 5.2. Infant Mortality in Russia and the Arctic Regions of Russia, 1989-2007 (Infants, Who Died Before Turning One Year Old per 1,000 Live Births)



The causes of mortality in the Arctic are similar to those in Russia as a whole. The main causes of death (about 90% of all death cases) include diseases of the circulatory system (first for both men and women), external causes (second for men, third for women), and neoplasms (third for men and second for women). In 2004-2006, nearly all regions experience a decrease in mortality caused by circulatory system diseases and external causes, especially among men. Nevertheless, the standardized mortality coefficient of circulation-related diseases increased in Nenets, Evenkia and Yamalo-Nenets Autonomous Okrugs, and in Sakha Republic (Yakutia).

For women, many regions showed increasing mortality in 2005-2006: Nenets Autonomous Okrug (neoplasms, circulation system diseases, digestive system disorders, external causes), Evenkia Autonomous Okrug (circulatory and digestive system diseases), Sakha Republic (Yakutia) (digestive system diseases and external causes), and Koryak Autonomous Okrug (certain infectious and parasitic diseases, neoplasms, circulation, and digestion diseases).

Infant mortality is one of the main indicators of human development. From 1989-2007, Arctic territories varied significantly in infant mortality. Infant mortality was comparable with the national average and trends for the oblasts and republics (excepting Sakha Republic (Yakutia)) in (Figure 5.2, left side). In all autonomous okrugs (Figure 5.2, right side), except Khanty-Mansiysk, infant mortality was considerably higher than the national average, although it decreased in recent years. Infant mortality patterns are unstable due to small populations in these regions.

While high suicide rates are characteristic of northern regions, Russia ranks second in the world with 30 suicides per 100,000 people. According to a WHO estimate, the critical suicide level is 20 cases per 100,000 people. Arctic territories with the highest suicide rates include Nenets and Koryak Autonomous Okrugs, the latter having the highest suicide rate at 133.6 cases per 100,000 people, almost five times the national average.

The demographic age profile is an important factor in estimating the impact of climate change on human health as the elderly are especially vulnerable to the impact of climate change. The population of the Arctic region tends to be younger than the national average. In 2007, the share of pensioners in larger oblasts such as Murmansk and Arkhangelsk, and in Komi Republic was 15-19%. This share is even smaller in the autonomous okrugs at 6.5-12.3% [Demographic Yearbook, 2007]. These could be caused by high mortality in working age people and migration of the elderly out of the region.

The incidence of a disease in the Russian Arctic is also unique. Residents of the Arctic face very cold temperatures combined with strong winds and high humidity. The physiological stress induced by the cold results in cold-related lung disease, upper respiratory tract disease and flu epidemics caused by weakened immune systems. Northern environments also aggravate respiratory diseases and exacerbate bronchial asthma attacks.

Official medical statistics indicated that in 2005-2006 the incidence of disease among adults in the Arctic and sub-Arctic was higher than the national average, particularly in Nenets and Koryak Autonomous Okrugs. In Nenets Autonomous Okrug, the incidence of adult diseases registered for the first time is double the national average, and the cumulative incidence is 1.5 times higher. High incidence of disease in adults is also characteristic of

Khanty-Mansiysk, Yamalo-Nenets and Chukotka Autonomous Okrugs, Komi Republic and Magadan Oblast. In those territories, respiratory diseases are increasingly common among adults. In Nenets and Koryak Autonomous Okrugs and in Chukotka, the incidence of serious illness such as pneumonia is higher than the national average, which is related to difficulties in timely access to health care [Human Disease Incidence in 2006..., 2007].

Children are also vulnerable to the impact of climate change. In the Arctic, the incidence of health disorders among children is considerably higher than the national average and has increased in the past decade, as up to 70% of children suffer from health disorders. The highest figures of disease incidence among children in 2005-2006 were in Nenets and Chukotka Autonomous Okrugs. The same period had an especially high incidence of children's respiratory diseases, including pneumonia, in almost all Arctic regions.

Children in the north have different health conditions early in life than children elsewhere in Russia. The difficult climate and polluted environment cause children in the Arctic to lag 2-5 years behind the national average in immune system development. Every fifth child is under-weight, and the penetration rate of helminths is higher than the national average. Children in the Arctic tend to have blood circulation tension in their lungs and reduced speed of pulmonary engorgement, which increases the risk of morphofunctional changes. Large numbers of children also display residual neurological symptoms and mental disorders, which makes it difficult to adapt to a multi-ethnic environment.

A significant part of children living in the Arctic also have cognitive disorders, considerable developmental lags and signs of emotional problems. Northern children develop premature and massive short-sightedness and astigmatism (57% of children aged 8-9). Arctic living conditions cause particular health conditions in children, including high rates of iodine deficiency, alcohol abuse, and low levels of physical activity. Children also suffer from emotional stress, which results in high rates of increased aggression (65.8%), hostility (73.7%) and anxiety (48.3%) in examined children. As children mature in the Arctic, there is an increase of mental conditions, including depression, increased aggression, anxiety and hostility [Sergey Tokarev, Head of Laboratory of Adolescent Pathologies, Research Institute of Medical Problems in the Extreme North, Russian Academy of Medical Sciences].

Rising temperatures in the Arctic also have certain positive effects on human health, as mortality is higher in winter. Cold weather increases the frequency of certain injuries (freezing, hypothermia, and accidents) and diseases (cardiovascular, respiratory, circulation, and skin conditions). A warmer climate in winter will reduce high winter mortality, especially through lowered cardiovascular and respiratory mortality.

4.3. Health Challenges for Indigenous Peoples

Approximately 160,000 indigenous people reside in the Russia's Arctic and sub-Arctic territories (Table 3).

BOX 3: Demography of Northern Indigenous Peoples

Russia has 40 small ethnic groups that are officially classified as "indigenous small-numbered peoples of the North, Siberia and the Far East" [http://www.severcom.ru/nations/]. Demographic information is available on twenty-six ethnicities, of which approximately 91,000 live north of the Arctic circle, and 70,000 inhabit sub-Arctic territories north of the 60th parallel. Nearly three quarters of the indigenous minority people live in rural areas (80% in the Arctic) and are dispersed across vast territories. Although they are classified as a single group, they differ significantly from each other in terms of ethnicity, geography, and demographic trends.

