IRON DEFICIENCY AND ANEMIA

QANUILIRPITAA? 2017

Nunavik Inuit Health Survey

ᓄᓇᕕᒻᒥ ᐃᓅᓯᓕᕆᔨᒃᑯᑦ ᑲᑎᒪᔨᖏᑦ
RÉGIE RÉGIONALE DE LA SANTÉ ET DES SERVICES SOCIAUX DU NUNAVIK
NUNAVIK REGIONAL BOARD OF HEALTH AND SOCIAL SERVICES

ᖁᓂᐃᓕᓴᐅᑉ?Qanuilirpitaa?
NUNAVIK 2017

IRON DEFICIENCY AND ANEMIA

QANUILIRPITAA? 2017

Nunavik Inuit Health Survey

ᓄᓇᕗᑦ ᐃᓕᓴᕐᓂᖅᓯᒪᔪᑦ ᑲᑎᒪᔨᖅ
RÉGIE RÉGIONALE DE LA SANTÉ ET DES SERVICES SOCIAUX DU NUNAVIK
NUNAVIK REGIONAL BOARD OF HEALTH AND SOCIAL SERVICES

Institut national de santé publique Québec

Nunavik Regional Board of Health and Social Services
P.O Box 900
Kuujjuaq, (Quebec) J0M 1C0
Phone number: 819-964-2222
Toll-free: 1 844-964-2244

Email: info@sante-services-sociaux.ca
Website: nrbhss.ca/en/health-surveys

Legal deposit – November 2020
Bibliothèque et Archives nationales du Québec
ISBN: 978-2-924662-15-1 (PDF)

AUTHORS

Audrey Lavoie
Direction de la santé environnementale et de la toxicologie
Institut national de santé publique du Québec
Département de médecine sociale et préventive,
Université Laval

Mélanie Lemire, PhD, Associate Professor
Département de médecine sociale et préventive,
Université Laval
Titular of the Littoral Research Chair – the Sentinelle North Partnership Research Chair in Ecosystem Approaches to Health
Axe santé des populations et pratiques optimales en santé – Centre de recherche du CHU de Québec – Université Laval

Benoit Lévesque, MD, MSc, Professor
Direction de la santé environnementale et de la toxicologie
Institut national de santé publique du Québec

Pierre Ayotte, PhD, Professor
Direction de la santé environnementale et de la toxicologie
Institut national de santé publique du Québec
Département de médecine sociale et préventive,
Faculté de médecine, Université Laval
Axe santé des populations et pratiques optimales en santé – Centre de recherche du CHU de Québec – Université Laval

EXECUTIVE DIRECTOR

Danielle St-Laurent, Director
Bureau d'information et d'études en santé des populations
Institut national de santé publique du Québec

SCIENTIFIC DIRECTORS

Pierre Ayotte, PhD, Professor
Département de médecine sociale et préventive,
Faculté de médecine, Université Laval
Axe santé des populations et pratiques optimales en santé – Centre de recherche du CHU de Québec – Université Laval
Institut national de santé publique du Québec

Françoise Bouchard, MD, MPH, FRCPC,
Director of Public Health
Nunavik Regional Board of Health and Social Services

STATISTICAL ANALYSIS

Marc-André Dubé, Statistician
Bureau d'information et d'études en santé des populations
Institut national de santé publique du Québec

Véronique Boiteau, Statistician
Bureau d'information et d'études en santé des populations
Institut national de santé publique du Québec

SCIENTIFIC EDITING

Marie-Josée Gauthier, Planning, Programming and Research Officer
Public Health Department
Nunavik Regional Board of Health and Social Services

Susie Gagnon, Scientific Advisor
Bureau d'information et d'études en santé des populations
Institut national de santé publique du Québec

LINGUISTIC REVISION

Alison McGain

VISUAL CREATION

Alphatek

COMMUNICATION

Nunavik Regional Board of Health and Social Services

SUGGESTED CITATION:

Lavoie, A., Lemire, M., Lévesque, B., Ayotte, P. (2020). Iron Deficiency and Anemia. Nunavik Inuit Health Survey 2017 *Qanuilirpitaa?* How are we now? Quebec: Nunavik Regional Board of Health and Social Services (NRBHSS) & Institut national de santé publique du Québec (INSPQ).

