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KUNGL. VETENSKAPS-AKADEMIEN
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SIBERIAN ENVIRONMENTAL CHANGE

Changing diets and traditional lifestyle of Siberian Arctic Indigenous Peoples and effects on health and well-being

Sergey Andronov, Andrey Lobanov, Andrey Popov, Ying Luo, Olga Shaduyko, Anatoliy Fesyun, Lilia Lobanova, Elena Bogdanova, Irina Kobel'kova

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Abstract The diet of Indigenous Peoples of North-Western Siberia is characterized by a significant proportion of traditional foods. Eating local products provides a ready-made set of macro- and microelements necessary for life in the challenging conditions of the Arctic. Currently, high consumption of traditional foods is typical in the season of fishing or reindeer slaughter, while out of season the consumption of easily digestible carbohydrates increases. Due to climate change, seasonal fishing and traditional migration routes are disrupted and, therefore, the consumption of traditional foods is decreasing. During 5 years of expeditions, we performed a cross-sectional screening of 985 Indigenous People from three districts of the Yamal-Nenets Autonomous Okrug. We analyzed the seasonality of acquisition and consumption of local reindeer and fish products and studied the traditional food storage among 90 Indigenous fishermen and hunters, who exploit cryostorage. As diet affects health, we studied the benefits of local food. The duration of the consumption season is decreasing and therefore the amount of consumption of local food is decreasing as well. This has adverse effects on health with increasing hypertension dissemination. The creation of stocks of fish and reindeer meat in villages and their year-round sale to the population is a necessary step for ensuring the food security and health of the inhabitants in the region.

Keywords Arctic seasonality of food consumption · Climate change · Indigenous peoples · Nutrition · Traditional nutrition · Yamal-Nenets Autonomous Okrug

INTRODUCTION

The diet of the Indigenous inhabitants of Western Siberia's Arctic zone, the Nenets, Khantys and Selkups is characterized by a significant share of traditional food products and the pronounced seasonality of local fish and reindeer meat consumption.

The most complete description of the traditional Nenets' diet was compiled by Kushelevsky in 1858. Kushelevskys's notes (Kushelevsky 1868) contain data on periods of famine in the Taz tundra (also in our study area) and allow us to compare the current nutrition among the Nenets with the problems almost two centuries ago. For example, Kushelevsky points out that the consumption of less than one medium-sized fish per day was considered starvation. The small herd-size and modest role of domestic reindeer meat is notable in these descriptions of Nenets' lives in the nineteenth and early twentieth centuries. At the time, domestic reindeer were used primarily for transport and their hides were used for repairing chums (nomadic "tents") and clothing. The basis of the diet was fish and a significant contribution was obtained from hunting. The meat of wild reindeer (*Rangifer tarandus*), goose (*Anser anser*), ptarmigan (*Lagopus lagopus*), hare (*Lepus*) and other game were an important part of the diet. Under adverse conditions for fishing and hunting, and lack of alternative food, hunger set in.

Kushelevsky's essay "Yuraki" (Nemirovich-Danchenko 1877) provides evidence that a significant amount of meat was consumed after a successful hunt. The domestic reindeer were slaughtered relatively rarely: "Yuraki (Gydan Nenets) value it (domestic reindeer) to such an extent that they sometimes hesitate to stab it, while after killing a wild reindeer they eagerly attack its meat and eat 14 lb (6.4 kg) each."

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Traditionally, the nutrition calendar of the Nenets depended on nomadic migrations and took into account the seasonality of different kinds of fish in different fishing sites. This allowed provision of fresh fish through the year (for example by ice-fishing in winter). Slaughter of reindeer was also linked to migration and herding routes. This allowed meat delivery to villages for almost 8 months a year, where it was sold and consumed by relatives (Kozlov et al. 2007; Chuprina 2018; Petrova 2018). Traditionally, Nenets living in the tundra had virtually no food stocks due to the nomadic way of life. Usually the transported stock is not larger than what a family consumes in 3 to 7 days. In the summer, the family has a stock of fish for a day. Residents of villages also rarely have a stock of traditional foods for more than 1–2 months. Salting and smoking of fish were practiced only by 10–15% of the population in the summer (Lobanova et al. 2013).

In contemporary studies, investigating Indigenous Peoples' diet without attention to seasonality has led to an erroneous idea about the high consumption of reindeer meat (Ionova 2004). Practice shows that at present, a high consumption of traditional foods is typical only for the season of fishing or reindeer slaughter. In contrast, out of season, the consumption of foods rich in easily digestible carbohydrates (white bread, gingerbread, sugar, condensed milk) increases. The consumption of butter and cereals (millet, buckwheat, rice) is also increasing (Lobanova et al. 2013).

The Peoples of the Arctic regions traditionally have used natural cryogenic resources (snow, ice, and underground in permafrost) for storing fish and reindeer meat (Melnikov et al. 2018; Lobanov et al. 2019). Nenets pay great attention to the period of storage: even in poor families, fish that has been stored for more than 3 months is not considered suitable for consumption. This approach is possibly justified by the fact that the nutritional value of local animal products is reduced during storage and, accordingly, the load for the detoxifying and antioxidant systems of the body increases. This is because, even if being properly stored, the concentrations of water-soluble vitamins and biologically active protein substances gradually decrease, and the valuable unsaturated fish fats oxidize, which reduces the antioxidant and antiatherogenic activity of the fats of northern fish (Crawford 1993; Baranenko et al. 2014; Kudrnáčová et al. 2018). If the rules of storage are violated, these deterioration processes become several times faster (Guryeva and Ivanova 2012; Rebezov et al. 2012).