Demographic indicators are rarely calculated for specific ethnicities and trends are assessed based on census data. Population dynamics depend not only on demographic processes (birth rate and mortality), but also on ethnic dynamics (assimilation). Recent decades have seen an increase in ethnic population groups at the expense of people of mixed ethnic origins. The ethnic population grew from 1979-1989 and increased significantly from 1989-2002, after assimilation in 1959-1979 decreased the population. Similar population gains unrelated to demography are also found among other indigenous peoples, such as Native Americans, including natives of Alaska and Australian aboriginals, and others.

Consequently, using census data on ethnic groups cannot be used to understand demographic trends. Instead, data on natural demographics collected in the USSR and Russia until 1997 can offer a picture of demographics in indigenous minorities using accepted statistical methods.

The birth rate among indigenous minorities in the North has been falling over the past forty years, although it is still higher than elsewhere in Russia. The cumulative birth rate factor is 2.2, which is nearly equal to the natural replacement rate and significantly higher than national average of 1.3. In the North, birth rates are higher than the natural replacement rate only among the Nenets (3.1) and Chukchi (2.3). However, the major demographic challenge remains the high mortality rate and low life expectancy among indigenous minorities. In the past 20 years, the gap between the mortality in indigenous minorities and the rest of the population has remained constant.

Indigenous minorities in the North have higher mortality rates and lower life expectancy than indigenous peoples of the non-Russian North (Figure 5.3).

Current demographic trends are caused by the extremely high mortality among adults. Adults living in the North are much more vulnerable to mortality than elsewhere (Figure 5.4). Among the Inuit, natives of Greenland, almost three fourths of men (74%) and 82% of women live for 60 years. Among northern indigenous minorities in Russia, the rates are lower at one third of men (37.8%) and less than two thirds of women (62.2%). These figures are 54 and 83%, respectively, for Russia as a whole, and 88 and 94% – for Denmark.

Mortality rates from external causes in northern indigenous minorities (36%) are over double the

Table 3

Northern Indigenous Population (2002 census)

Arctic – A Sub-Arctic – SA	Population of northern indigenous peoples
Arctic and Sub-Arctic	58,818 including 91,222 in the Arctic part
Murmansk Oblast (A)	1995
Arkhangelsk Oblast (excepting Nenets Autonomous Okrug) (SA)	625
Nenets AO (A)	7782
Komi Republic (SA) Vorkuta (A)	881 500
Yamalo-Nenets AO (A)	37287
Khanty-Mansiysk AO (SA)	28496

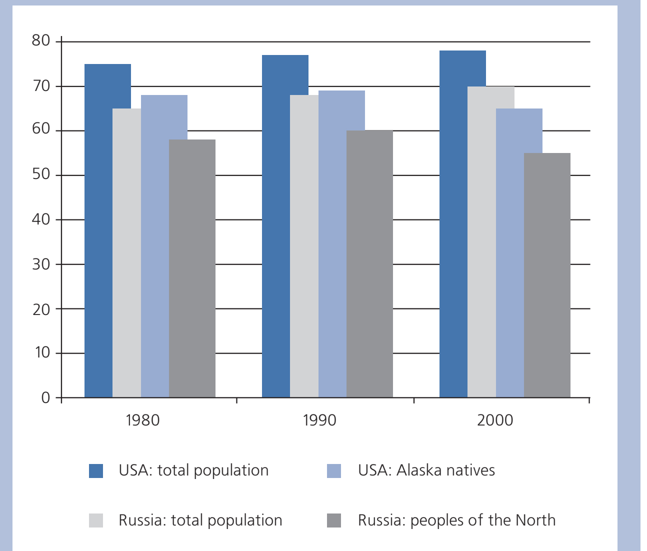
Arctic – A Sub-Arctic – SA	Population of northern indigenous peoples
Norilsk + 3 districts	1254
Taymyr AO (A)	9879
Evenkia AO (SA)	4078
Sakha Republic 13 northern ulus (A)	33133 16556
Khabarovsk Krai, Okhotsk District (A)	1259
Magadan Oblast (SA)	4995
Koryak AO (SA)	10239
Chukotka AO (A)	16865

Table 4

Natural Movement of Indigenous Peoples of the North of Russia (per 1000)

Periods	Live Births	Died	Natural increase	Infant mortality
1984-1988	30,2	10,5	19,7	41,1
1989-1993	25,7	10,8	14,8	30,4
1994-1998	19,8	12,6	7,2	32,5
1999-2002	17,6	11,7	5,9	27,6

Figure 5.3. Life Expectancy in Russia, Including Indigenous Minorities of the North, and the United States, Including Natives of Alaska



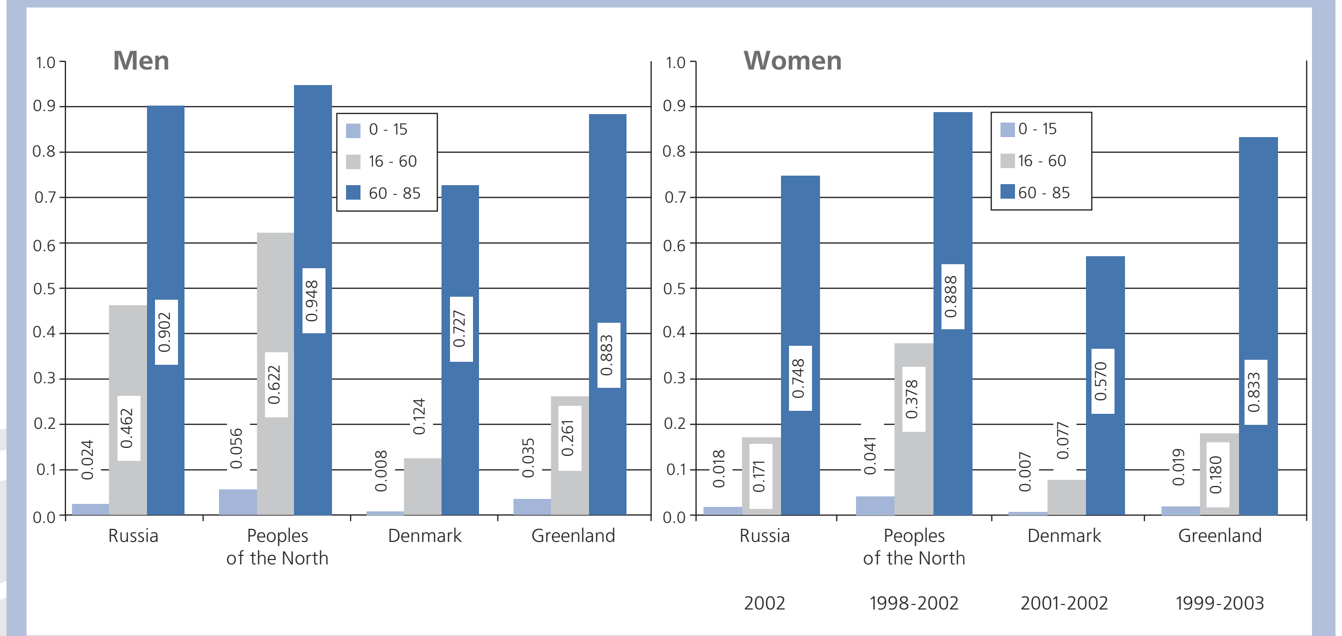
national average (15%). Accident-related mortality rates in Russia are over double the international average, and among Northern peoples this figure is double again the national average. From 1998-2002, the incidence of suicides among northern indigenous minorities was over 100 per 100,000 (compared to the national average of 38 per 100,000), and the incidence of homicides was 70 per 100,000 (compared to the national average of 27 per 100,000). Mortality caused by infectious diseases, mainly tuberculosis, is also very high among northern indigenous minorities (60 per 100,000), which is extremely high for a developed country in the twenty first century (compared to the national average of 23 per 100,000). This extremely high mortality rate among northern indigenous minorities could be considered as crisis in terms of demographic situation.

