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# Assessment of Dietary Intake among Inuvialuit in Arctic Canada Using a Locally Developed Quantitative Food Frequency Questionnaire

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Original Research

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**Key words: dietary assessment, Inuvialuit, Northwest Territories, quantitative FFQ, Arctic Canada**



**Objective:** Inuvialuit in Arctic Canada are experiencing a nutritional and lifestyle transition, characterized by a declining consumption of traditional foods, increased consumption of non-nutrient-dense store-bought foods (NNDF), and reduced levels of physical activity with a concurrent rise in chronic diseases. The aim of the present study was to determine dietary intake of Inuvialuit adults in the Northwest Territories, Canada, using a culturally specific, validated quantitative food frequency questionnaire (QFFQ).

**Methods:** A cross-sectional dietary survey of 213 randomly selected adults (≥19 years) was conducted in 3 remote communities in the Northwest Territories. Nonparametric analysis was used to compare mean nutrient intake, dietary inadequacy, and differences in nutrient density among men and women. Data were also analyzed to determine the top food groups contributing to energy and selected nutrients.

**Results:** With response rates of 65% to 85%, 43 men (mean age 43.2 ± 12.8) and 170 women (mean age 44.7 ± 13.9) completed the QFFQ. Mean daily energy intakes for men were 3478 ± 1474 kcal and for women they were 3299 ± 1653 kcal. For both sexes, protein, carbohydrates, and fat provided approximately 16%, 47%, and 28% of energy intake, respectively. NNDFs were the top contributors to energy (39%), fat (40%), carbohydrate (54%), sugar (74%), and sodium (23%) intake. Total traditional foods from the land, sea, and sky such as polar bear and wild birds contributed 11% of energy and 41% of protein intake. Most participants' daily intakes were below recommended levels for dietary fiber; vitamins A, E, and D; potassium; and magnesium. Mean daily energy, saturated fat, and sodium intakes exceeded recommendations.

**Conclusions:** We identified nutrient inadequacies and characterized food consumption among Inuvialuit. These data support nutritional interventions that encourage consumption of traditional foods. The cultural and ethnic differences in Canadian Arctic populations require specific tailoring of public health interventions and policy using population specific tools to meet local needs.

## INTRODUCTION

Inuvialuit are an Aboriginal ethnic group living in the Northwest Territories (NWT), Canada. Traditionally, Inuvialuit peoples relied on hunting, fishing, gathering, and food sharing as a way of life and basis of cultural identity [1,2]. Historically, high levels of physical activity were required to acquire nutrient-dense traditional foods (TF) such as caribou, Arctic char, and muskox, which all contributed greatly to the Inuvialuit diet and survival in the harsh northern climate [1,3].

Over the past few decades, Inuvialuit have been experiencing a nutritional and lifestyle transition characterized

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**Abbreviations:** AI =adequate intakes, AMDR = acceptable macronutrient distribution ranges, BMI = body mass index, EAR = estimated average requirements, MSL = material style of life, NNDF = non-nutrient-dense store-bought foods, NWT = Northwest Territories, QFFQ = Quantitative Food Frequency Questionnaire, RDA = recommended dietary allowances, SD = standard deviation, TF = traditional foods.

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by declining consumption of TF, increased consumption of non-nutrient-dense store-bought foods (NNDF), and reduced levels of physical activity for food acquisition and transportation [4–7]. As a result, current anthropometric research reveals that 58% of adults residing in the NWT fall into the overweight or obese body mass index categories compared to 52% of adults within Canada and 69.2% of US adults [8].

There are increasing rates of obesity, cardiovascular disease, diabetes, and certain types of cancers (colon, lung, and breast cancer) in the Arctic, which are accompanied by declining consumption of nutrient-rich TF [2,9,10]. The rising chronic disease rates in the NWT will add to Canada's economic health care costs. In the NWT, the total health care expenditure is the second highest of all of the provinces and territories in Canada at C$9906 per person per year [11]. In 2005, the Canadian government spent C$4.3 billion alone on obesity-related chronic conditions [12]. Public health agencies can use results from population-specific nutritional assessments to implement culturally specific nutritional intervention and education programs to reduce the risk of chronic disease among Inuvialuit in the Arctic.

