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# Mortality Rate Due to Circulatory and Alcohol-Dependent Diseases in Different Climatic Zones of Russia

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## Abstract

**AIM:** Evaluation of the impact of climatic factors on the formation of mortality due to circulatory diseases and a group of diseases related to alcohol consumption identified as alcohol-dependent.

**METHODS:** The study subject was the adult population residing in different climatic zones of Russia: in the second, third and fourth zones, with different conditions: average annual temperature (5.2°C; 1-2°C; -2.0°C), snow cover duration (≤ 150 days, ≤ 180 days, ≈ 220 days) sunshine duration and the presence of polar night and polar day in the territory of the fourth climatic zone. The assessment "impact-case of death" was carried out by calculating the standardized incidence ratio (SIR) with 95% confidence intervals (CI) for circulatory system diseases (CSD) and alcohol-dependent diseases (ADD) in accordance with the international classification of diseases (ICD-X).

**RESULTS:** The SIR of death from alcohol-dependent diseases for the female population in the 4th climatic zone (Murmansk Region) was the highest: the SIR of death from ADD 1.87; 95% CI (1.5-2.7), the SIR of death from CSD 1.3; 95% CI (1.2-2.3). For the female population in the 3rd climatic zone (Novosibirsk Region), the SIR of death has amounted to: SIRADD 1.52; 95% CI (1.2-1.87), SIRCSD 1.14; 95 CI (1.01-1.3). Living in the 3rd climatic zone was not so important for the health of the male population: the SIR of death from CSD 1.1; 95% CI (1.05-1.13); the SIR of death from ADD 0.8; 95% CI (0.65-0.98). However, living in the 4th climatic zone (Murmansk Region) poses a higher risk of death for the male population: SIRCSD 1.22 (22.0%); 95% CI (1.02-3.95); SIRADD 1.45 (45.0%); 95% CI (0.98-2.1).

**CONCLUSION:** Living in high northern latitudes contributes to higher levels of mortality, both female and male, from circulatory and alcohol-dependent diseases.

## Introduction

The number of studies aimed at assessing the interrelationship of climatic phenomena with public health is currently increasing. Typically, these studies focus on the influence of hot climate on public health or the waves of dramatic warming in Europe, North America, China, and Russia [1], [2], [3], [4], [5], [6], [7], [8], [9], [10].

However, a smaller number of studies are focused on the evaluation of the effect of low temperatures on public health [11], [12], [13], [14]. A large-scale cohort study has revealed an inverse correlation between average annual temperature, average annual sunny hours and alcohol consumption per capita (p = -0.5 and -0.57, respectively) [13].

Large Russian territory is located in regions where winter temperatures reach extremely low values against the backdrop of other important factors: high wind speed, the duration of snow cover, as well as photoperiodicity, high air ionization, sudden nonperiodic fluctuations of geomagnetic and static electric field strength, atmospheric pressure drops, and low partial density of oxygen in the air.

The climate of northern Russia causes mobilization of adaptation mechanisms of the human body. Long living on the territory with extremely low

winter temperatures and other climatic conditions unfavorable for public health is considered as a stress factor, which requires the mobilization of all resources of the body [15], [16], [17].

It is known that in the North, continuous adaptation to high latitudes leads to changes aimed at adjusting to the general biological mechanism of hypoxia. Peripheral vascular spasm and increased peripheral resistance at low environmental temperatures cause a tendency towards increasing blood pressure. At the same time, there is an increase in heart rate; a reduction in the minute volume of the circulatory system; an increase in blood circulation in order to ensure a smooth exchange of oxygen in tissue capillaries; an increase in the mass of the right ventricular myocardium in response to hypertension pulmonary circulation. The cardiovascular system is among the first to respond to extreme external factors [14], [15]. There is a high probability of formation of psychological tension among the population [7], [15], [16], which in turn can provoke alcohol consumption followed by widely ranging changes in health status [17], [18].