Table 5

Life Expectancy at Birth: Entire Russian Population and Indigenous Peoples of the North of Russia (years)

	Indigenous peoples of Northern Russia			Entire population of Russia			Lag of Indigenous peoples of Northern Russia		
	1978-1979	1988-1989	1998-2002	1978-1979	1988-1989	1998-2002	1978 -1979	1988-1989	1998-2002
Total	49,1	59,4	54,8	67,7	69,3	65,7	18,6	10,0	10,9
Male	44,3	54,0	49,1	61,7	64,5	59,6	17,4	10,5	10,5
Female	54,1	65,0	60,5	73,1	74,4	72,4	19,0	9,4	11,4

Figure 5.4. Probability of Death among Indigenous Northern Populations in Russia, Denmark and Greenland by age group



The negative impact of climate warming in the Russian Arctic is seen even more clearly than in other parts of the country. Global warming creates significant challenges for both public health and traditional natural resources management among indigenous peoples in the Arctic.

The thinning of the ice cover of East Siberian and Chukchi Seas and the northern part of Bering Straits and Beaufort Sea poses a formidable challenge for northern indigenous minorities. The absence of ice in summer and autumn has affected feeding conditions for the Pacific walrus, an animal traditionally hunted by indigenous peoples. As a result, the walrus population has declined, southern breeding grounds have disappeared, young walruses have increased morbidity, and the physical condition of adult animals has deteriorated. Indigenous people in the coastal villages of Eastern Chukotka continue to depend on the meat and grease of walruses, such that the decline in their population and health has a direct impact on traditional diets [Bogoslovskaya, 1996].

The lengthening ice-free season, thinning sea ice, changes in reindeer migration routes, and a decrease in the population of sea animals negatively affect traditional occupations among northern indigenous minorities. This, in turn, will affect traditional diets. Indigenous peoples in Chukotka facing thinning and early breakup of sea ice have experienced hunting difficulties, and this aggravates traumatism, a significant cause of morality among northern indigenous minorities.

Climate warming can challenge traditional food gathering and force the replacement of traditional nutrition with other food products. Northern indigenous minorities tend to consume a greater share of purchased food as their contact with mainstream Russian society increases. Until the late 1980s, Arctic indigenous minority diets broadly followed changes in diet with aboriginal communities of the non-Russian Arctic. Since the 1990s, the consumption of purchased food by Russian northerners fell steeply, and minorities returned to more accessible local produce [Kozlov et al., 2007].

As indigenous populations abandon traditional occupations and sources of nutrition for more modern diets; they experience a higher incidence of cardiovascular diseases, develop diabetes, tooth decay and obesity. Traditional diets are important not only for health but are also the foundation of cultural traditions. Hunting, fishing, gathering, and reindeer herding are important sources of livelihood for indigenous northern communities. Traditional livelihoods create a strong, positive bond between aboriginals and their environment, and help to preserve both their cultural heritage and their lands. In the indigenous communities of the North, the use of traditional resources is important for economic activity, social cohesion, and cultural identity. In northern territories, climate change also creates problems with traditional food storage, which results in a higher incidence of intestinal disorders.

Extreme weather caused by climate change may lead to difficulties in transportation. Air connections with smaller communities are irregular in many areas. People remain isolated for long periods of time in autumn and spring, when there is too much ice to make the waters navigable but not enough to use dog sleds or snowmobiles. As possibilities for traditional hunting, fishing and transport decline, there can be disruptions in food and other supplies. As well, an increased sense of isolation can cause personality conflicts, depression and other forms of social stress.

Climate change threatens current settlements and sources of livelihood through erosion, permafrost melting and changes in ecosystems. If northern indigenous minorities were forced to relocate, it would provoke swift, long-term cultural changes and the loss of traditions, leading, in turn, to mental disorders [Curtis et al.., 2007; Hamilton, 2003]. Climate change will continue driving rapid social change in these communities. This disrupts thousand year-old ties between ethnic communities and the environment that are at the heart of the identity, culture and welfare of northern indigenous peoples [Berner et al., 2005].

The increasing number of hot days in the Arctic also has negative consequences for the health of northern peoples. The most detailed study on this subject is available for Canada, where extremely high temperatures (up to 30°C) have resulted in breathing difficulties among the elderly in northern part of the country. Residents in some Arctic areas experience increased respiratory strain associated with extremely warm summer days [Furgal et al., 2002]. In northern Sweden, a one-degree increase in temperature has led to a steep rise in the number of cases of non-lethal, acute myocard imfarction, a type of heart attack [Messner, 2007].

4.4. Infectious Disease

Climate change is already affecting the incidence of infectious diseases in the Arctic. The movement of the forest zone northwards expands the habitat of agents and carriers of infectious diseases (such as ticks). As well, the increased incidence of diseases in marine mammals, birds, fish, and mollusks (including botulism, pneumoencephalitis, plague, sea bird flu and herpetiform virus epidemic in oysters) also increases the incidence of human infection [Climate Change..., 2007].

