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Differences in dietary quality and adequacy by smoking status among a Canadian Aboriginal population

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SUMMARY

Objective: To assess dietary adequacy and quality among Inuvialuit smokers compared with non-smokers in the Northwest Territories (NWT), Canada.
Study design: Cross-sectional study.
Methods: A validated quantitative food frequency questionnaire was administered between July 2007 and July 2008 to individuals of randomly selected households in three NWT communities to capture dietary intake and smoking habits over a 30-day recall period. Daily energy and nutrient intake, dietary adequacy, and the top food contributors to energy and selected nutrients were determined by smoking status.
Results: Intakes of energy and several nutrients were higher among male and female smokers compared with non-smokers. Male smokers had similar daily nutrient density (per 1000 kcal consumed) of all nutrients. Female smokers had significantly lower intake densities of protein, fibre, folate, magnesium, vitamin D, vitamin E ($P \leq 0.05$) and thiamin ($P \leq 0.01$), and higher intake densities of sugar and vitamins C and K ($P \leq 0.05$). Among male and female smokers, more than 50% had inadequate intakes of fibre, potassium and vitamin E. Non-nutrient-dense foods contributed similar amounts to energy intake, and traditional foods contributed 3–6% less to energy and protein intakes among smokers compared with non-smokers.
Conclusion: Adult Inuvialuit smokers had higher caloric intake and lower dietary quality, including less consumption of traditional foods, compared with non-smokers. Fewer dietary inadequacies were observed among smokers than non-smokers, which may be due to higher energy intake among smokers.

Introduction

Canadian Aboriginal populations, including Inuvialuit, an Inuit population in the Northwest Territories (NWT), have been experiencing a changing food environment throughout the last century, which has resulted in the decreased consumption of nutrient-dense traditional foods and increased consumption of processed, shop-bought foods, such as fizzy drinks and crisps, which are high in fat and sugar, and lack essential nutrients.[1–3] Previous dietary adequacy studies among this population have documented diets sufficient in energy, but with inadequate intakes of dietary fibre, calcium, vitamins A, C and E, and total folate.[3,4] In conjunction with altered dietary patterns, Inuvialuit have

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transitioned from a nomadic way of life to permanent settlements, where hunting and subsistence activities have decreased and dependence on vehicle transportation has increased.[1,5] Not surprisingly, obesity and chronic diseases related to sedentary lifestyles and poor diets have become increasingly prevalent in this population.[6,7] Compared with all of Canada, life expectancy is 13 years less and stroke mortality is two times higher among Canadian Inuit,[7] and the prevalence of self-reported heart disease is three times higher among Aboriginal populations (i.e. First Nations, Metis and Inuit/Inuvialuit).[8]

In addition to diet and physical activity, the health risk profile of Inuvialuit is affected by a high prevalence of daily smoking (61%) among all age groups,[9] which is approximately 3.5 times higher compared with Canada's national average (17%).[10] Free radicals and chemicals, such as acetaldehyde, released during tobacco combustion influence physiological changes including increased endothelial damage, low-density lipoproteins and atherosclerosis, making smoking an independent risk factor for cardiovascular disease, pulmonary disease and cancer.[11–14] In addition to direct tissue toxicity, the oxidative stress caused by smoking is believed to increase the demand or alter the metabolism of certain micronutrients such as beta carotene, folate, zinc, selenium and vitamins C, B6 and B12.[15] Several of these affected nutrients have been reported to be protective against certain cancers, especially of the upper aerodigestive tract (i.e. nasopharynx, oesophagus and salivary glands), that are associated with smoking and have much higher incidence among Circumpolar Inuit compared with all of Canada.[16] Smoking has also been shown to alter food preferences, leading to greater consumption of processed foods, sugar, meat and dairy, and lower consumption of fruit and vegetables.[17] Subsequently, higher intake of saturated fat and lower intakes of certain nutrients such as folate, fibre, iron, polyunsaturated fatty acids and vitamins C and A have been documented among smokers in different populations.[18,19] In addition to the risk of chronic diseases associated with smoking, it is plausible that smokers may experience higher risk for developing diet-related chronic diseases given the abundant macronutrient and inadequate micronutrient intakes and the altered metabolism of certain nutrients.

