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ARTICLE

Measuring Food and Nutrition Security in Circumpolar Communities

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ARTICLE INFO

Article history
Received: 20 May 2019
Accepted: 11 June 2019
Published Online: 30 August 2019

Keywords:
Arctic
Environment
Food security
Health
Nutrition

ABSTRACT

The issue of food and nutrition security (FNS) brings together concerns over a range of environmental, economic, social, and cultural changes which taken together influence the diets and health of the population. There have been many attempts to capture specific overlapping dimensions of food and nutrition security in circumpolar territories. None of them, however, has resulted in the elaboration of a comprehensive set of parameters which could reflect the entire complexity of transforming food consumption patterns in indigenous communities, strengthening of human pressure on the environment, and progressing climate change in the Arctic. To bridge the gap, the author employed a two-stage survey of international experts and promoted a set of eighteen measures along the availability, accessibility, utilization, and stability pillars. Introduction of a parameter rating scale allowed measuring and comparing food and nutrition statuses of indigenous communities on the per pillar basis. The key outcome of the study is the establishment of the FNS status scoring system which may become one of the potential solutions to the existing problem of effective translation of discrepant international and national parameters into a unified measurement applicable across circumpolar territories in Arctic countries.

1. Introduction

Food security is a physical, social, and economic access by all people at all times to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life [1]. A concept of food security includes aspects of nutrition but not sufficient, since nutrition includes healthy environment and often depends on the availability of nonfood resources (caring practices, health services, clean water, and sanitation). Quisumbing et al. [2] defined nutrition security as an adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times – an understanding which is wider than food security. According to Pangaribowo et al. [3], nutrition security is deemed to be achieved when secure access to an appropriately nutritious diet is coupled with a sanitary environment, adequate health services, and care. Weingartner [4] developed a definition of food and nutrition security (FNS) as a condition under which adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life. Therefore, FNS is used to combine the aspects of food security and of nutrition security, as well as to emphasize the importance of the complementarity and overlaps between food security and nutrition.

Food and nutrition insecurity is influenced by various

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DOI: https://doi.org/10.30564/mmpp.v1i2.856

factors, among which are population growth, availability of lands and water resources, and climate change [5]. In circumpolar territories, FNS brings together specific concerns over a range of interacting environmental, social, economic, and technological changes. These include environmental pollution and changing ecosystems that impede access to food; high costs of healthy foods and changes in food prices and in people's ability to pay [6]; changes in dietary preference and shifts in the social context in which food is produced and shared [7]; changes to infrastructure and technologies connected with both traditional and new ways of food production [8]. These considerations affect the four pillars of food security as defined by the Food and Agriculture Organization of the United Nations (FAO) [9]: availability, accessibility, utilization, and stability.

In the harsh environment of the Arctic, hunting and fishing have always been an important part of human existence [10], but traditional food provisioning is increasingly threatened by a lack of access to traditional lands, extinction and decreased density of plant and animal species, and changes in animal migratory patterns [11,12,13]. In indigenous communities, climate change acts through alteration of food web pathways for contaminants [14], while pollution increases the risk of disease transfer from animals to humans as a large volume of marine and terrestrial wildlife is consumed raw and inadequately frozen [15]. For those communities that traditionally rely on fishing, the impact of global climate change is important in terms of the availability, distribution, and resilience of marine resources as higher temperature of ocean water moves warmer marine species towards the northern latitudes [16,17].

In the recent decades, intensive exploration of natural resources of the Arctic and development of other kinds of economic activities have resulted in a substantial increase of Arctic population. Underconsumption of whole milk, fresh vegetables, meat, fish, and genuine fresh eggs as the major sources of complete proteins, vitamins, saline minerals, and other biologically active substances oppresses vital and working capacities of people [18]. Kozlov and Dorogovtsev [19] report that the people living in the circumpolar territories have higher activity-related energy expenditure compared to those living in the temperate climate – by 15-20%, on average. Nutrition and food ration adequate for the specifics of metabolism in the conditions of chronic environmental stress are the crucial components of the resilience of a human body to the adverse climatic and ecological impacts in the High North. To compensate higher losses of energy, Arctic rations have to include nutritious foods with higher content of proteins and animal fats – up to 35% of the total energy content, compared to 25% in the temperate zones [19].