Indigenous Arctic host species now suffer from numerous zoonoses, including rabies in foxes, brucellosis in ungulates, foxes and bears, echinococcus in rodents and dogs. The proliferation of these diseases could also be carried by animal populations as they migrate northwards. In addition, rising temperatures allows many insect species acting as disease carriers (for example, mosquitoes carrying West Nile Virus) to survive in wintertime, which sets the stage for the emergence of diseases new to the Arctic. The change of avian migratory routes can also expand the area affected by certain infectious diseases. The Arctic has become an increasingly hospitable destination for foreign Asian species that may be carriers of tropical diseases. Ships releasing ballast waters could also allow agents of infectious disease to reach the Arctic. The intrusion of competing species or diseases that affect local species could prove disastrous for fishermen and local residents.

4.4.1. Acute Intestinal Infections

Water-borne infectious diseases may also increase as climate change alters precipitation levels, as well as the accessibility and quality of drinking water. In a number of other countries, increasing temperatures combined with an expansion of water reservoirs has lead to a higher incidence of bacterial dysentery, campilobacteriosis, salmonellosis and other intestinal diseases.

The incidence of dysentery is higher across a significant part of the Arctic than the Russian national average. Dysentery was higher in 2005-2006 in Nenets Autonomous Okrug and Krasnoyarsk Krai, and in the last three years, in Taymyr, Chukotka and Arkhangelsk. The incidence of dysentery varies from year to year in other territories, which also suggests risks to public health. The low incidence of dysentery in Evenkia is likely due to under-registration of cases, as healthcare facilities are often remote. In spite its economic development, Khanty-Mansiysk Autonomous Okrug still has a high incidence of intestinal infections, although dysentery has decreased. As well, the incidence of acute intestinal infections of unidentified etiology and salmonellosis in Khanty-Mansiysk Autonomous Okrug is one of the highest in Russia.

Statistical data is not available on the incidence of viral hepatitis A for a number of autonomous okrugs. In 2005-2006, high incidence rates of viral hepatitis A were diagnosed in Arkhangelsk and Magadan Oblasts, and a very high level was reported in Chukotka. In 2000-2004, however, a much lower rate was registered in Magadan Oblast, which may be caused by either poor diagnosis or cyclicality in incidence.

Access to safe drinking water remains critical for human health, as infectious agents are still present in drinking water in many communities. The absence of clean water especially affects low income groups. According to Rospotrebnadzor, drinking water quality is worst in Sakha Republic (Yakutia), where 32% of tested water samples from reservoirs did not meet biological standards, a rate that is 1.3 times higher than the national average [On the Sanitary-Epidemiological Situation in the Russian Federation in 2006, 2007]. Water reserves in Sakha Republic (Yakutia) have deteriorated recently due to continued pollution, spring floods as river ice breaks up and autumn floods [Protodyakonov, 2007]. The findings of a special study indicate the spread of pathogenic viruses in the waters of the Lena river, which is the main source of drinking water for the

Table 6

Incidence of Bacterial Dysentery in the Russian Arctic (cases per 100,000), 2005-2007
[Collection of Statistical and Analytical Materials..., 2007, 2008]

Heightened level		Medium level		Low level	
2005	2006/2007	2005	2006/2007	2005	2006/2007
Chukotka AO		Komi Republic		Evenkia AO	
213,5	308,2 152,5	47,2	12,7 14,9	17,2	11,5
Arkhangelsk Oblast		Murmansk Oblast			
63,9	39,8 43,5	29,4	15,5 11,6		
Nenets AO		Khanty-Mansiysk AO			
35,8	52,4 11,9	35,2	16,7 17,8		
Taymyr AO		Yamalo-Nenets AO			
210,5	181,2 n/a	31,4	17,6 17,8		
Krasnoyarsk Krai		Sakha Republic (Yakutia)			
69,4	30,8 18,1	55,3	31,8 11,5		
		Magadan Oblast			
		26	31,2 62,9		
Russian Federation average: 2005 – 42.8; 2006 – 25.3; 2007 – 22.2					

n/a – data not available

Table 7

Incidence of Acute Hepatitis A in the Russian Arctic (cases per 100,000)
[Collection of Statistical and Analytical Materials..., 2007, 2008]

Heightened level		Medium or unstable		Low level	
2005	2006/2007	2005	2006/2007	2005	2006/2007
Chukotka AO		Khanty-Mansiysk AO		Komi Republic	
352,5	92,8 63,4	22	9,9 7,5	8,6	3,8 1,9
Arkhangelsk Oblast		Sakha Republic (Yakutia)		Krasnoyarsk Krai	
61,2	59 13,5	32,7	7,0 6,2	9,6	3,4 5,0
Murmansk Oblast		Magadan Oblast		Yamalo-Nenets Autonomous Okrug	
65,7	50,6 13,7	41,9	3,5 2,3	8,8	3,6 6,5
Russian Federation average: 2005 – 30.2; 2006 – 15.7; 2007 – 10.3					

republic's towns and villages [Eco-Epidemiological Assessment of the Quality of Water in the Lena River, 2006].

The poor quality of surface water sources is also common in Arkhangelsk Oblast (75-77% of tested samples in 2005-2006), Khanty-Mansiysk AO (50%), Yamalo-Nenets AO (53-61%), Sakha Republic (Yakutia) (29-42%), Magadan Oblast (28%). Biological testing also revealed poor quality water in 36-49% of water samples in Arkhangelsk Oblast and 37-33% in Yamalo-Nenets AO. Water samples in Sakha Republic (Yakutia) increasingly do not meet biological water quality standards. Even after treatments, such as disinfection, the water supply network of Arkhangelsk Oblast often does not produce water that meets biological water quality standards.

None of the Arctic territories enjoy high quality drinking water. A lack of safe drinking water affects the populations of Yamalo-Nenets and Chukotka AO. Up to 10% of residents in Koryak AO and up to 60% in Evenkia AO use untreated water from wells and rivers. Sewage facilities are absent along the entire Ob river in Yamalo-Nenets AO. However, special regional programmes to supply the population with good-quality drinking water have only been developed in Murmansk Oblast, Chukotka, and Yamalo-Nenets AO [On the Sanitary-Epidemiological Situation in the Russian Federation in 2006, 2007].

Climate change may cause further degradation of drinking water quality in the Arctic. The erosion of permafrost, on which cities, such as Norilsk, Yakutsk, and Anadyr are founded, may cause accidents that affect water supply and sewage systems, provoking increased intestinal infectious disease.