Limited information is available on dietary intake and quality among Inuvialuit, especially in relation to smoking status. The purpose of this study was to characterize and compare the dietary adequacy and quality among adult Inuvialuit in the NWT who reported daily smoking compared with non-smokers.

Methods

The survey instruments and data collection protocol have been described elsewhere.[20] In brief, the data are from three communities in the NWT with populations ranging from 400 to 3500 people. Within the three communities, 40–90% of residents were Inuit/Inuvialuit, with median family incomes ranging from $33,000 to $64,000 (Canadian dollars). Employment ranged from 35% to 60% and the communities had two to three grocery shops. The largest of the three communities ($n = 3500$) had the lowest percentage of Inuit/Inuvialuit residents, and highest family income, employment and number of grocery shops. A validated quantitative food frequency questionnaire (QFFQ) designed specifically for this population was administered between July 2007 and July 2008 to Inuvialuit residents in three communities in the NWT to collect data on dietary intake during the previous 30 days.[3,20] A food composition table specific for this population was developed primarily using the Canadian food composition tables within NutriBase, Clinical Nutrition Manager Version 7.17 (CyberSoft Inc., Phoenix, AZ, USA), supplemented with data from the Canadian nutrient file.

The mean (±standard deviation) daily energy and nutrient intakes were calculated for all participants. To compare the nutrient intakes of smokers and non-smokers, nutrient densities per 1000 kcal were calculated by dividing each participant's daily nutrient intake by their energy intake (kcal), multiplied by 1000. As nutrient densities were not normally distributed, the non-parametric Wilcoxon rank-sum test was used to determine significant differences in nutrient densities between smokers and non-smokers. Smokers were defined as individuals who smoked at least one cigarette per day.

Dietary adequacy was calculated using estimated average requirements based on gender and age group (19–30, 31–50, 51–70, >70 years) guidelines.[21,22] If estimated average requirements were not available, as for dietary fibre, vitamins D and K, pantothenic acid, potassium, sodium and calcium, adequate intake was used instead. The number and percentage of participants not meeting the recommendations were determined for selected nutrients by gender and smoking status.

Participants who reported extreme energy intake (<500 kcal or >5000 kcal, $n = 12$) were excluded from the analysis.[23] Data were analysed using SAS Version 9.2 (SAS Institute, Inc., Cary, NC, USA). All tests and P-values were two-sided, and $P < 0.05$ was taken to indicate significance. Institutional Review Board approval was obtained from the Committee on Human Studies at the University of Hawaii and the Office of Human Research Ethics at the University of North Carolina at Chapel Hill, as well as the Beaufort Delta Health and Social Services Authority Ethics Review Committee. The Aurora Research Institute in the NWT licensed this study.

Results

Among male ($n = 46$) and female ($n = 172$) participants, 31 men (mean age 39.8 ± 11.4 years) and 121 women (mean age 42.8 ± 12.2 years) reported smoking during the previous 30 days. Nutrient intakes are presented in Table 1 for reference. The average daily energy intake among male smokers was approximately 1180 kcal above the dietary reference intake (DRI; 2200 kcal), and 877 kcal higher than that for non-smoking men ($P = 0.02$; Table 1). Female smokers reported average daily energy intake that was 1332 kcal above the DRI (1800 kcal), and 554 kcal higher than that for non-smoking women ($P = 0.01$; Table 1). All males had similar percent energy from fat, carbohydrates and protein; however, male smokers reported higher average daily intakes of all nutrients ($P \leq 0.05$) with the exception of omega-3 fatty acid, vitamin C,

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Table 1 – Energy and selected nutrient intakes among adult Inuvialuit by gender and smoking status.[a]

