Evaluation of the impact of living conditions, as a set of social factors of the habitat, on mortality rates of the rural and urban population of the Nenets autonomous okrug in 2000–2019

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ABSTRACT

BACKGROUND: Currently, in the Arctic zone of the Russian Federation (AZRF), there are clear signs of a deterioration in the medico-demographic situation against the backdrop of a low level of development of social infrastructure. The study of the influence of living conditions, as a set of social factors of the habitat, formed by social infrastructure, on the mortality rates of the population of one of the AZRF regions, was carried out for the first time.

AIM: To assess the impact of living conditions, as a set of social factors of the habitat, on the mortality rates of the rural and urban population of the Nenets autonomous okrug (NAO) in the period 2000–2019.

MATERIALS AND METHODS: The databases "Housing and communal services and social infrastructure in NAO in 2000–2019" and "Death cases in NAO in 2000–2019" (including information on the population number and age-sex structure) of the NAO population in the context of individual settlements have been generated. Using the developed scoring system for assessing living conditions, a ranking (division into tertiles) of all rural NAO settlements was carried out according to the value of the integral index of living conditions (IILC). A comparative analysis (tertiles with the city, and tertiles with each other) of average annual age-standardized rates of overall mortality, mortality from the main causes and structural components of external causes (EC) of mortality was carried out. Relative epidemiological risks were calculated as the ratio of mortality rates in each tertile to the corresponding indicator for the urban population.

RESULTS: Average annual standardized rates (and relative risks) of mortality (total, EC, drowning, freezing, alcohol poisoning and transport accidents) of the NAO population "step by step" increase in the sequence "city — highest tertile — middle tertile — lowest tertile", i.e. as living conditions worsen (as the IILC decreases). Statistically significant differences were identified between the city and tertiles, as well as between the highest ("favorable" living conditions) and lowest ("unfavorable" living conditions) tertiles in terms of total mortality, mortality from EC, drowning and freezing. Mortality rates from alcohol poisoning and transport accidents also increase (but not statistically significant) as living conditions worsen. With the exception of suicides, the relative risks of mortality for individual EC reach maximum values in the lowest tertile.

CONCLUSION: Statistically significant inverse relationships have been identified between rates of total mortality, mortality from external causes (and its main structural components), and the values of the integral index of living conditions of the rural NAO population: as living conditions worsen, mortality rates (and relative risks) increase.

Keywords: Arctic; Arctic Zone of the RF; Nenets AO; living conditions; social factors of the habitat; social infrastructure; mortality; external causes of death; suicides; alcohol poisonings.

Оценка влияния условий проживания, как совокупности социальных факторов среды обитания, на показатели смертности сельского и городского населения Ненецкого АО в 2000–2019 гг.

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АННОТАЦИЯ

Обоснование. В настоящее время в Арктической зоне Российской Федерации наблюдаются явные признаки ухудшения медико-демографической ситуации на фоне низкого уровня развития социальной инфраструктуры. Исследование влияния условий проживания как совокупности социальных факторов среды обитания, формируемой социальной инфраструктурой, на показатели смертности населения одного из регионов Арктической зоны Российской Федерации проведено впервые.

Цель. Оценить влияние условий проживания как совокупности социальных факторов среды обитания на показатели смертности сельского и городского населения Ненецкого АО в 2000–2019 гг.

Материал и методы. Сформированы базы данных «Жилищно-коммунальное хозяйство и социальная инфраструктура в НАО за 2000–2019 годы» и «Случаи смерти в НАО за 2000–2019 годы» (включая информацию о численности и возрастно-половой структуре населения Ненецкого АО) в разрезе отдельных населённых пунктов. С использованием разработанной балльной системы оценки условий проживания выполнено ранжирование (разделение на тертили) всех сельских населённых пунктов Ненецкого АО по величине интегрального индекса условий проживания (ИИУП). Проведён сравнительный анализ (тертили с городом, тертили друг с другом) среднегодовых стандартизованных по возрасту показателей общей смертности, смертности от основных причин и структурных компонентов внешних причин смертности. Относительные эпидемиологические риски рассчитаны как отношения показателей смертности в каждом из тертилей к соответствующему показателю для городского населения.

Результаты. Среднегодовые стандартизованные показатели и относительные риски смертности (общей, от внешних причин, утоплений, замерзаний, отравлений алкоголем и транспортных несчастных случаев) населения Ненецкого АО ступенчато возрастают в последовательности «город — верхний тертиль — средний тертиль — нижний тертиль», то есть по мере ухудшения условий проживания (по мере снижения ИИУП). Выявлены статистически значимые различия между городом и тертилями, а также между верхним (благоприятные условия проживания) и нижним (неблагоприятные условия проживания) тертилями по показателям общей смертности, смертности от внешних причин, утоплениям и замерзаниям. Показатели смертности от отравлений алкоголем и транспортных несчастных случаев также возрастают (но статистически незначимо) по мере ухудшения условий проживания. За исключением суицидов, относительные риски смертности по отдельным внешним причинам достигают максимальных значений в нижнем тертиле.

Заключение. Выявлены статистически значимые обратные зависимости между показателями общей смертности, смертности от внешних причин (и её основных структурных компонентов) и величинами ИИУП сельского населения Ненецкого АО: по мере ухудшения условий проживания показатели и относительные риски смертности возрастают.

Ключевые слова: Арктика; Арктическая зона РФ; Ненецкий АО; условия проживания; социальные факторы среды обитания; социальная инфраструктура; смертность; внешние причины смерти; суициды; отравления алкоголем.