QANUILIRPITAA? 2017 HEALTH SURVEY

ACKNOWLEDGMENTS

On behalf of the Steering Committee, I would like to express my gratitude to all Nunavimmiut who participated in the *Qanuilirpitaa?* 2017 Health Survey.

This important health survey was made possible thanks to the long-lasting partnership between the Nunavik Regional Board of Health and Social Services, the *Institut national de santé publique du Québec* and researchers from the Centre de recherche du CHU de Québec – Université Laval, McGill University and Trent University.

The valuable contribution of Inuit research advisors, leaders from each community, as well as representatives from the Avataq Cultural Institute, the Ungava Tulattavik Health Centre, the Inuulitsivik Health Centre, the Kativik Regional Government, Kativik Ilisarniliriniq, Makivik Corporation, the northern villages and the Qarjuit Youth Council is gratefully acknowledged. The Steering Committee and the Data Management Committee of *Qanuilirpitaa?* 2017 guided and enriched this work throughout the different phases, from planning to data interpretation and contextualization.

We want to highlight the invaluable contribution of Pierre Ayotte and Françoise Bouchard, the scientific directors, and Danielle St-Laurent, the project's executive director. We are also indebted to Geneviève Hamel, Suzanne Bruneau, Suzanne Côté and Nathalie Ouellet who coordinated the planning and realization of the survey.

We are sincerely thankful to the Inuit interviewers who carried out exceptional work in often challenging circumstances.

We are also grateful to all of the professionals, technicians, students, ground team and clerical staff, as well as the crew of the Canadian Coast Guard Ship *Amundsen*.

Finally, this survey could not have been undertaken without the financial support of the Nunavik Regional Board of Health and Social Services, the Kativik Regional Government, Makivik Corporation, Kativik Ilisarniliriniq, the *ministère de la Santé et des Services sociaux du Québec*, ArcticNet, the Amundsen Science Ship Fund and the Northern Contaminants Program.

Numerous people have contributed at different stages of the survey process; many of them are listed below, and there are many more.

Minnie Grey

Chairperson, *Qanuilirpitaa?* Steering Committee
Executive Director, NRBHSS

In memory of Audrey Flemming and Linda Shipaluk.

PRINCIPAL INVESTIGATORS AND INUIT ADVISORS*

Adult component
Pierre Ayotte
Chris Furgal
Mélanie Lemire
Benoît Lévesque
Michel Lucas
Mary Pilurtuut

Youth component
Richard Bélanger
Gina Muckle
Louisa Yeates

Community component
Nancy Etok
Christopher Fletcher
Kitty Gordon
Betsy Palliser
Mylène Riva

Oral health
Aimée Dawson
Chantal Galarneau

Men's Health
Gilles Tremblay

STEERING COMMITTEE AND DATA MANAGEMENT COMMITTEE (DMC) PARTICIPANTS
Minnie Grey (Steering Committee chair)
Marie Rochette (DMC co-chair)
Robert Watt (DMC co-chair)
Alicia Aragutak
Ellen Avard
Jean-Etienne Bégin
Françoise Bouchard
Suzanne Bruneau
Marie-Noëlle Caron
Maria Cengarle
Yasmine Charara
Suzanne Côté
Serge Déry
Aleashia Echalook
Mona Eepa Belleau
Maggie Emudluk
Barrie Ford
Susie Gagnon
Marie-Josée Gauthier
Yoan Girard
Lucy Grey
Geneviève Hamel
Olivia Ikey
Suzy Kauki
Elena Koneak Labranche
Christine Leblanc
Stéphanie Léveillé
Eliana Manrique
Murray McDonald
Jennifer Munick
Tunu Napartuk
Jeannie Nungak
Josepi Padlayat
Geneviève Pellerin
Fabien Pernet
Maata Putugu
Hilda Snowball
Danielle St-Laurent
Jobie Tukkiapik
Larry Watt
Shirley White-Dupuis

INTERVIEWERS/NURSES
Linda Amidlak
Thomas Annanak
Lydia Audlaluk
Jeannie Calvin
Caroline Couture
Louis-Frédéric Daigle
Véronique Dion Roy
Geneviève Dorval
Véronique Doutreloux
Philippe Dufresne
Victoria E. Forest
Audrey Flemming
Jeannie Flemming
Elisabeth Gagné
Virginie Gargano
Suzie Gordon
Sarah Imak
Léa Laflamme
Pierre Lejeune
Alexandre Léveillé
Paul Marcoux
Josée Michaud
Laura McKeeman
Claude Morency
Caroline Moisan
Julie Nastapoka
Julie Picard
Michel Poulin
Linda Shipaluk
Évelyne Thibault
Mina Tukai
Amelia Tukkiapik Whiteley