Nutrients	Men			Women		
	Non-smoker ($n = 15$)	Smoker ($n = 31$)	DRI[b]	Non-smoker ($n = 51$)	Smoker ($n = 121$)	DRI[b]
Age (years)	49.5 ± 16.4	39.8 ± 11.4 *	–	48.8 ± 16.5	42.8 ± 12.2 *	–
Energy (kcal)	2503.0 ± 1543.6	3380.5 ± 1190.1 *	2200[c]	2578.3 ± 1252.4	3132.4 ± 1393.7 **	1800[c]
% of energy from protein	16.8 ± 4.3	17.4 ± 5.6	10–35[d]	18.8 ± 5.8	17.5 ± 6.2 *	10–35[d]
% of energy from carbohydrates	48.3 ± 6.6	48.1 ± 8.9	45–65[d]	47.3 ± 7.8	49.1 ± 9.8	45–65[d]
% of energy from fat	33.0 ± 4.5	32.2 ± 5.5	20–35[d]	32.8 ± 5.0	31.7 ± 5.9	20–35[d]
Protein (g)	96.9 ± 45.3	150.1 ± 82.4 **	–	120.6 ± 67.1	137.3 ± 79.4	–
Carbohydrate (g)	308.0 ± 202.8	397.2 ± 129.9 *	–	307.1 ± 178.9	380.1 ± 176.2 **	–
Sugars (g)	144.5 ± 98.9	200.1 ± 80.0 *	<25% of energy[b]	144.4 ± 117.8	194.3 ± 102.2 ***	<25% of energy[b]
Dietary fibre (g)	13.5 ± 10.5	18.0 ± 7.2 *	38[e]	16.2 ± 9.1	18.5 ± 10.8	25[e]
Fat (g)	91.1 ± 54.8	121.7 ± 45.6 *	–	93.5 ± 48.5	112.1 ± 58.1 *	–
Saturated fat (g)	28.4 ± 15.1	41.1 ± 16.4 **	<10% of energy[f]	30.7 ± 16.2	36.7 ± 18.1 *	<10% of energy[3]
Mono–unsaturated fat (g)	33.1 ± 18.6	45.1 ± 17.7 *	–	34.2 ± 17.4	40.8 ± 21.5	–
Polyunsaturated fat (g)	13.8 ± 8.9	18.5 ± 7.1 *	–	15.9 ± 10.0	18.3 ± 11.8	–
Omega-3 fatty acid (g)	1.6 ± 0.6	2.1 ± 1.1	–	1.9 ± 1.1	2.1 ± 1.4	–
Omega-6 fatty acid (g)	14.3 ± 12.8	17.1 ± 6.1 *	–	15.2 ± 12.8	17.1 ± 13.7	–
Cholesterol (mg)	351.9 ± 135.0	513.7 ± 254.3 **	As low as possible	387.5 ± 220.8	446.9 ± 253.8	As low as possible
Vitamin A (μg-RAE[g])	519.4 ± 211.9	740.1 ± 347.5 *	900[h]	632.1 ± 329.2	768.4 ± 414.5 *	700[h]
Thiamin (mg)	1.8 ± 0.8	2.6 ± 1.1 *	1.2[h]	2.3 ± 1.7	2.4 ± 1.3	1.1[h]
Riboflavin (mg)	2.9 ± 1.2	4.5 ± 2.1 **	1.3[h]	3.6 ± 2.3	4.2 ± 2.0 *	1.1[h]
Niacin (mg)	29.4 ± 14.8	39.8 ± 13.7 *	16[h]	34.1 ± 23.2	37.1 ± 20.3	14[h]
Pantothenic acid (mg)	7.1 ± 3.1	12.0 ± 6.3 ***	5[e]	8.9 ± 5.3	10.8 ± 5.4 **	5[e]
Vitamin B6 (mg)	2.1 ± 1.3	2.8 ± 0.9 *	1.3[h]	2.6 ± 2.0	2.7 ± 1.6	1.3[h]
Total folate (μg-DFE[i])	385.0 ± 218.3	522.4 ± 228.2 **	400[h]	418.4 ± 219.2	463.4 ± 228.8	400[h]
Vitamin B12 (μg)	9.3 ± 5.3	14.6 ± 8.0 *	2.4[h]	14.6 ± 12.3	14.1 ± 10.8	2.4[h]
Iron (mg)	17.8 ± 7.7	27.6 ± 18.3 *	8[h]	21.9 ± 13.2	25.7 ± 15.1	18[h]
Vitamin C (mg)	167.7 ± 138.4	206.1 ± 141.2	90[h]	137.8 ± 165.2	192.4 ± 143.9 **	75[h]
Vitamin D (μg)[j]	4.8 ± 2.0	7.1 ± 4.1 *	5[e]	6.6 ± 4.8	7.0 ± 6.0	5[e]
Vitamin E (mg)[k]	3.4 ± 1.7	5.7 ± 2.5 **	15[h]	4.5 ± 2.4	5.1 ± 2.6	15[h]
Vitamin K (μg)	87.1 ± 61.0	204.5 ± 208.7 ***	120[e]	103.3 ± 60.4	164.3 ± 126.0 ***	90[e]
Calcium (mg)	989.7 ± 399.1	1432.7 ± 788.2	1000[e]	1101.4 ± 631.0	1296.9 ± 760.9 *	1000[e]
Magnesium (mg)	265.9 ± 138.8	392.3 ± 167.6 **	420[h]	326.9 ± 151.2	372.4 ± 164.8	320[h]
Potassium (g)	2.8 ± 1.3	4.3 ± 2.0 **	4.7[e]	3.4 ± 1.5	4.1 ± 1.9 *	4.7[e]
Sodium (g)	3.5 ± 2.3	5.5 ± 3.0 **	1.5[e]	4.4 ± 2.5	4.7 ± 2.5	1.5[e]
Selenium (μg)	134.9 ± 75.8	170.7 ± 87.0	55[h]	143.1 ± 71.2	178.6 ± 131.0	55[h]
Zinc (mg)	13.1 ± 6.2	21.9 ± 9.9 **	11[h]	16.6 ± 10.3	20.2 ± 11.7 *	8[h]