评估生活条件作为栖息地社会因素的集合对2000–2019年涅涅茨自治区农村和城市人口死亡率的影响

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简评

论证。目前，在俄罗斯联邦北极地区，由于社会基础设施发展水平低，医疗和人口状况有明显恶化的迹象。作为生活环境的一系列社会因素，社会基础设施对俄罗斯联邦北极地区人口死亡率的影响研究尚属首次。

目标。　评估2000-2019年生活条件作为栖息地社会因素对涅涅茨自治区农村和城市人口死亡率的影响。

材料与方法。编制了　"2000-2019年涅涅茨自治区的住房和公用事业和社会基础设施　"和"2000-2019年涅涅茨自治区的死亡人数　"数据库（包括各居住区的涅涅茨自治区人口数量和年龄性别结构的信息）。使用制定的生活条件评估评分系统，按照生活条件综合指数值对涅涅茨自治区的所有农村居民点进行了排序（分为三等分）。对总死亡率、主要死因死亡率和外部死因结构成分的年均年龄标准化比率进行了比较分析（与城市的三等分，三等分之间的比较）。相对流行病学风险的计算方法是，每个三等分层的死亡率与城市人口相应指标的比率。

结果。涅涅茨自治区人口的年均标准化死亡率和相对死亡率（一般死亡率、外因死亡率、溺水、冰冻、酒精中毒和交通事故）按　"城市-上三等分-中三等分-下三等分　"的顺序逐步升高，即随着生活条件的恶化（下降）而上升。在一般死亡率、外因死亡率、溺水死亡率和冰冻死亡率方面，城市和三等分之间以及高（生活条件好）和低（生活条件差）三等分之间存在明显的统计学差异。随着生活条件的恶化，酒精中毒和交通事故的死亡率也在增加（但在统计上微不足道）。除自杀外，某些外部原因造成的相对死亡风险在最低三等分中达到最大值。

结论。据统计，一般死亡率、外因死亡率（及其主要结构成分）指标与涅涅茨自治区农村人口生活条件综合指数值之间存在明显的反比关系：随着生活条件的恶化，指标值和相对死亡风险都会增加。

关键词：北极；俄罗斯联邦北极区；涅涅茨自治区；生活条件；居住地的社会因素；社会基础设施；死亡率；外部死因；自杀；酒精中毒。

BACKGROUND

The Strategy for the Development of the Arctic Zone of the Russian Federation (AZRF) and ensuring national security up to 2035[1] includes the main dangers, challenges, and threats that form risks for the development of the Arctic Zone, among other things, clear signs of deterioration of the medical and demographic situation, where, along with a decrease in natural population growth, migration outflow and population decline, there is a lag behind the national values of indicators characterizing the quality of life of the population, low level of development of social, housing, communal, transport, and other services, as well as a decline in the quality of life of the population.

Research results indicate that in the regions of the AZRF, the levels of total mortality of the rural population significantly exceed those of the urban population; for external causes of death, the differences are significant. The most common external causes of death in the AZRF were suicide, murder, transport accidents (primarily during the operation of small motor vehicles), drowning, frostbite, burns, and alcohol poisoning [1].

The population in the AZRF, primarily rural and including the indigenous people, is characterized by the highest (in comparison with the national average) rates of total mortality, especially high levels of alcohol-attributed mortality (AAM) from external causes, including alcoholic suicides. Alcoholism in the AZRF develops due to a complex of factors, among which is the lack of opportunities for any leisure activity other than drinking owing to low quality of living conditions [1].

Many villages in the AZRF are deprived of land transport communication with administrative centers and neighboring settlements. In many villages, there is high housing deterioration, outdated technical equipment of buildings and structures, and lack of centralized energy, gas, water supply, and wastewater disposal. Moreover, some villages are provided exclusively with delivered water, and some do not have any water supply (residents deliver water on their own and harvest ice from nearby reservoirs); the majority of villages do not have an organized waste collection and disposal system, and several small villages lack schools, kindergartens, cultural centers, and sports facilities; and many villages are characterized by limited public access to medical care [2].

The abovementioned features of the rural territories of the AZRF are typical for Nenets Autonomous Okrug. Several recent studies [2-6] reported the medical and demographic data and living conditions and social factors of the habitat

of the rural and urban population of Nenets Autonomous Okrug in the context of individual settlements for the period 2000–2019.

The demographic situation in Nenets Autonomous Okrug has been found to be deteriorating in recent years; there are obvious signs of the formation of a pronounced depopulation trend among the urban and rural population in the okrug. The situation among the rural population was characterized as critical; with such high mortality rates, so far compensated by a high birth rate, and even higher rates of migration loss, further (and in the future irreversible) reduction in the "habitability" of rural territories of Nenets Autonomous Okrug is expected [3]. The rural population of Nenets Autonomous Okrug demonstrates a low life expectancy (a difference of more than 10 years) and significantly higher levels of total mortality and mortality from external causes in comparison with the urban population [3].

We have established the concept of living conditions as a set of social factors of the habitat formed by the social infrastructure of the settlement and scientifically substantiated the concept of harmful effects of social factors of the habitat as the absence, shortage, or inadequate functioning of any elements of social infrastructure [1].

To assess the impact of living conditions on the medical and demographic status of rural areas in the AZRF, a targeted approach using a scoring system for assessing living conditions has been developed, which allows ranking individual settlements by the magnitude of infrastructure indices and integral index of living conditions (IILC) [1].

This study aimed to assess the impact of living conditions and social factors of the habitat on the mortality rates of rural and urban population of Nenets Autonomous Okrug in 2000–2019.

MATERIALS AND METHODS

Information on all cases of death of the population of Nenets Autonomous Okrug for a 20-year period (2000–2019) was obtained from the annual "Death Logs in Nenets Autonomous Okrug," which was regularly filled in by employees of the Department of Medical Statistics of the Nenets Okrug Hospital (Naryan-Mar) based on information in the medical death certificates from the Registry Office of Nenets Autonomous Okrug Administration.

