Climate Change Impact on Public Health in the Russian Arctic
This publication has been prepared by a team of Russian experts and consultants. The analysis and policy recommendations in this publication do not necessarily reflect the views of the UN system and the institutions, by which the experts and consultants are employed.

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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 2.1°C 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...
Arctic region. Indigenous minorities in the Arctic often include 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 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 some of the world's largest metallurgical works, quarries, mining and processing enterprises, coalmines, nuclear weapons test sites, radioactive waste storage sites 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, Arkhangelsk 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 Arkhangelsk Oblast with the average income per capita below 10 thousand RUB). 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 considered as a determinant of the living standard for the Russian Arctic population, in the Republic of 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 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 1.4 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 of 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 indigenous peoples also 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 their equipped service. 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 the Yamal-Nenets 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 if 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 from regions that intensively use these substances in agriculture. Increasing temperature of permafrost soils in the Arctic also corrodes metal containers and accelerates pollution of 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.

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 biphenyl (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 atmospheric aerosol concentrations of the northern hemisphere coincide with the rapid shift of maximum condensation and fallout of the aerosol components of chlorogenic pesticides to 65-70 degrees north. These aerosol components are often transmitted through the atmosphere and precipitation to the Arctic region. 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.
Climate Change Impact on Public Health in the Russian Arctic

[Grebenets, 2006] are particular causes for concern. Coastal erosion 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 increased 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.

According to estimates for recent years, air pollution accounts for 37% of first-discovered incidence of a disease 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.

One survey of the impacts of climate change in Russia and neighbouring countries cites severalexamples of such situations [Russia and Neighbouring Countries... , 2008]. An apartment building collapsed following melting permafrost in the upper streams of the Yenisei River, and 400 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 due to permafrost [Grebenets, 2006, Anisimov, Lavrov, 2004]. Approximately 250 buildings in Norilsk industrial district had significant damage caused by deteriorating permafrost and approximately 47 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 degrada- tion along the coast of the Kara Sea may lead to intensified coastal erosion, which moves the coast- line back by 2-4 meters per year [Anisimov, Lavrov, 2004].

Coastal destruction has already appeared in Arctic territories of the United States (Shishmaref) and Canada (Tuktoyaktuk). Coastal degradation also appears to be a problem for residents of Inupiat and on the island of Sarichev.

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, permafrost affects building stability, changing the structure of ecosystems, as well as the damage to structures built on permafrost. The city of Norilsk has severe permafrost, the border of the forest zone toward 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 permafrost is observed for September ice in Siberian seas for 1945-2005. The temperature division of annually 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).

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 varied from −10°C to −2°C on the coast and −10°C to −16°C in central and southern areas, which is 4-7°C higher than usual. In November 2006, abnormally warm weather occurred as average monthly tempera- tures 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 tempera- tures, which is characteristic of climate change else- where [Report on Environmental Protection and Sustainable Natural Resources Management in Murmansk Oblast in 2006, 2007].

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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 espe- cially hard-hit by floods, which pose a significant threat for vital infrastructure in communities and threaten public health.

Natural disasters may have indirect conse- quences for public health, including increased mos- quito populations after flooding, the activation of ticks and other insect carriers, increases in the period of inactivity, the decrease in the operation of water supply and sewage facili- ties, which aggravates the risk of intestinal infec- tions.

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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 flooded 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 set up in the face of the expected spring thaw flooding. Food 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 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 a result, wells 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 supply facilities 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, or 50% of the population, 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 rubles.

4. The Russian Arctic Human Settlement and Health

4.1. Human Settlements


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 Krasnoyarsk Krai. Evenkia Autonomous Okrug, south 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% of 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

<table>
<thead>
<tr>
<th>Region</th>
<th>Urban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>1695.8</td>
<td>245.7</td>
<td>1941.5</td>
</tr>
<tr>
<td>Sub-Arctic</td>
<td>3676.2</td>
<td>1068.4</td>
<td>4744.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>5372.0</td>
<td>1314.1</td>
<td>6686.1</td>
</tr>
</tbody>
</table>

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.

Kandalaksha in Murmansk Oblast, individual districts in Arkhangelsk Oblast, Komi Republic, Karelia, Khanty-Mansiysk Autonomous Okrug, some districts in Tomsk and Irkutsk Oblasts, Krasnoyarsk Krai, Primorye and Khabarovsk Krai, the republics of Buryatiya and Tyva.