Recent research indicates that the current Inuvialuit diet may be deficient in several essential nutrients, such as dietary fiber; calcium; vitamins A, C, and E; and folate, whereas fat, sugar and energy intakes exceed recommended levels [4,7]. A comprehensive dietary assessment is necessary to explore the link between the Inuvialuit diet and the prevalence of chronic disease risk factors. This assessment has provided valuable dietary data for monitoring the nutritional transition. It has also facilitated the development of a population-specific quantitative food frequency questionnaire (QFFQ) [7].

QFFQs have multiple advantages over other dietary assessment tools, including ease of administration and reduced time and cost [13,14]. A population-specific QFFQ can capture dietary intakes over an extended period of time in populations with distinctive foods and dietary practices, such as the Inuvialuit [15,16]. For epidemiological studies, the most widely used tool for doing a comprehensive dietary assessment is a QFFQ [13]. This tool allows for long-term assessment of all food items and food groups consumed over an extended period of time, which can then be used to establish trends and investigate diet–disease risk factors [17,18] and to monitor dietary changes due to Westernization and climate change within the Inuvialuit population. However, subjects may not accurately recall or report information on their dietary intake and this could misrepresent food intake in a population [19].

The aim of the present study was to determine the dietary intake and adequacy of Inuvialuit adults by using a culturally specific, validated QFFQ that assesses all foods consumed. Nutrient intakes were quantified and compared to current dietary recommendations, dietary adequacy among Inuvialuit was assessed, and the major food sources of energy and selected nutrients in the Inuvialuit diet were determined.

## SUBJECTS AND METHODS

### Setting and Sampling

The population and setting for this study has previously been described in detail [1]. In brief, a cross-sectional study was conducted in 3 communities of the Beaufort Delta region in the NWT, Canada. Community populations range from 400 to 3500 people, 40%–90% of whom identify as Inuvialuit. The accessibility of the communities varied from having road access to being semi-isolated and isolated (accessible only by plane), with limited availability of a wide variety of foods. The communities had one or two stores that supplied the majority of nonlocal foods. Other means of obtaining foods included hunting, fishing, and delivery of food by barge for a brief period of time in the summer when the ice has melted [1]. Inuvialuit adults ($\geq$19 years of age) were randomly selected by households using up-to-date government housing maps. Pregnant and breastfeeding women were excluded due to different nutritional requirements, changes in dietary habits, and energy expenditure. The person in each household primarily responsible for obtaining and preparing foods was targeted.

### Data Collection

A culturally appropriate QFFQ was developed specifically for the study population and included substantial amounts of community input [7]. A validation substudy revealed that the QFFQ was valid and could be used to assess dietary intake, adequacy, and contribution of foods to specific nutrient intakes [15]. Trained interviewers administered the QFFQ and interviews were conducted primarily in English, and community translators assisted with interviews conducted in the local language (Inuvialuktun). Participants were asked to report the frequency of consumption for all foods and beverages listed on the QFFQ over the previous 30 days with 8 frequency categories, which ranged from *never* to *2 or more times per day*. Culturally appropriate food models were used to estimate the amounts usually consumed. Recipes and portion weight data (in grams) were collected following a standard manual of procedures. Traditional foods were categorized into land, sea, and sky, which included foods such as caribou, muskox, polar bear, local fish, and wild birds. The store-bought NNDFs included, but were not limited to, pastries, pizza, crackers, salad dressing, sweetened drinks, and sweets [4].

This study was approved by the Institutional Review Boards from the Office of Human Research Ethics at the University of North Carolina, Chapel Hill, and the University of Hawaii. At the time of the study, the corresponding author was employed by the University of North Carolina. The Aurora Research Institute, Inuvik, NWT, Canada, also issued a research licence. Written and signed consent was obtained from all participants.

### Statistical Analyses

Frequency values from the QFFQ were converted into mean daily frequencies of consumption and multiplied by portion weights (in grams) to obtain overall daily grams consumed for each food item on the QFFQ, allowing for per person calculation. Daily nutrient intake was then calculated using a culturally specific food composition table developed using collected recipes and the Canadian food composition database in NutriBase Clinical Nutrition Manager v. 7.17 (CyberSoft Inc., Phoenix, AZ).