Arctic plants and animals have adaptive mechanisms for survival in the harsh, tundra conditions. When eating local plant and animal products, a person receives a ready-made set of proteins, fats, trace elements, vitamins and biologically active substances, which are necessary for building enzymatic chains needed for adapting to the cold and other unfavorable geoclimatic conditions of the Arctic (Agadzhanyan and Petrova 1996; Lobanov et al. 2017). The unique and healing effect of traditional products is, according to Tutelyan (Tutelian and Sukhanov 2004; Tutelian and Onishchenko 2009), directly linked to their composition of macro- and microelements.

Indigenous health and adaptation to the harsh conditions of the Arctic depends on the consumption of traditional products (local fish, reindeer meat, reindeer liver and blood, wild plants) (Yoshida 1997). According to Lobanov et al. (2017), 20% of the total volume of reindeer meat is consumed by the herders themselves, 18% is sold in Indigenous villages or transferred to relatives and 62% is exported outside the Yamalo-Nenets Autonomous Region. On average, a family of nomadic Nenets reindeer herders, consisting of 2–4 adults and 3–7 children, consumes no more than 10–12 reindeer per year. In addition, part of the meat is transported to relatives living in villages with an Indigenous Population. Until recently, a significant portion of reindeer meat was also sold in the villages and towns with an Indigenous Population or cities close to the herding routes. This traditional nutrition is the main tool for preventing diseases of the cardiovascular and respiratory systems and metabolic disorders for the Indigenous Peoples (Lobanova et al. 2014). With the loss of traditional nutrition, hypertension, dyslipidemia, chronic bronchitis and overweight become even more prevalent among the Indigenous Peoples in comparison to the population of newcomers (Lobanov et al. 2018).

Currently, the situation has dramatically changed. As the average annual temperature in the Arctic is rising at a rate about two times higher than in more southern latitudes (Roshydromet: Report on climate features on the territory of the Russian Federation 2017; IPCC. Special Report 2018), climatic changes in the territory and their impacts are pronounced. In particular, the hydrological regime of rivers has changed and late freezing and early melting have disrupted the traditional herding routes, resulting in a shortening of the period for delivering meat to the villages. The seasons for fishing certain species of fish have also significantly changed. Periods without fishing have also started to appear and conditions for food storage have changed. It is notable that economic and social factors also play a significant role in guaranteeing the Indigenous Peoples' supply of traditional foods.

One of the recent administrative changes is that measures by local authorities to prevent infections and regulate retail trade have led to a sharp decrease in the supply of reindeer meat and fish to villages. It is forbidden to trade with a sled and well-equipped slaughterhouses, as a rule, work only with large exporters. As a result, reindeer meat from small private farms is practically not sold in

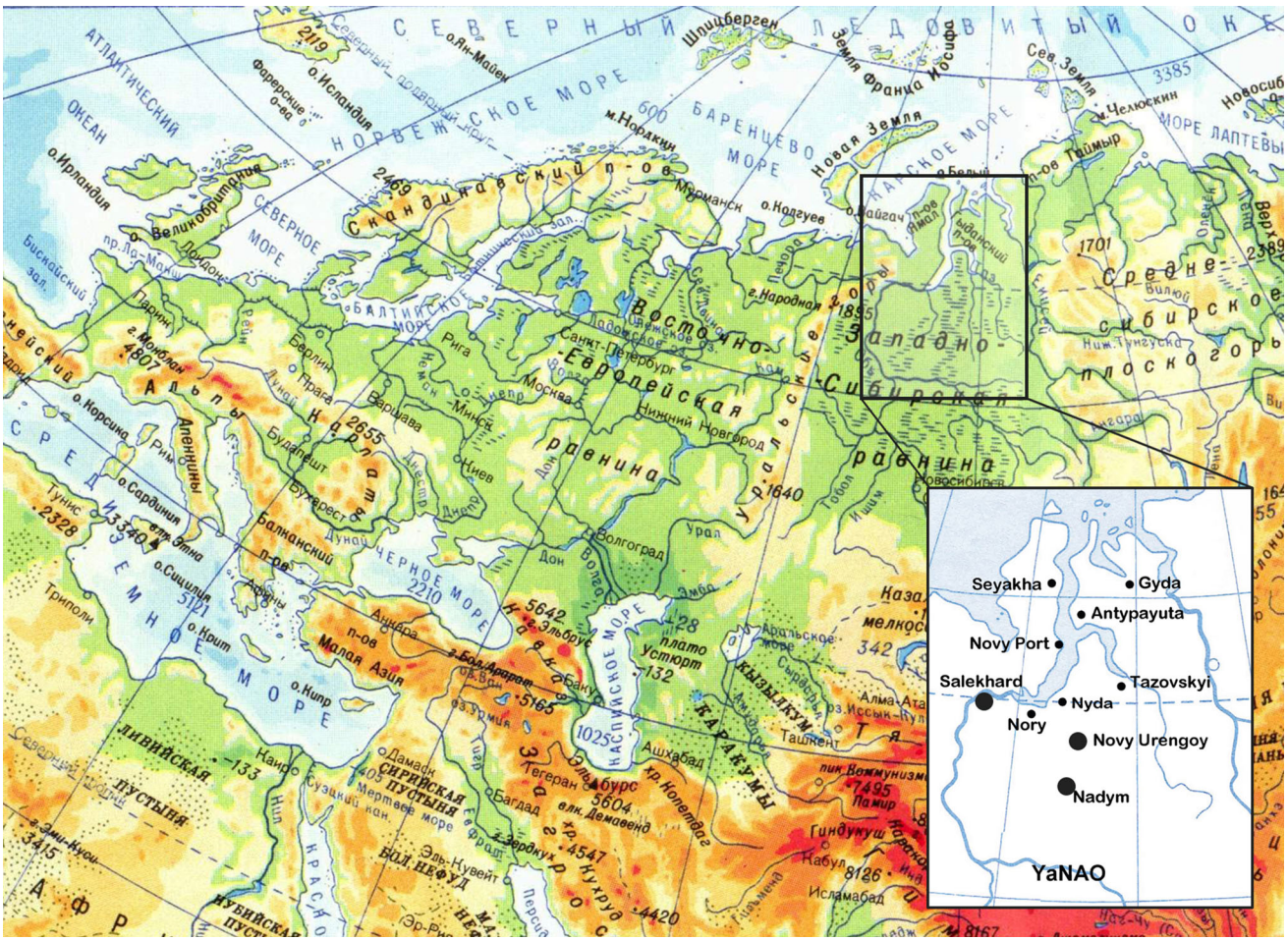

Fig. 1 Physical map of Russia with the study region marked (left) and research sites among large towns marked green (right). (Physical map of Russia. Scale 1:8M. 720 × 1100 mm. Omsk cartographic factory, 2005. Cartographic basis-Roskartografiya, 2004.)

