Vitamin A and D Intakes in Food Mail Pilot Project Communities

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Background

In 2001 and 2002, baseline nutrition surveys were conducted for the Food Mail Pilot Projects in Kugaaruk, Nunavut, Kangiqsujuaq, Nunavik and Fort Severn, Ontario. In the published reports we presented vitamin A intake in Retinol Equivalents (RE) since this was the only unit available from existing nutrient databases [1 2 3]. The 2000 Dietary Reference Intakes (DRIs) calculated the requirement for vitamin A in µg Retinol Activity Equivalents (RAE). The RAE estimates the vitamin A activity of provitamin A carotenoids to be half the vitamin A activity assumed when using retinol equivalents.

Vitamin D intake was not analysed in the baseline survey reports due to the extent of missing values for country foods.

Since there has been some concern that vitamin A and D intakes may be less than desirable in this population, it seemed appropriate to recalculate vitamin A intake once the RAE values became available and to take advantage of new vitamin A and D values published for country foods.

Method

Twenty-four hour recalls were conducted by trained local interviewers among non-pregnant, non-lactating Inuit women aged 15 to 44 from Kugaaruk, Nunavut (n=62) and Kangiqsujuaq, Nunavik (n=70) and First Nations women from Fort Severn, Ontario (n=53). Eighteen lactating women from Kugaaruk were also included. Repeat recalls were conducted among 50 to 77% of participants. Nutrition supplements were not included in the analysis.

Vitamin A (RAE) and vitamin D (µg) values per 100 grams were obtained from the 2005 Canadian Nutrient File (CNF). Missing values for market foods were obtained from the USDA national database [4]. However, data from the USDA database on foods fortified with vitamin A were not used. Missing values for country foods were obtained from estimates provided by Kuhnlein et al [5]. Vitamin A values are not available for moose flesh, beaver and dried arctic char. Vitamin D values are not available for ptarmigan and dried Arctic char. However, only very small amounts of these foods were reported.

The 24-hour recall data were analysed using the Iowa State University methodology. Through a series of transformations, this software used the observed nutrient intakes and repeat observations to estimate the distribution of the population's usual intake. The program corrects for day-to-day variation, inter-individual variation and day of week variation generating an adjusted mean and median intake and calculates the percentage of non-pregnant, non-lactating women whose usual intakes were below the Estimated Average Requirement (EAR) [6]. Twenty-four hour recalls were only analysed for lactating women in Kugaaruk. The calculation of the adjusted mean and median intake of vitamin D for lactating women was made without adjusting for the day of the week. Since a couple of very large readings occurred on the same day of the week, adjusting for the day of the week created a median that was unreasonable.

To calculate the simple mean intake by food group and Food Mail category, the first and repeat recalls were averaged for each respondent who completed two recalls and combined with the data from women who completed only one recall. These values were averaged to provide the mean contribution of each food group and Food Mail category to vitamin A and D intake. The most important food sources within each Food Mail category were then identified. In this analysis all women, including those who were pregnant or lactating, were included.

Vitamin A

Studies have consistently shown a low vitamin A intake in northern diets which is attributed to the choice of market food consumed and the influence of cost and availability of good sources of vitamin A such as fortified milk and dark yellow vegetables [1 2 3 7 8 9 10].

Vitamin A is essential for normal vision and a healthy skin, to prevent night blindness, and for a normal immune response (the ability to fight infection and prevent tumours and respiratory infections) [11 12 13 14 15]. In developing countries, blindness due to vitamin A deficiency affects 3 to 10 million children [16 17]. Vitamin A deficiency interferes with the formation of haemoglobin and therefore vitamin A supplementation in combination with iron may be more effective than iron alone in treating iron-deficiency anaemia [18]. Animal studies have shown that vitamin A deficiency interferes with the normal development of the fetus and causes birth defects among those fetuses that survive [19].