4.4.2. Natural Focal Diseases

Climate warming affects the incidence of natural focal diseases by changing the environment of carrier populations and the development of disease agents inside carriers, allowing arthropod carriers to transfer more human and animal diseases. In the process, changed living conditions for carrier populations and development conditions for agents that develop in the carrier lead to increased transmission of human and animal diseases. Increasing temperatures accelerate the development of disease agents, make disease transmission more efficient, and expand the geographic area affected by disease.

Climate change in Russia during the 20th century has already affected the spread of natural focal infections, including the geography of agents, carriers and hosts, and the geographic distribution of foci. The impact of climate on natural focal infections also occurs against the backdrop of other changes in the environment, including shifts in environmental and socio-economic conditions. In particular, tick-borne encephalitis varies based on vaccination rates, preventive measures and the frequency of contacts between humans, agents, and carriers, which often happens during time spent at rural summer properties. Incidence also reflects cyclical fluctuations in the populations of carriers and hosts.

Tick-borne encephalitis. In the Arctic, endemic areas suffering from tick-borne encephalitis include Khanty-Mansiysk AO, as well as certain districts in Arkhangelsk Oblast and Komi Republic (Table 8). Official statistics do not allow estimates of incidence rates indicators in Taymyr and Evenkia AO of Krasnoyarsk Krai as well as Nenets AO. However, the incidence of tick-borne encephalitis in Krasnoyarsk Krai is 7-11 times higher than the national average.

Table 8

Incidence of Tick-Borne Encephalitis in the Russian Arctic (Cases per 100,000), 2005-2007
[Collection of Statistical and Analytical Materials..., 2007, 2008]

Heightened level		Low level	
2005	2006/2007	2005	2006/2007
Arkhangelsk Oblast, including Nenets AO		Murmansk Oblast	
6,6	6,5 8,5	0,3	0,1 0
Krasnoyarsk Krai, including Taymyr and Evenkia AO		Yamalo-Nenets AO	
26,9	23,8 18,0	0,7	0,6 0
		Khanty-Mansiysk AO	
		2,5	2,2 0,7
		Komi Republic	
		0,4	1,0 0,6
Russian Federation average: 2005 – 3.2; 2006 – 2.44; 2007 – 2.2			

Climate change has shifted the habitats of carriers of tick-borne encephalitis to the northeast in both European Russia and Siberia and has extended the period of tick activity [Zlobin et al., 2004, Danchinova et al., 2005, Alexeyev, 2006]. Spectral analysis of time series also revealed a correlation between climate conditions and tick population in Krasnoyarsk Krai. Climate change increases the productivity of forest biogeocenoses, accelerates the development of ticks, extends activity periods, and increases the population of tick feeders. It is difficult to assess the actual tick situation in the Arctic, as research has not been carried out in Murmansk Oblast and Yamalo-Nenets AO in 2007, and research was incomplete in Arkhangelsk Oblast [www.epinorth.org/eway].

In recent years, the highest incidence rate has been registered in Arkhangelsk Oblast, where incidence rates are 2.0-2.5 times the national average. Increased incidence of tick-borne encephalitis in Arkhangelsk Oblast is caused both by warmer winters and less frequent anti-tick treatment.

BOX 4: Climate Change and the Number of Tick Victims in Arkhangelsk Oblast

The impact of climate change on the spread of ixodic tick-borne diseases, such as tick-borne encephalitis and tick-borne borreliosis has created a crisis. In 2006, 18 of 25 administrative units of Arkhangelsk Oblast had endemic tick-borne encephalitis. The incidence of tick-borne encephalitis in Arkhangelsk Oblast differs significantly from the situation in Russia as a whole (Figure 5.5). While the incidence of tick-borne encephalitis has halved since the late 1990s in Russia, the incidence rate tripled in Arkhangelsk Oblast during the same period. In the 1980s, there were only a few cases of tick-borne encephalitis in the oblast, whereas in 2006, as many as 82 victims were reported.

To assess the impact of climate change on the number of tick victims, researchers used data on the number of people affected by ticks in the districts and towns of Arkhangelsk Oblast and data on air temperature from 29 meteorological stations in the oblast. To obtain more representative data, districts and towns of Arkhangelsk Oblast were broken down into three nominal groups by geographic zone: northern, central, and southern zones (Figure 5.6). Northern areas are currently not classified as endemic for tick-borne encephalitis.

Average annual temperature was stable at +0.75°C until the 1990s, varying from -1.5 to +2.6°C per year. Since the late 1980s, the average annual temperature has gradually risen. In 2007, the annual average temperatures in the oblast was +2.5°C, an increase of 1.75°C from the stable temperature levels of the 1960s to the 1980s. The number of tick victims in the 1980s was low, at 200-350 victims a year. However, the number of victims rose in the early 1990s to nearly 1,500 per year and remained stable until 1998. The number of victims has grown since 2001, and the number of victims reached almost 6,000 in 2007.

Figure 5.5. Incidence of Tick-Borne Encephalitis in the Russian Federation and Arkhangelsk Oblast

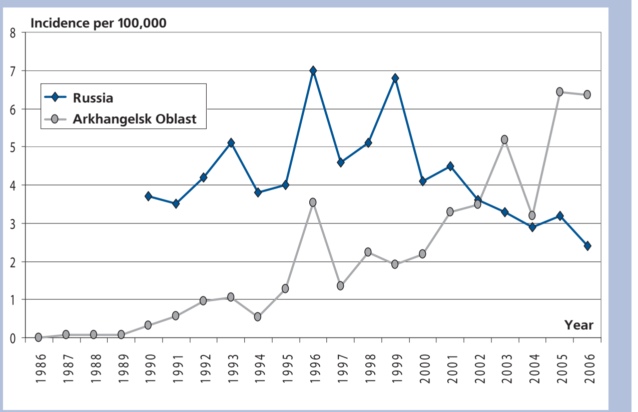


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Figure 5.6. Districts of Arkhangelsk Oblast. Groups of Districts Marked by Colour

