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HOW ARE WE?

IRON DEFICIENCY AND ANEMIA AMONG WOMEN IN NUNAVIK



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IRON DEFICIENCY AND ANEMIA AMONG WOMEN IN NUNAVIK

AUTHORS

Céline Plante^{1,2}, Carole Blanchet¹ and
Huguette Turgeon O'Brien²

¹ Institut national de santé publique du Québec

² Département des sciences des aliments et de nutrition, Université Laval

STATISTICAL ANALYSES

Louis Rochette

Unité Connaissance-surveillance,
direction Planification, recherche et innovation,
Institut national de santé publique du Québec



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Direction Risques biologiques, environnementaux et occupationnels, Institut national de santé publique du Québec

Serge Déry
Direction régionale de santé publique du Nunavik

EDITING AND COORDINATION

Michèle A. Dupont, Élisabeth Papineau and Mélanie Anctil
Unité Connaissance-surveillance, Direction Planification, recherche et innovation
Institut national de santé publique du Québec

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BACKGROUND OF THE NUNAVIK INUIT HEALTH SURVEY

The monitoring of population health and its determinants is essential for the development of effective health prevention and promotion programs. More specifically, monitoring must provide an overall picture of a population's health, verify health trends and how health indicators vary over distance and time, detect emerging problems, identify priority problems, and develop possible health programs and services that meet the needs of the population studied.

The extensive survey conducted by Santé Québec in Nunavik in 1992 provided information on the health status of the Nunavik population (Santé Québec, 1994). The survey showed that health patterns of the population were in transition and reflected important lifestyle changes. Effectively, the Inuit population has undergone profound sociocultural, economic, and environmental changes over the last few decades. The Inuit have changed their living habits as contact with more southerly regions of Quebec increased. A sedentary lifestyle, the switch to a cash-based domestic economy, the modernization of living conditions and the increasing availability and accessibility of goods and foodstuffs imported from southern regions have contributed to these changes. These observations suggest the need for periodic monitoring of health endpoints of Nunavik Inuit to prevent the negative impact of risk factor emergence and lifestyle changes on subsequent morbidity and mortality from major chronic diseases.

In 2003, the Nunavik Regional Board of Health and Social Services (NRBHSS) decided to organize an extensive health survey in Nunavik in order to verify the evolution of health status and risk factors in the population. The NRBHSS and the Ministère de la Santé et des Services sociaux (MSSS) du Québec entrusted the Institut national de santé publique du Québec (INSPQ) with planning, administering and coordinating the survey. The INSPQ prepared the survey in close collaboration with the Unité de recherche en santé publique (URSP) of the Centre hospitalier universitaire de Québec (CHUQ) for the scientific and logistical component of the survey. The Institut de la statistique du Québec (ISQ) participated in methodology development, in particular the survey design.

The general aim of the survey was to gather social and health information on a set of themes including various health indicators, physical measurements, and social, environmental and living conditions, thus permitting a thorough update of the health and well-being profile of the

Inuit population of Nunavik. The survey was designed to permit a comparison of the 2004 trends with those observed in 1992. Data collected in 2004 also allowed researchers to compare the Inuit to other Quebecers.

Target population

The health survey was conducted among the Inuit population of Nunavik from August 27 to October 1, 2004. According to the 2001 Canadian census, the fourteen communities of Nunavik have a total of 9632 inhabitants, 91% of whom identified themselves as Inuit. The target population of the survey was permanent residents of Nunavik, excluding residents of collective dwellings and households in which there were no Inuit aged 18 years old or older.

Data collection

Data collection was performed on the Canadian Coast Guard Ship Amundsen, thanks to a grant obtained from the Canadian Foundation for Innovation (CFI) and the Network of Centres of Excellence of Canada (ArcticNet). The ship visited the fourteen villages of Nunavik, which are coastal villages. The study was based on self-administered and interviewer-completed questionnaires. The study also involved physical and biological measurements including clinical tests. The survey was approved by the Comité d'éthique de la recherche de l'Université Laval (CERUL) and the Comité d'éthique de santé publique du Québec (CESP). Participation was voluntary and participants were asked to give their written consent before completing interviews and clinical tests. A total of 677 private Inuit households were visited by interviewers who met the household respondents to complete the identification chart and the household questionnaire. A respondent was defined as an Inuit adult able to provide information regarding every member of the household. The identification chart allowed demographic information to be collected on every member of the household. The household questionnaire served to collect information on housing, environment, nutrition and certain health indicators especially regarding young children.

All individuals aged 15 or older belonging to the same household were invited to meet survey staff a few days later, on a Canadian Coast Guard ship, to respond to an interviewer-completed questionnaire (individual questionnaire) as well as a self-administered confidential questionnaire. Participants from 18 to 74 years of age were also asked to complete a food frequency questionnaire and a 24-hour dietary recall, and to participate in a clinical

session. The individual questionnaire aimed to collect general health information on subjects such as health perceptions, women's health, living habits and social support. The confidential questionnaire dealt with more sensitive issues such as suicide, drugs, violence and sexuality. During the clinical session, participants were invited to answer a nurse-completed questionnaire regarding their health status. Then, participants had a blood sample taken and physical measurements were performed including a hearing test, anthropometric measurements, an oral glucose tolerance test (excluding diabetics) and toenail sampling. Women from 35 to 74 years of age were invited to have a bone densitometry test. Finally, participants aged 40 to 74 could have, after consenting, an arteriosclerosis screening test as well as a continuous measure of cardiac rhythm for a two-hour period.