While there is no evidence of acute vitamin A deficiency in the North, subclinical symptoms, such as recurrent lower respiratory tract infections, are widespread [20 21]. Children with mild vitamin A deficiency have a higher risk of respiratory infections and diarrhea [22]. Low vitamin A intake may cause more adverse effects in northern communities where binge drinking is common [23 24]. Alcohol interferes with the metabolism and storage of vitamin A and exacerbates the adverse effects of too little or too much vitamin A [25 26 27 28]. The metabolic interactions of alcohol and vitamin A are believed to play a role in the development of fetal alcohol syndrome (FAS) [29 30 31 32]. Congenital heart defects and FAS, both of which are common in some Inuit communities, are considered to be the result of poor vitamin A and folate intake in addition to excessive alcohol consumption [33 34] .

Vitamin A requirements are based on maintaining adequate liver stores to cover increased needs during periods of stress and low vitamin A intake. The EAR for vitamin A for non-pregnant, non-lactating women aged 15 to 44 is 500 µg RAE per day. For lactating women in this age group, the EAR is increased to 900 µg RAE [35].

The adjusted mean intake of vitamin A was 370 µg RAE in Kugaaruk, 308 µg RAE in Kangiqsujuaq and 280 µg RAE in Fort Severn (Table 1). Median intakes were 368 µg RAE for Kugaaruk, 285 µg RAE for Kangiqsujuaq and 272 µg RAE for Fort Severn women. By comparison, Egeland et al. found that Inuit women aged 15 to 40 had a mean vitamin A intake of 514 µg RAE [36]. The NHANESIII, a national American nutrition survey, reported a median intake for women 19 to 30 and 31 to 50 of 583 µg RAE and 640 µg RAE respectively [35]. For lactating women in Kugaaruk, the adjusted mean and median intake was 227 µg RAE and 226 µg RAE.

Virtually all women (90 to 100%) in the three pilot communities had an inadequate Vitamin A intake. More women in Kugaaruk had a usual intake below the EAR despite a higher median intake, because the distribution is more narrowly spread than in Kangiqsujuaq (Figure 1). Egeland et al. estimated that 60% of Inuit women between the age of 15 and 40 had a vitamin A intake below the EAR, whereas based on the same survey, Kuhnlein reports only 47% were below the EAR [5 36]. The difference may be attributed to the methodology used by Egeland where participants reporting <10th percentile of energy intake and those reporting intake over four standard deviations of the kilocalories were excluded from the analysis. This analytical procedure would likely change the automatic transformations applied by the SIDE software, resulting in a modest effect on the estimation of the percentage of the population below the EAR.

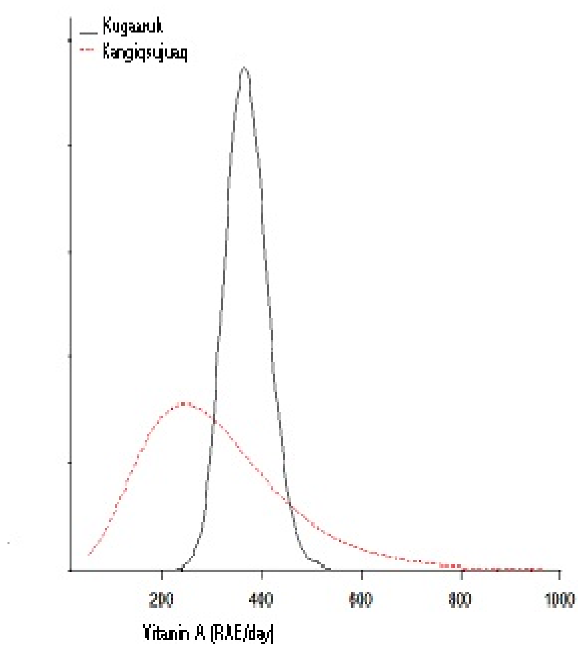

Figure 1 Probability distributions for vitamin A intake among women 15 to 44 in Kugaaruk and Kangiqsujuaq

Kuhnlein reported 100% of Dene/Métis women under 40 with inadequate intakes [5]. In the NHANESIII survey 20 to 28% of women 19 to 50 were below the EAR for vitamin A [35].