Along with food availability issues, the inclusion of Nordic territories to the global production chains has brought along increased anthropogenic stressors on the ecosystems, environmental pollution [20], and safety and quality of food. Wesche and Chan [21] found that in the Western Canadian Arctic, vulnerability of communities to changing food security was differentially influenced by a range of factors, including current harvesting trends, levels of reliance on individual species, opportunities for access to other traditional food species, and exposure to climate change hazards. Hastrup et al. [22] analyzed how an increasing fear of contaminants had created a new sense of food and nutrition insecurity in the Arctic and addressed the emerging issue of carcinogens identified in common food-items in the North. The significant fact is that the Arctic and sub-Arctic communities are isolated. On the one hand, agricultural products and food are shipped long distances from the southern parts of the planet. On the other hand, the existing supply chains are rather vulnerable to the region's litany of both natural and human-made disasters, including blizzards, earthquakes, volcanoes, and shipping strikes [23].

Neither disruptions of food supply nor nutrition insecurity problem are new phenomena in the Arctic. There have been many attempts to use the common food security survey modules to assess FNS in northern communities. Dresscher [24] analyzed food security strategies and explicated how they managed to balance the subsistence hunt with the commercial one in the High Arctic. Koutouki et al. [25] examined food system changes and planning from a community health and management perspective and discussed the relationship between FNS, gender, livelihoods, and ecosystem capacity. Ready [26] attempted to develop the tools that provided reliable and valid assessments of country food access, specifically including traditional knowledge and social support networks in the circumpolar territories. Gao [27], Erokhin [28], and Ivolga [29] addressed food security issues through the prism of sustainable rural development but did not focused on nutrition issues. Zabrodin and Layshev [30] conducted a comprehensive analysis of food security issues in northern communities in terms of crop and vegetable production, animal husbandry, and fishing, but considered only availability dimension of FNS.

None of the previous studies, however, was originally designed for use in mixed economies of circumpolar regions where both market and traditional (hunted, fished, and gathered) foods contribute to peoples' diets [26]. None of them has therefore resulted in the development of a comprehensive set of parameters reliable in food and, primarily, nutrition contexts in the Arctic. To date, there ex-

 DOI: https://doi.org/10.30564/mmpp.v1i2.856

ists no pan-Arctic assessment that focuses specifically on the role of various FNS factors in improving the quality of life of people. The conceptualizations of FNS measures do not take into full account the existing food practices and specific nutrition issues of indigenous peoples and those living in the circumpolar territories [31]. The purpose of this study is to conceptualize an approach to the assessment of FNS in circumpolar territories with the differentiation of the factors influencing food and nutrition status of people living in various environments and consuming various types of food.

2. Materials and Methods

There have been developed various measures to capture overlapping dimensions of food and nutrition security. FAO's indicator of undernourishment (FAOIU) is commonly used for the assessment of the mean quantity of calories available for human consumption, the inequality in access to those calories among the population, and the mean minimum amount of calories required by the population [32]. In the Arctic, however, the calorie availability itself is a poor predictor of nutritional development [33] since the degree of dietary diversity should be monitored to ensure nutrition security [34]. Dasgupta [35] and Svedberg [33] also complained that the aggregation of specific minimum dietary requirements for different age groups might result in a large underestimation of undernutrition.

The dimensions of availability and utilization are covered by the Global Hunger Index (GHI), which assesses the state and evolution of hunger as a proxy for food insecurity by combining undernourishment, child wasting, child stunting, and child mortality. In terms of nutrition security, however, GHI is found to be unsatisfactory since it omits both accessibility and stability pillars which are critically important in circumpolar communities. In addition, the elements of hunger are correlated which causes double counting [36].