The mean, standard deviation, and median daily energy and nutrient intakes were calculated for all participants and are presented for comparison with the recommended dietary allowances or adequate intakes for men and women age ≥ 19 years [20]. Dietary adequacy was determined using the estimated average requirements (EARs) according to specific sex/age groups. Adequate intake values were used for dietary fiber, potassium, and sodium [20], because EARs were not available. Nutrient densities were calculated (amount of each nutrient per 1000 kcal). The top 10 foods contributing to energy and nutrient intakes were also determined. Material style of life was assessed if anyone in the participant's household owned any of a series of 20 different items in working condition such as snowmobiles, cars or trucks, televisions, home computers, and fishing nets [21].

Due to the small sample size of several subgroups, data are presented as one category for males (≥19 years) and as 2 categories for females (19–50 years and >50 years). Participants who reported extreme energy intake (<500 kcal, $n = 0$, or >7000 kcal, $n = 17$) were excluded from the analyses. A nonparametric Wilcoxon rank-sum test was performed to test for significant differences in mean intakes of nutrients between men and women. Differences were considered statistically significant at $p < 0.05$. All statistical analyses were performed using SAS statistical software, version 9.3 (SAS Institute Inc., Cary, NC).

**Table 1.** Characteristics of Inuvialuit men and women

| Variables | Men ($n = 43$) Mean ± SD | Women ($n = 170$) Mean ± SD | $p$ Value |
|---|---|---|---|
| Age (years) | 43.2 ± 12.8 | 44.7 ± 13.9 | 0.68 |
| BMI[1] | 28.6 ± 7.7 | 29.6 ± 9.5 | 0.48 |
| | $n$ (%) | $n$ (%) | |
| BMI[1] category[2] | | | |
| Normal weight (<25.0 kg/m$^2$) | 13 (31.7) | 47 (29.4) | |
| Overweight (25–29.9 kg/m$^2$) | 13 (31.7) | 40 (25.0) | |
| Obese (≥30.0 kg/m$^2$) | 15 (36.6) | 73 (45.6) | 0.44 |
| Marital status | | | |
| Single | 21 (50.0) | 62 (37.4) | |
| Married or common law | 21 (50.0) | 104 (62.6) | 0.08 |
| Education | | | |
| None/some junior HS | 13 (31.0) | 55 (33.1) | |
| Junior HS or HS completed | 21 (50.0) | 68 (41.0) | |
| College, trade school, or university | 8 (19.0) | 43 (25.9) | 0.59 |
| Employed in household | | | |
| 0 | 14 (32.5) | 41 (24.8) | |
| 1 | 19 (44.2) | 61 (37.0) | |
| 2 | 8 (18.6) | 46 (27.9) | |
| 3 or more people | 2 (4.7) | 17 (10.3) | 0.09 |
| Self-employed members in household[3] | | | |
| 0 | 27 (63.8) | 126 (76.4) | |
| 1 | 16 (37.2) | 34 (20.6) | |
| 2 or more people | 0 | 5 (3.0) | 0.27 |
| Material Style of Life Scale | | | |
| ≤7 | 14 (42.4) | 50 (38.2) | |
| 8–12 | 8 (24.4) | 30 (22.9) | |
| ≥12 | 11 (33.3) | 51 (38.9) | 0.57 |

BMI = body mass index, HS = high school.
[1]Based on World Health Organization classification [37].
[2]Numbers and percentages might not add up to the total $n$ as a result of missing responses.
[3]Self-employed examples include artists, carvers, and hunters.
[4]Material Style of Life Scale [4,21].

## RESULTS

With a response rate of 65%–85% (varying by community), a total of 213 Inuvialuit adults, 43 men with a mean age of 43.2 ± 12.8 years old and 170 women with a mean age of 44.7 ± 13.9 years old, completed the QFFQs. Table 1 describes the characteristics of Inuvialuit men and women. There was no significant difference between men and women for any of the tested variables: age, body mass index category, smoking, marital status, education, number of people living in a household employed or self-employed, and material style of life.

Mean and standard deviation daily energy intakes for men and women were 3487 ± 1474 kcal and 3299 ± 1653 kcal, respectively; which exceeded the recommended intake of 2200 kcal for men and 1800 kcal for women (Table 2). Mean percentages of energy from protein (15.6% and 16.2%), carbohydrates (46.3% and 48.1%), and fat (28.6% and 28.4%) for men and women, respectively, were similar and within the recommended acceptable macronutrient distribution ranges. Over half of the carbohydrate intake for both men (62%) and women (53%) was in the form of sugar. One third of total fat consumed was saturated fat for both sexes. For both men and women, mean intakes for B vitamins exceeded the dietary recommendations. The mean consumption of total iron, vitamin C, calcium, selenium, and zinc was also above the recommendation for men and women. Mean daily sodium intakes far exceeded the adequate intakes for both sexes. However, mean intake for dietary fiber; vitamins A, D, and E; magnesium (for men only); and potassium did not meet the dietary recommendations. There was no statistically significant difference between men and women for any of the listed nutrients.