Such a low intake in the pilot communities is surprising in view of the country food sources of Vitamin A available in these communities. Excellent sources (a mean above 1500 µg per 100 grams) include beluga blubber and oil, narwhal blubber, ringed seal liver, walrus liver and caribou liver. Moderate vitamin A sources (a mean between 100 and 1500 µg per 100 grams) include the flesh and muktuk of beluga, narwhal muktuk, seal blubber and flesh, walrus blubber and flesh including fatty flesh, bone marrow and kidney of caribou, muskox flesh, and polar bear flesh. Although caribou and Arctic char are low in vitamin A, their frequent consumption makes them a reasonable source, according to Kuhnlein [5].

There are also a number of store foods that provide vitamin A including beef and pork liver and fatty fish, margarine, milk and cheese. Vitamin A can also be produced by the body from β-carotene, a pigment found mostly in dark yellow and orange fruit and vegetables such as peaches, carrots, squash and sweet potatoes. Lower amounts of carotene are found in dark green vegetables.

The most important sources of vitamin A in Kugaaruk were country food (32%) particularly Arctic char, polar bear and caribou (Table 2). Nutritious Perishables provided 29% of vitamin A. The most important food groups within this category were miscellaneous foods, such as frozen pizza, which contributed 14% of vitamin A, and fats and oils (butter and margarine) which provided 13%. Priority Perishable foods (mostly fruit and vegetables) provided only 16% of vitamin A. Non-perishable foods (mainly canned beef stew and dehydrated soups) provided 13% of vitamin A.

In Kangiqsujuaq, country food provided only 17% of vitamin A, again mainly from Arctic char (12%) (Table 2). Priority Perishables (mainly fruits and vegetables) accounted for 28% of vitamin A intake and Nutritious Perishables (mainly fats and oils such as margarine and butter and miscellaneous foods like pizza), 27%.

In Fort Severn, Priority Perishables (eggs, dairy products and fruits and vegetables) contributed 42% of vitamin A (Table 2). Nutritious Perishables provided 27% of vitamin A with fats and oils and miscellaneous foods, like pizza, the principal sources. In this community, women consumed less than half as much country food as women in Kugaaruk or Kangiqsujuaq. Since most of the country food was caribou which contains very little vitamin A, country food supplied only 3% of intake.

Egeland reported that Inuit women 15 to 40 obtained 98 to 123 µg vitamin A (RAE) from country food [36]. In contrast, women in the pilot communities obtained 9 to 99 µg RAE of vitamin A from country food.

The conversion of vitamin A in Retinol Equivalents to Retinol Activity Equivalents makes animal sources, especially country food in Kugaaruk and Kangiqsujuaq, a more important source of vitamin A than presented in the earlier reports. The actual amount of vitamin A coming from country food in Kugaaruk also increased because new values for vitamin A were added to the database.

Table 1. Vitamin A intake, women 15 to 44, 24-hour recall								
Location/ Group	**Year**	**Number of Observations**	**n**	**Mean (µg RAE)**	**Adjusted mean (µg RAE)**	**Adjusted median (µg RAE)**	**EAR (µg RAE)**	**% below the EAR**
Kugaaruk/ Non-pregnant, non-lactating	2001	102	62	318	370	368	500	100
Kugaaruk/ Lactating	2001	30	18	243	227	226	900	100
Kangiqsujuaq/ Non-pregnant, non-lactating	2002	105	70	315	308	285	500	90
Fort Severn/ Non-pregnant, non-lactating	2002	94	53	315	280	272	500	99