The Global Food Security Index (GFSI) as a more comprehensive measure of FNS since it assesses food security across the availability, accessibility, and utilization pillars. Nevertheless, GFSI is not an appropriate indicator for our study because its safety dimension almost ignores health issues as risks to and determinants of FNS. Particularly, health environments are assessed beyond the access to potable water, which is a critical parameter of FNS in the Arctic. Second, calculation methodology does not allow assessing the contribution of particular factors which led to a final score [3].

The US Department of Agriculture applies food security survey modules (FSSM) to assess actual consumption of the individuals or families. In northern Canada, FSSM standard version was adapted to the indigenous populations, particularly, in Nunavut [37]. This method is helpful in monitoring food and nutrition situation when repeated in the same population on a regular basis [8], which is difficult in nomadic indigenous communities.

In 2013, an international workshop which was conducted in collaboration between the Arctic Human Health Expert Group, Sustainable Development Working Group, and Arctic Monitoring and Assessment Programme within the Arctic Council elaborated six most informative indicators of food security in the Arctic: healthy weight, traditional food proportion in diet, monetary food costs, non-monetary food accessibility, foodborne diseases, and food-related contaminants [8]. Some indicators, however, were used in a context rather than food security, deemed to need further development, and were not feasible for comparisons among Arctic countries.

Since the search has not revealed unified FNS indexes, the authors employed Delphi approach to identify the indicators appropriate for comparative assessment of food-nutrition dimensions. A rationale of using the Delphi approach was that the majority of studies related to nutrition issues in the Arctic were diverged widely, narrowly aimed, small in scope, regionally self-contained, and focused on specific food problems in specific territories.

At stage one, 57 respondents representing 32 research institutes from 11 countries selected the most perspective FNS measures along the four pillars of availability, accessibility, utilization, and stability. The questionnaire consisted of two blocks. In block 1, the respondents rated 29 candidate FNS parameters ($n_{1\text{-}29}$) suggested by the authors (Table 1) on a five-grade scale from 0 (least significant) to 4 (most significant).

Table 1. FNS parameters included in the survey

FNS pillars	Parameter
Availability	Per capita dietary energy supply
	Per capita consumption of meat and meat products
	Per capita consumption of milk and dairy products
	Per capita consumption of fruits
	Per capita consumption of vegetables
	Per capita consumption of fish
	Body mass index
	Proportion underweight
	Proportion obese
	Diet diversity score
	Proportion of traditional food in a diet

DOI: https://doi.org/10.30564/mmpp.v1i2.856

Accessibility	General food basket
	Nutritious food basket
	Proportion of food expenditures in total household's expenditures
	Proportion of population living below a minimum subsistence income
	Proportion of households with a hunter, a herder, or a fisherman in a family
	Accessibility of hunting and fishing equipment
	Accessibility of sufficient land and water areas for hunting, fishing, and herding
	Environmental conditions for traditional activities in indigenous communities
Utilization	Incidence rate in humans
	Chemical contaminants in food
	Microbiological contaminants in food
	Per capita wastewater discharge
	Self-estimated food safety
	Percentage of households having running water available in their homes
	Percentage of households having access to the quality assured sources of water
	Air pollutant emissions
Stability	Extreme weather conditions when a traffic with the mainland is interrupted
	Safety net programs

Source: author's development

The selection of FNS measures out of candidate parameters was performed based on the scores awarded (x_n). A threshold of 50% of maximum possible score (x_{max}) was set to decide on the promotion ($x_n > 50\%$ of x_{max}) or rejection ($x_n < 50\%$ of x_{max}) of a parameter n.