Survey sampling and participation

The survey used a stratified random sampling of private Inuit households. The community was the only stratification variable used. This stratification allowed a standard representation of the target population. Among the 677 households visited by the interviewers, 521 agreed to participate in the survey. The household response rate is thus 77.8%. The individual response rates are obtained by multiplying the household participating rate by the individual collaboration rate since the household and individual instruments were administered in sequence. The collaboration rate corresponds to the proportion of eligible individuals who agreed to participate among the 521 participating households. In this survey, about two thirds of individuals accepted to participate for a response rate in the area of 50% for most of the collection instruments used in the survey. A total of 1056 individuals signed a consent form and had at least one test or completed one questionnaire. Among them, 1006 individuals answered the individual questionnaire, 969 answered the confidential questionnaire, 925 participated in the clinical session, 821 had a hearing test, 778 answered the food frequency questionnaire, 664 answered the 24-hour dietary recall, 282 had an arteriosclerosis test, 211 had a continuous measure of their cardiac rhythm for a two-hour period and 207 had a bone densitometry test. More details on the data processing are given in the Methodological Report.

INTRODUCTION¹

According to the World Health Organisation (WHO), there are over two billion people around the world suffering from anemia. Iron deficiency, which is the main cause of anemia, is the most common nutrition disorder worldwide (WHO, 1998). Iron deficiency anemia (IDA) is particularly prevalent among babies, children, women, ethnic groups and low-income families and, to a greater extent, among people living in developing countries (WHO, 2001). In 2001, the prevalence of anemia among women was estimated at 10.3% in industrialized countries and 42.3% in non-industrialized countries (WHO, 2001). The prevalence of anemia in Aboriginal children of Canada is eight times higher than among similar non-aboriginal populations in Canada and is especially high among Inuit children (Christofides et al., 2005). Until now, the prevalence of anemia in Nunavik women was unknown, however it was suspected that similar results existed. WHO recognizes anemia as a widespread public health problem having major consequences on health as well as on social and economical development (WHO, 2001). The economic implications of iron deficiency are linked to the therapeutic costs involved in curing anemia, impaired pregnancy outcomes and the medical costs associated with a higher prevalence of certain infections.

Anemia is a condition characterized by a reduction in the total circulating hemoglobin. There are different types of anemia, which are classified according to the cause of the anemia: a default in the production of red blood cells may be attributable to an iron, vitamin B₁₂ or folate deficiency. An abnormal destruction of red blood cells as observed in the course of chronic diseases or in the case of a hereditary disease may also cause anemia. However, IDA is the most widespread type of anemia and its etiology is multifactorial. Among women, IDA is primarily prevalent during childbearing years and adversely affects pregnancy outcomes, increasing maternal and infant morbidity and mortality. IDA is generally associated with pallor, weakness and tiredness. This disorder has a negative impact on immune status and physical work capacity. It can impair cognitive performance in all individuals.

¹ For ease of readability, the expression "Inuit" is used throughout the theme paper to define the population under study even though a small percentage of individuals surveyed identified themselves as non-Inuit. Refer to "Background of the Health Survey" for further details regarding the definition of the target population.

The main risk factors of IDA are: inadequate iron intake (due to an iron-deficient diet or inadequate absorption), increased iron requirements, and blood loss. Indeed, the daily diet must include sufficient amounts of high bioavailable iron. Some components of foods, such as tannins in tea and phytates in wheat bran, reduce iron absorption if they are consumed with iron during the same meal. Moreover, a low vitamin C intake reduces iron absorption. Vitamin A deficiency may also affect iron metabolism and iron store mobilization, resulting in anemia (International Vitamin A Consultative Group (IVACG), 1998). Studies conducted among humans and animals suggest that improvement in vitamin A status can cure anemia, while increasing iron utilization and mobilization of iron stores (IVACG, 1998). During pregnancy, women's physiological needs for iron are increased (Makrides et al., 2003). Moreover, pregnancy is associated with higher rates of iron deficiency and iron deficiency anemia, particularly among teenage and multiparous women (Viteri, 1998). Blood loss is also an important cause of iron deficiency, with abundant menses leading to a significant loss of iron among certain women (Barr et al., 1998). Finally, lead poisoning is also recognized as an etiologic factor for anemia because of its interference with iron absorption and metabolism (Papanikolaou et al., 2005).

In recent decades, important changes in lifestyle habits and dietary patterns occurred among the Inuit population, contributing to the decreased consumption of country foods that are good sources of iron. Consequently, dietary intake of store-bought foods now exceeds that of country foods (Blanchet & Rochette, 2007).

Up to now, no data on the prevalence of anemia among non-pregnant women in Nunavik were available. A study conducted from 1989 to 1991 using prenatal follow-ups of Nunavimmiut pregnant women (n = 187) indicated that 39% had hemoglobin levels below 120g/L during the first trimester of pregnancy (Hodgins et al., 1998).

In 2004, blood samples, and dietary and medical information were collected from Nunavik women during the extensive Nunavik Inuit Health Survey 2004. Hematological levels of hemoglobin, serum ferritin, serum iron, vitamin A, vitamin B₁₂ and folic acid were measured in order to determine the prevalence and the etiology of anemia among women in Nunavik (see Rochette & Blanchet, 2007 for details).

➤ Objectives

The main objective of this report is to present the prevalence of iron deficiency and anemia and their associated risk factors among Nunavik women. The specific objectives are to:

- Determine the main types of anemia and the prevalence of iron deficiency anemia (IDA) in Nunavik women as well as the prevalence of iron, vitamin A, folic acid and vitamin B₁₂ deficiencies;
- Determine the relationship between socio-economic and health status, dietary intake and eating patterns and the prevalence of iron deficiency and anemia.

METHODOLOGICAL ASPECTS

➤ Study population and sampling

The study sample consisted of 502 women aged between 18 and 74 years including 26 pregnant women. The sample size of the present study represents 20% of the adult female population of Nunavik and is representative of this population. The results presented in this report exclude women who did not have a blood test. The global response rate for measurements of iron status parameters was 58.2%.