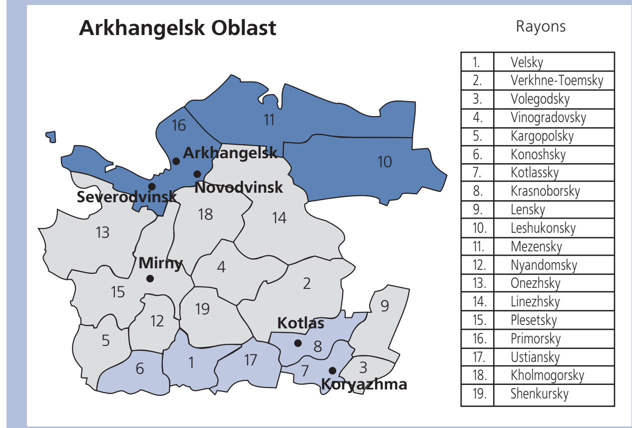
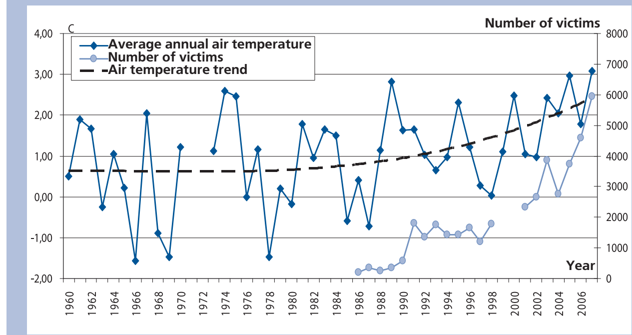


Figure 5.7. Change of Annual Average Temperatures and Number of Tick Victims in Arkhangelsk Oblast as a Whole



In southern districts, the average annual temperatures increased from +1.7 to 3.2°C (Figure 5.8). The average annual number of tick victims in the 1990s was 1,200, and in 2007 it reached 3,418. In central districts, temperatures rose from +1.0 to 2.7°C, although there had been a small decrease in temperature during the 1970s (Figure 5.9). The number of victims in the 1990s remained insignificant at 100-300 cases per year, but rising temperatures since 2001 increased the number of victims to 2,300 cases per year in 2007, a ten-fold increase within a decade. The northern districts do not suffer from endemic tick-borne encephalitis and have the lowest temperatures in the oblast. The only cases of tick attacks were registered in 2004 (Figure 5.10), but since then the number of victims has grown each year.

This data offers preliminary conclusions on the impact of climate change on ixodic tick attacks in Arkhangelsk Oblast. The number of victims appears to increase with rising temperatures. In northern districts, the first victims appear as annual average temperatures exceed +1°C. A steep increase in the number of victims follows as annual average temperature exceeds 1.5°C. Northern districts suffered their first incidence of tick victims. Victims in central districts grew ten-fold and in southern districts grew three-fold. Tick proliferation is very rapid, and a few warm years are enough to create a sustainable population of Ixodes persulcatus ticks in northern territories. The impact of climate change on tick victims must also account for other factors, including population dynamics, population mobility, cyclical natural processes and areas of acaricide treatment. To reduce incidence in Arkhangelsk Oblast and in the Arctic, preventive measure should be taken to halt transmission by ixodic ticks, including vaccination, building awareness on the risks of tick-borne disease, and the application of specific and non-specific prevention methods.

Figure 5.8. Change of Annual Average Temperatures and Number of Tick Victims in the Southern Group of Districts of Arkhangelsk Oblast

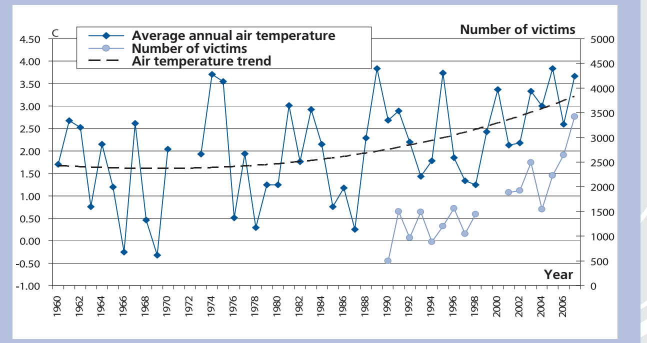


Figure 5.9. Change of Annual Average Temperatures and Number of Tick Victims in the Central Zone of Arkhangelsk Oblast

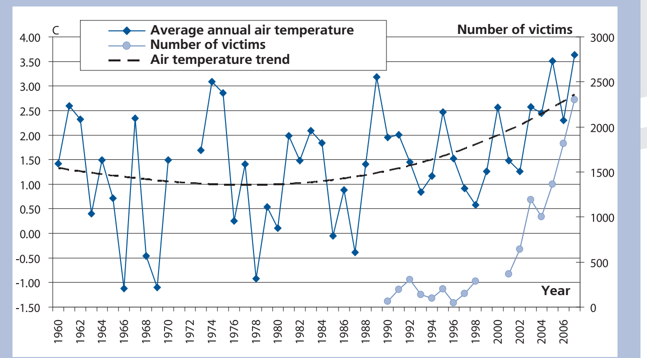
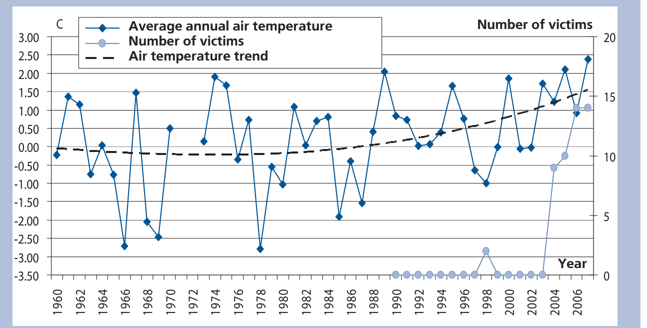


Figure 5.10. Change of Annual Average Temperatures and Number of Tick Victims in the North of Arkhangelsk Oblast



West Nile Fever. West Nile Fever (WNF) is a natural focal viral infection transmitted by mosquitoes. The WNF virus can infect many different species of birds and mammals. It was first identified on the East Coast of North America in 1999, and by 2002, it had spread across 43 states and six Canadian provinces. Although the virus originated in tropical Africa, it has already been found in Arctic mosquitoes. Climate change improves conditions for mosquitoes that act as carriers. Warm winters have caused the disease to spread across the United States and Canada, where 962 people have already died, prompting a special programme in Alaska to monitor for the WNF virus. It was expected that natural foci would emerge and clinical cases of WNF would be reported in northern Russia. In fact, this emergence has already occurred, with a few cases detected in Novosibirsk Oblast [Platonova et al., 2006].