In block 2, the respondents suggested and rated alternative measures (m) not included in the questionnaire form. The selection of promoted and rejected indicators was performed based on the mean of the sample (x_{aver}), where $x_m > x_{aver}$ and $x_m < x_{aver}$ stood for promotion and rejection, respectively.

At stage two, based on the promoted parameters, there was established the FNS status scoring system. Promoted parameters were scored on the scale from 0 (the lowest) to 4 (the highest). A threshold level of security was set within a 10% corridor around respective standard criteria (V_s) – international (I_{aver}) and national (N_{aver}) average, as well as internationally accepted criteria of adequate nutrition established by the World Health Organization (WHO) and the FAO. So far, cross-country comparisons of FNS issues in the Arctic have been hindered by the lack of comparable international data as many of the indicators reported in national databases have not matched and have not been readily available in national statistical sources across Arctic countries. A rationale for choosing a mixture of standardized and average criteria was to conceptualize an approach to the assessment of FNS in the entire region of the Arctic and make it applicable internationally by translating both international and national average indicators into a unified scoring system. Varying abnormalities of an actual value of a promoted parameter (V_p) from a standard (V_s) were reflected as various degrees of either security or insecurity (Table 2).

Table 2. Scale to measure FNS score: parameters

Parameter / score	Critical insecurity	Insecurity	Security	High security	Superior security
V_p	<80% of V_s	80-90% of V_s	$V_s \pm 10\%$	110-120% of V_s	>120% of V_s
Score	0	1	2	3	4

Source: author's development

At stage three, the established scale is applied to score the promoted p-parameters and thereby to rate security/insecurity status per each of the four FNS pillars.

3. Results

A two-stage survey resulted in the establishment of a set of FNS parameters relevant in the circumpolar communities (Table 3). Ten out of 29 n-parameters were promoted, eight alternative m-measures were suggested by the respondents.

Most of the respondents agreed that per capita criteria of adequate nutrition established by the WHO were the most appropriate measures of availability of food products essential to a healthy diet in the Arctic in terms of availability of meat and meat products, milk and dairy products, vegetables, bread, and fish and fish products. Along with the WHO's criteria, the experts advised using traditional food proportion in the diet as an FNS indicator relevant in the Arctic. Body mass index, proportion underweight, proportion obese and other individual anthropometric indicators were scored low and thus rejected.

Since the primary means for obtaining and producing food in indigenous communities are provided by hunting, herding, fishing, and gathering activities, 43 respondents suggested using a presence of a hunter, a herder, or a fisherman in a family as one of the food accessibility measures. As for the marketed food, two of the commonly used FAO measures of accessibility [1] (proportion of food expenditures in total household's expenditures and proportion of population living below a minimum subsistence income were agreed upon to reflect the ability of households to generate sufficient income which, along with own production, can be used to meet food needs. The selection of was also based on the idea that within a monetary dimension, an access to food required a steady income in order to ensure a consistent, year-round supply