The problem of the influence of meteorological factors on the body has been studied for a long time. The works that appeared more than 30 years ago raised the issue of the need for a comprehensive study of the influence of meteorological factors on human health [14]. Diseases of the cardiovascular system are characteristic of the northern territories of Russia (3rd and 4th zones) and their prevalence among the working-age population ranges from 60 to 75% [13], [15]. Works draw attention to the fact that heart and blood vessels diseases as a cause of death have a higher proportion in the northern territories than in the middle zone of the country. There is every reason to believe that essential hypertension is one of the typical diseases of adaptation to extreme conditions of high latitudes, which is a serious problem.

The aim of this work is to assess the influence of natural and climatic factors of different climatic zones of Russia on the formation of male and female population mortality from circulatory system diseases (CSD) and deaths associated with alcohol use (alcohol-dependent causes of death). The object of the study was the adult population living in rural areas in the 2nd, 3rd and 4th climatic zones of Russia.

## Material and Methods

An epidemiological study of mortality (male and female) has been carried out in three regions of Russia in different climatic zones. The choice of regions was based on their similar key socio-economic characteristics, i.e. it is advisable to minimize other differences that are hindering factors for the identification of the role of climatic factors in the formation of public health.

The allocation of climatic zones was based on climate characteristics that affect the processes of heat exchange, and subjectively on the perception of a comfort climate [19], [20], [21].

Important factors influencing health reasonably include socioeconomic characteristics (income, health care, etc.) and ethnic composition, since a traditional diet and lifestyle can also influence health.

It is virtually impossible to ensure the similarity of territories in all socio-economic, environmental and geographic parameters. Therefore, first of all, the choice of regions for comparative analysis was based on those factors, which affect the public according to many researchers [22], [23], [24]. The average income, unemployment rate, and medical care were taken into account. Please explain tools to measure the difference of climate, how to measure alcohol concentration and respiration rate.

The climate characteristic of the areas selected for the study is formed on the basis of official long-term Russian Hydrometeorological Service meteorological data on temperature, humidity, speed and the prevailing direction of movement of air masses, rainfall, solar radiation, number of days per year with negative air temperatures and other climate indicators. For the measurement of all climate parameters, the specialists of the hydrometeorological service use instruments and equipment verified by metrological agencies and corresponding to the established requirements by the measurement range and permissible error.

Based on climate indicators, the space of Russia is conditionally divided into four climatic zones: 1st – Arctic, 2nd – Subarctic, 3rd – Moderate, $4^{th}$ – Subtropical. Climate data obtained by specialists of the Russian Hydrometeorological Service are published in the form of climate reference books and are available for various purposes (in construction, agriculture, when planning energy consumption, designing heat-protective clothing for working in an open area, for comparing the comfort of living of the population). Based on the difference in the complex of climatic indicators, the main ones of which are temperature and air velocity, the Penza region belongs to the 3rd climatic zone, the Novosibirsk region belongs to the 2nd climatic zone, the Murmansk region belongs to the 1st climatic zone.

The Murmansk (4th climatic zone), Novosibirsk (3rd climatic zone) and Penza Regions (2nd climatic zone) are located in different climatic zones but have closest socio-economic parameters. The national composition is mostly presented by the Russian population: 89.0%, 93.1%, and 86.8%, respectively. The number of physicians per 10,000

people, as well as the ratio of average income per capita (rubles per month) to the subsistence minimum, was higher in the Murmansk Region (Table 1).

**Table 1: Basic socio-economic characteristics of the Penza, Novosibirsk, and Murmansk Regions of Russia [25]**

| Socio-economic characteristics | Climatic zone | | |
|---|---|---|---|
| | 2nd | 3rd | 4th |
| | Penza region | Novosibirsk Region | Murmansk Region |
| Rural population | 1,368,657 | 2,731,176 | 771,100 |
| The ratio of average income per capita (rubles per month) to the subsistence minimum | 2.87 | 3.0 | 3.25 |
| Population with income below the subsistence minimum (% of total population) in 2016 | 12.6 | 12.1 | 10.9 |
| Unemployment rate, % | 4.6 | 5.1 | 7.2 |
| Number of physicians, people (per 10,000 inhabitants) | 39.3 | 55.9 | 57.0 |

More doctors per 10,000 people in the Murmansk and Novosibirsk Regions could promote the availability of medical care, and, hence, better detection of diseases. Secondly, the availability of medical care helps to reduce mortality, since diseases are detected at an earlier stage and their timely treatment brings greater success.