➤ Blood sampling and laboratory analysis

Women fasted for eight hours before venipuncture. Hematological measurements included hemoglobin (Hb), serum ferritin (SF), serum iron (SI), transferrin saturation (TSAT), total iron binding capacity (TIBC), retinol, vitamin B₁₂ and serum folate. Hemoglobin (Hb) analysis was performed with a Beckman-Coulter GEN.S automatic analyzer whereas serum ferritin (SF) was carried out using a Elecsy-2010 system from Roche Co. Serum iron (SI), transferrin saturation (TSAT), and vitamin B₁₂ were measured in frozen centrifuged blood at Laval Hospital's Biochemical Centre, using a Hitachi 917 automatic analyzer with chemicals from Roche Diagnostic. Serum folate was measured by immuno-assay and electroluminescence (ECL), using Roche reagents and Roche-Elecsys. Other biochemical parameters included serum retinol measured by the high-performance liquid chromatography (HPLC) method. Blood lead levels were determined according to a laboratory method called the inductively coupled plasma mass spectrometry or ICP-MS (INSPQ method: M-557). The C-reactive protein (CRP), which is an acute phase reactant indicating the presence of

infection or inflammation state, is a marker commonly used in conjunction with biochemical parameters of iron status (Gibson, 2005). CRP was measured in EDTA-treated plasma using the Behring Latex-Enhanced (highly sensitive) CRP essay.

➤ **Assessment of iron status and anemia**

There are many methods in the literature to determine the prevalence of iron deficiency (Gibson, 2005). Considering the biochemical measurements available in the present study, we used the model of Patterson and colleagues (2001). According to this model, women are considered iron deficient (ID) if they have depleted iron stores (SF < 15 µg/L) or if they have low iron stores (SF 15-20 µg/L) plus, at least, two abnormal values among the three following biochemical parameters: SI < 10 µmol/L, TIBC ≥ 68 µmol/L, TSAT < 15%. Women with CRP ≥ 10 mg/L and SF < 50 µg/L are also classified as iron deficient since serum ferritin levels increase in the presence of infection or inflammation (Gibson, 2005). This criterion was added to Patterson's model.

In the present study, anemia is defined as a Hb concentration < 120 g/L for non-pregnant adult women as recommended by the WHO (WHO, 2001). Iron deficiency anemia (IDA) is defined as co-existing anemia and iron deficiency. When anemia occurred without iron deficiency, other etiological factors such as the presence of infection or inflammation, lead contamination, and folate or B₁₂ deficiency were investigated. Also, the presence of low serum iron (SI < 10 µmol/L) and anemia, without evidence of iron deficiency was considered suggestive of an anemia of chronic disorder (ACD) (Guralnik et al., 2004; Sears, 1992).

Pregnant women are considered separately in this paper since iron parameters are influenced by pregnancy and specific cut-off points are necessary to assess iron status among these women. Moreover, since the trimester of pregnancy is unknown, the cut-off point used to diagnose anemia in pregnant women is an Hb < 110 g/L as recommended by the WHO (WHO, 2001). Iron deficiency was identified by low iron stores (SF < 15 µg/L) since the use of this single parameter is considered the best indicator of iron storage in pregnant women (Van den Broek et al., 1998; Byg et al., 2000). For pregnant women, IDA was also defined as the presence of both anemia and iron deficiency. Specific cut-off points for SI, TSAT and TIBC during pregnancy are used as proposed in the literature (Blight et al., 1997).

➤ **Dietary assessment**

Data on dietary intake and eating habits were obtained from four questionnaires. A food frequency questionnaire and a 24-hour dietary recall were completed with non-pregnant women during a face-to-face interview conducted by trained interviewers.

The food frequency questionnaire measured the consumption frequency of 69 food items and beverages and the usual serving size. Foods were divided into two major groups: country foods (referring to foods obtained by fishing, hunting and gathering) and store-bought foods (including most foods imported from southern Quebec).

The 24-hour dietary recall quantifies the food intake of an individual during a specific day (Willett, 1990). Respondents had to recall all foods and beverages consumed the day before the interview (delimited time: 12:01 a.m. to 12:00 a.m.) and report the place where the meals were eaten. Models of standardized food servings were used to help the interviewer and the respondent better define and describe the amounts of food eaten. The estimated average requirement (EAR) cut-point method was used to assess nutrient adequacy for vitamins and elements with the exception of iron in menstruating women (aged 18 to 49). In the latter case, the probability approach was used since iron requirements are not symmetrically distributed in menstruating women.

Data on food habits were obtained from the individual and household questionnaires. Questions about food insecurity were also included in these questionnaires. These questionnaires provided information on socio-economic characteristics, smoking habits and health problems. Complementary information on alcohol consumption and menopausal status was obtained from the confidential and the clinical session questionnaires.

➤ **Data analysis**

In this study, all estimations were weighted in order to take into account the different probability of selecting each individual induced by the survey design, in addition to the non-response and differences observed between the sample and the population. When a variable was not normally distributed, the natural logarithm was used for statistical analyses and the geometric mean and median were used as the measures of central tendency since they were less affected by extreme values. A log-transformation was applied to all blood parameters, with the exception of Hb,

folate and retinol, which were normally distributed. The mean level of folate may be underestimated since the value 45.2 nmol/L has been given to measurements that were above the detection limit (≥ 45.2 nmol/L).