Table 2. Mean vitamin A intake (µg RAE per day) from major sources, all women 15 to 44						
	Kugaaruk, Nunavut		**Kangiqsujuaq, Nunavik**		**Fort Severn, Ontario**	
Food Mail category/food group	**µg RAE**	**% of total**	**µg RAE**	**% of total**	**µg RAE**	**% of total**
Priority Perishables	50	***16***	86	**28**	128	**42**
Dairy Products	7	***2***	24	***8***	43	***14***
Eggs	13	***4***	21	***7***	54	***18***
Fruits and Vegetables	30	***10***	41	***13***	30	***10***
Nutritious Perishables	89	***29***	82	***27***	81	***27***
Meat, Poultry, Fish	2	***1***	12	***4***	3	***1***
Fats and Oils	41	***13***	34	***11***	46	***15***
Miscellaneous (frozen pizza)	44	***14***	28	***9***	29	***9***
Non-perishables	39	***13***	43	***14***	62	***20***
Dairy Products	12	***4***	1	**-**	21	***7***
Cereal Products	1	**-**	1	**-**	7	***2***
Fruits and Vegetables	1	**-**	21	***7***	7	***2***
Miscellaneous (beef stew, soups)	24	***8***	19	***6***	26	***9***
Country food	99	***32***	52	***17***	9	***3***
Convenience Perishables	27	***9***	23	***8***	17	***6***
Meat, Poultry, Fish (fried chicken)	7	***2***	6	***2***	3	***1***
Miscellaneous (packaged sandwiches)	20	***6***	17	***6***	13	***4***
Total (all sources)	309		306		302	

Note: “-” indicates a value of less than 1.

Vitamin D

In the general Canadian and American population there is evidence of vitamin D insufficiency [37 38]. This situation is expected to be worse in the Arctic due to the long periods of darkness and the low consumption of fortified milk. Vitamin D deficiency and rickets have been reported among Aboriginal groups in the Arctic as well as in northern Manitoba [39 40 41].

Vitamin D is essential for the normal absorption of calcium and phosphorus from the diet and the prevention of rickets in children and osteomalacia in adults. Recently there has been considerable research into the role of vitamin D in processes other than bone formation (for example, in the prevention of cancer, childhood-onset diabetes and autoimmune diseases such as multiple sclerosis) and its conversion by extrarenal tissue involving cell proliferation and immunity [42 43]. Insufficient vitamin D may increase the risk of colon, breast and prostate cancer as well as the risk of juvenile type-1 diabetes and autoimmune diseases [44 45 46 47 48].

Humans can obtain all of their requirement for vitamin D through exposure to sunlight. However, many factors can interfere with the synthesis of vitamin D, including excessive exposure to sun, an increase in skin melanin pigmentation, the use of sunscreen and living at latitudes above 40 degrees North where vitamin D synthesis is absent for three to four months [49 50 51 52]. In the high Arctic, this period is extended up to 9 months and roughly corresponds to latitudes where the UV index is less than 3 [53 54 55]. Older adults are also less efficient in synthesizing vitamin D from the sun [56]. Both infants and older adults living in northern regions are at higher risk of vitamin D deficiency. Individuals suffering from different intestinal disorders such as severe liver failure, Crohn's disease and sprue often develop vitamin D deficiency because they are unable to absorb vitamin D from food [57]. Individuals who are unable to produce sufficient bile or who have a disease of the small intestine are also more apt to develop vitamin D deficiency. Obese individuals are also more likely to suffer from vitamin D insufficiency [58].

The wide variety of factors affecting vitamin D synthesis from the sun make it difficult to accurately determine an EAR. Because the scientific data are not available to estimate an EAR, an Adequate Intake (AI) of 5 µg (200 IU) per day for non-pregnant, non-lactating women of child-bearing age is the reference value used [59]. The AI represents the intake considered likely to maintain adequate levels of vitamin D in the blood for individuals with limited or uncertain exposure to sunlight. The AI assumes that no vitamin D is available from exposure of the skin to the sun. An upper limit of 50 µg or 2000 IU is currently set for adults [59].

Recent research suggests that sufficient evidence exists to set an EAR and Recommended Dietary Allowance (RDA) for vitamin D and that the current AI is too low to protect against vitamin D insufficency [60 61] . The Tolerable Upper Intake Level is also being questioned [62]. In conditions of restricted exposure to sunlight, the oral dose of dietary vitamin D required to sustain serum 25(OH)D levels in subjects with excellent vitamin D stores is 12.5 µg (500 IU) per day in young adults [60].