Thus, the indicators reflecting the availability of medical care and the level of material security can imply a lower level of mortality in the Murmansk and Novosibirsk Regions compared to the Penza Region. Climatic characteristics vary dramatically in the selected regions of Russia (Table 2).

**Table 2: Characteristics of some climatic parameters in the Penza, Novosibirsk and Murmansk Regions of Russia [25], [26]**

| Climate features | Climatic zone | | |
|---|---|---|---|
| | 2nd | 3rd | 4th |
| | Penza Region | Novosibirsk Region | Murmansk Region |
| | Temperate continental | Continental | Subarctic marine |
| Average t°C in January | -9.8; -10.7 | -16; -17 | -10; -12 |
| Wind speed (m/s) | 3.6 | ≤ 6.0 | ≥ 7.0 |
| Duration of snow cover (days) | ≤ 150 | ≤ 180 | 220 |
| Average t°C in July | 20.2 | 18.3 | 8-14 |
| Average annual temperature, °C | 5.2 | 1-2 | -2.0 |
| Duration of sunshine (hours/year) | 1700-2000 | 1700-2000 | ≤ 1700 |
| Climate features | - | - | Polar night: 02.12–11.01 Polar day: 22.05–22.07 |
| Heating season duration (days) (at t ≥ 8°C) | 200 | 225 | 274 |

An air transfer from the west to the east dominates in the territory of the Penza Region, as throughout the whole climatic zone, that is why the climate is strongly influenced by Atlantic air masses.

The Novosibirsk Region is located in the south-east of the West Siberian Plain. Plain territories allow free spreading of cold waves from the north and the waves of heat from the southwest. In this regard, the winter can be characterized by both severe frost and short thaws.

The Murmansk Region is located in the subarctic zone on the Kola Peninsula; the climate is temperately arctic, maritime, influenced by the warm Gulf Stream. The region is located on the border between the vast mainland area and the Barents Sea. Almost the entire territory lies north of the Arctic Circle. The Murmansk coast suffers the greatest wind speed: up to 40 m/s and more. Due to high humidity and strong winds, even a light frost is hard to endure. The period of polar night is characterized by the deficit of natural light and UV radiation.

When conducting a comparative analysis of mortality in different regions of Russia, the main attention was focused on diseases of the circulatory system (CSD) and alcohol-dependent diseases (ADD) that were allocated in accordance with ICD-X.

In addition to acute alcohol intoxication, the last group of death causes included: harmful alcohol consumption, alcohol addiction, other and unspecified mental disorders and behavioral disorders caused by alcohol; alcoholic psychosis; encephalopathy, dementia, degeneration of the nervous system caused by alcohol; alcoholic polyneuropathy, alcoholic myopathy, alcoholic cardiomyopathy, alcoholic gastritis, cirrhosis, alcoholic pancreatitis, accidental alcohol poisoning, intentional self-poisoning and effects of alcohol.

Calculations of mortality rates were based on the Rosstat data: information analysis content: regional data on the population of the Russian Federation by sex and age, distribution of deceased by sex, age groups and death causes (statistical form No. S51), statistical bulletin “Socio-economic indicators of poverty”, statistical bulletin “Population income and expenditure”, Demographic Yearbook of Russia 2014-2016.

In order to exclude the impact of region-specific production and ecological factors of the urban environment, the age-specific mortality rates of the rural population in different climatic zones were compared.

Age structural differences recalibrate mortality rates. In the Murmansk Region, the number of men aged 20-29 was two times higher than the corresponding number in the Novosibirsk and Penza Regions, and the proportion of older age groups, by contrast, was substantially less.