**Table 2.** Energy and Selected Nutrient Intakes among Inuvialuit Men and Women in NWT

| Nutrients | Men ($n = 43$) | | Women ($n = 170$) | | $p$ Value |
|---|---|---|---|---|---|
| | Mean (SD) | RDA[1] | Mean (SD) | RDA[1] | |
| Energy (kcal)[2] | 3487 (1474) | 2200 | 3299 (1653) | 1800 | 0.25 |
| % of energy from protein[3] | 15.6 (5.6) | 10–35 | 16.2 (6.0) | 10–35 | 0.69 |
| % of energy from carbohydrates[3] | 46.3 (9.1) | 45–65 | 48.1 (11.9) | 45–65 | 0.18 |
| % of energy from fat[3] | 28.6 (6.4) | 20–35 | 28.4 (6.8) | 20–35 | 0.93 |
| Protein (g) | 130.9 (75.1) | 56 | 105.5 (76.2) | 46 | 0.57 |
| Carbohydrate (g) | 329.3 (183.5) | — | 382.2 (199.8) | — | 0.37 |
| Sugars (g)[3] | 203.4 (110.6) | <25% of energy | 201.3 (126.2) | <25% of energy | 0.74 |
| Dietary fiber (g)[4] | 21.9 (13.2) | 38 | 21.2 (16.7) | 25 | 0.47 |
| Fat (g) | 108.3 (47.3) | — | 101.5 (54.1) | — | 0.18 |
| Saturated fat (g)[3] | 36.2 (15.7) | As low as possible | 34.2 (17.7) | As low as possible | 0.23 |
| Monounsaturated fat (g) | 39.4 (16.8) | — | 36.9 (19.8) | — | 0.13 |
| Polyunsaturated fat (g) | 16.1 (8.9) | — | 15.4 (9.6) | — | 0.33 |
| Omega-3 fatty acid (g) | 1.8 (0.9) | — | 1.8 (1.2) | — | 0.63 |
| Omega-6 fatty acid (g) | 15.7 (12.11) | — | 14.3 (11.5) | — | 0.16 |
| Cholesterol (mg)[3] | 588.8 (730.5) | As low as possible | 420.0 (240.1) | As low as possible | 0.29 |
| Vitamin A ($\mu$g-RAE) | 671.0 (429.3) | 900 | 685.8 (476.5) | 700 | 0.48 |
| Thiamin (mg) | 2.4 (1.0) | 1.2 | 2.5 (1.6) | 1.1 | 0.66 |
| Riboflavin (mg) | 4.1 (2.0) | 1.3 | 4.2 (2.3) | 1.1 | 0.74 |
| Niacin (mg) | 36.0 (14.7) | 16 | 36.8 (22.8) | 14 | 0.37 |
| Pantothenic acid (mg)[4] | 10.1 (6.1) | 5 | 10.0 (5.3) | 5 | 0.80 |
| Vitamin B-6 (mg) | 2.5 (1.1) | 1.3 | 2.7 (1.9) | 1.3 | 0.74 |
| Total folate ($\mu$g) | 495.5 (252.1) | 400 | 455.5 (233.9) | 400 | 0.29 |
| Vitamin B-12 ($\mu$g) | 12.7 (7.7) | 2.4 | 14.2 (11.4) | 2.4 | 0.96 |
| Iron (mg) | 24.6 (16.6) | 8 | 24.2 (14.7) | 18 | 0.73 |
| Vitamin C (mg) | 240.0 (185.7) | 90 | 206.6 (194.3) | 75 | 0.20 |
| Vitamin D ($\mu$g)[5] | 6.8 (4.3) | 15 | 7.3 (6.3) | 15 | 0.77 |
| Vitamin E (mg)[6] | 4.7 (2.5) | 15 | 4.6 (2.5) | 15 | 0.83 |
| Calcium (mg) | 1351.7 (746.7) | 1000 | 1312 (792.2) | 1000 | 0.55 |
| Magnesium (mg) | 362.5 (175.7) | 420 | 360.1 (163.7) | 320 | 0.96 |
| Potassium (g)[4] | 3.9 (2.0) | 4.7 | 3.9 (1.8) | 4.7 | 0.94 |
| Sodium (g)[4] | 5.0 (3.1) | 1.5 | 4.8 (2.8) | 1.5 | 0.43 |
| Selenium ($\mu$g) | 158.4 (80.5) | 55 | 166.9 (118.7) | 55 | 0.67 |
| Zinc (mg) | 18.4 (9.3) | 11 | 18.3 (11.0) | 8 | 0.44 |