COMMUNICATION AND TRANSLATION
Minnie Amidlak
Annie Baron
Nicolas Baltazar
Brigitte Chalifoux
Caroline D'Astous
Nina Gilbert
Alasie Hickey
Nathalie Labonté
Irène Langis
Josée Lévesque
Robert Mackey
Émilie Pelletier
Eva Pilurtuut
Ida Saunders
Jenny Simpraseuth
Rhéal Séguin

DENTISTS/RESPIRATORY THERAPISTS
Élaine Audet
Lucie Bélanger
Hélène Fournier-Noël
Marie-Rose Gagnon Beaumont
Isabelle Gauthier
Gabrielle Gingras
Ariane H. Morin
Cassiopée Paradis-Gagnon

GROUND-STAFF
Stéphane Anctil
Julien Arsenault
Marie Bernard
Justine Blanco Lalande
Christian Brunet
Virginie Chadenet
Catherine Godin
Josianne Grenier
Dominique Hamel
Robert Ladouceur
Trina Manac'h
Laurence Millette
Guillaume Proulx
Sylvie Ricard
Camille Tremblay-Fournier
As well as all local research assistants and local logistics staff

ADMINISTRATIVE SUPPORT AND INFORMATIC TECHNOLOGIES
Vincent Gilbert
Denis Granghon
Eva Gunn
Ginette Laflamme
Liv Larsen
Richard Leboeuf
Sylvie Muller

DATA PROCESSING, QUALITY CONTROL AND LAB WORK
Véronique Boiteau
Marc-André Dubé
Marianne Dubé
Denis Hamel
Judith Labrecque
Jacinthe Larochelle
Caroline Moisan
Nathalie Ouellet
Louis Rochette
Mélanie St-Onge
Mélanie Tessier
Hamado Zoungrana

COMMUNITY COMPONENT/ MOBILIZATION
David Arsenault
Marie Baron
Imane Cheriet
Marie-Hélène Dion-Gagnon
Sarah Fraser
Melody Lynch
Marie-Claude Lyonnais
Cindy Ruel

AND MANY MORE!

** Each name is listed only once even though it may have been mentioned in more than one category.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ACI	Anemia of chronic inflammation
BMI	Body mass index
CBC	Complete blood count
CCGS	Canadian Coast Guard Ship
CHMS	Canadian Health Measures Survey
CV	Coefficient of variation
eGFR	Estimated glomerular filtration rate
FFQ	Food frequency questionnaire
Hb	Hemoglobin
hs-CRP	High sensitivity C-reactive protein
H. pylori	Helicobacter pylori
ID	Iron deficiency
IDA	Iron deficiency anemia
IDE	Iron deficient erythropoiesis
IDWA	Iron deficiency without anemia
IgG	Immunoglobulin G
IHS	Inuit Health Survey
INSPQ	Institut national de santé publique du Québec
MCV	Mean corpuscular volume
PR	Prevalence ratio
SAT	Stool antigen test
SF	Serum ferritin
SI	Serum iron
TIBC	Total iron binding capacity
TSAT	Transferrin saturation
UA	Unexplained anemia
WHO	World Health Organization

1 BACKGROUND OF THE *QANUILIRPITAA?* 2017 HEALTH SURVEY

The *Qanuilirpitaa?* 2017 Health Survey is a major population health survey conducted in Nunavik that involved the collection, analysis and dissemination of information on the health status of Nunavimmiut. The last health survey conducted prior to it in Nunavik dated from 2004. Since then, no other surveys providing updated information on the health of this population had been carried out. Thus, in February 2014, the Board of Directors of the Nunavik Regional Board of Health and Social Services (NRBHSS) unanimously adopted a resolution to conduct a new health survey in all 14 Nunavik communities, in support of the Strategic Regional Plan.

The general objective of the 2017 health survey was to provide an up-to-date portrait of the health status of Nunavimmiut. It was also aimed at assessing trends and following up on the health and health determinants of adult participants since 2004, as well as evaluating the health status of Nunavik youth. This health survey has strived to move beyond traditional survey approaches so as to nurture the research capabilities and skills of Inuit and support the development and empowerment of communities.