The statistical estimation of “impact-death case” was performed by calculating the standard incidence ratio (SIR) with a 95% confidence interval (CI) [23], [27].

The standardized incidence ratio (SIR) of adverse health effects was calculated as the ratio of the actual number of disease cases among exposed individuals to their expected number derived on the assumption that risk indicators in the control are taken as a standard. 95%CI of the relative risk was calculated using the following formula:

$$95\%CI = \exp^{\ln OP \pm 1.96\sigma\,(\ln OP).}$$

The control was the population in the 2nd climatic zone (Penza Region), since climatic characteristics of this region are more favorable to the population in comparison with the 3rd and 4th climatic zones. The standard was selected for the specific material and in relation to the established objectives. Extensive and intensive indicators that reflect the structure of death causes and their frequency in certain age groups were also calculated.

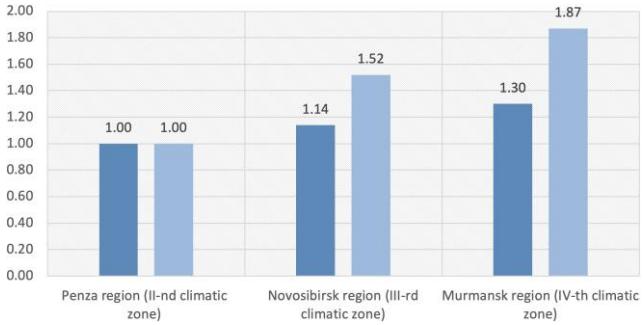


*Figure 2: Standardized incidence ratio (SIR) for circulatory diseases (CSD) and alcohol-dependent diseases (ADD) in 2016 for women (20-79 years) in rural areas living in different climatic zones (indicators for the Penza Region were taken for 1.0)*

## Results

Diseases of the circulatory system (CSD) traditionally occupy the first place among other death causes. The studied federal subjects of Russia are no exception. Among all death causes for males (20-79 years) in the studied regions of Russia, the proportion of deaths from CSD ranged from 44.4% in the Penza Region up to 48.6% in the Murmansk Region. The greatest percentage of female deaths from CSD was in the Murmansk Region – 62.4%, in the Penza Region – 58.4%, in the Novosibirsk Region –55.4%.

Studies have shown that alcohol-dependent death causes in the Novosibirsk Region constitute 5.1% among all causes, in the Murmansk Region – 10.0%. The corresponding factors for women were two times lower (Figure 1).

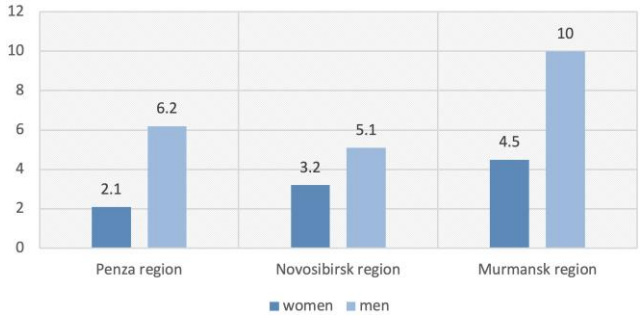


*Figure 1: Proportion of alcohol-dependent death causes among all causes for individuals aged 20-79 living in various climatic zones of Russia in 2016*

Most of these death causes (30.0-40.0%) were registered in the age group 20-39 years. The proportion of these deaths causes decreases with age.

The leading place in the structure of the alcohol-dependent death causes in the Murmansk Region belongs to cardiomyopathy (68.0% for men and 57.0% for women). In two other regions, this factor was lower: in the Novosibirsk Region – 21.4% for men, 45.2% for women. In the Penza Region, the proportion of deaths from alcohol cardiomyopathy was much lower – 15.1% for men and 25.0% for women.

Figure 2 and 3 present the standardized incidence ratio for two groups of causes for the male and female population.