 DOI: https://doi.org/10.30564/mmpp.v1i2.856

Table 3. FNS status scoring system: parameters

FNS pillars	FNS parameters	Measure	Score				
			0	**1**	**2**	**3**	**4**
Availability	Per capita consumption of meat products	kg/year	<56.1	56.1-63.0	63.1-77.1	77.2-84.1	>84.1
	Per capita consumption of dairy products	kg/year	<287.9	287.9-323.8	323.9-395.9	396.0-431.9	>431.9
	Per capita consumption of vegetables	kg/year	<112.2	112.2-126.2	126.3-154.3	154.4-168.4	>168.4
	Per capita consumption of bread	kg/year	<96.4	96.4-108.4	108.5-132.6	132.7-144.6	>144.6
	Per capita consumption of fish and marine mammals	kg/year	<6.7	6.7-7.5	7.6-9.2	9.3-10.1	>10.1
	Traditional food proportion in a diet	%	<30	30-45	45-55	55-70	>70
Accessibility	Proportion of food expenditures in total household's expenditures	%	<80% of N_{aver}	80-90% of N_{aver}	N_{aver} ± 10%	110-120% of N_{aver}	>120% of N_{aver}
	Proportion of population living below a minimum subsistence income	%	<80% of N_{aver}	80-90% of N_{aver}	N_{aver} ± 10%	110-120% of N_{aver}	>120% of N_{aver}
	Proportion of households with a hunter, a herder, or a fisherman in a family	%	<30	30-45	45-55	55-70	>70
Utilization	Incidence rate – nutritional and metabolic disorders	per 1,000	<80% of I_{aver}	80-90% of I_{aver}	I_{aver} ± 10%	110-120% of I_{aver}	>120% of I_{aver}
	Incidence rate – diseases of the digestive system	per 1,000	<80% of I_{aver}	80-90% of I_{aver}	I_{aver} ± 10%	110-120% of I_{aver}	>120% of I_{aver}
	Per capita wastewater discharge	m^3/year	<80% of I_{aver}	80-90% of I_{aver}	I_{aver} ± 10%	110-120% of I_{aver}	>120% of I_{aver}
	Percentage of households having running water available in their homes	%	<80% of N_{aver}	80-90% of N_{aver}	N_{aver} ± 10%	110-120% of N_{aver}	>120% of N_{aver}
	Percentage of households having access to the quality assured sources of water	%	<80% of N_{aver}	80-90% of N_{aver}	N_{aver} ± 10%	110-120% of N_{aver}	>120% of N_{aver}
	Air pollutant emissions	tons/km^2	<80% of I_{aver}	80-90% of I_{aver}	I_{aver} ± 10%	110-120% of I_{aver}	>120% of I_{aver}
Stability	Extreme weather conditions when a traffic with the mainland is interrupted	days/year	>60	40-60	30-40	20-30	<20
	Safety net programs	programs	0	0	1	1-2	>2
	Food availability support programs	programs	0	0	1	1-2	>2

Source: author's development

of high-quality goods in the stores and a ready supply of healthy wildlife to be harvested [6]. To overcome the lack of comparable international data, the respondents suggested using national average as a baseline for both proportion of food expenditures in total household's expenditures and proportion of population living below a minimum subsistence income.

Utilization pillar was described by food safety indicators which allowed measuring the occurrence of foodborne diseases. The suggested n-parameter of incidence rate in humans was replaced by two specific m-parameters: incidence rates of nutritional and metabolic disorders and diseases of the digestive system. According to the respondents, both diseases are monitored in Arctic countries and thus appropriate for international comparisons. Utilization requires not only an adequate diet but also a healthy physical environment, including safe drinking water and adequate sanitary facilities [4]. 39 respondents recognized water security in terms of the availability, accessibility, and safety of water resources as a critical FNS issue in the Arctic. A parameter of air pollutant emissions was suggested by 34 experts. In country-level studies, national average data were recommended as a baseline to measure the percentage of households having running water available in their homes and having access to the quality assured sources of water. For the remaining utilization parameters, international data may be used since every country in the Arctic region is already monitoring wastewater discharge and air pollutant emissions [8].

Stability is commonly measured by the composition of

DOI: https://doi.org/10.30564/mmpp.v1i2.856

food available as indicated by FAO's index of variability of food production [1] and the variability of access as represented by volatile food prices [38]. The respondents emphasized extreme weather conditions, energy scarcity, and economic and social disruption as the factors of adverse effects on the stability of food supply in the circumpolar territories. In the Arctic, where possibilities of agricultural production are limited and food prices depend on transportation costs and weather conditions rather than on global market fluctuations, FNS stability pillar should be measured by a duration of a period of extreme weather conditions when a traffic with the mainland is interrupted. Other relevant indicators are safety net programs and food availability support programs, because, in the remote northern areas, people depend on food delivery programs the whole year round, not only in the times of market disruptions.