Qanuilirpitaa? 2017 included four different components: 1) an adult component to document the mental and physical health status of adults in 2017 and to follow up on the adult cohort of 2004; 2) a youth component to establish a new cohort of Nunavimmiut aged 16 to 30 years old and to document their mental and physical health status; 3) a community component to establish the health profiles and assets of communities in a participatory research approach; and 4) a community mobilization project aimed at mobilizing communities and fostering their development.

This health survey relied on a high degree of partnership within Nunavik (Nunavik Regional Board of Health and Social Services, Makivik Corporation, Kativik Regional Government (KRG), Kativik Ilisarniliriniq (KI), Avataq Cultural Institute, Qarjuit Youth Council, Inuulitsivik Health Centre, Ungava Tulattavik Health Centre), as well as between Nunavik, the Institut national de santé publique du Québec (INSPQ) and academic researchers from three Canadian universities: Université Laval, McGill University and Trent University. This approach followed the OCAP principles of Ownership, Control, Access and Possession (First Nations Center, 2007) (First Nations Information Governance Centre, 2007).[1] It also emphasized the following values and principles: empowerment and self-determination, respect, value, relevance and usefulness, trust, transparency, engagement, scientific rigour and a realistic approach.

TARGET POPULATION

The survey's target population was all permanent Nunavik residents aged 16 years and over. Persons living full time in public institutions were not included in the survey. The most up-to-date beneficiaries register of all Inuit living in Nunavik, obtained from the Makivik Corporation in spring 2017, was used to construct the main survey frame. According to this register, the population of Nunavik was 12 488 inhabitants spread out in 14 communities. The register allowed respondents to be selected on the basis of age, sex and coast of residence (Hudson coast and Ungava coast).

SURVEY FRAME

The survey used a stratified proportional model to select respondents. Stratification was conducted based on communities and age groups, given that one of the main objectives of the survey was to provide estimates for two subpopulations aged, respectively, 16 to 30 years and 31 years and over. In order to obtain precise estimates, the targeted sample size was 1 000 respondents in each age group. Assuming a 50% response rate, nearly 4 000 people were required to obtain the necessary

1. OCAP® is a registered trademark of the First Nations Information Governance Centre (FNIGC).

sample size. From this pool, the number of individuals recruited from each community was proportionate to population size and took into account the number of days that the survey team would remain in each community – a situation that imposed constraints on the number of participants that could be seen. Within each stratum, participants were randomly selected from the beneficiaries register. However, the individuals from the 2004 cohort, all 31 years old and over (representing approximately 700 individuals), were automatically included in the initial sample.

DATA COLLECTION

Data were collected from August 19, 2017 to October 5, 2017 in the 14 villages. The villages were reached by the *Amundsen*, a Canadian Coast Guard Icebreaker, and participants were invited on board the ship for data collection purposes.

Two recruitment teams travelled from one community to another before the ship's arrival. An Inuk assistant in each community helped: identify, contact and transport (if necessary) each participant; inform participants about the sampling and study procedures; obtain informed consent from participants (video) and fill in the identification sheet and sociodemographic questionnaire.

Data collection procedures for the survey included questionnaires, as well as clinical measurements. The survey duration was about four hours for each wave of participants, including their transportation to and from the ship. Unfortunately, this time frame was sometimes insufficient to complete the data collection process. This survey received ethical approval by the Comité d'éthique de la recherche du Centre Hospitalier Universitaire de Québec – Université Laval.

Aboard the ship, the survey questionnaires were administered by interviewers, many of whom were Inuit. Face-to-face interviews were conducted using a computer-assisted interviewing tool. If there were problems with the laptop connections, paper-form questionnaires were filled out. The questionnaires were administered in Inuktitut, English or French, according to the preference of the participants. Interviewers received training in administering the questionnaires prior to the start of the survey. The questionnaires were divided into five blocks: psychosocial interview (blocks 1 and 3), physical health and food security interview (block 2), food frequency questionnaire (block 4), and sociodemographic interview (block 5).

The survey also included a clinical component, with tests to document aspects of physical health, sampling of biological specimens (such as blood, oropharyngeal swabs, urine, stool, and vaginal swabs), spirometry, and an oral clinical exam. These sessions were supervised by a team comprised of nurses, respiratory therapists, dentists, dental hygienists and assistants, and laboratory technicians.