The impact of cold climate on female mortality from CSD and ADD is obvious and is confirmed by the accuracy of the obtained results. The SIR of death from ADD for the 4th climatic zone (Murmansk Region) was the highest: the SIR of death from ADD 1.87; 95%CI (1.5-2.7); the SIR of death from CSD 1.3; 95%CI (1.2-2.3). For the female population in the Novosibirsk Region (3rd climatic zone), the SIR of death was: $SIR_{ADD}$ 1.52; 95%CI (1.2-1.87), $SIR_{CSD}$ 1.14; 95%CI (1.01-1.3).

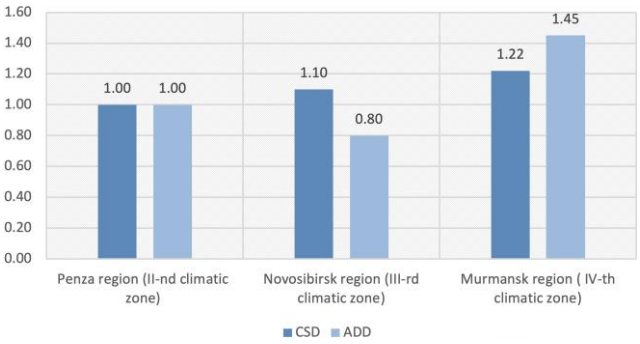


*Figure 3: Standardized incidence ratio for death from circulatory diseases (CSD) and alcohol-dependent diseases (ADD) in 2016 for men (20-79 years) in rural areas living in different climatic zones (indicators for the Penza Region were taken for 1.0)*

Living in the 3rd climatic zone was not so important for the health of the male population: the SIR of death from CSD 1.1; 95%CI (1.05-1.13); the SIR of death from ADD 0.8; 95CI (0.65-0.98). However, living in the 4th climatic zone (Murmansk Region) poses a higher risk of death for male population: the SIR of death from CSD 1.22 (22.0%); 95%CI (1.02-3.95); the SIR of death from ADD 1.45 (or 45.0%); 95%CI (0.98-2.1).

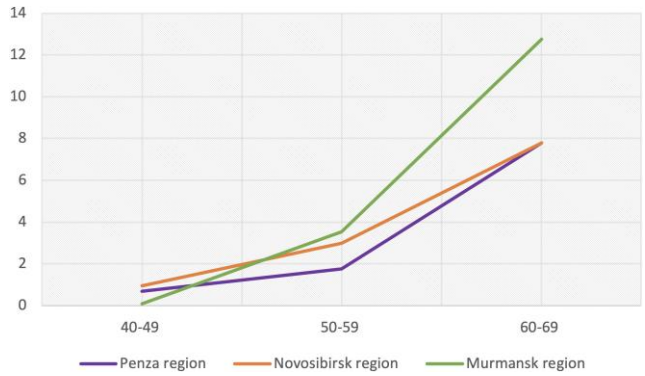


*Figure 4: Mortality from CSD in the Penza, Novosibirsk and Murmansk Regions in 2016 (per 1000 women living in rural areas) p ≤ 0.005*

Assessment of age-related mortality from CSD has shown increased mortality of individuals over 40, for both males and females. Differences in mortality increase along with age.

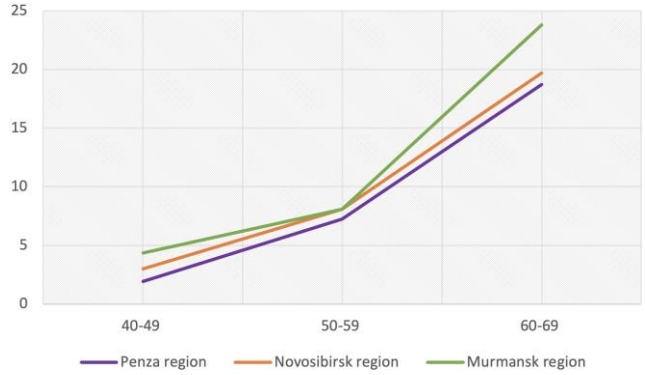


*Figure 5: Mortality from CSD in the Penza, Novosibirsk and Murmansk Regions in 2016 (per 1000 men living in rural areas) p ≤ 0.005*