RDA = recommended dietary allowance, RAE = retinol activity equivalent.

[1]Recommended Dietary Allowance for men and women ≥ 19 years of age. Recommendation on saturated fat intake by Joint WHO/FAO [20].

[2]Estimated number of calories needed to maintain energy balance for men and women ≥ 19 years of age at the level of very low physical activity–sedentary level.

[3]Acceptable macronutrient distribution ranges and recommendations on sugar, saturated fat, and cholesterol for men and women ≥ 19 years of age.

[4]Adequate intake.

[5]As cholecalciferol in the absence of adequate exposure to sunlight.

[6]As alpha-tocopherol.



Nutrient density (amount of nutrient per 1000 kcal) was not significantly different for any nutrient when comparing men and women (Table 3).

The percentages of men and women with intakes below EAR are reported in Table 4 The mean daily intakes of dietary fiber fell below the recommendations for ≥68% of participants. Participants' mean daily intakes of vitamins D and E and potassium were inadequate for ≥71%, ≥98%, and ≥66%, respectively. A greater percentage of men compared to women consumed inadequate intakes of vitamin A (49% vs 25–40%) and magnesium (54% vs 26–43%). However, these differences were not statistically significant. In contrast, more women than men fell below the EAR for calcium (23%–57% vs 23%, $p < 0.0001$). The vast majority of the participants were above the EAR for thiamine, riboflavin, and niacin (all ≥91%) and for vitamin $B_{12}$ (≥98%), iron (≥94%), and selenium (≥97%). A significant difference was found for the percentage of women over age 50 below EAR for vitamin $B_6$ compared to men and younger women ($p = 0.0006$).

Table 5 describes the top 10 food sources of energy and selected nutrients among this population of Inuvialuit adults. Store-bought NNDFs were the top contributors to energy (39%), total fat (40%), carbohydrate (54%), sugar (74%), fiber (26%), and sodium (23%) intake. Traditional foods from the land were the top contributors to protein (28%) and iron (33%) intake. Total TF (land, sea, and sky) contributed to 11% of the total energy consumed and 41% of total protein intake. Non-nutrient-dense foods (mainly chips and fried potatoes), fruits, and white bread