PARTICIPATION

There were a total of 1 326 participants, including 574 Nunavimmiut aged 16 to 30 years old and 752 Nunavimmiut aged 31 years and over, for total response rates of 30.7% and 41.5%, respectively. The participants' distribution between the two coasts (Ungava and Hudson) was similar. The distribution of men and women was unequal, with twice as many women (873) than men (453) participating in the survey. If the results obtained from this sample are to be inferred to the target population, survey weights must be used.

Overall, as compared to the 2004 survey, the response rate (i.e., the rate of participants over the total number of individuals on the sampling list) was lower than expected, especially among young people. This includes the refusal rate and especially a low contact rate. Several reasons might explain the low response rate, including the short time period available to contact individuals prior to the ship's arrival in the community and non-contact due to people being outside of the community or on the land. Nevertheless, among the individuals that were contacted (n = 1 661), the participation rate was satisfactory with an internal participation rate of 79.7% More details on the collection, processing and analysis of the data are given in the Methodological Report (Hamel, Hamel, & Gagnon, 2020).

2 INTRODUCTION

Anemia from all causes affects approximately one third of the population worldwide (World Health Organisation (WHO), 2017). This health condition is characterized by a decreased hemoglobin (Hb) concentration in the blood, limiting the capacity of red blood cells to transport oxygen to the different organs/tissues of the body. The etiology of anemia is context-specific (population group, region, general environment) and multifactorial; causes include nutritional deficiencies, chronic infections and non-communicable diseases, acute and chronic hemorrhages, and inherited blood disorders, among others (Petry et al., 2016). Anemia is often classified into three categories: iron deficiency anemia (IDA), anemia of chronic inflammation (ACI) and unexplained anemia (UA).

Iron deficiency (ID), commonly assumed to cause half of all cases of anemia, is the most prevalent nutritional deficiency worldwide (Lynch, 2007). It is most prevalent among young children, women of childbearing age, and individuals living in developing countries (WHO, 2015). ID progresses through three overlapping stages: iron depletion, iron deficient erythropoiesis (IDE) and IDA (WHO, 2017). The main causes of ID are inadequate iron intake, increased iron needs and high iron loss (Lynch, 2007). Since iron status relies substantially on dietary iron intake, a daily diet must have sufficient amounts of bioavailable iron. However, some food components, such as tannins and polyphenols in tea, phytates in grains, and calcium can act as iron inhibitors, reducing iron absorption when they are consumed together (Hurrell & Egli, 2010). Vitamin C, on the other hand, enhances iron absorption and can overcome the negative effects of all inhibitors on iron absorption (Hurrell & Egli, 2010). Consequences of ID arise at every stage of severity and can be observed as early as during the iron depletion stage, in the form of delayed or impaired cognitive development in children, an alteration of immune defence mechanisms and a decrease in energy and work performance (Beard, 2001). In addition to these repercussions, anemia of all causes can lead to impaired motor development in children, heart failure and renal failure in older adults, while it can increase hospitalization, disability, and mortality in more severe cases (Kassebaum et al., 2014; Penninx et al., 2003). According to the WHO, anemia is a significant public health concern, having major consequences on human health and social and economic development (WHO, 2017). Indeed, between 1990 and 2010, anemia was responsible for 68.3 million years of life lost to disability worldwide, outstripping the number lost to major depression or chronic respiratory diseases (Kassebaum et al., 2014).

Although the prevalence of ID (4%) and anemia (3%) in the general Canadian population are among the lowest in the world (Cooper, Greene-Finestone, Lowell, Levesque, & Robinson, 2012), both outcomes have been a cause of concern in the Canadian Arctic for many years. Results from the previous *Qanuippitaa?* health survey conducted in 2004 indicated that ID and anemia affected 36% and 43% of non-pregnant women, respectively (Plante, Blanchet, Rochette, & O'Brien, 2011). In the same survey, women aged 50 years and over had a lower prevalence of ID than women of childbearing age (18 to 49 years). After menopause, iron loss from menstrual bleeding ceases and subsequently, iron requirements are lower, decreasing the risk of ID. In contrast, pregnancy is associated with higher rates of ID and anemia due to physiological hemodilution and increased iron needs for the fetus (Centers for Disease Control & Prevention, 1998).