Indigenous villages unless they have their own slaughterhouses and refrigeration units for storing meat.

As traditional foods are so important for Indigenous Peoples' health and well-being, the changes in natural and climatic conditions, combined with socio-economic ones, could have a significant impact the Indigenous population. We therefore need to understand how changes in climate, lifestyle and regulations affect traditional diets and health of local and Indigenous Peoples. An additional aim of our study is to make Russian research in this field more widely available to a global community. This paper contributes to a series of studies on Siberian environmental change (Callaghan et al. 2021).

MATERIALS AND METHODS

To study the basic patterns of consumption of traditional food products, we initially conducted a cross-sectional screening with the participation of 985 Indigenous inhabitants of the Arctic zone of Western Siberia (Table 1). The participants lived in the villages and tundra of the Yamalo-Nenets Autonomous Okrug (YaNAO), located on the coast of the Ob, Taz and Gydan bays of the Kara Sea (Fig. 1 left).

To study changes in the consumption of traditional food in the areas with the largest population leading a traditional lifestyle, repeated studies were carried out during a period when the traditional food products (fish and reindeer meat) were easily available in villages visited during the period 2012–2017.

The same people were sampled throughout the study. The age class distributions of the people sampled are presented in Table 1. The average age of all participants was 43.0 years. Most participants were between 32.0 and 53.0 years, with the total ranging from 18 to 70 years. 308 (31.3%) of the participants were men and 677 (68.7%) women. From year to year, there were no differences between the proportions of males/females and various age classes sampled as the sample remained constant throughout the study.

Table 1 Sampling sites and number of people surveyed (n = 985): the sample size remained the same on each sampling occasion

Settlements/ number in each	Surveyed groups			
	Men (n = 310)	Women (n = 675)	Indigenous, living in the settlements (n = 758)	Indigenous, living in tundra (n = 227)
Gyda (n = 287)	106	181	178	109
Antypayuta (n = 100)	34	66	83	17
Tazovsky (n = 210)	54	156	169	41
Seyakha (n = 77)	16	61	54	23
Novy Port (n = 76)	21	55	61	15
Nyda (n = 100)	23	77	87	13
Nori (n = 41)	21	20	39	2
Kutopyugan (n = 94)	35	59	87	7
Age groups across all settlements and tundra at the start of observation,				
18–29 age	58	111	118	51
30–39 age	56	143	146	53
40–49 age	58	149	165	42
50–59 age	97	207	263	41
60–75 age	41	65	66	40

The sequence of the survey was as follows: during an expedition to the village, respondents were invited to participate in the survey. After explaining the aims and content of the research and obtaining consent for participation, the person invited to take the survey was noted in a registry and received a questionnaire (Appendix S1). The questionnaire was developed using the methodological recommendations of the Russian Academy of Medical Science (RAMS) Nutrition Institute (1996, 2016) (Methodological recommendations… 1996, 2016).

All 985 people receiving a questionnaire were interviewed during visits to the villages and tundra settlements between 2012 and 2017 (see Table 2 legend for specific years) and the same people were medically examined at the beginning of the research by a general practitioner, a pulmonologist and a cardiologist. If patients had shown severe somatic pathology, they would have been excluded from the survey, but no such cases were found.

An analysis of the traditional foods (reindeer meat, reindeer liver, muksun fish—*Coregonus muksun*, chokur—*Coregonus nasus*, pyzhyan—*Coregonus pidschian*, vendace—*Coregonus sardinella*, pike—*Esox lucius*) was carried out using frequency and survey methods (Martinchik and Baturin 1998; Ionova 2004). The amount of food consumed was estimated using a catalogue graphically depicting a range of portions of foods and dishes (Martinchik et al. 1995). The amount of traditional products consumed over the previous 30 days was estimated in an interview.

On each visit/sampling occasion, blood pressure of the participants was measured three times according to the Korotkov method and the presence of arterial hypertension (AH) was established in accordance with the recommendations for AH (Ionov et al. 2018; Williams et al. 2018).

To build AH risk models, non-linear logit regression was used with stepwise inclusion of variables by the maximum likelihood method. Due to the fact that the

Table 2 Changes of daily consumption of reindeer meat and local fish among the Indigenous population. Years of sampling were each year between the two years, including start and end years, shown for each village with the exception of Nyda that was sampled in only three years. Rates of change were determined from averages of individual between year comparisons

Consumption dynamics %				
Food type	Location	Sampling years	Number of respondents	Change in consumption (%)
Reindeer meat	Seyakha	2012, 2013, 2014, 2015	77	− 20.1
	Gyda	2012, 2013, 2014, 2015, 2016	287	− 48.2
	Tazovsky	2013, 2014, 2015, 2016, 2017	210	− 39.7
	Nyda	2014, 2015 and 2017	100	− 49.8
Fish	Seyakha	2012, 2013, 2014, 2015	77	− 70.6
	Gyda	2012, 2013, 2014, 2015, 2016	287	− 36.9
	Tazovsky	2013, 2014, 2015, 2016, 2017	210	− 42.2
	Nyda	2014, 2015 and 2017	100	− 39.2