Based on the scores of promoted parameters (x_p), aggregated per-pillar and total FNS scores may be applied to rate a particular territory or community on the scale between critical insecurity and high security (Table 4).

Table 4. FNS status scoring system: pillars

FNS pillars	Critical insecurity	Insecurity	Security	High security
Availability	0-5	6-11	12-17	18-24
Accessibility	0-2	3-5	6-8	9-12
Utilization	0-3	4-7	8-11	12-16
Stability	0-2	3-5	6-8	9-12

Source: author's development

Security is rated as high when all p-parameters within a particular pillar are scored greater than or equal to 3 (≥110% of V_s), or . In a similar manner, security is recognized as established when the values of all parameters fall within a V_s±10% corridor and scored greater than or equal to 2, or . The aggregated per-pillar score below 2n shows the situation of insecurity, below 1n – critical insecurity.

4. Discussion

4.1 Availability

Availability refers to the physical existence of food, be it from own production or on the markets [4]. FAO's availability pillar is assessed by over 50 indicators of food production and balance on the macro, household, and individual levels [1], including dietary diversity of major food groups (cereals, milk, meat, sugar, vegetables oils, fruits, vegetables, and starchy roots), frequency of consumption (vegetables, meat and fish, dairy products), and micronutrient supplements, among others [3]. In the established scoring system, the promoted parameters reflect both FAO's availability thresholds and WHO's criteria of adequate nutrition for such particular food products traditionally consumed in the North as meat and meat products, milk and dairy products, fish and fish products, vegetables, and bread.

De Haen et al. [32] and Svedberg [39] reported that stunting, underweight, and wasting directly reflected the imbalances in nutrition and revealed undernutrition and its major causes. Nevertheless, individual anthropometric indicators were rejected as relevant FNS measures in circumpolar communities. It supports previous findings of Walker et al. [40] who revealed that even though anthropometric indicators served as a relevant measure of nutritional outcomes, they did not cover specific essential nutrients, vitamins, and minerals that might be deficient in particular Arctic communities. Brustad et al. [41] and Johansson et al. [42] proposed using body mass index and proportion obese as the measures with a relatively high information value in the conditions of the Arctic environment. Both n-parameters were rejected by the respondents as those not applicable to the unified scoring system. Most of the Arctic countries abundantly collected data in children but did not provide regular statistic data in adults. Hoddinott and Yohannes [43] and Nachvak et al. [44] suggested that the drawbacks of anthropometric indicators might be compensated by the utilization of diet diversity measures, but the survey demonstrated that DDSs are of limited usefulness in the North due to the low diversification of the diets. In furtherance of the studies of Daures et al. [45] and Kabagambe et al. [46], the respondents agreed that in circumpolar territories, the use of medical and biomarker indicators was restricted because they could be affected by environmental and climatic factors and are not available for all nutrients.

Nilsson et al. [8] and Egeland et al. [47] demonstrated that, along with the WHO's criteria, traditional food proportion in diet was one of the most relevant parameters of food and nutrition security in the Arctic. The selection of this parameter is in line with the existing literature. Jeppesen et al. [48] concluded that traditional food was positively associated with type 2 diabetes mellitus, impaired fasting glucose, and fasting plasma glucose. Sheehy et al. [49] reported that more traditional foods in the diet translated into greater dietary adequacy for proteins and a number of vitamins and minerals including vitamin A, several B-vitamins, iron, zinc, magnesium, potassium, sodium and selenium. According to Wesche and Chan [21], traditional food reduces the intake of saturated fats, sucrose, and excess carbohydrates that often are found in marketed food. The use of traditional food proportion in diet as a parameter

 DOI: https://doi.org/10.30564/mmpp.v1i2.856

of nutrition security is particularly relevant in a situation when increased exposure to western lifestyles contributes to a non-directed dietary change, moving away from nutritious traditional food towards a non-balanced westernized diet.