Malaria. An increasing threat from malaria cases features prominently among the negative impacts of climate change listed in the fourth IPCC report. According to the most recent estimates, the geography of malaria in the 21st century will move northward, as the northern borders of malarial mosquitos moves northwards and their populations are reinforced by growing southern populations. It is expected that territories with endemic human malaria will suffer a longer infection transmission season, and the number of people at risk from malaria will grow significantly. Although malaria is presently not a significant risk in Russia, it could return to Russia.

Botulism. In the Arctic, botulism is associated with the consumption of reindeer. Infestations are possible, where indigenous northern people store reindeer meat in permafrost.

Parasitizes. The proliferation of parasitizes is a major challenge for the Arctic region. Higher incidence of lambliasis are consistently reported in many Arctic territories (Nenets, Khanty-Mansiysk and Yamalo-Nenets Autonomous Okrugs, Magadan Oblast and Krasnoyarsk Krai), as well as higher incidences of enterobiosis (Nenets and Chukotka Autonomous Okrugs). A very high incidence of difillobotriosis (over 20 times the national average) has been found among residents of Nenets, Taymyr, Yamalo-Nenets and Evenkia AO, and Sakha Republic (Yakutia). As well, very high rates of opistorchosis among the residents of Khanty-Mansiysk and Yamalo-Nenets AO are caused by the consumption of infected fish. Teniarinchosis remains an endemic problem in Nenets and Yamalo-Nenets AO, linked to the custom of eating the raw brain of reindeer. As the climate warms, the geography of many carriers of parasitic diseases may move north, including field mice, foxes, and dogs.

Highly Dangerous Infections. The incidence of tularaemia is higher than the national average in the Arctic region for certain years in Nenets and Taymyr AO, although this disease was absent or rare in other territories. This does not necessarily imply that tularaemia will emerge with global warming, as outbreaks of tularaemia were also reported in the 1950s and 1960s in Yakutia. Given the climate and geography of Magadan Oblast that allow the presence of certain rodent carriers, the conditions are in place not only for tularaemia but also for leptospirosis, lesteriosis and pseudo-tuberculosis.

Numerous foci of anthrax also existed in the Arctic regions, but only Sakha Republic (Yakutia) has over 200 burial sites for infected animals.

Storage sites for domestic and industrial waste may also facilitate the spread of infectious diseases. For example, foxes carrying rabies tend to congregate near waste dumps. Used tires create an ideal environment for the proliferation of mosquitoes carrying hemorrhagic fevers. In the face of the risk posed by climate change to the spread of infectious disease, Arctic countries have agreed to create a single epidemiological database. Russia has yet to join these efforts.

BOX 5: Highly Dangerous Infections in Sakha Republic (Yakutia)

Rabies has become increasingly widespread in Yakutia in the recent decades, both in its regular form and in a special Arctic variant known as "wild-play" [Yegorov, Chernyavsky et al.., 1996; Karpov, Chernyavsky, Karataeva, 1997; Epidemiological Surveillance..., 2000].

The regular form of rabies occurs in 15 taiga and mountain-taiga districts of Yakutia and is associated with animals such as wolves, foxes, dogs, reindeer, horses, and cattle. The second form of Arctic rabies occurs most frequently in the districts of Bulunskiy, Anabarskiy, Ust-Yanskiy, Allaikhovskiy and Nizhnekolymskiy. In these districts, rabies affects Arctic foxes, wolves, foxes, dogs, lemmings, and reindeer. Climate change has changed the migration routes and habitat of wild animals hosting the rabies agent. It has also improved conditions for infection agents with warmer winters, which may lead to further expansion of this infection.

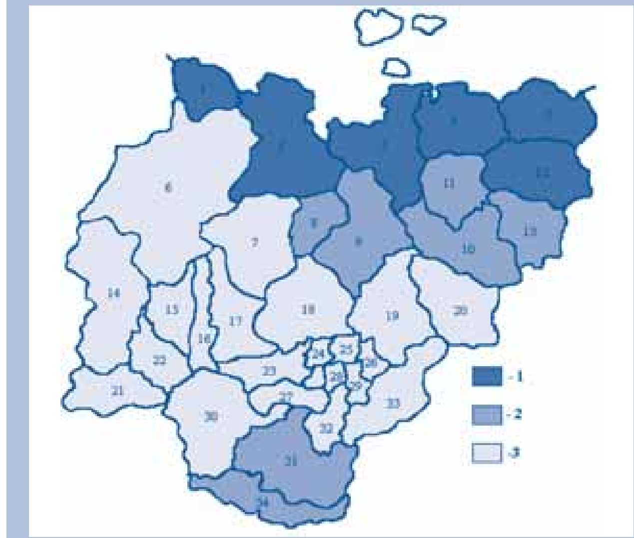
Warmer winters and expanded habitats may also awaken foci of anthrax and possibly smallpox. In the past, numerous anthrax sites existed in the Arctic territories. Sakha Republic (Yakutia) alone has over 200 burial sites for infected animals. Anthrax can spread to humans and many species of wild and domestic animals. Since it was detected 200 years ago, anthrax has been registered in 240 locations in 24 districts of Yakutia. Anthrax spores can survive in the soil for decades or even centuries. As new areas are developed for mining, construction and agriculture, there is a risk of disease agents entering humans or animals and reviving the infection, especially at burial sites for infected animals. This risk is especially acute in drier years when soil is made bare by trampling and pasturing, which allows agent spores to enter animals.

Climate change in the Arctic may also increase risks of highly dangerous infections by improving the geography of carriers, as warmer winters and thicker snow cover aid winter hibernation. Melting permafrost in sites, where human victims of disease are buried and the remains of mammoths in permafrost may also lead infections that were dangerous in the 18th-19th centuries to return.

There are already examples of this possibility. In the early 1990s, an old cemetery was discovered on a lake bank near the village of Pokhodsk in the lower stream of the Kolyma River, with buried remains of smallpox victims from 1884-1885. In the second half of the nineteenth century, an epidemic of smallpox killed two fifths of the population of Kolyma Okrug. Another smallpox outbreak in the valley of the Indigirka killed almost the entire population of the town of Zashiversk. Research findings indicate that viable viruses may survive in the tissues of people killed by smallpox that are buried in permafrost. This finding was also supported in a study of virus strains that were stored in the National Collection for 26 years and survived [Belanov et al.., 1997]. Authors of the study calculated that infectious material in tissues may survive under negative temperatures for up to 250 years.