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

dependent variable (presence or absence of AH) is dichotomous (binary), we chose logistic regression. The probability (p) of arterial hypertension was calculated using the formula:

$$p = 1/1 + e^{-z}, \text{ where } z = b_1 * x_1 + b_2 * x_2 + \cdots + b_n * x_n + a, \quad (1)$$

where x_1 is the value of independent variable; e the mathematical constant equal to 2.7183; b_1 the regression coefficient of logistic regression; a constant (Buyul and Tsefe 2005). A quantitative assessment of the risk of getting a disease or its fast development was calculated as the ratio of the chances in the presence or absence of the studied disease (Buyul and Tsefe 2005):

$$\text{OR} = \frac{a * d}{b * c}. \quad (2)$$

A test was carried out for the normality of the W (Shapiro–Wilk test). The data are presented in the format Mean ± SD. To assess the significance of differences between groups, the χ^2 criterion was used. To assess the significance of differences between two unrelated samples, the Mann–Whitney U test was used. All results were processed using the software package Statistica for Windows, v. 8.0 (StatSoft Inc., USA) and Microsoft Excel (Microsoft, USA). The statistical significance was set at $p < 0.05$ (Rebrova 2002).

To explore further potential effects of changing diet on health, we measured Body Mass Index (BMI) and related health indicators. Determination of BMI was calculated according to the formula of A. Ketle (Ahern et al. 2012): BMI = body weight (kg)/height (m^2). The bioimpedance method using the "Diamant" rheoanalyzer (St. Petersburg) (Gerasimchik and Girsh 2019) was used to measure the remaining health indicators: Fat mass (%), Lean mass (%), Active cell mass (%), Total liquid (L), Extracellular fluid (L) and Intracellular fluid (L).

To analyze the seasonality of consumption and methods for storing reindeer and local fish (traditional foods), during expeditions to villages, we surveyed 90 Indigenous People, who used natural cold storage. These people were a sub-sample of the overall 985 people surveyed. They were followed each sample year and were chosen based on their specific experience and expertise. They included foremen of fishing brigades, procurers, and heads of communities and households who are experts who ensure the operation of storage facilities. These experts save some of the traditional products for future use using ice wells in the permafrost and ice cellars. These storage methods allowed the duration of consumption of traditional foods to be extended.

To quantify the efficiency of storage, we conducted an analysis of data for measuring daily temperature in storage.

RESULTS

The reindeer meat and fish of the local whitefish family were the most prevalent of the traditional foods. There is a pronounced and steady trend demonstrating the lowered consumption of these traditional foods by the local population. Between 2012 and 2017, the consumption of fish and reindeer meat decreased by 20–70% among the Indigenous inhabitants of the Yamalo-Nenets Autonomous Okrug (Lobanov 2017). The rate of change was on average 9.7% per year (for reindeer meet) and average 11.5% per year (for local fish), range from 5 to 17.6% per year (Table 2).

The consumption of reindeer meat varies between villages and years (Table 2) and also between seasons. During the season of reindeer slaughter (winter), the average consumption of reindeer meat is more than 500 g day^{-1} per an adult. During the fishing season, consumption of fish is more than 1000 g day^{-1} (Fig. 2). Despite the rather high figures for seasonal consumption, the relatively short duration of the season when these traditional food products are consumed results in a longer season when less healthy western food is eaten.

The total duration of the season of reindeer meat consumption is 150–180 days and fresh fish consumption 120–200 days (Fig. 3). Currently, reindeer meat is present in the diet of most villagers for only 5–6 months a year. However, there is considerable variation among villages.

As the season of traditional food consumption is short, using traditional skills to store local food using natural cryo-resources has been one of the elements ensuring a stable food supply system all year round. Our field studies analyzed traditional food storage systems. We analyzed data of daily temperature in several cryostores of different types that were located in permafrost areas of the Yamalo-Nenets Autonomous Okrug. Some of them still operate (Fig. 4a). The cryostorage ventilation system allowed the tunnel walls to freeze to − 20 °C during the winter, which made it possible to maintain the temperature in the range of − 9 to − 12 °C in summer (Fig. 4b). This temperature allows not only the cooling, but also the freezing of intact fish.

The diets, changes in diets and traditional food storage all have effects on the health of the Indigenous and local People. We examined the change in the prevalence of arterial hypertension between 2012 and 2017. Despite the dramatic increase in the prevalence of arterial hypertension in this period, we have discovered the non-linear character of the relationship between the consumption of local food and the prevalence of arterial hypertension (Fig. 5). This non-linearity occurs since arterial hypertension develops gradually with a lag in relation to the decrease in the

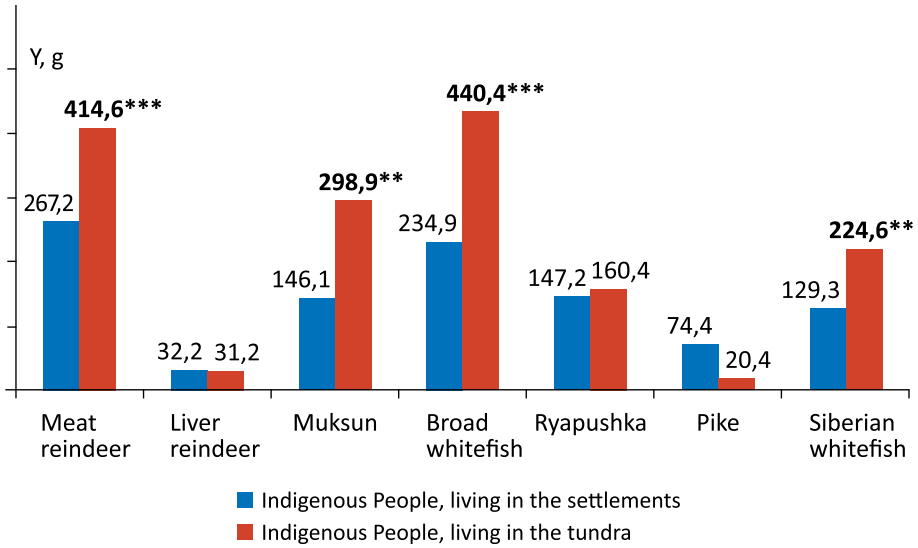

Fig. 2 Consumption of traditional food by the village and tundra population of the Yamalo-Nenets Autonomous Okrug in the season of reindeer slaughter and fishing season (g/per day) (averaged between 2012–2017, population size = 985). The numbers of respondents can be found in Table 1