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Table 2: Number of Residents (in Thousands)

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Residents (in Thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctic</td>
<td>694.5</td>
</tr>
<tr>
<td>Sub-Arctic</td>
<td>105.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>800.2</td>
</tr>
</tbody>
</table>

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, out-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 fifth of its population, decreasing from 1,147,000 to 893,000 residents. Mortality increased to double the birth rate in...
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.

**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 1990s 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.

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.

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

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 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 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 and Yamalo-Nenets Autonomous Okrugs, and in Sakha Republic (Yakutia).

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 (excluding 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.

**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)**
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 health disorders among children. Children in the Arctic tend to have higher respiratory disease incidence rates 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 morpho-functional changes. Large numbers of children also display residual neurological symptoms and mental disorders, which makes it difficult to adapt to a multi-ethnic environment.

**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 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 fallen 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 Autonomous Okrug (SA) and the Khanty-Mansiysk Autonomous Okrug (SA).

For example, in the Murmansk Autonomous Okrug, the birth rate factor is 2.56, which is significantly higher than the national average of 1.3. In the North, birth rates are higher than the natural replacement rate only among the Nenets Autonomous Okrug (SA) and the Khanty-Mansiysk Autonomous Okrug (SA).

4.3. Health Challenges for Indigenous Peoples

Approximately 160,000 indigenous people reside in the Russian Arctic and sub-Arctic territories (Table 3).
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 resource 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 [Bogolovskaya, 1996].

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 late 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. Factors such as 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 minority cultures are 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 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, pneomococcalpneumitis, plague, sea bird flu and herpofeom 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 reindeer (including botulism, pneumococcalpneumitis, plague, sea bird flu and herpofeom virus epidemic in oysters) also increases the incidence of human infection [Climate Change..., 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, pneomococcalpneumitis, plague, sea bird flu and herpofeom 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
Climate Change Impact on Public Health in the Russian Arctic

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, which makes disease transmission more efficient, and expands the geographic area affected by disease.

The incidence of dysentery is higher across a significant part of the Arctic than the national average. Dysentery was higher in 2005-2006 in Nenets Autonomous Okrug and Krasnoyarsk Krai, and in the last three years, in Tyumy, 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 Evenki 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 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 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 cyclicity 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 [Protodyakov, 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 Russian Federation average: 2005 – 30.2, 2006 – 15.7, 2007 – 10.3

(references and tables)

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, changing 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, animals, 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 B). Official statistics do not allow estimates of incidence rates indicators in Taymyr and Evenki 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.

(references and tables)

(references and tables)
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 [Zobin 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 biocenoses, 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. 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 temperature 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.

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 has been a small decrease in the number of tick victims. In northern districts, the first victims appeared as annual average temperatures exceed +1°C. A steep increase in the number of victims follows as annual average temperature exceeds 1.3°C. Northern districts suffered their first incidence of tick victims. Victims in central districts grew three-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 measures should be taken to halt transmission by ixodic ticks, including vaccination, building awareness of the risks of tick-borne disease, and the application of specific and non-specific prevention methods.
West Nile Fever. West Nile fever (WNF) is a natural 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. Warmer 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 northwest, as the northern borders of malarial mosquitoes 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 risk of travel 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 incidences of leishmaniasis are consistently reported in many Arctic territories. [1] A very high incidence of filobotriosis (over 20 times the national average) has been found among residents of the town of Taymyr, Yamalo-Nenets and Evenkia AO, and Sakha Republic (Yakutia). As well, very high rates of opisthorchiasis among the residents of Khanty-Mansiysk and Yamalo-Nenets AO are caused by the consumption of infected fish. Teniarinichosis 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 tularemia 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 tularemia will emerge with global warming, as outbreaks of tularemia 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 tularemia but also for leptospirosis, leishmaniosis 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. Using tills as an ideal environment for the proliferation of mosquitoes carrying hemorrhagic fever. 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.

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, inborn 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:

1. 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.

2. Precaution, aiming to prevent the impact of climate change on human health through assessment and preventive measures.


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.

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 Arctic, including the environmental and social community monitoring involving northern indigenous peoples.

2. Develop regional scenarios for the Russian Arctic based on 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 emerging infectious diseases 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. Organize experts in various fields concerned with 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.

REFERENCES