Dependant variables used were biochemical indicators of iron status, the presence of iron depletion, iron deficiency anemia and iron, folate or vitamin B₁₂ deficiencies. Independent variables were socio-demographic and economic characteristics, lifestyle habits, food habits, consumption of country foods and some store-bought foods, and nutrient intake. In terms of the education variable, it is important to specify that the choice of answers for post-secondary training were not well adapted to the context of the survey's target population. The answers given for this category reveal that there was likely confusion during data collection between training that requires a post-secondary diploma and training that does not (e.g. driver's license, fishing license, etc). Therefore, the number of people with post-secondary education was likely overestimated. Moreover, there is also a potential bias for the question on income due to a non-response rate of 15%.

The data used in this module come from a sample and are thus subject to a certain degree of error. The coefficient of variation (CV) has been used to quantify the accuracy of estimates and the Statistics Canada scale was used to qualify the accuracy of estimates. The presence of an "E" footnote next to an estimate indicates a marginal estimate (CV between 16.6% and 33.3%) and constitutes a warning for subsequent users of the high variability of that data. Estimates with unreliable levels of accuracy (CV > 33.3%) are not presented and have been replaced by the letter "F".

Variance analysis adjusted for survey design was used to compare means or geometric means of blood parameters and the chi-square test with a correction for design effect was used to compare the prevalence of anemia, iron deficiency and iron deficiency anemia. Statistical analyses for comparisons have been conducted at a threshold of $\alpha = 0.05$. Analyses were carried out using SAS and SUDAAN softwares (SAS Institute Inc., 2003; SUDAAN Version 9.0, 2005).

This theme paper contains only descriptive results with no adjustment for cofactors. A second phase of results publication will include more elaborate statistical analyses, which will be published in various scientific journals.

RESULTS

I. IRON STATUS AMONG NUNAVIK WOMEN

Parameters of iron status and other biochemical indicators among non-pregnant women are shown in Table 1. According to the reference cut-off for hemoglobin levels in non-pregnant women (Hb < 120 g/L), anemia was prevalent among 38% of Nunavik women. Also, 20% of the anemic women had moderate anemia (Hb 100-110 g/L) and 11%^E severe anemia (Hb < 100 g/L), while the participants with more severe anemia (Hb < 70 g/L) were too few to report (data not shown). Serum iron, serum ferritin and transferrin saturation were also abnormally low. A high level of total iron binding capacity (TIBC), which indicates low iron status, was present in 14% of women. More than 99% of women had normal values for vitamin B₁₂, folate and vitamin A. The proportion of insufficient levels for these nutrients was very low and did not permit further statistical analyses. High CRP levels were present in 6.6% of Nunavik women. Results showed that 7.3% of women had a blood lead level higher than the WHO cut-off point (> 0.48 μ mol/L). However, the majority of these subjects (about 65%) were not anemic (data not shown).

Table 1

Mean and prevalence of abnormal values of iron status parameters and other biochemical indicators among non-pregnant women aged 18 to 74 years, Nunavik, 2004

Biochemical parameters	Mean	CI 95%	Cut-off point	Prevalence of values below or above the cut-off point (%)
Hemoglobin (g/L)	122.4 ^a	121.4-123.4	< 120	37.5
Ferritin (μ g/L)	24.1 ^g	22.4-26.0	< 15	29.5
Iron (μ mol/L)	10.3 ^g	9.8-10.7	< 10	41.7
TSAT (%)	18.1 ^g	17.3-19.0	< 15	28.6
TIBC (μ mol/L)	56.7 ^g	56.0-57.5	≥ 68	13.7
B ₁₂ (pmol/L)	382.4 ^g	371.1-394.0	< 145	F
Folate (nmol/L)	27.5 ^a	26.8-28.1	< 9.5	F
Retinol (μ mol/L)	2.07 ^a	2.02- 2.11	< 1.05	F
Lead (μ mol/L)	0.172 ^g	0.164-0.181	> 0.48	7.3
CRP (mg/L)	1.30 ^g	1.16-1.45	> 10	6.6

TSAT = Transferrin saturation; TIBC = Total Iron Binding Capacity; CRP = C-Reactive Protein.

^a Arithmetic means; ^g Geometric means.

F Unreliable estimate.

Source: Nunavik Inuit Health Survey 2004.

Using a multiparameter index based on serum ferritin (Table 2), the prevalence of iron deficiency has been estimated at 35% among Nunavik women. Among non-pregnant women of childbearing age, iron deficiency anemia was the main type of anemia, affecting more than 50% of anemic women and reaching two-thirds of anemic women 18 to 29 years old (data not shown). Among women aged 50 to 74, the main type of anemia seemed to be related to chronic inflammation since over 40% of anemic women had parameters suggestive of an anemia of chronic disorders (ACD). Indeed, the proportion of anemia attributable to chronic inflammation was significantly greater in post-menopausal women (data not shown).

Table 2

Prevalence of anemia and iron status among non-pregnant women aged 18 to 74 years, Nunavik, 2004

Variable / Conditions	Prevalence (%)
Anemia	
Hb < 120 g/L	37.5
Iron deficiency (ID)	
Total	34.8
<i>Criterion 1:</i> Ferritin < 15µg/L	29.7
<i>Criterion 2:</i> Ferritin 15-20 µg/L + CRP<10 mg/L + 2/3 (SI < 10 µmol/L, TIBC ≥ 68 µmol/L, TSAT < 15%)	2.4 ^E
<i>Criterion 3:</i> Ferritin 15-50 µg/L if CRP ≥ 10 mg/L	2.7 ^E
Iron status	
IDA : ID + Anemia	17.5
IDWA : ID + No anemia	16.8
OA : No ID + Anemia	20.0
Normal : No ID + No anemia	45.6

IDA = Iron deficiency anemia; ID = Iron deficiency as defined above; IDWA = Iron deficiency without anemia; OA = Other anemia; Hb = Hemoglobin; SI = Serum Iron; TIBC = Total iron binding capacity; TSAT = Transferrin saturation; CRP = C-Reactive Protein.

^E Interpret with caution.