4.2 Accessibility

Access is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods for a nutritious diet [50]. Accessibility depends on the ability of households to generate sufficient income which, together with own production, can be used to meet food needs [4]. The FAO measures accessibility using five groups of indicators: prices and income, poverty, infrastructure, living standards of households, and food consumption [1].

In the Arctic, however, FNS has not only monetary but a significant non-monetary dimension, which is reflected in the established scoring system. The set of promoted parameters corresponds with the previous findings of Lambden et al. [13] and Duhaime and Bernard [51], who revealed that food security in the Arctic was affected by an access of local residents to traditional foods, as well as an access to store-bought food. Within a monetary dimension, an access to food requires a steady income in order to ensure a consistent, year-round supply of high-quality goods in the stores and a ready supply of healthy wildlife to be harvested. Among the available approaches to the assessment of monetary accessibility, Nilsson et al. [8] proposed to use a cost of nutritious food basket as a comparable and potentially standardized measure. This measure, however, was rejected due to a fact that to reflect the actual level of consumption it had to be correlated to the purchasing power of population. Instead, the respondents suggested using a proportion of food expenditures in total household's expenditures – the lower the share the higher the security on the accessibility pillar.

The set of p-parameters also reflects a fact that people in the remote northern communities do not rely on marketed food solely. In terms of money, their food expenditures are low. But they still have to deal with the high cost of many commodities such as oil, fuel, and transportation essential for hunting, fishing, or reindeer herding activities [52]. That is why the parameter of a proportion of food expenditures in total household's expenditures is considered in conjunction with a proportion of the population living below a minimum subsistence income. This measure is applicable to the assessment of the accessibility of both marketed and traditional food. Inclusion of another non-monetary parameter, a presence of a hunter, a herder, or a fisherman in a family, is supported by a majority of the respondents and corresponds with the findings of Huet et al. [53], who considered it as the most relevant non-monetary aspect of food accessibility in the North and one of the easiest measures to collect and monitor.

Environmental conditions suitable for hunting or fishing are very important to reflect the degree of food accessibility in the circumpolar territories, but Nilsson et al. [8] considered impossible to develop them into the relevant FNS measures due to the difficulties in their monitoring. Rejection of the three initially suggested n-parameters of accessibility of sufficient land and water areas for hunting, fishing, and herding, and environmental conditions for traditional activities in indigenous communities is in keeping with the common perception of environmental parameters as those not surveyed regularly and therefore not feasible for measuring accessibility pillar.

4.3 Utilization

Utilization is a measure of a population's ability to obtain sufficient nutritional intake [3] and convert it into energy. Kuhnlein [54,55], Batal et al. [56], and Blanchet et al. [57] have confirmed that, in terms of utilization, traditional food is more nutritious and more nutrient-dense than market food and remains important to the quality of the diets in indigenous communities. The poor nutritional quality of many retail foods that are available in the North increases the risk of nutritional deficiencies [58]; furthermore, the high cost of these foods, mainly due to their transport [59,60], can impact households' food security status, particularly when local foods are not readily available [61]. Consequently, FNS utilization pillar should be assessed with the implementation of food safety indicators which allow measuring the occurrence of food-borne diseases.

The initial selection of n-parameters was based on the recommendations of Nilsson et al. [8] to use incidence rates in humans as the most relevant indicator of nutrition security. The respondents suggested to specify this measure by introducing two m-parameters of incidence rates of nutritional and metabolic disorders and diseases of the digestive system. This promotion correlates with the previous findings of Eganyan [62], Dudarev et al. [63], Revich et al. [64], Parkinson and Butler [65], and Thomas et al. [66], who all repeatedly reported those two diseases among the most widespread ones in both indigenous communities and urban settlements in the Arctic. Both parameters are monitored in many Arctic countries and thus appropriate for international comparisons.