The information was transferred to an electronic database format, which included each case of death of permanent residents of Nenets Autonomous Okrug over a 20-year period (a total of 9026 records), with details of sex, age, ethnicity, place of residence (registration in a particular settlement), and date and place of death, indicating the main cause of death and related diseases (conditions) that contributed to the onset of death; each case of death in the database was assigned a three-digit ICD-10 code [5]. The database "Cases of death in Nenets Autonomous Okrug for 2000–2019" is

registered in the database registry of the Federal Service for Intellectual Property[2].

Data on the number and age–sex structure of the population for each of the 42 settlements of Nenets Autonomous Okrug for each year over a 20-year period (2000–2019) were obtained from the medical information and Analytical Department of the Department of Health, Labor, and Social Protection of the Population of Nenets Autonomous Okrug. This information expands the possibilities of processing and analysis of the created mortality database, as it allows calculations of the annual dynamics of the number and age–sex structure of residents of any settlement (and their groups), to standardize mortality rates by age and analyze the indicators in space and time, including the grouping of settlements by various criteria [5].

The sources of information on the socio-household and socio-cultural infrastructure of rural settlements of Nenets Autonomous Okrug were explanatory notes to the regional territorial planning schemes of the okrug, explanatory notes to the draft general plans of municipalities, passports of municipalities, programs for the development of municipal infrastructure of Nenets Autonomous Okrug, schemes of water supply, wastewater disposal and other design and technical documentation, and the "Database of indicators of municipalities" of Rosstat [2, 4].

Regarding individual rural settlements in Nenets Autonomous Okrug, information on energy supply (heat, electricity, and gas), water supply, wastewater disposal, waste collection and disposal, healthcare, education (including preschool), culture, leisure, sports, and the service sector were collected. The data were transferred to the electronic format of the database "Housing and communal services and social infrastructure in Nenets Autonomous Okrug for 2000–2019"[3].

Scoring system for assessing living conditions (social infrastructure) in rural settlements of Nenets Autonomous Okrug

Social infrastructure as a set of socio-residential and socio-cultural infrastructures was assessed using a point system, of which the socio-household infrastructure (ISHI), socio-cultural infrastructure (ISCI), and IILC indices were calculated for each rural settlement of Nenets Autonomous Okrug [1].

Table 1 presents the scoring of the components of socio-household (heat supply, boiler fuel type, water supply, water treatment, water quality, shops, canteens, and bathhouses) and socio-cultural infrastructures (healthcare facilities, sports facilities, kindergartens, schools, and cultural centers) used in this study to calculate the ISHI, ISCI, and IILC.

ISHI and ISCI were calculated as the sum of points for each component according to the following formulas:

$$ISHI = X_1 + X_2 + ... + X_8;$$
$$ISCI = Y_1 + Y_2 + ... + Y_5.$$

The IILC is the sum of the points of the infrastructure indices: IILC = ISHI + ISCI.

Division into tertiles the rural settlements in Nenets Autonomous Okrug

The entire set of settlements of Nenets Autonomous Okrug was divided according to the size of the calculated individual (for each settlement) IILC into tertiles (highest, middle, and lowest), that is, into three groups with high, medium, and low IILC indices. The number of settlements included in each of the tertiles differed, owing to the need to form three groups of settlements comparable not by the number of settlements, but by population size (Table 2). A small population in any of the tertiles and a small number of deaths would make it impossible to correctly compare mortality rates between tertiles.

Then, for each tertile and for the urban population of Nenets Autonomous Okrug, we calculated the annual average (for 2000–2019) standardized rates of total mortality, mortality from circulatory diseases, external causes and cancer, and the main structural components of external causes of mortality (i.e., suicides, drowning, freezing, homicide, alcohol poisoning, and transport accidents), with calculation of 95% confidence intervals (95% CI).

Methods of statistical data processing

A direct standardization method was used to calculate standardized mortality rates. For general mortality and mortality from diseases of the circulatory system and external causes, the European Standard of 1976 was used as the standard for the age structure of the population [7], which was used by Rosstat in calculating mortality rates in the Russian Federation regions and in the whole country, whereas for mortality from cancer, the world standard Segi–Doll of 1966 was used [8, 9], which is used by the population "Cancer Registry" of the Russian Federation at the Herzen Moscow Research Institute of Oncology and the International Agency for Cancer Research.

The normality of the distribution of mortality rates was assessed with the Shapiro–Wilk criterion and quantile diagrams.

To identify significant differences when comparing multi-year average annual mortality rates in the two compared population groups, the Mann–Whitney test was

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2 Certificate of state registration of the database No. 2020622857 Russian Federation. Cases of death in Nenets Autonomous Okrug for 2000-2019 years: No. 2020622722: submitted on 18.12.2020: published on 29.12.2020 / A.A. Dudarev, A.V. Dozhdikov; applicant Federal Budget Institution of Science "North-West Public Health Research Center."

3 Certificate of state registration of the database No. 2022620237 Russian Federation. Housing and communal services and social infrastructure in Nenets Autonomous Okrug for 2000–2019 : No. 2022620070 : submitted on 13.01.2022: published on 26.01.2022 / A.V. Dozhdikov, A.A. Dudarev; applicant Federal Budget Institution of Science "North-West Public Health Research Center."