Source: Nunavik Inuit Health Survey 2004.

In Table 3, data from pregnant women are presented separately since, for some biochemical parameters, different cut-off points were used. In these subjects, the prevalence of anemia was 37% using the reference cut-off point suggested by the WHO (Hb < 110 g/L). Iron deficiency affected 64% of pregnant women. Thus, the prevalence of IDA was 34%^E indicating that ID was the main source of anemia among these women. Using a higher cut-off point for serum ferritin (SF < 30 µg/L) as proposed by some authors (Byg et al., 2000; Blight et al., 1997), we found that all cases of anemia in pregnant women were related to iron deficiency.

Table 3

Mean values and prevalence of abnormal iron status parameters among pregnant women, Nunavik, 2004

Biochemical parameters	Mean	CI 95%	Cut-off point	Prevalence of values below or above the cut-off point (%)
Hemoglobin (g/L)	110.4 ^a	107.1-113.6	< 110	36.9 ^E
Ferritin (µg/L)	14.2 ^g	11.4-17.8	< 15	64.1
Iron (µmol/L)	11.4 ^g	10.0-13.0	< 12	56.7
TSAT (%)	15.9 ^g	13.5-18.6	< 16	50.9 ^E
TIBC (µmol/L)	71.7 ^g	67.5-76.4	≥ 70	57.9

TSAT = Transferrin saturation; TIBC = Total Iron Binding Capacity; CI = Confidence interval.

^a Arithmetic means; ^g Geometric means.

^E Interpret with caution

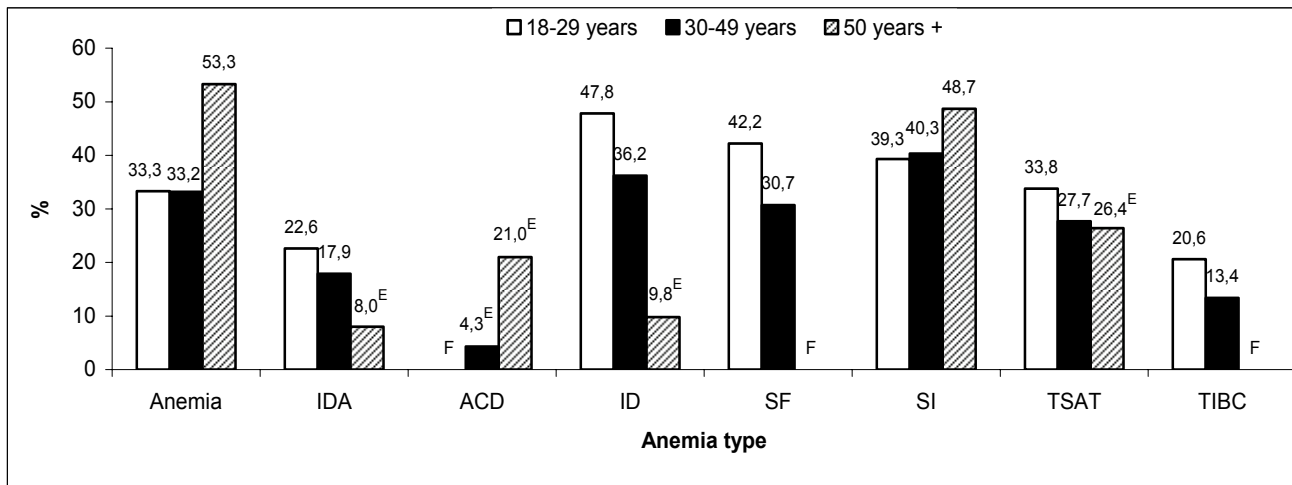
Source: Nunavik Inuit Health Survey 2004.

II. IRON STATUS ACCORDING TO THE CHARACTERISTICS OF THE WOMEN

The prevalence of anemia types and of iron status parameter levels indicative of iron deficiency by age group among non-pregnant women in Nunavik is illustrated in Figure 1. Age is significantly associated with levels of iron status parameters. Indeed, anemia was more prevalent among women aged 50 to 74 than in the younger age group, while the prevalence of iron deficiency and iron deficiency anemia decreased progressively with age. In fact, all iron status parameters measured are associated with age, with the exception of serum iron and transferrin saturation levels. A high level of total iron-binding capacity was more prevalent among women aged 18 to 29 than among women aged 30 to 49. Finally, more than 94% of women aged 50 to 74 had normal values of SF and TIBC.

Figure 1

Prevalence of anemia types and parameter levels indicative of iron deficiency by age group among non-pregnant women aged 18 to 74 years, Nunavik, 2004



IDA = Iron deficiency anemia; ACD = Anemia of chronic disorders; ID = Iron deficiency; SF = Serum Ferritin; SI = Serum Iron; TSAT = Transferrin saturation; TIBC = Total iron binding capacity.

E Interpret with caution.

F Unreliable estimate.

Source: Nunavik Inuit Health Survey 2004.

Marital status was significantly related to iron status, single women being more affected by ID than women married or living with a partner (Table A1, Appendix). Women who had a job had a better iron status than women who were not employed (women who were students, retired, housekeepers, on unemployment insurance, on welfare or any other status as their main occupation). Indeed, anemia, ID and IDA were more prevalent in unemployed women. Personal income was significantly related to iron deficiency, with women having a total personal income under \$20 000 being more affected by ID. Although an incomplete high school education was related to a poorer iron status compared to a lower or higher level of education, the prevalence of anemia was higher in women with a lower education level. Moreover, a higher prevalence of ID was noted among women living in a food insecure household, defined as not having enough food to eat in the house the month before the survey, according to the household respondent.