* Significantly different from non-smokers of same gender, $P \leq 0.05$.
** Significantly different from non-smokers of same gender, $P \leq 0.01$.
*** Significantly different from non-smokers of same gender, $P \leq 0.001$.
a Values are means and standard deviations.
b The dietary reference intakes (DRI) are presented in this table using adequate intake and recommended dietary allowancefor men and women aged 31–50 years, acceptable macronutrient distribution ranges and recommendation on saturated fat intake by Joint WHO/FAO (Institute of Medicine of the National Academies, 2005; Joint WHO/FAO Expert Consultation, 2003).
c Estimated amounts of calories needed to maintain energy balance for women aged 31–50 years at the level of very low physical activity/sedentary.
d Acceptable macronutrient distribution range.
e Adequate intake.
f Recommendation on saturated fat intake by Joint WHO/FAO.
g Retinol activity equivalent.
h Recommended dietary allowance.
i Dietary folate equivalent.
j As cholecalciferol. In the absence of adequate exposure to sunlight.
k As alpha-tocopherol.

calcium and selenium. Average daily intakes of dietary fibre, vitamins A and E, magnesium and potassium were below the DRI for all males regardless of smoking status. Among female smokers, percent energy from protein was lower and percent energy from carbohydrates and fat were similar to non-smokers. Average daily intakes of energy, carbohydrates, sugar, fat, saturated fat, vitamins A, C and K, riboflavin, pantothenic acid, calcium, potassium and zinc were higher among female smokers than non-smokers ($P \leq 0.05$; Table 1). All female participants reported average daily intakes of dietary fibre, vitamin E and potassium below recommended levels.

Nutrient intake density was not significantly different for any nutrient between male smokers and non-smokers (Table 2). Female smokers had significantly lower nutrient intakes per 1000 kcal of protein, dietary fibre, folate, vitamins D and E, magnesium ($P \leq 0.05$) and thiamin ($P \leq 0.01$), and higher intakes per 1000 kcal of sugar and vitamins C and K ($P \leq 0.05$; Table 2). Twenty to fifty percent of all smokers were below the recommended intakes of calcium, folate, magnesium and vitamins A, D and K, and more than 50% of smokers were below the DRI for fibre, potassium and vitamin E (Table 3). The proportion of male and female smokers below the DRI for all nutrients was lower compared with non-smokers.