Table 1. Components used to calculate the infrastructure indices for each rural settlement in the Nenets Autonomous Okrug

Components	Designation	Differentiation	Scores
Socio-household infrastructure			
Heat supply (heating system)	X_1	Socially significant objects and apartment buildings	2
		Individual heating	0
Boiler fuel type	X_2	Gas or diesel	2
		Coal	0
Water supply	X_3	Decentralized	3
		Not organized	0
Water pretreatment	X_4	Available	2
		Unavailable	0
Drinking water quality	X_5	Complies with hygienic standards	3
		Does not meet hygienic standards	0
Shops	X_6	Two or more	2
		One	0
Canteens	X_7	Available	1
		Unavailable	0
Bathhouses	X_8	Available	1
		Unavailable	0
Socio-cultural infrastructure			
Healthcare (type of institution)	Y_1	Local hospital	4
		Outpatient clinic	3
		First-aid posts	2
Indoor sport facilities	Y_2	Sports complex	3
		School gym	1
		Lack	0
Kindergartens	Y_3	Available	1
		Unavailable	0
Schools	Y_4	Available	1
		Unavailable	0
"Houses of culture"	Y_5	Available	1
		Unavailable	0

used; the critical level of statistical significance (p) was assumed to be 0.05.

The Kruskal–Wallis test was used to identify significant differences when comparing average annual mortality rates in three or more compared groups. The critical level of statistical significance of p (adjusted for Bonferroni) was assumed to be 0.008 when comparing four groups. Subsequent a posteriori pairwise comparisons were performed using the Mann–Whitney test.

The relative epidemiological risk was calculated as the ratio of the mortality rate in each of the tertiles to the corresponding indicator in the background (control) population, which is, in the present study, the urban population of Nenets Autonomous Okrug.

Statistical data was analyzed using the MS Excel 2021 and IBM SPSS Statistics (version 26) software packages.

RESULTS

General mortality and the main causes of death

The indicators of total mortality and mortality from the main causes of the urban and total rural population

Table 2. Parameters of tertiles formed from 40 NAO villages

Tertile	Living conditions	Integral index of living conditions	Number of settlements	Population number
Highest	Favorable	20–22	6	4844
Middle	Satisfactory	13–19	9	4727
Lowest	Unfavorable	2–12	25	4318

of Nenets Autonomous Okrug (in comparison) are shown in Figure 1.

Excess of the average annual mortality rates of the rural population over the corresponding mortality rates of the urban population of Nenets Autonomous Okrug was 35% ($p < 0.001$; the differences were significant) for total mortality, 11% ($p = 0.185$) for mortality from diseases of the circulatory system, and 165% ($p < 0.001$) for mortality from external causes, whereas the cancer mortality rate of the rural population was 11% ($p = 0.204$) lower than that of the urban population of the Okrug (Fig. 1). Clearly, external causes considerably contributes to the 35% excess of the average annual total mortality rate of the rural population of Nenets Autonomous Okrug in comparison with that of the urban population.

The rates of total mortality and mortality from major causes of the urban population of Nenets Autonomous Okrug in comparison with the rural population divided into tertiles are presented in Figure 2 with the indication of the significance of differences in the compared populations.

The average annual standardized *total mortality* rates increase in the sequence "city—highest tertile—middle tertile—lowest tertile"; that is, as living conditions worsen, IILC decreases. Mortality rates in all three tertiles exceeded the urban level: by 1.5 times ($p < 0.001$) in the middle and lowest tertiles, and by 13% in the highest tertiles. It is crucial to identify significant differences in the levels of total mortality (33.5%) between the highest (favorable living conditions) and lowest (unfavorable living conditions) tertiles ($p < 0.001$).

Mortality rates from diseases of the circulatory system in the middle and lowest tertiles were 25% and 17% higher than the urban level, respectively, whereas in the highest tertile, the mortality rate was slightly lower than the urban level. Significant differences in mortality from diseases of the circulatory system in tertiles were not revealed in a pairwise comparison with the urban population ($p > 0.008$). Mortality from diseases of the circulatory system in the highest tertile was 1.3 times lower than the average ($p = 0.001$) and 1.25 times lower than that in the lowest tertile.

Similar to the total mortality, *mortality from external causes* demonstrate an inverse relationship between the quality of living conditions and mortality rates. With the worsening of living conditions (from the highest to the lowest tertile), mortality from external causes increases. The average annual mortality rates from external causes in the highest, middle, and lowest tertiles were 2–3 times higher
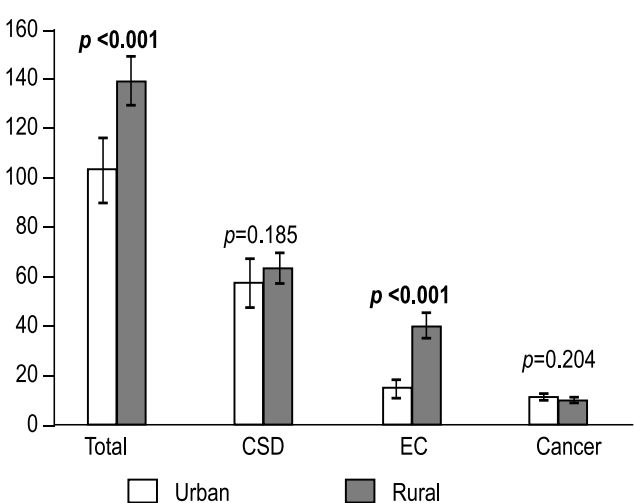

Fig. 1. Average annual (2000–2019) age-standardized rates of total mortality, mortality from circulatory system diseases (CSD), external causes (EC) and cancer, per 10 thousand of the urban and rural Nenets Autonomous Okrug population with the designation of 95% CI and *p*-value.

than the urban level ($p < 0.001$). It should be emphasized that the mortality rate from external causes in the highest tertile (favorable living conditions) was 1.5 times lower ($p = 0.001$) than that in the lowest tertile (poor living conditions).

Cancer mortality rates of the urban population in Nenets Autonomous Okrug were 4%–16% higher than the levels in tertiles. No significant differences were noted in cancer mortality rates when comparing tertiles with each other and with the urban population. The significance levels of the Kruskal–Wallis criterion exceeded 0.05. The cancer mortality rate in the highest tertile was 11% lower than that in the lowest tertile.