**Table 3.** Nutrient Density per 1000 kcal of Selected Nutrients among Adult Inuvialuit Men and Women in NWT

| Nutrients | Men ($n = 43$) Mean ± SD | Women ($n = 170$) Mean ± SD | $p$ Value |
|---|---|---|---|
| Protein (g) | 39.0 ± 13.9 | 40.4 ± 15.0 | 0.69 |
| Carbohydrate (g) | 115.6 ± 22.6 | 120.2 ± 29.7 | 0.18 |
| Sugars (g) | 59.5 ± 22.4 | 63.8 ± 27.7 | 0.49 |
| Dietary fiber (g) | 6.2 ± 2.5 | 6.6 ± 3.6 | 0.53 |
| Fat (g) | 31.8 ± 7.1 | 31.6 ± 7.6 | 0.93 |
| Saturated fat (g) | 10.7 ± 2.6 | 10.8 ± 3.0 | 0.55 |
| Monounsaturated fat (g) | 11.7 ± 2.9 | 11.5 ± 2.9 | 0.95 |
| Polyunsaturated fat (g) | 4.7 ± 1.7 | 4.7 ± 1.5 | 0.58 |
| Omega-3 fatty acid (g) | 0.5 ± 0.2 | 0.6 ± 0.3 | 0.76 |
| Omega-6 fatty acid (g) | 4.5 ± 2.6 | 4.2 ± 2.0 | 0.76 |
| Cholesterol (mg) | 140.2 ± 57.1 | 134.0 ± 54.8 | 0.42 |
| Vitamin A ($\mu$g-RAE) | 217.5 ± 83.0 | 254.4 ± 118.9 | 0.14 |
| Thiamin (mg) | 0.7 ± 0.2 | 0.8 ± 0.2 | 0.23 |
| Riboflavin (mg) | 1.2 ± 0.5 | 1.4 ± 0.7 | 0.08 |
| Niacin (mg) | 10.8 ± 2.9 | 11.4 ± 4.0 | 0.63 |
| Pantothenic acid (mg) | 3.1 ± 1.7 | 3.4 ± 2.1 | 0.10 |
| Vitamin B-6 (mg) | 0.7 ± 0.2 | 0.8 ± 0.3 | 0.12 |
| Total folate ($\mu$g) | 149.3 ± 47.5 | 150.8 ± 62.7 | 0.80 |
| Vitamin B-12 ($\mu$g) | 3.9 ± 2.1 | 4.3 ± 2.6 | 0.50 |
| Iron (mg) | 7.4 ± 3.2 | 7.5 ± 2.9 | 0.58 |
| Vitamin C (mg) | 71.5 ± 55.2 | 62.0 ± 43.0 | 0.52 |
| Vitamin D ($\mu$g)[1] | 2.1 ± 1.2 | 2.5 ± 2.3 | 0.64 |
| Vitamin E (mg)[2] | 1.4 ± 0.5 | 1.5 ± 0.5 | 0.74 |
| Calcium (mg) | 403.3 ± 138.4 | 418.1 ± 173.3 | 0.78 |
| Magnesium (mg) | 109.5 ± 36.3 | 119.1 ± 47.6 | 0.17 |
| Potassium (g) | 1.2 ± 0.4 | 1.3 ± 0.6 | 0.07 |
| Sodium (g) | 1.4 ± 0.4 | 1.5 ± 0.6 | 0.77 |
| Selenium ($\mu$g) | 49.3 ± 21.7 | 54.7 ± 34.4 | 0.62 |
| Zinc (mg) | 5.5 ± 2.0 | 5.7 ± 2.2 | 0.65 |

RAE = Retinol activity equivalent.
[1]As cholecalciferol in the absence of adequate exposure to sunlight.
[2]As alpha-tocopherol.

were the top 3 contributors to fiber intake (26%, 14%, and 13%, respectively).

## DISCUSSION

This study presents dietary data and nutrient intakes obtained from a validated QFFQ developed specifically for Inuvialuit in the NWT. These data support the hypothesis that Inuvialuit are undergoing a nutritional transition from a diet that traditionally consisted of highly nutritious nutrient-dense foods to one that is based primarily on store-bought NNDF. Traditional foods contributed considerably to protein and iron intake, and NNDF are the top contributors to energy, fat, carbohydrate, sugar, fiber, and sodium intake.

These dietary changes have had a significant impact on dietary adequacy among Inuvialuit and other northern Aboriginal populations [1,22]. In our previous analysis of this population, most Inuvialuit adults did not meet the recommendations for dietary fiber; vitamins A, $B_6$, C, D, and E; calcium; and folate [4,7]. Similarly, the present study found that many Inuvialuit adults were consuming inadequate amounts of dietary fiber; vitamins A, D, and E; as well as potassium and magnesium. Concurrently, mean daily energy, saturated fat, and sodium intakes far exceeded the amounts recommended for optimal health.

**Table 4.** Dietary Inadequacy among Inuvialuit Men and Women (% below estimated average requirement[1])

| Nutrients | Men% ≥19 years ($n = 43$) | Women% 19–50 years ($n = 115$) | Women% >50 years ($n = 55$) | $p$ Value |
|---|---|---|---|---|
| Dietary fiber[2] | 86 | 68 | 82 | 0.81 |
| Vitamin A[3] | 49 | 25 | 40 | 0.51 |
| Vitamin C | 23 | 11 | 25 | 0.61 |
| Vitamin D[4] | 84 | 75 | 71 | 0.15 |
| Vitamin E[5] | 98 | 98 | 100 | 0.32 |
| Thiamin | 9 | 4 | 9 | 0.93 |
| Riboflavin | 2 | 0 | 0 | 0.12 |
| Niacin | 2 | 3 | 6 | 0.36 |
| Pantothenic acid | 16 | 10 | 20 | 0.49 |
| Vitamin B-6 | 7 | 8 | 29 | 0.0006 |
| Folate[6] | 26 | 30 | 40 | 0.12 |
| Vitamin B-12 | 2 | 1 | 0 | 0.24 |
| Calcium | 23 | 23 | 57 | <0.0001 |
| Magnesium | 54 | 26 | 43 | 0.48 |
| Potassium[2] | 77 | 66 | 80 | 0.59 |
| Iron | 0 | 6 | 0 | 0.82 |
| Selenium | 0 | 3 | 2 | 0.56 |
| Zinc | 16 | 7 | 13 | 0.68 |