Among men and women combined, non-nutrient-dense foods (NNDF) were the primary contributors to energy, fat and carbohydrates, and traditional foods were the primary contributor to protein, regardless of smoking status (Tables 4 and 5). Alcohol contributed 4.4% and 2.0% to total energy among smokers and non-smokers, respectively. Comparing smokers with non-smokers, NNDF contributed similar amounts to energy (38.9% vs 39.1%), less to fat (−2.8%) and more to carbohydrates (+2.0%; Tables 4 and 5). Smokers reported lower contribution of traditional land, sea and sky foods to energy (−2.5%) and protein (−6.3%) compared with non-smokers. The contribution of fruit to energy was similar (−0.7%) between smokers and non-smokers.

Discussion

To the authors' knowledge, this is the first study to describe dietary differences of adult Inuvialuit by smoking status. Overall, altered dietary intake and decreased dietary quality among smokers, especially females, aligned with previous research in multiple populations.[24] Considering dietary patterns, all participants reported high contribution of NNDF and low contribution of traditional foods to energy intake, which was expected giving the ongoing nutritional transitions in this population.[3] The contribution of nutrient-dense

Table 2 – Nutrient density per 1000 kcal of selected nutrients among adult Inuvialuit by gender and smoking status.[a]

Nutrients	Men		Women	
	Non-smoker ($n = 15$)	Smoker ($n = 31$)	Non-smoker ($n = 51$)	Smoker ($n = 121$)
Protein (g)	42.1 ± 10.6	43.5 ± 13.9	47.1 ± 14.4	43.7 ± 15.6 *
Carbohydrate (g)	120.8 ± 16.5	120.2 ± 22.2	118.3 ± 19.6	122.8 ± 24.4
Sugars (g)	58.6 ± 22.5	62.2 ± 26.1	54.9 ± 22.1	64.3 ± 25.2 *
Dietary fibre (g)	5.2 ± 1.3	5.4 ± 1.9	6.4 ± 1.7	5.9 ± 2.2 *
Fat (g)	36.7 ± 5.0	35.8 ± 6.1	36.4 ± 5.6	35.3 ± 6.6
Saturated fat (g)	11.9 ± 2.3	12.0 ± 2.5	12.0 ± 2.2	11.7 ± 2.6
Mono–unsaturated fat (g)	13.5 ± 2.2	13.3 ± 2.5	13.4 ± 2.2	12.9 ± 2.6
Polyunsaturated fat (g)	5.5 ± 0.9	5.6 ± 1.4	6.1 ± 1.7	5.7 ± 1.9
Omega-3 fatty acid (g)	0.7 ± 0.2	0.6 ± 0.3	0.7 ± 0.3	0.7 ± 0.3
Omega-6 fatty acid (g)	5.2 ± 1.5	5.2 ± 1.4	5.7 ± 2.7	5.2 ± 2.3
Cholesterol (mg)	165.2 ± 60.1	152.3 ± 55.7	155.6 ± 58.0	144.2 ± 52.9
Vitamin A (μg-RAE[b])	241.3 ± 84.8	219.6 ± 75.6	267.5 ± 126.1	259.2 ± 116.4
Thiamin (mg)	0.8 ± 0.3	0.8 ± 0.2	0.9 ± 0.2	0.8 ± 0.2 **
Riboflavin (mg)	1.4 ± 0.6	1.4 ± 0.5	1.4 ± 0.5	1.4 ± 0.8
Niacin (mg)	12.4 ± 2.9	12.0 ± 2.6	12.7 ± 3.3	11.9 ± 3.5
Pantothenic acid (mg)	3.3 ± 1.7	3.7 ± 1.8	3.6 ± 1.5	3.7 ± 2.4
Vitamin B6 (mg)	0.9 ± 0.2	0.8 ± 0.2	1.0 ± 0.3	0.9 ± 0.3
Total folate (μg-DFE[c])	168.4 ± 53.6	154.5 ± 32.8	172.2 ± 55.1	153.7 ± 61.9 *
Vitamin B12 (μg)	4.4 ± 2.7	4.3 ± 2.0	5.3 ± 3.1	4.4 ± 2.3
Iron (mg)	8.1 ± 3.0	8.0 ± 3.2	8.5 ± 2.9	8.1 ± 3.0
Vitamin C (mg)	75.5 ± 57.8	62.9 ± 46.6	49.7 ± 33.2	62.8 ± 40.9 *
Vitamin D (μg)[d]	2.3 ± 1.1	2.2 ± 1.2	2.8 ± 1.9	2.4 ± 2.4 *
Vitamin E (mg)[e]	1.5 ± 0.4	1.7 ± 0.6	1.8 ± 0.5	1.6 ± 0.5 *
Vitamin K (μg)	45.2 ± 40.4	65.7 ± 64.9	47.7 ± 41.3	63.0 ± 80.3 *
Calcium (mg)	454.5 ± 154.1	409.7 ± 122.4	440.1 ± 160.5	421.0 ± 153.6
Magnesium (mg)	115.7 ± 34.6	116.6 ± 27.9	133.2 ± 34.3	124.3 ± 50.7 *
Potassium (g)	1.2 ± 0.4	1.3 ± 0.4	1.4 ± 0.4	1.4 ± 0.7
Sodium (g)	1.4 ± 0.3	1.6 ± 0.5	1.8 ± 0.9	1.5 ± 0.4
Selenium (μg)	61.3 ± 29.0	49.8 ± 14.2	59.0 ± 24.2	58.9 ± 37.9
Zinc (mg)	5.7 ± 1.8	6.4 ± 1.9	6.4 ± 2.0	6.4 ± 2.3