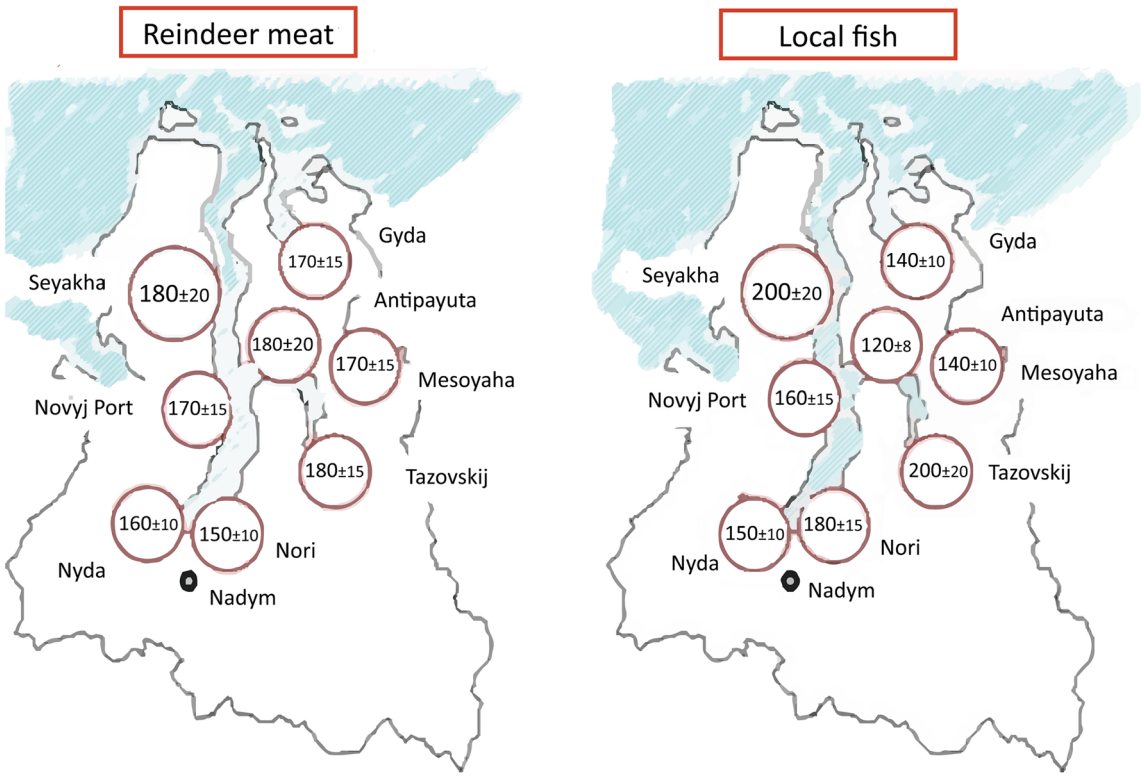

Fig. 3 Variation among villages of mean seasonal 240 consumption of reindeer meat and local fish in the Yamal-Nenets Automonous Okrug during (2012–2017), days per year (means ±SD)

consumption of traditional food products (detailed results not shown here: Andronov et al. 2016; Andronov et al. 2017).

The effect of changing diet on health was also assessed by measuring changes in body mass and related health factors. As the normal BMI range is 18.0–24.9 kg m^{-2} according to the World Health Organization, all the sampled population were overweight (pre-obesity) at 25.0–29.9 kg m^{-2}. Overall, there were no significant changes in BMI over the period of investigation. In

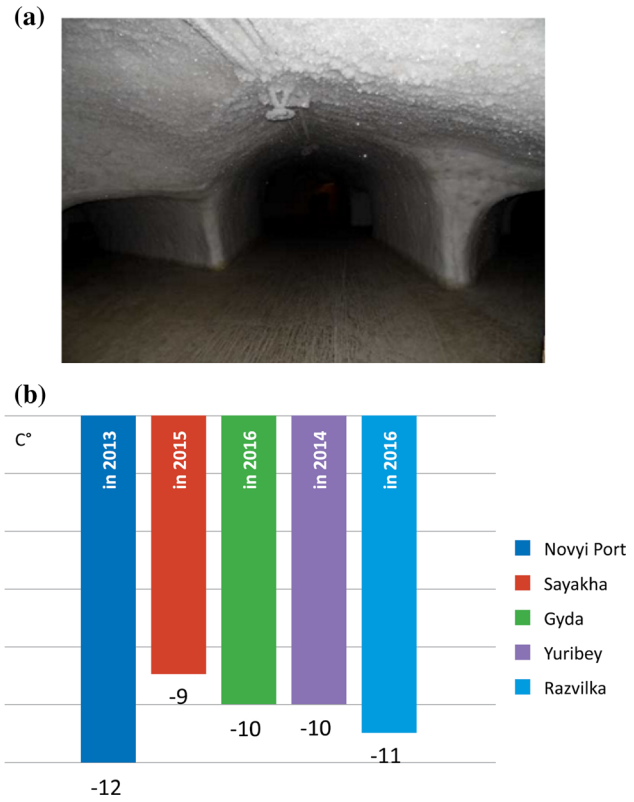

Fig. 4 Cryostorage in Yamalo-Nenets AO. **a** An operating cryostore in Novy Port, in 2013. **b** Air temperature measured twice per day in 5 permafrost cryostore chambers (5–10 August, for the years marked in the figure)