Iron status parameters were associated with many lifestyle habits. Smoking and the consumption of 11 or more alcoholic drinks on the same occasion were associated with a higher prevalence of ID (Table A1, Appendix). Also, ID and IDA were more prevalent among women who took illicit drugs in the last 12 months in comparison with those who did not use drugs. Women who gave birth

to a child between 0 and 4 years before the survey were much more affected by ID and IDA. The prevalence of ID was lower and the prevalence of anemia was higher among women who declared having any kind of chronic health problem (including heart disease, cancer, diabetes, high blood pressure and/or high cholesterol) compared to those who did not suffer from any of these chronic health conditions. The number of menopausal women (including those who had a hysterectomy) affected by ID or IDA were too few to report. Inversely, 43% and 21% of non-menopausal women respectively suffered from ID and IDA. However, half of the menopausal women were anemic compared to 34% in non-menopausal women. Thus, the prevalence of anemia not related to iron deficiency was higher in menopausal women (45% vs. 13%, $p < 0.0001$).

III. IRON STATUS ACCORDING TO FOOD INTAKE OF NUNAVIK WOMEN

When examining the relationship between median daily intake of meat and the iron status of Nunavik women, results from the food frequency questionnaire showed that there was no significant difference between higher and lower meat consumers (Table 4). However, a lower prevalence of depleted iron stores was observed among women eating a higher proportion of country meat.

Table 4
 Iron status of non-pregnant women aged 18 to 74 years according to daily food intake, Nunavik, 2004

Independent variables	Median	Intake < or ≥ median	Anemia Iron depletion* ID IDA			
			(%)			
Total meat (country + store-bought meat)	268 g/day	Below	36.1	29.6	34.2	18.0
		Above	37.9	31.2	39.0	17.9
Country meat proportion (country meat / total meat)	40%	Below	36.0	34.2^a	40.1	20.0
		Above	36.4	26.2	32.0	15.7
Sweets and chips (cakes, cookies, candies, chips)	31 g/day	Below	33.6	22.3^a	28.2^a	13.6^{E a}
		Above	39.4	38.7	44.2	22.1
Sweet beverages (soft drink, punch)	444 ml/day	Below	36.2	22.7^a	28.8^a	14.1^a
		Above	36.5	38.1	43.4	21.5
Hot beverages (tea, coffee, herbal tea)	710 ml/day	Below	37.1	31.3	36.8	16.7
		Above	35.7	28.9	35.0	18.5

ID = Iron deficiency; IDA=Iron deficiency anemia.

* Iron depletion is defined as ferritin level < 15 µg/L.

^a Estimates in bold and with an exponent are significantly different (p < 0.05)

^E Interpret with caution.

Source: Nunavik Inuit Health Survey 2004.

Conversely, greater consumption of sweets, chips and sweet beverages was associated with a higher prevalence of iron deficiency, iron deficiency anemia and depleted iron stores.

Data collected with the 24-hour dietary recall revealed that intake of vitamins A, C, and B₁₂ and folate were not associated with iron status parameters among these Nunavik women (data not shown). Overall, 22% of Nunavik women did not meet the iron recommendation the day prior to the interview. The median iron intake was 13.62 mg/day the day prior the interview. Since iron intake does not include supplements and are not adjusted for day-to-day variation, intake may be underestimated and the prevalence of inadequate intake overestimated. Nevertheless, a higher prevalence of inadequate iron intake was observed among women having depleted iron stores (SF < 15µg/L) (27% vs. 20%, p = 0.035) (data not shown). Also, the prevalence of inadequate iron intake was higher among women with IDA in comparison with women suffering from anemia not related to iron deficiency (23% vs. 15%^E, p = 0.047) (data not shown).

DISCUSSION

Anemia

The prevalence of anemia among Nunavik women has been estimated at 38%, the prevalence being 33% among women of childbearing age and 53% among those aged 50 years or over. The prevalence of anemia and the mean level of hemoglobin in the present study were similar to those observed in Nunavimmiut women during their first trimester of pregnancy (Hodgins et al., 1998). It is well known that at the beginning of the pregnancy, Hb values are similar to those of non-pregnant women. The prevalence of anemia among Nunavik women is about nine times higher than that observed in Canadian women (~4%) (National Institute of Nutrition, 2002). Thus, as reported for aboriginal children (Christofides et al., 2005), the proportion of women affected by anemia is much higher in the Nunavik than the non-aboriginal population. In 1973, the Nutrition Canada Survey showed that the prevalence of anemia in Inuit communities of the Northwest Territories was about twice the level reported the same year for the general population (Nutrition Canada, 1975). In addition, the prevalence of anemia among Nunavik women in 2004 was three times higher than that observed in 1973 among Inuit from the Northwest Territories. These results suggest that a great disparity still exists between Inuit communities and the

rest of Canada. Changes in dietary habits, particularly the substitution of country foods by a Western diet can partly explain these differences.

➤ **Iron depletion and iron deficiency**

In developing countries, 25 to 30% of women have no iron reserves at all (WHO, 2001). Using a serum ferritin cut-off point indicative of depleted stores ($SF < 12\mu\text{g/L}$), we found that the prevalence of iron depletion in Nunavik women was 24%. Hence, the prevalence of iron depletion observed in Nunavik women is similar to levels observed in developing countries.

The proportion of iron deficient women (34.8%) who also suffered from anemia was 51%. In the United States, the proportion of iron deficient women of childbearing age who also suffer from anemia is about 30 to 40% (Dallman et al., 1984). This may indicate a higher proportion of severe iron deficiency in Nunavik than in the U.S.

Women of childbearing age are especially at risk for iron deficiency because of the iron loss during menstruation and pregnancy. The prevalence among women aged 18 to 49 was much higher than that observed in menopausal women (50 and over). Since menopause stops iron loss due to menstrual bleeding, iron requirements are lower in menopausal women. Hence, older women are at lower risk of iron deficiency than women of childbearing age.