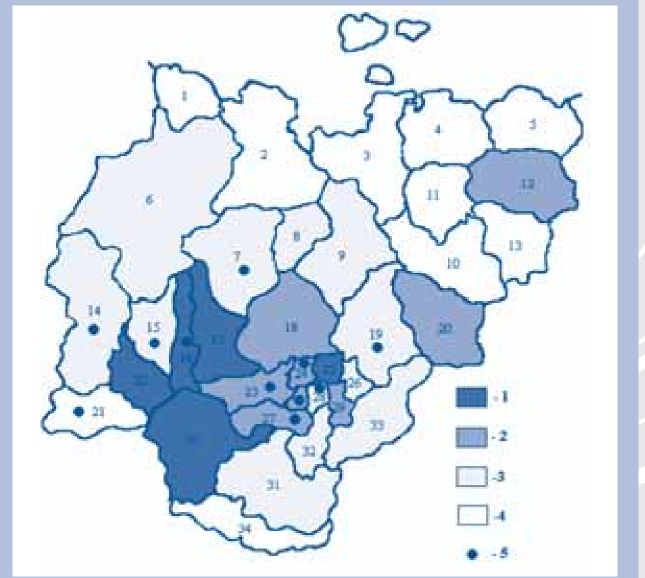
The study of samples of the naturally frozen brain of a Yukagir mammoth, estimated at over 18,000 years old, identified a high concentration of at least seven morphotypes of viable thermo-tolerant aerobic bacteria, with unstable characteristics permitting to relate to new species (except 3 N), which could become pathogens for humans [Belabanov et al..., 1997].

Figure 5.11. Distribution of Rabies Infections in Yakutia [Karpov et al.., 1997]



1 – high level of incidence (10 – 18 disease outbreaks)
2 – medium level of incidence (3 - 6 disease outbreaks)
3 – low level of incidence (1 – 2 disease outbreaks)

Figure 5.12. Map of Anthrax Epizoology and Epidemiology (1918 – 1996)



1 – high level of incidence (7 – 11 disease outbreaks)
2 – medium level of incidence (4 - 6 disease outbreaks)
3 – low level of incidence (1 - 3 disease outbreaks)
4 – anthrax-free zone
5 – incidence among humans in administrative areas

5. Recommendations

The countries most concerned with climate warming have prepared national action plans to reduce climate change risks to human health. Russia should draft similar plans for the Arctic, which would take into account its natural and climatic features, its unique epidemiology, public health, health challenges facing northern indigenous peoples, and the state of the public health system. The implementation of such an action plan in Yakutia in 2001 to address the consequences of flooding could serve as a positive example.

For communities with high levels of pollution, special programmes should be developed to assess the scale, intensity and consequences of pollution from heavy industrial firms, especially where long-term, significant changes to health have been observed. Such research will allow assessments of pollution and other health risks, which will help working out measures to reduce pollution, rehabilitate polluted areas and plan to neutralize accumulated waste.

Although there is currently intensive outbound migration from the Arctic, inbound migration in the future is always possible with prospects for the development of a Northern Maritime Route or new deposits of hydrocarbons, diamonds, and metals.

The development of government programmes to prevent and eliminate the negative effects of climate change on human health in the Russian Arctic requires joint efforts from medical staff, biologists, ecologists, climatologists, meteorologists, hydrologists, as well as experts in modelling and forecasting. Such federal and regional programmes should be based on three major principles:

- **Preventive action**, where timely measures are taken to notify stakeholders about the impact of climate change on human health and to eliminate the causes of these impacts.
- **Precaution**, aiming to prevent the impact of climate change on human health through assessment and preventive measures.
- **Medical ethics**, particularly principles adopted by the World Medical Association.

The priority must be to develop national and regional action plans to reduce the negative impact of climate change on human health in the Russian Arctic and sub-Arctic.

To reduce the impact of climate change on human health, these plans should be based on the findings from expert evaluations on the influence of climate on human health and on consultations with representatives of federal, regional and local authorities, business community, academia and the public. The plans should become a framework for strategic papers that determine goals, tasks and major measures with performance benchmarks and funding sources. Actions within national and regional plans should become components in existing federal, agency and regional programmes.

The international workshop *Impact of Global Climate Change on Human Health in the Russian Arctic* proposed the following major goals under the action plan:

1. Support and reinforce the system of assessing regional climate change in the Russian Arctic, including the environmental and social community monitoring involving northern indigenous peoples.

2. Develop regional scenarios for the Russian Arctic based on global models of climate change.

3. Reinforce efforts to assess the epidemiological situation in all regions of the Russian Arctic, in particular areas inhabited by northern indigenous peoples.

4. Develop preventive programmes to minimize adverse consequences of climate change for human health.

5. Strengthen government health surveillance over the sanitary situation in Arctic communities that are vulnerable to climate change.

6. Develop recommendations and action plans to protect the population against the consequences of emergencies associated with climate change (natural disasters, extreme weather conditions, and infection outbreaks), including early-warning plans, information about emergency medical assistance, shelters and emergency evacuation plans.

7. Train healthcare experts in various fields concern the impact of climate change on human health in the Arctic, involving regional research institutes and universities.

8. Raise awareness about the impact of climate change on human health among federal and regional officials.

9. Expand basic and applied research into the impact of global climate change on human health in the Arctic, inter alia to:

- identify the regions and population groups most vulnerable to the impact of climate change and its economic consequences
- assess the impact of climate change on the ecology of agents and epidemic process of infectious and parasitic diseases
- assess the impact of climate change on the increase in the infiltration of various pollutants (heavy metals, persistent organic compounds) through the melting of permafrost
- assess the incidence of infections in sea mammals, fish, and birds used as food or having contacts with humans
- assess the impact of changes in the level of tropospheric ozone on human health in the Arctic
- comprehensively assess the impact of climate change on traditional lifestyles and on the health of northern indigenous peoples

10. Expand international cooperation to assess the impact of climate change on human health in the Arctic using the capacity of individual Arctic countries, the Arctic Council and its working groups (including the Arctic Human Health Initiative and the Arctic Network of Infectious Disease Monitoring), the Arctic Forum, the European Commission, United Nations programmes and agencies and the World Bank.

11. Assess the effectiveness and adequacy of existing federal and regional systems of sanitary-epidemiological monitoring and epidemiological emergency response in the context of climate change and develop recommendations for their improvement.

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