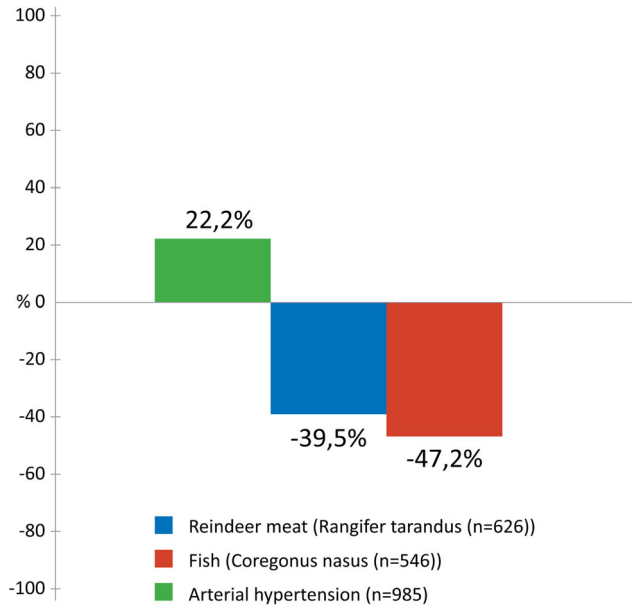

Fig. 5 The lag between decreasing traditional food diets and onset of arterial hypertension. The percentages are differences in % of the population with arterial hypertension at the start and end of the study and % reductions in consumption of traditional food over the study period

contrast, there were significant increases in fat mass, lean mass and active cell mass (Table 3).

Fewer women than men were overweight and fewer tundra dwellers than settlement dwellers were overweight (date available on request).

DISCUSSION

The average annual meat consumption among the nomads living in the harsh conditions of the Russian Arctic is lower in comparison to people living in milder climatic zones outside the study area. The average meat consumption of the Indigenous inhabitants in the Russian Arctic is 240 g per day per consumer, which is comparable to the average meat consumption in Russia (241.0 g day^{-1} $person^{-1}$). In many regions of the Russian Federation, meat consumption is significantly higher. For example, in the Moscow region, meat consumption amounts to 286.0 g day person. Meat consumption in the United States is almost a third higher than that of the inhabitants of the tundra (331.5 g day^{-1} $person^{-1}$). On an average, in the Yamalo-Nenets Autonomous Okrug, including the "newcomer population," meat consumption amounted to 307.0 g day person (Social status and living standards of the Russian population 2019). A similar rather low level of meat consumption was revealed in a study of the Indigenous inhabitants of the neighboring Nenets Autonomous Okrug (Murashko and Dallmann 2011). If there is a lack of reindeer meat, the basis of the diet is local fish. Consumption of local fish averages 171.5 g day person, which is almost thrice the fish consumption of the population in central Russia (60.3 g day^{-1} $person^{-1}$) (Social status and living standards … 2019).

The consumption of reindeer meat varies between villages and years (Table 2) and also between seasons (Fig. 2). Currently, reindeer meat is present in the diet of most villagers for only 5–6 months a year (Fig. 3). In the spring, summer and early autumn, the delivery of meat from the tundra to the Indigenous villages practically stops. In summer, nomadic Nenets slaughter a small number of animals to obtain skins suitable for sewing clothes. Meat is mostly sold to shift workers of the near-by oil and gas fields.

The consumption patterns of traditional food we present (e.g., Fig. 3) serve as a baseline against which recent changes can be measured. These changes are due to both anthropogenic and climate change impacts, although the anthropogenic changes start to dominate over climate changes.

Anthropogenic changes include new regulations. For example, currently the trade from sledges in the villages and cities of the Yamalo-Nenets Autonomous Region is

Table 3 Changes in body mass and related health factors for 674 people out of the total sample of 985. Numbers in bold font denote significant differences over time

Settlements/number in each	Health indicators (Mean ± SD)						
	Body mass index (kg m^{-2})	Fat mass (%)	Lean mass (%)	Active cell mass (%)	Total liquid (L)	Extracellular fluid (L)	Intracellular fluid (L)
Gyda 2012 (287)	26.6 ± 5.6	29.8 ± 6.9	70.2 ± 6.9	45.9 ± 4.3	26.4 ± 4.4	8.8 ± 1.4	17.6 ± 3.0
Gyda 2016 (287)	27.2 ± 5.0	**31.9 ± 7.0*****	**67.1 ± 7.6*****	**41.5 ± 5.0*****	26.8 ± 5.2	8.9 ± 1.6	17.9 ± 2.6
Tazovsky 2013 (210)	27.4 ± 5.2	28.6 ± 8.1	71.4 ± 8.1	46.6 ± 4.9	28.2 ± 4.1	9.5 ± 1.4	18.8 ± 2.9
Tazovsky 2017 (210)	26.9 ± 5.5	**30.9 ± 6.5*****	**69.1 ± 6.3*****	**44.5 ± 5.0*****	27.5 ± 5.3	9.3 ± 1.8	18.2 ± 3.4
Seyakha 2012 (77)	26.6 ± 4.2	28.0 ± 6.6	72.0 ± 6.6	46.9 ± 4.7	28.7 ± 4.5	9.7 ± 1.6	19.0 ± 3.0
Seyakha 2015 (77)	25.7 ± 4.4	**24.6 ± 13.3***	**75.4 ± 8.9****	**48.4 ± 4.4***	28.5 ± 5.2	10.2 ± 2.2	18.3 ± 3.2
Nyda 2014 (100)	28.8 ± 5.9	27.6 ± 8.9	72.4 ± 8.9	46.7 ± 5.5	30.0 ± 5.7	10.4 ± 2.2	19.7 ± 3.7
Nyda 2015 (100)	27.6 ± 6.5	26.9 ± 5.6	73.1 ± 5.6	47.1 ± 5.6	31.2 ± 5.2	11.0 ± 3.6	20.2 ± 4.6