According to Weingartner [4], utilization requires not only an adequate diet but also a healthy physical environment, including safe drinking water and adequate sanitary facilities. Nilsson et al. [8] particularly recognized

DOI: https://doi.org/10.30564/mmpp.v1i2.856

water security in terms of the availability, accessibility, and safety of water resources as a critical FNS issue in the Arctic since waterborne infectious diseases had been reported among the people living in the circumpolar territories in many Arctic countries. The respondents followed a similar line of argumentation and promoted all water-related n-parameters, including per capita wastewater discharge, percentage of households having running water available in their homes, and percentage of households having access to the quality assured sources of water.

4.4 Stability

The period over which FNS is being ensured refers to stability. The main risks which might have adverse effects on availability, accessibility, and utilization of food in the circumpolar territories are extreme weather conditions, energy scarcity, and economic and social disruption [3]. Stability is commonly measured by the composition of food available as indicated by an index of variability of food production [1] and the variability of access as represented by volatile food prices [38]. However, in the Arctic, where possibilities of agricultural production are limited and food prices depend on transportation costs and weather conditions rather than on global market fluctuations, FNS stability dimension should be measured by a duration of a period of extreme weather conditions when a traffic with the mainland is interrupted. The initial selection and further promotion of this measure correlates well with the findings of von Braun and Torero [67].

Due to the risk of disruption in transport communication in winter, even those northern communities which traditionally rely on subsistence have become increasingly dependent on costly imports of unhealthy frozen food with extended shelf life. Despite the commonly agreed relevance of traditional food in establishing food and nutrition security in the North, both the availability and safety of traditional food are affected by the environmental contamination of traditional food sources and the impact of global climate change on ecosystems [68,69]. Due to the increased problems of contamination, there have been the restrictions on the consumption of marine mammals introduced in some territories in the Arctic [70]. Therefore, our findings support Nilsson et al. [8] who concluded that per-person dietary energy supply, a commonly used FNS indicator, was not very useful in the Arctic since some food might be wasted. Instead, alternative measures of food availability support programs and safety net programs were suggested and promoted as relevant parameters of stability pillar.

5. Conclusion

In this paper, the authors attempted to convey the existing complexity of problems faced by the northerners today as food security was but one of several, often interrelating issues affecting their well-being. The study investigated how various parameters of food availability, accessibility, utilization, stability, and safety along with environmental pollution factors were interrelated with food supply and consumption, intake of nutrients, and, ultimately, food and nutrition security in circumpolar communities. By surveying the experts representing various countries, including Nordic states and Russia, the authors attempted to bridge a gap in existing FNS-related studies and reveal the most feasible indicators appropriate for comparative assessment of food-nutrition dimensions in circumpolar communities. An employment of Delphi approach allowed elaborating a set of measures along the four pillars of food and nutrition security, while the establishment of the FNS status scoring system provided a tool to rate and compare various parameters of food and nutrition status in different types of circumpolar territories on the per pillar basis.

Although the study suggested a platform for an analysis of the variations within the dimensions of food and nutrition security in the Arctic, the issue remains open-ended and discussible. The constructed scoring system along with an approach to the selection of feasible FNS measures may become one of the solutions to the existing problem of effective translation of discrepant international and national parameters into a unified system applicable across circumpolar territories in Arctic countries. However, due to the ongoing process of environmental and economic change in the North, a further focus on finding the most feasible indicators of food and nutrition insecurity problem could place the issue in the larger context of social-ecological change that affects the resilience of the Arctic and health and well-being of its inhabitants. Climate change, rising food prices, and oil, gas, and mineral development require reevaluation of how wildlife and other resources are managed in the Arctic, as well as how such rapid changes might negatively impact food consumption patterns in indigenous communities. Progressing nutritional transition suggests that future studies and FNS interventions should consider the monetary and non-monetary aspects of food accessibility, affordability of healthy retail food choices, in addition to increasing the availability of traditional foods and ensuring stability of food supply.

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