Comparative analysis of the relative epidemiologic risk of total mortality and mortality from major causes in tertiles

For each tertile, based on the average annual standardized mortality rates, the relative epidemiological risks (relative to the urban population of Nenets Autonomous Okrug) of total mortality and mortality from the main causes: diseases of the circulatory system, external causes, and cancer were calculated (Table 3).

All calculated relative epidemiological risks (total mortality and mortality from diseases of the circulatory system, external causes, and cancer) increased from the
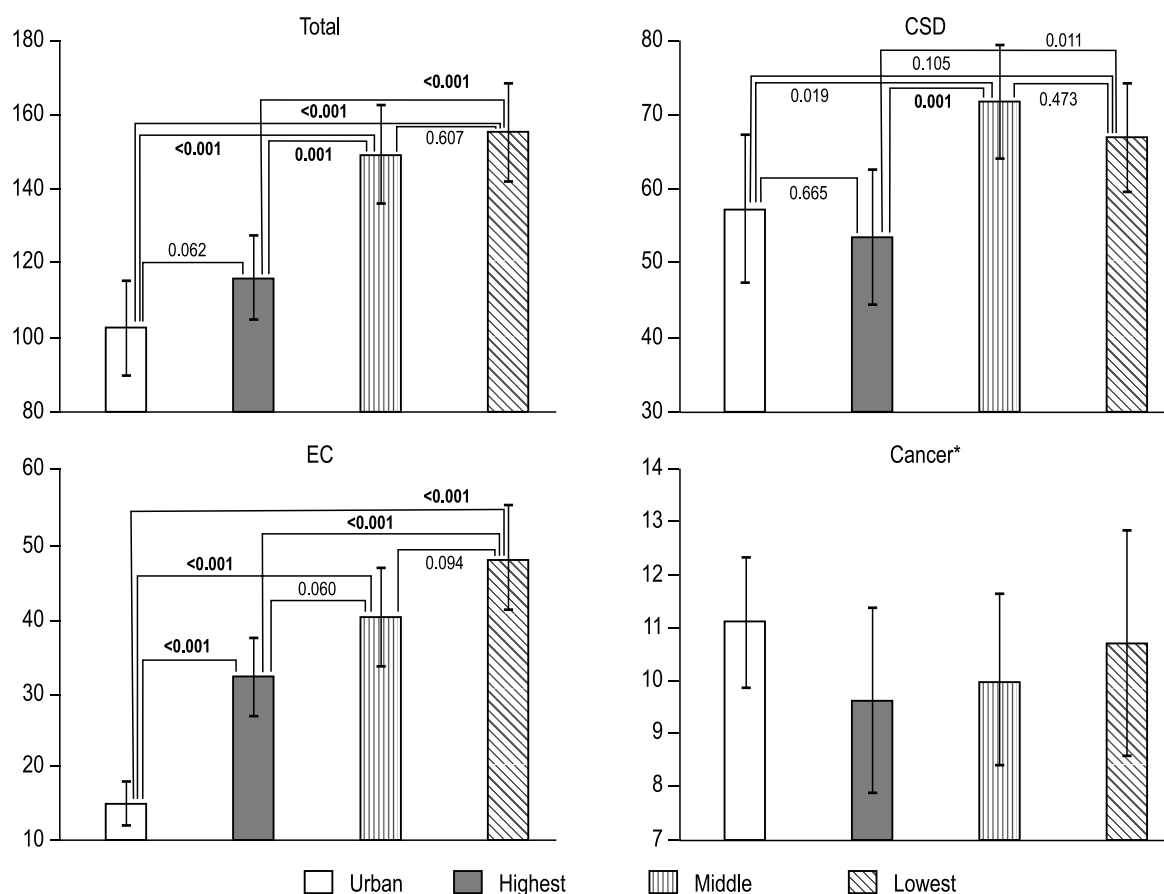
Fig. 2. Average annual (2000–2019) age-standardized rates of total mortality, mortality from circulatory system diseases (CSD), external causes (EC) and cancer, per 10 thousand of the urban population compared to rural Nenets Autonomous Okrug population divided into tertiles (highest, middle and lowest), with the designation of 95% CI and *p*-values for the compared mortality rates in the populations; * differences between the compared populations are statistically insignificant, since the Kruskal–Wallis test level exceeds 0.05.

highest tertile to the lowest, that is, from favorable living conditions to unfavorable. Regarding total mortality, an increased relative risk (≥1.5) was observed in the middle and lowest tertiles. The relative risk of mortality from diseases of the circulatory system in the middle and lowest tertiles did not reach 1.5, indicating that such risk values were slightly increased. Owing to external causes of mortality, a high relative risk (2–3) was observed in the highest and middle tertiles; the maximum risk (>3.5) was observed in the lowest tertile. The relative risk of mortality from cancer in all tertiles was close to 1, whereas the lower limits of the CI did not reach 1, indicating the absence of an increased risk.

Thus, the unfavorable living conditions of the rural population of Nenets Autonomous Okrug, corresponding to

the lowest tertile, were associated with the highest rates of total mortality and mortality from external causes, the highest values of the relative risk of total mortality, and the maximum values of the relative risk of mortality from external causes.

Mortality from external causes

Previously, it was demonstrated that the differences in the structure of the total mortality of the rural and urban population of Nenets Autonomous Okrug were primarily due to external causes of mortality, the levels and relative risks of which were highest in the rural population, especially in the lowest tertile. Here, using the methodology described above, the main structural components of the external causes of

Table 3. Values of relative epidemiological risks of total mortality and mortality from major causes, calculated for each tertile (with 95% CI)

Tertiles	Total mortality	Mortality from circulatory system diseases	Mortality from external causes	Mortality from cancer
Highest	1.17 (1.05–1.30)	0.98 (0.83–1.14)	2.29 (1.92–2.66)	0.93 (0.74–1.12)
Middle	1.49 (1.38–1.61)	1.36 (1.18–1.54)	2.83 (2.40–3.26)	0.92 (0.77–1.07)
Lowest	1.57 (1.41–1.70)	1.26 (1.09–1.43)	3.51 (2.91–4.11)	1.01 (0.78–1.24)

death (i.e., suicides, drownings, freezing, homicides, alcohol poisonings, and transport accidents) were analyzed.