## Discussion

Large Russian territory is located in high latitudes, with low environmental temperatures, long winter, and the polar night. The climate of the northern territories promotes the formation of mortality from cardiovascular diseases and death causes that are connected with alcohol to one degree or another. The need to exclude the "hindering" factors related to the socio-economic sphere of life has made this work more complex. A comparative analysis of health indicators for population living in regions in different climatic zones (2nd, 3rd, 4th climatic zones of Russia) with similar socio-economic characteristics has revealed that mortality from cardiovascular diseases among the population living in the Novosibirsk and Murmansk Regions (3rd and 4th climatic zones) is growing more intense with age. In this case, one can talk about the premature aging of the population living in the northern territories.

The obtained data are consistent with earlier studies that describe a syndrome of "polar" stress, which reduces adaptive reserves of the human body, accelerating the premature aging. This is demonstrated by higher and earlier indicators of mortality from circulatory diseases (CSD) [13], [15]. The widespread belief of wider alcohol consumption in northern latitudes is apparently not groundless. This is evidenced by more meaningful consequences for the health of people living in high latitudes: a high risk of death from alcohol-dependent causes among all causes is noted in the 3rd (for women) and 4th (for men and women) climatic zones (Novosibirsk Region, Murmansk Region).

In turn, this can provoke a wide range of diseases. The results obtained are consistent with the data described by other researchers [21], [28], [29], [30], [31], [32].

The mortality study of the male population of Izhevsk (3rd Climate Zone) showed that most causes of death, with the exception of tumors, correlate with alcohol consumption [28]. For three decades, fluctuations in mortality from circulatory system diseases (CSD) almost simultaneously follow the same tendency as the mortality rate from causes clearly associated with alcohol [27]. This trend is particularly noticeable in the fluctuations in mortality from coronary heart disease (CHD) and from cerebrovascular disease (CVD). But, as the authors indicate, those who died of alcoholic cardiomyopathy had the highest level of alcohol in the blood (1.45‰). In contrast, in those who died from all forms of cerebrovascular disease, the level of alcohol in blood was zero or very low.

Long-term studies conducted in Surgut (4th climatic zone) showed that the frequency of hospitalization of hypertensive patients increases during cold periods of the year by 2-3 times on average. Obliterating diseases of the vascular system appear at a younger age and often have a malignant course. The development of the atherosclerotic process in its classical version begins at the age of 40–50 years. Once arisen, the obliterating process has no tendency to reverse development, and the result of this process in 40% of patients is disability [31], [32].

The above studies address the health of the male population living in the northern regions of Russia. But as the obtained results showed, for the female population living in the northern regions, the damage from alcohol-related diseases significantly exceeds the losses of those who live in more comfortable climatic conditions.

The calculation of values and significance of standardized incidence ratio indicate the relationship between mortality from causes, which occur due to alcohol consumption with climatic characteristics of

the northern regions.

In conclusion:

1. The natural and climatic conditions of the 4th, 3rd and 2nd climatic zones of Russia (Murmansk, Novosibirsk, and Penza Regions) vary in average annual temperature (by more than -5°C and -7°C), wind speed in winter by two and more times, average temperature in January (-17°C versus -9.8°C) and in the number of sunny days. The distinctive features of the Murmansk Region are: polar night, a long winter period: more than 270 days, with strong winds.

2. It has been revealed that the contribution of the climatic factor in the 4th climatic zone to the formation of male mortality from circulatory diseases and alcohol-dependent death causes has amounted to 22.0% and 45.0%, as compared with those factors obtained for the population of the 2nd climatic zone (Penza Region).

3. The climate of the 3rd and 4th climatic zones of Russia has the greatest impact on the health of the female population. The contribution of the climatic factor to the formation of female mortality from circulatory diseases and death causes associated with alcohol consumption compared with those factors obtained for the population of the 2nd climatic zone (Penza Region) have amounted to 30.0% and 87.0%, respectively.

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