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

being strictly restricted, which contributes to the reduced share of local products in the residents' diet. Further, there is an active campaign against poaching fish and strict fishing quotas for whitefish have been introduced. In the northern part of the Yamal Peninsula, additional anthropogenic activities have affected fishing. Large-scale building operations in 2013 and 2014 and reclamation of the coastal area of Gulf of Ob resulted in the fishless period growing to 10 months. The commercial exploitation of tundra lakes by village fishermen accordingly increased, as they were left not only without means of earning but also they lost the main component of their diet. In addition, overfishing of whitefish in tundra lakes in the Yamal Peninsula in the period of 2013–2016 led to a significant depletion of fish stocks. This consequently impoverished the diet of nomadic Nenets, who have the opportunity to replenish fish stocks in lakes only during a period dictated by the annual calendar of herd movements. Climatic changes, such as the shortening of the periods of snow and ice (Titkova and Vinogradova 2017), interact with the anthropogenic factors to further reduce the fishing seasons in the territory although there are variations among villages. Titkova and Vinogradova (2017) showed that the period with temperature below 0 °C has shorted by 15 days between 2010 and 2015 in the territory of Western Siberia. It is important when fishing that the ice is thick enough to support people but not too thick to make cutting holes too difficult. Due to a significant decrease of winter snow-fall (Titkova and Vinogradova 2017), the snow period is also getting shorter and rain-on-snow events cause ice layers to form on the surface (Bulygina et al. 2010). These events cause starvation of reindeer and even death (Sokolov et al. 2016). Starvation causes a reduction in the reindeer meat's nutritional value to local people.

The importance of changes in diet is that a traditional diet is much healthier for Indigenous People and "newcomers" than modern, carbohydrate-rich diets. We have shown that although body mass was not significantly affected by changing diet, fat mass significantly increased in two of the four villages (although there was a marginal decrease in one village). Correspondingly, lean mass and active cell mass decreased in two villages (and increased in one). In our previous studies (Kochkin et al. 2019), we showed that the consumption of different types of fats had an impact on the stability of the nervous system and tolerance to cold stress. It is likely, therefore, that a venison-enriched diet will show high efficiency in adaptation to cold stress.

Also, a diet with reindeer meat, which has a high content of unsaturated fatty acids, statistically significantly increases the antiatherogenic fractions of blood lipids. This prevents the deposition of cholesterol in the vessel wall and thereby plays a significant role in the prevention of diseases such as heart attacks and ischemic strokes (Martsekha et al. 2010; Gnedov et al. 2015). Our related studies showed that to reduce the risk of developing chronic bronchitis, an adult needs to consume at least 190 g of reindeer meat per day (Protasova et al. 2018), for the prevention of overweight, 160 g of reindeer meat and for the prevention of hypertension 470 g of reindeer meat or 50 g of liver was required (Lobanov et al. 2017).

The experiments with the laboratory animals indicate how people are benefiting from a diet of fish as well as reindeer meat. Also, it was shown that a diet with local fish helps to maintain a normal body weight in people. This is probably due to the fact that river fish contain a complete set of amino acids, essential trace elements and fat-soluble vitamins, which facilitate maintenance of a normal body weight (Tyaptiryanov 2015).

An increase in the elasticity of the vascular wall with people's consumption of river fish was also shown which is most likely associated with a set of essential trace elements

and polyunsaturated fatty acids (linoleic, linolenic, arachidonic) (Gnedov 2010; Kaiser and Gnedov 2015). Again, the increase of elasticity can reduce the risk of cardiovascular complications such as heart attack and stroke.

When it comes to a diet of freshwater fish living in the estuaries of the Ob, Nadym and Taz rivers, a significant role is played by mollusks eaten by the fish (Proskura et al. 2013; Krasnenko et al. 2016). Mollusks concentrate zinc and copper and, consequently, the meat of fish that eat mollusks and the meat of predatory fishes are rich in these microelements. Zinc and copper are necessary for the functioning of nervous, endocrine and antioxidant systems as well as for the functioning of the cytochrome chain enzymes. Further, they are extremely important for the maintenance of reproductive function and the functioning of cellular and humoral immunity.

The highest prophylactic activity is found in fish of the whitefish family, which is probably due to the high content of omega-3 fatty acids in these fish species (Gladyshev 2012; Robbek et al. 2015), and in reindeer meat (Ionova 2004). Additionally, pike fish shows high activity, which is possibly associated with a high content of magnesium and zinc in pike (Antipova et al. 2016). These data allow us to conclude that changes in the diet as a result of a decrease in whitefish stocks due to the anthropogenic and climate changes discussed above may reduce the adaptive capacity of a significant part of the population to harsh climatic conditions and can dramatically affect the health of more than 50 thousand people (almost the all population of Yamal), for whom fish is the basis of the diet.

Furthermore, our results show how reduced consumption of all fish species and reindeer products are decreasing significantly due to a combination of anthropogenic activities, regulations and climate change. We have discussed how traditional diets are important for health. However, our results on the delay in hypertension following a reduction in consumption of fish and reindeer meat (Fig. 5 and Andronov et al. 2016, 2017, 2018) indicate that even more health problems will appear in the future, although the causes of hypertension are complex and require further study. As development in the Arctic is increasing dramatically and global warming is amplified there, we can expect the health of the people living there to be significantly affected due to some extent to the future increasing lack of traditional foods and their beneficial qualities. However, if the diet of traditional foods can be maintained or increased, the resilience of Indigenous and local People to ongoing environmental change can be increased.