Figure 3 presents the rates of separate external causes of mortality of the urban and rural population of Nenets Autonomous Okrug.

Excess of the average annual indicators of separate external causes of mortality of the rural population over the corresponding mortality levels of the urban population of Nenets Autonomous Okrug amounted to 2.6 times for suicides, 4.4 times for drownings, 7.6 times for freezing, 2.2 times for murders, 2.1 times for alcohol poisoning, and 1.6 times for transport accidents. All rural rates were significantly higher than the urban ones, except for transport accidents.

Notably, suicides, drownings, and freezing considerably contributed to the external causes of mortality of the rural population in Nenets Autonomous Okrug, the levels of which were several times higher than the corresponding indicators for the urban population. Moreover, the incidence of homicides, fatal alcohol poisoning, and traffic accidents in rural areas exceeded urban levels, but the magnitude of the "city–village" differences for these causes of mortality was lower (from 1.6 to 2.2 times).

Mortality rates from certain external causes of the urban population of Nenets Autonomous Okrug in comparison with the rural population divided into tertiles are shown in Fig. 4, indicating the significance of differences in the compared populations.

A comparative analysis of mortality from certain external causes in the urban and rural population of the Nenets Autonomous District, divided into tertiles, revealed a similar situation in the following pairs: suicides and homicides, drowning and freezing, and alcohol poisoning and transport accidents.

Suicide and homicide mortality *rates significantly increased from* the city to the middle tertile, but slightly decreased toward the lowest tertile. Mortality rates in all three tertiles exceeded the urban level by 2–3 times. Moreover, the differences were significant in suicides and insignificant in homicides. No significant differences were found in suicide and homicide mortality rates between tertiles.

Mortality from drowning and freezing were increasing in the sequence "city—highest tertile—middle tertile—lowest tertile," that is, as living conditions deteriorate. Significant differences in mortality rates in all tertiles when compared with the city were noted in freezing and drowning (except for the highest tertile). It should be noted that mortality rates from drowning and freezing in the highest tertile (favorable
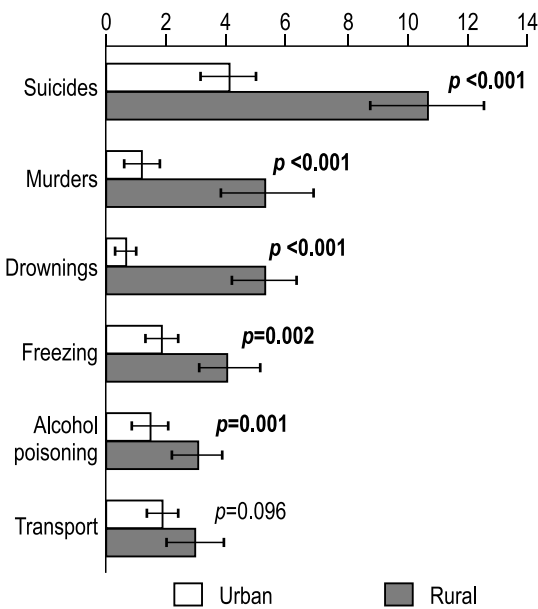

Fig. 3. Average annual (2000–2019) age-standardized rates of mortality from selected external causes, per 10 thousand of the urban and rural Nenets Autonomous Okrug populations with the designation of 95% CI and *p*-values.

living conditions) were 2.2 times lower (differences are significant) compared to that in the lowest tertile (unfavorable living conditions).

Mortality rates from alcohol poisoning and transportation accidents also increased in the sequence "city—highest tertile—middle tertile—lowest tertile" and reach in the lowest tertile twice the city level ("city—lowest tertile"). However, significant differences in mortality rates from alcohol poisoning and transportation accidents were not found when comparing tertiles with each other and with the city.

For each tertile, based on the average annual standardized mortality rates, the *relative epidemiological risks* (relative to the urban population of Nenets Autonomous Okrug) of mortality from certain external causes were calculated (Table 4).

All obtained relative epidemiological risks of mortality from certain external causes (i.e., suicides, homicides, drowning, freezing, alcohol poisoning, and transport accidents) increased from the highest to the lowest tertile, that is, from favorable living conditions to unfavorable. Mortality risks due to certain external causes, except for suicides, reached the highest values in the lowest tertile; maximum risk values were recorded for drownings (9) and freezing (15). The relative risks of mortality from alcohol poisoning in the

Table 4. Values of relative epidemiological risks of mortality from individual external causes, calculated for each tertile (indicating 95% CI)