[1]Estimated average requirement [20].
[2]Adequate intake used for comparison [20].
[3]Retinol activity equivalents.
[4]As cholecalciferol.
[5]As alpha-tocopherol.
[6]Dietary folate equivalents.

Vitamins A, D, and E; magnesium; and potassium are found in high amounts in the nutrient-dense traditional Inuvialuit diet, which also contains significantly less fat, carbohydrates, and sugar [2,23]. NNDF were consumed approximately 6 times more frequently per day than TF in the Inuvialuit population [4]. These consumption patterns, coupled with the previously mentioned nutrient inadequacies, provide strong evidence for the ongoing nutritional transition [4,7]. The results from the present study support promoting TF in addition to reducing NNDF consumption as an important component of nutritional intervention programs. This change could potentially address nutrient inadequacies while reducing the high energy intake among Inuvialuit. The impact of the interventions has been previously published [24].

Vitamin D recommendations were not met by the majority of Inuvialuit men (84%) and women (71%–75%). Adequate vitamin D intake is essential throughout all life stages to prevent osteoporosis and to maintain bone health as well as for prevention of nonskeletal chronic diseases such as cancer and diabetes [25]. For the majority of the year, sunlight exposure in the Cana-

**Table 5.** Top 10 Food Sources of Energy and Selected Nutrients among Inuvialuit in the NWT[a]

| Foods | Contribution to Energy (%) | Foods | Contribution to Protein (%) | Foods | Contribution to Fat (%) | Foods | Contribution to Carbohydrate (%) |
|---|---|---|---|---|---|---|---|
| NNDF | 39.1 | Land TF | 28.1 | NNDF | 39.8 | NNDF | 53.7 |
| Beef and pork | 9.7 | Beef and pork | 16.4 | Beef and pork | 18.2 | White breads | 12.7 |
| White breads | 8.7 | Dairy | 10.2 | Dairy | 10.8 | Fruits | 7.1 |
| Land TF | 8.1 | Sea TF | 9.3 | Land TF | 5.6 | Dairy | 4.0 |
| Dairy | 7.3 | NNDF | 8.8 | White breads | 5.4 | Cereals | 3.3 |
| Alcohol | 4.1 | White breads | 5.0 | Sea TF | 3.5 | Wheat breads | 2.4 |
| Fruits | 3.3 | | 4.8 | Sky TF | 3.5 | Land TF | 2.2 |
| | | Chicken/turkey | | | | | |
| Sea TF | 2.9 | Sky TF | 4.0 | | 3.4 | Rice | 1.8 |
| | | | | Chicken/turkey | | | |
| | 2.2 | Soups/stews | 3.6 | Nuts | 2.1 | Potatoes | 1.8 |
| Chicken/turkey | | | | | | | |
| Soups/stews | 1.9 | Other seafood | 1.5 | Soups/stews | 1.8 | Noodles | 1.6 |
| Total | 87.3 | | 91.7 | | 94.1 | | 90.6 |

| Foods | Contribution to Sugar (%) | Foods | Contribution to Fiber (%) | Foods | Contribution to Sodium (%) | Foods | Contribution to Iron (%) |
|---|---|---|---|---|---|---|---|
| NNDF | 73.5 | NNDF | 26.0 | NNDF | 22.9 | Land TF | 33.4 |
| Fruits | 10.9 | Fruits | 13.7 | Beef and pork | 16.8 | NNDF | 13.2 |
| Dairy | 7.0 | White breads | 12.9 | White breads | 12.3 | White breads | 12.4 |
| Wheat breads | 2.1 | Wheat breads | 7.5 | Sea TF | 9.5 | Beef and pork | 7.9 |
| Cereals | 1.7 | Vegetables | 6.8 | Dairy | 7.7 | Cereals | 7.0 |
| Vegetables | 0.8 | Cereals | 6.1 | Land TF | 5.8 | Sky TF | 4.2 |
| Alcohol | 0.7 | Soups/stews | 4.7 | Unclassified foods | 5.8 | Sea TF | 3.9 |
| White breads | 0.7 | Land TF | 4.6 | Soups/stews | 5.2 | Soups/stews | 2.7 |
| Unclassified foods | 0.6 | Potatoes | 4.5 | Cereals | 2.8 | Wheat breads | 2.6 |
| Beef and pork | 0.5 | Beef and pork | 2.6 | Wheat breads | 2.2 | Dairy | 2.4 |
| Total | 98.5 | | 89.4 | | 91.0 | | 89.7 |