* Significantly different from non-smokers of same gender, $P \leq 0.05$.
** Significantly different from non-smokers of same gender, $P \leq 0.01$.
a Values are means and standard deviations.
b Retinol activity equivalent.
c Dietary folate equivalent.
d As cholecalciferol. In the absence of adequate exposure to sunlight.
e As alpha-tocopherol.

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Table 3 – Percent of Inuvialuit men and women below the dietary reference intake by smoking status.

Nutrients	Non-smokers[a] ($n = 66$) (%)	Smokers[a] ($n = 152$) (%)
Dietary fibre (g)[b]	86.4	83.6
Calcium (mg)[b]	66.7	42.1
Total folate (μg-DFE[c])[d]	43.9	28.9
Vitamin A (μg-RAE[e])[d]	50.0	30.3
Vitamin B6 (mg)[d]	22.7	8.6
Vitamin C (mg)[d]	28.8	17.1
Vitamin D (μg)[b,f]	72.7	50.0
Vitamin E (mg)[d,g]	100.0	97.4
Iron (mg)[d]	4.5	3.9
Zinc (mg)[d]	18.2	6.6
Thiamin (mg)[d]	9.1	6.6
Riboflavin (mg)[d]	1.5	0.0
Niacin (mg)[d]	7.6	1.3
Pantothenic acid (mg)[b]	24.2	7.2
Vitamin B12 (μg)[d]	0.0	0.7
Vitamin K (μg)[b]	56.1	27.6
Magnesium (mg)[d]	50.0	29.6
Potassium (g)[b]	81.8	68.4
Sodium (g)[b]	4.5	3.9
Selenium (μg)[d]	1.5	2.6

a Includes men and women.
b Adequate Intake (AI) used for comparison.
c Dietary Folate Equivalent.
d Estimated Average Requirement (EAR) used for comparison.
e Retinol Activity Equivalent.
f As cholecalciferol in the absence of adequate exposure to sunlight.
g As alpha–tocopherol.

traditional foods to total energy and protein intakes was lower among smokers, suggesting a slightly more pronounced nutrition transition among smokers in this study.

All smokers in this study reported significantly higher average daily energy and nutrient intakes compared with non-smokers. Energy intake among male and female smokers was approximately 550–880 kcal higher than that for non-smokers, which is consistent with previous studies.[24] Similarly, smokers in this study reported a higher contribution of alcohol to total energy intake compared with non-smokers (+2.4%), which has been observed in other studies and might help to explain the increased energy intake among smokers, as increased dietary intake has been associated with alcohol consumption.[25,26] Male smokers reported a higher percent contribution of alcohol to energy compared with female smokers (9% vs 2.3%), and the difference in alcohol contribution to energy between male smokers and non-smokers was +5.7%, which may help to explain the more pronounced difference in energy intake between males (data not shown). Differences in nutrient intake density among female smokers were similar to previous studies in other populations, with the exception of a higher intake of vitamin C amongst smokers in this study. This suggests differences in dietary preferences and quality among female smokers compared with non-smokers.[27] There were no significant differences in nutrient intake density between male smokers and non-smokers, which may be due, in part, to the small male sample size.