The percentage below the AI cannot be used to calculate the prevalence of inadequate intakes for groups because the AI for vitamin D is not based on the observed mean intakes of healthy populations but on the level presumed to maintain a serum 25(OH)D above the concentration below which rickets or osteomalacia would occur. It was assumed that reported intakes of healthy individuals was sufficient and this level was doubled to allow for a safety factor.

Daily vitamin D supplements of 800 IU (20 µg) are currently recommended for northern women during pregnancy by the Canadian Paediatric Society but there is no information on compliance [63].

Assessing vitamin D intake is complicated because the vitamin D fortification of processed foods is highly variable [38].

Adjusted mean and median Vitamin D intake for women in each community is presented in Table 3. Adjusted mean intakes ranged from 2.8 µg in Fort Severn to 26.7 µg in Kugaaruk. Median intakes ranged from 2.8 µg in Fort Severn to 12.6 µg in Kugaaruk, with adjusted mean intakes exceeding the AI for all Inuit women and considerably below the AI for First Nation women in Fort Severn. By comparison, median intakes of women aged 20 to 29 years and 30 to 39 years in the NHANES III were estimated to be 2.9 µg and 3.1 µg, respectively [64]. Kuhnlein reported the mean vitamin D intake of Inuit women below age 40 exceeded the AI, whereas mean intake of younger Yukon First Nation women was well below the AI [5].

The best country food sources of Vitamin D (> 5 µg per 100 grams) include beluga blubber and oil, narwhal blubber, ringed seal liver, arctic char flesh, cisco eggs, lake trout flesh, loche eggs and liver and sculpin [5]. Moderate country food sources (between 0.5 and 5 µg) are bearded seal flesh, beluga muktuk, ringed seal blubber as well as brain and eyes, caribou kidney and liver, muskox fat, wild duck, oysters, trout, whitefish and burbot.

There are very few store foods containing vitamin D. Excellent sources include Atlantic herring and canned salmon with bones. Moderate sources include fortified skim milk powder, fluid and evaporated milk, ground beef, liverwurst, beef liver and kidney and margarine.

In Kugaaruk, country food (mostly Arctic char) provided 90% of vitamin D (Table 4). Small amounts of vitamin D were supplied by Nutritious Perishable foods (3%) such as ground beef and margarine.

Country food (mostly Arctic char) was also the major source of vitamin D in Kangiqsujuaq (90%) (Table 4). Small amounts of vitamin D were provided by Nutritious Perishables (5%) including ground beef, chicken and margarine, and by Priority Perishables (4%) including fluid milk.

In contrast, Fort Severn women obtained only 4% of their vitamin D from country food (caribou, whitefish and pike) (Table 4). Thirty-nine percent came from Priority Perishables (mostly fluid milk and eggs), and one third from Nutritious Perishables such as ground beef and margarine. Non-perishables (mainly evaporated milk) supplied 21% of vitamin D.

Table 3. Vitamin D intake, women 15 to 44, 24-hour recall

Location/Group	Year	Number of Observations	n	Mean (µg)	Adjusted mean (µg)	Adjusted median (µg)	AI (µg)
Kugaaruk/ Non-pregnant, non-lactating	2001	102	62	24.7	26.7	12.6	5.0
Kugaaruk/ Lactating*	2001	30	18	32.4	17.1	12.3	5.0
Kangiqsujuaq/ Non-pregnant, non-lactating	2002	105	70	16.3	17.4	11.0	5.0
Fort Severn/ Non-pregnant, non-lactating	2002	94	53	3.5	2.8	2.8	5.0

* With the exception of lactating women in Kugaaruk, Vitamin D estimates were calculated after adjusting for the day of the week and standardizing the variance to the variance of the first recall. For lactating women in Kugaaruk, the vitamin D intake estimates were calculated without adjusting for the day of the week but standardizing the variance to the variance of the first recall since a couple of individuals reported a very high intake and the resulting median after adjusting for the day of the week was not reasonable.