NNDF = non-nutrient-dense foods, TF = traditional foods.

[a]NNDF include pop, chips, sweetened juice, margarine, coffee creamer, fried potatoes, and desserts. Land TF include caribou, muskox, and polar bear. Sea TF include seal, muktuk, Arctic char, trout, and white fish. Sky TF include ptarmigan, duck, geese, swan and crane.

dian Arctic is insufficient to meet vitamin D needs [25]. It is important for nutritional interventions to focus on strategies that encourage consumption of traditional foods rich in vitamin D, such as fatty fish, marine mammals, liver, and other organ meats [2,4], which will improve vitamin D intakes.

Vitamin E is found in highest concentration in edible vegetable oils such as wheat germ oil, sunflower oil, and canola oil; nuts; leafy green vegetables; fruit; as well as fatty meats [26]. Greater than 98% of this study population was below the recommended intakes for vitamin E, which may be attributed to NNDF being consumed 6 times more frequently than fruits and vegetables [4]. The difficulty of transporting perishable foods, such as fruits and vegetables, to remote Arctic communities greatly inflates prices and reduces quality, in turn reducing consumer acceptability and consumption [27]. This could be a contributing factor to the limited intake of vitamin E and dietary fiber in the Inuvialuit diet. The infrequent consumption of fruits, vegetables, and whole grains has been observed previously in this population [28] and is reflected in the results showing that 68%–86% of Inuvialuit in this study did not meet the recommendations for dietary fiber.

Over the past few decades, Aboriginal populations have experienced a nutrition transition from consumption of traditional foods such as char, caribou, moose, and deer to non-nutrient-dense foods coupled with declining levels of physical activity [5,6,29,30]. The changing food and physical environment in northern Arctic communities has been linked with a higher prevalence of chronic disease [2,31]. In the Inuvialuit region of Canada, it is estimated that more than 30% of people have one or more chronic health conditions [32,33], and 58% of the population residing in the NWT are overweight or obese, compared to 52% of the Canadian population [8]. The data presented here are from the first study to assess long-term dietary intake among Inuvialuit and have important public health implications for both the NWT and Canada as a whole, such as providing evidence for culturally appropriate nutrition programs and policies.

It is widely accepted that the high prevalence of smoking impacts on the burden of chronic diseases [34]. Inuvialuit have a high prevalence of smoking daily (61%) compared with the rest of Canada (17%) [35]. However, a significant difference does not exist in the dietary adequacy of smokers compared to nonsmokers [36].

This culturally specific QFFQ instrument is easy to use and reasonably simple to conduct. Furthermore, it has been validated in this relatively remote ethnic population with unique dietary patterns [15]. Thus, this survey tool may be particularly suited for repeated measurements needed to monitor dietary patterns over time, such as the current nutrition transition being experienced by Inuvialuit. The tool could also provide evidence for revitalizing traditional practices and evaluating regional policy changes and other health interventions.

This study was not without limitations. The ability to generalize results to Inuvialuit outside of the study population is limited by the disproportionately small number of men included in the sample. However, the study targeted the main food shopper and preparer in each household, most of whom were women.

The validated, population-specific QFFQ used identified high energy intake and several nutrient inadequacies among Inuvialuit. Our results contribute substantially to the limited information available on dietary intake among Inuvialuit. These data can be used to further monitor the nutritional transition and inform public health programming and policy development for Inuvialuit in the Canadian Arctic.

## CONCLUSIONS

We identified nutrient inadequacies and characterized food consumption among Inuvialuit. These data support nutritional interventions that encourage consumption of traditional foods. The cultural and ethnic differences in Canadian Arctic populations require specific tailoring of public health interventions and policy using population specific tools to meet local needs.

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