The proportion of male and female smokers below recommended intakes for all nutrients of interest was lower among all smokers compared with non-smokers; therefore, smokers appeared to have fewer dietary inadequacies compared with non-smokers. This might be attributable to the higher overall energy intake among smokers, such that the high energy consumed outweighs the low nutrient density of the foods consumed. The DRI does not account for the increased demand that smoking places on certain nutrients; therefore, the lower proportion of smokers below recommended intakes might not indicate improved dietary adequacy.

A noted change in nutrient profiles of smokers is the increased demand that smoking places on antioxidants such as vitamins A, C and E. Vitamin A deficiency in smokers occurs from a combination of decreased intake and depletion of vitamin A in the body as a result of tobacco smoke and may help protect against emphysema.[28] The average daily intake of vitamin A was significantly higher among male and female smokers compared with non-smokers, but the average intake was below the DRI for males and only slightly higher than the DRI for females. Overall, one-third of all smokers did not meet the recommendations for vitamin A intake. Culturally

Table 4 – Top 10 food sources of energy and selected nutrients among adult Inuvialuit smokers in the Northwest Territories.

Foods	Energy (%)	Foods	Protein (%)	Foods	Fat (%)	Foods	Carbohydrates (%)
Non-nutrient-dense foods	38.9	Traditional land foods	27.2	Non-nutrient-dense foods	38.7	Non-nutrient-dense foods	54.3
Beef and pork	10.1	Beef and pork	17.1	Beef and pork	18.9	White breads	12.6
White breads	8.7	Dairy	10.1	Dairy	10.8	Fruits	6.8
Traditional land foods	7.8	Traditional sea foods	9.9	White breads	5.8	Dairy	4.0
Dairy	7.2	Non-nutrient-dense foods	8.7	Traditional land foods	5.5	Cereals	3.0
Alcoholic beverages	4.4	White breads	5.0	Traditional sky foods	3.7	Wheat breads	2.4
Fruits	3.1	Chicken/turkey	4.6	Traditional sea foods	3.7	Traditional land foods	2.1
Traditional sea foods	3.1	Traditional sky foods	4.4	Chicken/turkey	3.2	Rice	1.8
Chicken/turkey	2.0	Soups and stews	3.7	Nuts	2.1	Potatoes	1.8
Traditional sky foods	2.0	Wheat breads	1.4	Soups and stews	1.8	Alcoholic beverages	1.6
Total	87.5		92.0		94.3		90.5

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Table 5 – Top 10 food sources of energy and selected nutrients among adults Inuvialuit in the Northwest Territories who do not smoke.

Foods	Energy (%)	Foods	Protein (%)	Foods	Fat (%)	Foods	Carbohydrates (%)
Non-nutrient-dense foods	39.1	Traditional land foods	31.3	Non-nutrient-dense foods	41.5	Non-nutrient-dense foods	52.3
White breads	10.0	Beef and pork	12.4	Beef and pork	14.7	White breads	14.4
Traditional land foods	9.4	Traditional sea foods	11.9	Dairy	10.1	Fruits	8.2
Beef and pork	7.9	Dairy	9.2	White breads	6.3	Dairy	4.0
Dairy	7.0	Non-nutrient-dense foods	8.5	Traditional land foods	6.1	Cereals	3.5
Fruits	3.8	White breads	5.3	Traditional sky foods	4.2	Wheat breads	2.5
Traditional sea foods	3.7	Chicken/turkey	5.2	Traditional sea foods	4.0	Traditional land foods	2.2
Chicken/turkey	2.5	Traditional sky foods	4.6	Chicken/turkey	3.9	Rice	1.7
Traditional sky foods	2.3	Soups and Sstews	2.5	Nuts	1.8	Potatoes	1.7
Cereals	2.1	Seafood	1.8	Soups and stews	1.4	Noodles	1.5
Total	87.7		92.6		94.0		91.9