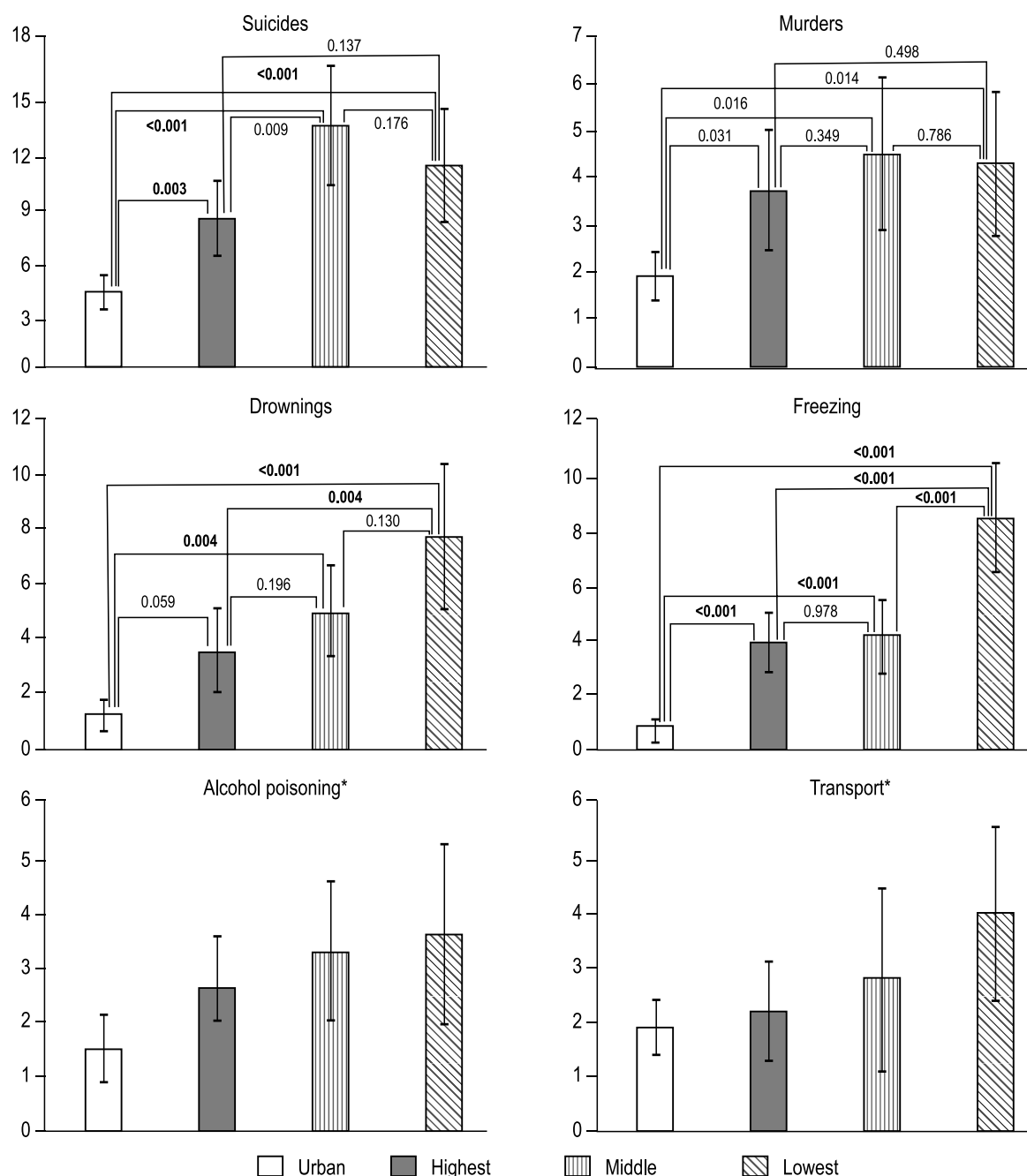| Tertiles	Suicides	Murders	Drownings	Freezing	Alcohol poisoning	Transport accidents
Highest	2.55 (1.53–3.56)	2.17 (1.18–3.17)	3.46 (1.88–5.05)	7.87 (3.44–12.31)	2.75 (1.18–4.31)	0.94 (0.59–1.29)
Middle	3.81 (2.72–4.90)	2.74 (1.74–3.75)	5.07 (2.41–7.72)	6.86 (3.65–10.07)	4.57 (1.59–7.56)	2.19 (0.35–4.03)
Lowest	3.30 (2.16–4.45)	3.13 (1.60–4.65)	9.00 (4.75–13.25)	15.00 (6.63–23.37)	4.98 (0.00–10.63)	2.52 (1.57–3.46)

Fig. 4. Average annual (2000–2019) age-standardized rates of mortality from external causes, per 10 thousand of the urban population compared to the rural Nenets Autonomous Okrug population divided into tertiles (highest, middle and lowest), with the designation of 95% CI and *p*-values for the compared mortality rates in the populations; * differences between the compared populations are statistically insignificant, since the Kruskal–Wallis test level exceeds 0.05.

lowest tertile and from traffic accidents in the highest and middle tertiles were insignificant, as the lower limits of the CI did not reach 1.

DISCUSSION

Several studies have indicated that alcohol abuse is the main cause of premature death and a direct trigger of external causes of death in the Far North [1].

In a study conducted using materials from a 2011–2012 forensic medical examination in Arkhangelsk, ethanol in the blood of the deceased was found in one in four, regardless of the cause of death. Moreover, in almost every second case of death from external causes, ethanol was detected in the blood of the deceased, in severe (3‰–5‰) or fatal (>5‰) concentrations [10].

Alcohol intoxication reduces fear, but increases aggression and proneness to conflict, which leads to poorly controlled actions when handling fire and weapons (often ending in unintentional or intentional injuries and murders) and when driving vehicles on land and water. Notably, there are no roads in the rural areas of Nenets Autonomous Okrug,

and the local population is actively engaged in hunting and fishing (often in combination with alcohol intake) and uses motor vehicles of increased injury risk (quad bikes, snowmobiles, swamp walkers, all-terrain vehicles, etc.) as means of transportation off-road and unsafe small boats and speedboats for transportation along Arctic rivers and lakes, where the water temperature is close to 0°C even in summer.

Chronic alcohol abuse often leads to depressive states, which often form suicidal behavior. Autopsy materials showed that alcohol was present in the blood of 74% of men and 83% of women (among Nenets: 78% of men and 92% of women) who died from suicide in Nenets Autonomous Okrug in 2002–2012, which significantly exceeded the figures of the Arkhangelsk region (59% of men and 47% of women) for the same period [11].