➤ **Iron deficiency anemia**

Iron deficiency anemia (IDA) is the third and last stage of iron deficiency. The prevalence of IDA in non-pregnant women in Nunavik is 18%. According to the WHO (WHO, 2001), the prevalence of ID is usually 2.5 times more elevated than the prevalence of IDA. In the present study, the relative proportion of ID to IDA was about twice as high. This difference could be explained by the fact that the WHO projection is based on U.S. national surveys where the prevalence of anemia is lower (WHO, 2001).

Results also indicated that IDA was higher in women of reproductive age and that 20% of women aged 18 to 49 suffered from IDA. This prevalence is higher than that reported for industrialized countries. According to WHO recommendations, “When the prevalence of IDA reaches the 20-30% level in the age-gender group under evaluation, it may be more effective – and possibly more efficient – to provide universal supplementation to that

entire group than to screen for individual case-management purposes” (WHO, 2001: 29). A similar recommendation was put forward by a decision analysis based on the U.S. national survey (Binkin & Yip, 1990).

➤ **Classification of anemia**

Anemia affects 38% of Nunavik women while 18% suffer from iron deficiency anemia. Hence, iron deficiency anemia is a major type of anemia affecting almost half of these women. These results correspond with the conclusion of the WHO indicating that even though there are many causes of anemia, dietary iron deficiency is usually either the main or a major contributing factor (WHO, 2001). In the present study, the proportion of cases of anemia related to iron deficiency differs among age groups. This proportion reached more than 60% among women of reproductive age versus only 15% in women aged 50 to 74. Iron deficiency anemia is the main type of anemia in younger women, while anemia of chronic disorders (ACD) seems to be the major type in older women. Also, misclassification of IDA may occur among older women, since ferritin levels and chronic disorders rapidly increase at the beginning of menopause (Gibson, 2005). Measurement of serum transferrin receptors, which was unfortunately not available in this study, is very useful in distinguishing iron deficiency from the anemia of chronic inflammation.

Anemia was less frequently associated with ID among older women. This may reflect lower iron needs and the higher consumption of country iron-rich meat in this age group (Santé Québec, 1995; Blanchet et al., 2000; Blanchet et al., 2002). In the present study, the rate of anemia increased rapidly among women aged 50 years and over. Similar results among elders were reported in other studies (Guralnik et al., 2004; Smith, 2000). Since mean corpuscular volume (MCV), red cell distribution width (RDW) and erythrocyte folate were not available in this study, the recognition of different types of anemia is more difficult. These parameters would have been useful to confirm the presence of hypochromic anemia (related to IDA) and megaloblastic anemia (in case of folate (B_9) or/and vitamin B_{12} deficiency).

Measurement of blood parameters of other nutrients showed a low prevalence of vitamin A, B_9 and B_{12} deficiency in Nunavik women. Thus, among Nunavik women, these deficiencies do not seem to be an important cause of anemia in this population nor a widespread problem.

➤ **Pregnant women**

The prevalence of anemia in pregnant Nunavik women is similar to the level observed in non-pregnant women. A previous study conducted from 1989 to 1991 involving a prenatal follow-up of Nunavimmiut women found a similar prevalence of anemia (Hodgins et al., 1998). At term, 40% of Nunavik pregnant women were anemic (Hb < 115g/L), which is comparable to the level of 37% (Hb < 110g/L) found in pregnant women in the earlier study (Hodgins et al., 1998). In addition, among pregnant women, the prevalence of iron deficiency and iron deficiency anemia is almost twice the rate observed in non-pregnant women. In the literature, pregnancy is considered an important "risk factor" for iron deficiency and iron deficiency anemia (Bodnar et al., 2002; Sserunjogi et al., 2003; Cardenas et al., 2006). Also, compliance regarding iron supplementation is often problematic. The present survey reveals that 47% of women with a recent pregnancy declared that they did not take any iron supplements during their last pregnancy even though iron supplements are prescribed to 85% of pregnant women in Nunavik (Hodgins et al., 1998). Also, the occurrence of pregnancy during the four years before the survey was related to a more precarious iron status in Nunavik women.

➤ **Characteristics of women**

Lower personal income, an incomplete secondary school education, food insecurity and the status of being single were associated with iron deficiency while employed women had a better overall iron status (less anemia, ID and IDA) than non-working women. Similar results have been reported elsewhere (Bhargava et al., 2001). However, since many of these characteristics may be age-related factors, their real influence on iron status must be precisely studied, considering the confounding effect of age.

Lifestyle habits, such as smoking, heavy drinking and use of illicit drugs, were related to a lower level of iron status among Nunavik women. It is well known that smoking increases hemoglobin concentration and this effect is related to carbon monoxide exposure (El Zayadi et al., 2002; Cogswell et al., 2003). Moreover, the WHO suggests using a lower cut-off point for Hb in smokers according to the number of cigarettes smoked daily in order to compensate for the masking effect of smoking on anemia detection (WHO, 2001). However, the effect of smoking on the other iron indices is not clear (Cogswell et

al., 2003). Alcohol and drug use may also alter iron metabolism (Cogswell et al., 2003).

➤ **Food intake**

The relationship between iron status and food intake may vary according to the age of women. Thus, additional statistical analyses are needed to further this study. A lower prevalence of depleted iron stores was observed among women eating a higher proportion of country food. This may be related to the fact that the iron content of country meat is higher than that of store-bought meat. Higher intake of sweets, chips and sweet beverages was also related to a higher prevalence of ID, IDA and anemia. Women consuming these high caloric foods in great amounts probably consume lower amounts of nutritious foods.