Table 4. Mean vitamin D intake (µg per day) from major sources, all women 15 to 44

	Kugaaruk, Nunavut		Kangiqsujuaq, Nunavik		Fort Severn, Ontario	
Food Mail category/food group	**µg**	**% of total**	**µg**	**% of total**	**µg**	**% of total**
Priority Perishables	0.2	***1***	0.6	**4**	1.4	**39**
Dairy Products	0.0	***-***	0.4	***3***	0.9	***25***
Eggs	0.1	***1***	0.0	***0***	0.5	***14***
Nutritious Perishables	0.7	***3***	0.7	***5***	1.1	***33***
Dairy Products	0.0	***-***	0.0	***-***	0.1	***3***
Meat, Poultry, Fish	0.4	***2***	0.3	***2***	0.6	***16***
Fats and Oils	0.3	***1***	0.3	***2***	0.4	***13***
Non-perishables	0.6	***2***	0.1	***1***	0.7	***21***
Dairy Products	0.4	***1***	0.0	***-***	0.7	***20***
Country food	25.4	***90***	13.1	***90***	0.1	***4***
Convenience Perishables	1.3	***5***	0.1	***1***	0.1	***2***
Miscellaneous (packaged sandwiches)	1.3	***4***	0.1	***1***	0.1	***2***
Total (all sources)	28.2		14.6		3.5	

Note: “-” indicates a value of less than 1.

Discussion

Nearly all women in the pilot communities had an inadequate intake of vitamin A and the mean intake of vitamin D among Fort Severn women was far below the level currently used as an adequate intake.

Our surveys were conducted during only one season (late fall in Kugaaruk and Fort Severn, and spring in Kangiqsujuaq). The possibility that the surveys occurred during a period of low country food consumption may partly explain why our mean vitamin A intake was lower than that reported by Egeland [36]. She found that Inuit women under 40 were four times more likely to have a vitamin A intake below the EAR compared to women over 40 and the difference was due to a higher consumption of traditional food by older women. Kuhnlein and Receveur showed that vitamin A intake among Inuit was more than doubled on days when traditional food was consumed [65].

In our original report simple (unadjusted) mean and median intakes were presented for vitamin A, since RAE values are required for use with the Iowa State University software. As expected, the unadjusted mean intakes in RAEs in these communities are lower than originally reported in REs.

In our earlier reports on the baseline surveys, we found a mean intake of vitamin A (RE) similar to that reported by Kuhnlein for all Inuit women aged 20 to 40 in 2000 [66]. The contribution of market foods to vitamin A intake in the Inuit pilot communities was also similar. However, in later reports by Egeland and Kuhnlein for the same population the mean intake of vitamin A (RAE) among Inuit women under 40 was much higher than our findings and higher than earlier reported in RE [5 36].

An accurate assessment of vitamin A or D status would require clinical investigation. However, an inadequate vitamin A intake would result in less than desirable liver stores, and contribute to a reduced immune response and a higher rate of infectious disease. Unfortunately, we do not have any data on the prevalence of FAS and the rate of congenital heart defects in these communities, but low vitamin A and folate intakes may increase the probability of their occurrence. Insufficient vitamin D intake could predispose women to osteomalacia and increase the risk of certain forms of cancer and autoimmune diseases. All of these dietary inadequacies would increase the burden on the health care system.

Improving vitamin A and D intakes will require changes to existing food patterns. Country foods that are rich sources of these vitamins need to be promoted among young First Nations and Inuit women despite the concern about low levels of contaminants found in these foods [5]. Small servings of liver (50 g) are advised during early pregnancy or when there is a risk of pregnancy. According to the U.S. Centers for Disease Control, liver can be consumed in moderation during pregnancy [67]. There are also market foods that are considered excellent or moderate sources of both vitamins. However, price, quality and availability have been consistently shown to be the major barriers to the purchase of fruits, vegetables and milk in isolated northern communities [1 2 3 68]. Therefore sustained efforts will be necessary to improve the quality and availability of market food sources and to reduce their cost.

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