In this regard, a single external cause of death "alcohol poisoning" (X45 according to ICD-10) is only a small proportion of a significant number of deaths directly or indirectly related to alcohol consumption.

The question arises, can we determine what proportion of the values of mortality rates from separate causes is the alcohol component based on publicly available statistical data? The answer is no, we cannot for various reasons. Significant disadvantages of the existing practice in Russia in diagnosing and accounting for mortality from causes related to alcohol abuse have been noted in many studies [10, 12–15]: a small proportion of autopsies of the deceased (pathoanatomical studies) with a tendency to further decrease, alcohol analysis is not mandatory during autopsy, poor quality of postmortem diagnosis of visceral manifestations of alcoholic illness, low reliability of primary medical documentation, intentional and unintentional errors (concealment or loss) of accounting for alcohol-attributed mortality (AAM), "alcoholic" diagnoses are considered last (in the absence of other options), and lack of a unified national standard for accounting for AAM.

It follows from the above that the urgency of the problem of excessive AAM is due to the lack of data on its real scale and structure. Its consequence is critical—the distortion of the characteristics of risk groups of excessive AAM, which, in turn, does not allow the development of effective preventive programs [10].

In a study that determined the sources and causes of underestimation of alcohol-related losses in the Russian population, the following argument was provided: "the source of possible statistical manipulations is obvious: alcohol losses are socially significant and are accompanied by constant monitoring and control. So, if death occurred as a result of a traffic accident, and the concentration of alcohol in the blood of the deceased exceeded 5‰ (a deliberately lethal dose), then the medical death certificate will indicate a traffic accident as the cause, and not alcohol poisoning, and the official statistics will not reflect the alcoholic etiology of this death. As a result, it can be stated that the picture of the mortality structure in Russia as a whole and at regional levels is significantly distorted due to the underestimation of

alcohol losses" [13].

Thus, the assessment of mortality of the rural population of Nenets Autonomous Okrug from external causes related to alcohol consumption in terms of mortality from "alcohol poisoning" will be incomplete; the cumulative losses caused by alcohol is expected to be higher because of the underestimation of alcoholic suicides, homicides, drownings, freezing, transport accidents, and other external causes (i.e., missing persons, "gone to the tundra," etc.).

The present study utilized data from death certificates from the Registry Office, which do not contain information on pathologoanatomical examinations for alcohol (even if they were conducted); hence, "alcohol losses" from any causes of death, except for "alcohol poisoning" were not analyzed, the diagnosis of which was probably made based on completed alcohol tests.

It is important to emphasize that the latter fact allows us to use mortality from "alcohol poisoning" as the only publicly available (and confirmed by the results of analyses) tool for assessing and comparing alcohol-associated mortality in populations and selected population groups. Analysis of mortality from alcohol poisoning in Nenets Autonomous Okrug using the developed scoring system for assessing living conditions and dividing rural settlements into tertiles demonstrated an increase (although insignificant) in mortality rates in the sequence "city—highest tertile—middle tertile—lowest tertile," where mortality rates in unfavorable living conditions (lowest tertile) was 38% higher than mortality rates in favorable living conditions (highest tertile) and 140% (2.4 times) higher than in the city (Fig. 4).

CONCLUSION

The conducted research, which was based on the generated databases "Cases of death in the Nenets Autonomous Okrug for 2000–2019" and "Housing and communal services and social infrastructure in the Nenets Autonomous Okrug for 2000–2019" using the developed scoring system for assessing living conditions, which allows ranking (dividing into tertiles) rural settlements of Nenets Autonomous Okrug by the magnitude of infrastructure indices and IILC, demonstrated the following:

The average annual standardized rate of the total mortality of the rural population of Nenets Autonomous Okrug exceeds the mortality rate of the urban population by a third, mainly due to a 1.5-fold excess of the "rural" mortality rate from external causes over the "urban" level (the differences are significant).

The rates of the total mortality of the population of Nenets Autonomous Okrug increase in the sequence "city—highest tertile—middle tertile—lowest tertile"; that is, as living conditions deteriorate, the IILC decreases. Significant differences were found in the levels of total mortality between the highest (favorable living conditions) and lowest (unfavorable living conditions) tertiles.

Mortality rates from external causes increase stepwise with the deterioration of living conditions. Differences in mortality rates from external causes between the city and tertiles and between the highest and lowest tertiles were significant;

The relative epidemiological risks of total mortality and mortality from external causes increase significantly from the highest tertile to the lowest that is, from favorable living conditions to unfavorable. The relative risks of mortality from external causes reach a maximum value in the lowest tertile.

Excess of the average annual rates of separate external causes of mortality of the rural population over the corresponding mortality levels of the urban population of Nenets Autonomous Okrug amounted to 2.6 times for suicides, 4.4 times for drownings, 7.6 times for freezes, 2.2 times for murders, 2.1 times for alcohol poisoning, and 1.6 times for transport accidents. All rural rates were significantly higher than urban ones, except for transport accidents.

Significant differences in mortality rates were noted for drowning and freezing under favorable living conditions compared with unfavorable ones (in the highest tertile, the indicators were 2.2 times lower).

Mortality rates from alcohol poisoning and transport accidents increase stepwise, but insignificantly, as living conditions deteriorate and reach twice the urban level in the lowest tertile.

The relative epidemiological risks of mortality from certain external causes (suicides, homicides, drownings, freezing, alcohol poisoning, and transport accidents) increase from the highest to the lowest tertile. With the exception of suicides, the risks of mortality from certain external causes reach the highest values in the lowest tertile; the maximum risk values were recorded for drowning and freezinges.

The shortcomings of the existing practice in Russia for the diagnosis and accounting of AAM, primarily mortality from certain external causes associated with alcohol abuse in the AZRF, are considered.

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