The results from the 24-hour dietary recall must be interpreted with caution since estimates of a single day's intake overestimate the prevalence of insufficient intake (Gibson, 2005). However, it is interesting to observe that total iron intake the day before the survey is associated with the iron status of Nunavik women. The estimation of bioavailable iron intake taking into account iron absorption enhancers (Monsen et al., 1978) and inhibitors (Tseng et al., 1997) will be part of the second phase of publication of the results in various scientific journals. It is a more precise indicator of iron status.

CONCLUSION

The prevalence of iron deficiency anemia poses a significant health problem in women of childbearing age in Nunavik. A third of these women are affected by anemia and nearly half of women aged 18 to 29 are iron deficient. Most anemias (60%) in women 18 to 49 are related to iron deficiency. Among women 50 and over, half of them are anemic and 8%^E suffer from IDA. Thus, a high proportion of anemia in this age group is probably due to infection or inflammation. Adverse effects of iron deficiency on health and productivity are well documented. Results of the present study, particularly those concerning characteristics of women related to iron status, will help to identify which Nunavik women are at higher risk of iron deficiency anemia.

Also, given that new mothers, pregnant women and women aged 18 to 29 showed a prevalence of iron deficiency anemia of more than 20%, their poorer iron

status should be of major concern. The WHO recommends universal supplementation in cases of IDA prevalence between 20 and 30%. Nevertheless, since iron supplementation is a short-term solution and compliance is low, long-term intervention programs in nutrition must be considered for Nunavik. Moreover, targeting the prenatal period should be considered given that it is important to prevent iron deficiency before pregnancy since “strong evidence shows that iron deficiency in the first trimester of pregnancy results in significant decrements in fetal growth” (Beard, 2000: 1289S). Additionally, Nunavik has high rates of teen pregnancies, 8% of births being from women under age 18, a rate 10 times greater than the provincial rate (ministère de la Santé et des Services sociaux (MSSS), 2004). Since expectant teenage mothers are at even greater risk of iron deficiency anemia (Viteri, 1998), teenage girls in Nunavik should also be targeted in prevention programs.

KEY ISSUES

- ↪ Anemia and iron deficiency each affect more than a third of non-pregnant women in Nunavik while iron deficiency anemia is present in about one out of six women.
 - ↪ Iron deficiency is present in about 40% of the women of childbearing age (18 to 49). Therefore, most anemias are due to iron deficiency in those women.
 - ↪ Among women 50 and over, iron deficiency is present in 1 out of 10 women but more than half are affected by anemia. Therefore, the high anemia prevalence in these women is probably due primarily to the impairment of iron metabolism caused by chronic disease.
 - ↪ Among pregnant women, rates of iron deficiency and iron deficiency anemia reach two thirds and one third of expectant mothers respectively, which is higher than in non-pregnant women. Poorer iron status was also noted in new mothers.
 - ↪ Food insecurity, smoking, heavy drinking and illicit drug use were also related to poorer iron status.
 - ↪ Being older and having higher personal income were associated with less iron deficiency.
- ↪ Higher consumption of sweets, chips and sweet beverages was associated with a higher prevalence of iron deficiency and iron deficiency anemia, whereas a higher consumption of country foods was associated with a lower rate of iron depletion.
 - ↪ A higher prevalence of inadequate iron intake the day prior to the interview was observed among women having depleted iron stores. Also, the prevalence of inadequate iron intake the day before the interview was higher among women affected by iron deficiency anemia compared with those who have anemia without iron deficiency.

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APPENDIX

Table A1

Prevalence of iron deficiency, iron deficiency anemia and anemia according to characteristics of non-pregnant women aged 18 to 74 years, Nunavik, 2004

Categories	Anemia (%)	ID (%)	IDA (%)
Age group			
18-29 years	33.3^a	47.8^b	22.6^b
30-49 years	33.2^a	36.2^b	17.9
50 years and +	53.3^b	9.8^{E a}	8.0^{E a}
Marital status			
Single	36.2	44.0^b	20.9
Married or common law	36.0	31.6^a	15.6
Separated, divorced or widowed	44.4 ^E	30.7^{E a}	19.3 ^E
Job status			
Work	31.8^a	33.0^a	15.7^a
Other	46.8^b	42.3^b	24.4^b
Income			
Less than \$20 000	36.8	39.9^b	18.3
\$20 000 and over	28.7	25.4^a	12.9 ^E
Education level			
Elementary school completed or less	50.2^b	18.3^{E a}	13.2 ^E
Secondary school not completed	36.2^a	46.1^b	22.0
Secondary school completed or higher	25.1^a	28.9^a	13.2 ^E
Food insecurity			
Yes	39.4	44.4^b	22.7
No	36.8	31.4^a	15.7
Smoking			
Yes	34.9	40.1^b	19.6
No	44.7	17.8^{E a}	12.3 ^E
No. of drinks at same occasion			
≤ 10 drinks	36.7	35.1^a	18.7
≥ 11 drinks	30.2 ^E	52.8^b	F
Illicit drug use			
Yes	34.2	47.3^b	23.2^b
No	37.7	27.3^a	14.0^a
Recent pregnancy			
Yes (< 4 years)	34.6	46.7^b	21.9^b
No (≥ 4 years or never)	38.3	26.9^a	14.3^a
Chronic health problem			
Yes	49.4^b	25.7^a	16.0 ^E
No	32.3^a	39.1^b	18.5
Menopausal status			
Yes	50.6^b	F	F
No	34.2^a	43.0	21.2

IDA = Iron deficiency anemia; ID = Iron deficiency as defined above; BMI = Body Mass Index.

^{a, b} Estimates in bold and with different exponent are significantly different ($p < 0.05$).

E Interpret with caution.

F Unreliable estimate.

Source: Nunavik Inuit Health Survey 2004.

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Qanuippitaa?

HOW ARE WE?