It is necessary to carry out regular research and monitoring to confirm these conclusions and to get more reliable information for local decision makers for developing public healthcare and prevention systems.

CONCLUSIONS

1. The consumption of reindeer husbandry and fishing products has a pronounced seasonal character in all the regions of the Arctic zone of the Western Siberia. The total duration of the consumption season for reindeer meat is 150–180 days and for fresh fish 120–200 days.
2. Despite the high level of consumption of reindeer products per season (about 500 g day^{-1} $person^{-1}$), the average annual consumption of meat by the inhabitants of the tundra and Indigenous villages of the Yamalo-Nenets Autonomous Okrug is on average 240 g day^{-1} $person^{-1}$, which is less than the consumption of meat in the central regions of Russia and industrialized countries (USA).
3. In the Arctic zone of Western Siberia, the average annual consumption of fish is three times the average consumption in Russia and amounts to 171.5 g day^{-1} $person^{-1}$.
4. Guaranteeing the Indigenous population's access to traditional food products is the most important task for reducing the prevalence of arterial hypertension and its complications among the Indigenous Population of the Arctic. Also it plays an important role in the prevention of a number of nutritional-dependent diseases, previously not widely spread among the Indigenous Arctic population.
5. The availability of reindeer and fish products is one of the main factors affecting the health and adaptive capabilities of the inhabitants of the Russian Arctic. Therefore, it is necessary to develop a new model of local entrepreneurship, adapted to changing economic and climatic conditions. This requires collaboration between environmental scientists, medical doctors, economists, politicians and associations of Indigenous and local People.
6. Consequently, it is necessary to carry out regular research and monitoring to inform local decision makers so they can improve public healthcare and prevention systems.

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AUTHOR BIOGRAPHIES

Sergey Andronov is a senior research scientist of the laboratory for studying the mechanisms of action of physical factors at the National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, Moscow, Russia. His main research interests are medicine, therapy, adaptation in the Arctic and traditional nutrition in the prevention of chronic non-infectious diseases. He has a Candidate of Medical Sciences degree, European equivalent – Ph.D. in Medical Science.
Address: National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, 32, Novy Arbat Street, Moscow, Russia 121099.
e-mail: sergius198010@mail.ru

Andrey Lobanov is a head of the laboratory at the National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, Moscow, Russia. He is a senior research scientist at the Tomsk State University, Tomsk Russia. His research interests include impacts of climate change on health and well-being of population in the North, adaptation to harsh climate conditions and reproductive health problems of the indigenous people of the Arctic. He has a degree of Doctor of Medical Sciences.
Address: National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, 32, Novy Arbat Street, Moscow, Russia 121099.
Address: Tomsk State University, 36 Lenina Pr, Tomsk, Russia 634050.
e-mail: alobanov89@gmail.com

Andrey Popov is a senior research scientist at State institution "Scientific centre of Arctic research" of Yamalo-Nenets Autonomous Okrug. His research interests include natural healing resources, physiotherapy and impact of the north climate factors on health. He has a Candidate of Medical Sciences degree, European equivalent – PhD in Medical Science.

Address: Scientific centre of Arctic research, 20 Republic street, Salekhard, Russia 629008.
e-mail: anpopov2007@yandex.ru

Ying Luo is a researcher at the Arctic and Antarctic research center, Guangdong University of Foreign Studies, South China Business College, Guangdong, China. Her research interests include Natural Healing Resources and Traditional Medicine.
Address: Guangdong University of Foreign Studies, Guangzhou, China.
e-mail: luoying777@vip.163.com

Olga Shaduyko (✉) is a Director of the Excellence Support Unit of Tomsk State University, Russia. Her main interests include Climate Change and its Social Consequences, International Cooperation and Science Diplomacy.
Address: Tomsk State University, 36 Lenina Pr, Tomsk, Russia 634050.
e-mail: dolcezzamia@mail.ru

Anatoliy Fesyun is a Director of the National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, Moscow, Russia. His main research interests include Health Rehabilitation and Management in the System of Healthcare. He has a degree of Doctor of Medical Sciences.
Address: National Medical Research Center for Rehabilitation and Balneology of the Ministry of Health of Russia, 32, Novy Arbat Street, Moscow, Russia 121099.
e-mail: fad68@yandex.ru

Lilia Lobanova is a senior research scientist at State institution "Scientific centre of Arctic research," of Yamalo-Nenets Autonomous Okrug. Her research interests include the study of impact of the Arctic magnetic- and meteofactors on health and the methods of alimentary and reflex correction of adaptation capabilities to it. She has a Candidate of Medical Sciences degree, European Equivalent – Ph.D. in Medical Science.
Address: Scientific centre of Arctic research, 20 Republic street, Salekhard, Russia 629008.
e-mail: lidiya2809@yandex.ru

Elena Bogdanova is an associate professor at the Department of Economics and Management, Institute of Humanities Northern Arctic Federal University, Severodvinsk, Russia, Ph.D. in Economics, Ph.D. in Phil. Her main research interests are the comprehensive assessment of the issues of saving the population of the Arctic region: Economic, Legal and Medical-Social Aspects.
Address: Institute of Humanities, Northern Arctic Federal University, 6 Captain Voronin Street, Severodvinsk, Arkhangelsk Region, Russia 164500.
e-mail: elena.bogdanova@gmail.com

Irina Kobel'kova is a senior research scientist at the Federal research center for nutrition, biotechnology, and food safety, Moscow, Russia. Her research interests include sports nutrition and sports anthropology. She has a Candidate of Medical Sciences degree, European equivalent – Ph.D. in medical science.
Address: Federal Research Center for Nutrition, Biotechnology and Food Safety, 2/14 Passage Ust'inskiy, Moscow, Russia 109240.
e-mail: irinavit66@mail.ru