appropriate nutrient-rich sources of vitamin A include sea mammal fats and organ meats from traditional foods, which could be promoted to achieve dietary adequacy. Additionally, available market sources of vitamin A including frozen vegetables such as carrots, broccoli and squash could be encouraged. Due to high oxidative stress, smokers experience an increased turnover of ascorbic acid and subsequently have a higher vitamin C intake requirement than non-smokers (males: 125 mg/day; females: 110 mg/day).[29,30] Smokers in this study had higher vitamin C intake than non-smokers, and the average daily intake of vitamin C among smokers exceeded the increased requirements for both genders. Vitamin E intake was extremely low among all participants, but might be especially notable for smokers. Vitamin E is important in preventing lipid peroxidation that occurs among smokers and contributes to the development of coronary heart disease and lung cancer.[31,32] Traditional foods are excellent sources of vitamin E, including char, lake trout white fish, as well as crowberry and cloudberry from plant sources. Additionally, market food sources include fresh fruit and vegetables, canned fish, meats, and frozen fruit and vegetables. Given the low intake of vitamin E among smokers and non-smokers, public health strategies/health practitioners should embark on educational and health promotion strategies that will improve intake of these nutrients.

A high proportion of smokers had nutrient profiles which might increase the risk of adverse cardiovascular outcomes. Magnesium is an indicator for diet quality as it is found in nutrient-dense foods and is involved in a wide range of cellular mechanisms. Magnesium deficiency can be a risk factor in the pathogenesis of metabolic syndrome and several cardiovascular outcomes.[33–35] A high proportion (68%) of smokers were below the recommended potassium intake, which could have implications for hypertension as higher potassium mitigates the hypertensive effects of sodium.[36] Sodium intake among smokers was three to four times higher than the DRI, and was likely underestimated as the questionnaire did not assess salt used during cooking or dining. The unfavorable intakes of these nutrients combined with high energy, saturated fat and cholesterol intakes might increase the risk of obesity, atherosclerosis, high blood pressure and cardiovascular disease among smokers in this population.[37,38] Maintenance of traditional dietary patterns and incorporation of healthy market-based foods such as fruit and vegetables to achieve dietary adequacy in both smokers and non-smokers is warranted in Arctic Aboriginal populations, including Inuvialuit. Ample epidemiological studies suggest that smokers consume less fruit and vegetables compared with non-smokers.[39–41]

Multiple factors in addition to smoking influence dietary intake (especially in Aboriginals of Arctic Canada), including age, access to food, education and income.[42] Socio-economic status, measured by education and income, is associated with altered dietary intake and smoking status, but this study did not explore these differences due to the small sample size.[43] The small sample contributed to further study limitations by prohibiting the in-depth exploration of dietary intake differences by level of smoking, such as amount smoked, past cigarette use, and combined smoking and alcohol consumption. Previous literature has shown differences in the intake of various food groups and nutrients based on these factors, including a previous study among this population which documented higher consumption frequency of traditional foods, fruit and vegetables among Inuvialuit men and women with higher material style of life scores, a proxy for socio-economic status.[4] Generalizability of these results to the male Inuvialuit population is limited due to the small male sample size; however, this study aimed to include the main food shopper and preparer of the household, and these tasks are generally undertaken by women. Despite these limitations, this study was able to provide an overview of the differences in dietary intake between Inuvialuit smokers and non-smokers, and highlight certain dietary inadequacies which might put smokers at higher risk for several diet- and smoking-related chronic diseases.

Conclusion

Adult Inuvialuit smokers in this study had increased energy intake and consumed less nutrient-dense, traditional foods than non-smokers. The high energy intake among smokers

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likely contributed to fewer dietary inadequacies compared with non-smokers; however, controlling for alcohol consumption might help to explain this result. The dietary inadequacies present among smokers in this study may contribute to increased risk of cardiovascular disease and aerodigestive cancers. From a public health standpoint, this information emphasizes the need for smoking cessation programmes and nutrition education in this population to decrease the risk of diseases related to smoking and diet.

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Ethical approval

Institutional Review Board approval was obtained from the Committee on Human Studies at the University of Hawaii, Office of Human Research Ethics at the University of North Carolina at Chapel Hill and the Beaufort Delta Health and Social Services Authority Ethics Review Committee. The Aurora Research Institute in the NWT licensed this study.

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Competing interests

None declared.

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