Furthermore, the Inuit Health Survey of 2007-2008 (IHS) revealed that 6.5% of men and 29.4% of women living in the Inuit Nunangat (excluding Nunavik) had ID, while 16.1% of men and 21.7% of women were anemic (Jamieson, Weiler, Kuhnlein, & Egeland, 2012, 2013). The prevalence difference between men and women can be attributed to distinctive physiological phenomena, such as menstrual blood loss, periods of increased iron requirement, such as pregnancy, or hormonal differences (Murphy, 2014). The prevalence of ID and anemia among Nunavik men has yet to be documented but is expected to be comparable to that of men from other Inuit populations in Canada.

Nunavimmiut have been experiencing an important dietary transition in the past decades, characterized by a decrease of nutrient-rich country foods and an increase in nutrient-poor market foods (Krümmel, 2009). These changes have been associated with an increased risk of nutritional deficiencies (Jamieson et al., 2012). Alongside

ID, other nutritional deficiencies can also lead to anemia. Indeed, folic acid and vitamin B12, among others, are central components to the normal production of red blood cells (Fishman, Christian, & West, 2000).

Moreover, higher rates of chronic diseases, Helicobacter pylori (*H. pylori*) infection and obesity among Inuit in Canada could lead to ACI (Christofides, Schauer, & Zlotkin, 2005). Hepcidin – a peptide hormone released by the liver – is elevated during inflammation and decreases iron absorption, iron recycling and iron stores mobilization, leading to low circulating iron despite adequate iron stores, and thereafter anemia (Nemeth & Ganz, 2006). *H. pylori*, a gastrointestinal infection affecting Arctic populations disproportionally (Goodman, Jacobson, & van Zanten, 2008), is associated with ID and anemia through inflammation and several other mechanisms. First, *H. pylori* causes gastric hypoacidity, which, in turn, reduces iron absorption. Second, the bacteria can also compete for iron. Third, iron loss via gastrointestinal bleeding is another possible mechanism (Barabino, 2002). Several research groups have studied the association between *H. pylori* and anemia in different Inuit populations, but the results remain controversial (Baggett, Parkinson, Muth, Gold, & Gessner, 2006; Centers for Disease Control & Prevention, 1988; Miernyk et al., 2013; Parkinson et al., 2000).

Obesity, which is considered a low-grade inflammatory disease (Greenberg & Obin, 2006), has previously been associated with increased ID prevalence among various populations (Menzie et al., 2008; Nead, Halterman, Kaczorowski, Auinger, & Weitzman, 2004). However, studies in Inuit populations have yielded opposite associations. Jamieson, Weiler, Kuhnlein, and Egeland (2016) reported that adiposity was positively associated with Hb among Canadian Inuit and obesity was negatively associated with ID among women in the Inuit Nunangat (Jamieson et al., 2013). They also suggested that this association could be due to the fact that obese Canadian Inuit consumed more calories from iron-rich country foods and other nutrients (Kuhnlein, Receveur, Soueida, & Egeland, 2004) compared to normal weight individuals.

High exposure to lead is also recognized as a potential risk factor for anemia (Hegazy, Zaher, Abd el-hafez, Morsy, & Saleh, 2010; Jain et al., 2005). Lead exposure among Nunavimmiut which is higher than in the general Canadian population, has been attributed to the use of lead ammunition for hunting (Couture et al., 2012). Conversely, reverse causality must be considered since divalent metals such as lead share common absorptive pathways with iron (Flanagan, Haist, & Valberg, 1980). Thus, as ID triggers the upregulation of divalent metal transporters, it increases the intestinal absorption not only of iron but of lead as well (Margrete Meltzer et al., 2010). In 2004, Plante et al. (2011) found no association between blood lead concentrations and anemia among Nunavimmiut.

Low selenium has been shown to be a risk factor for anemia in various populations (Semba et al., 2006; Van Nhien et al., 2009). The selenium status of Nunavimmiut is very high compared to other populations (Lemire et al., 2015). In Nunavimmiut blood, selenium is mainly present in the form of selenoneine, an organoselenium compound that accumulates in red blood cells (Achouba et al., 2019). Selenoneine possesses antioxidant properties (Yamashita & Yamashita, 2010), and could potentially help protect against the oxidation of Hb and myoglobin, and in turn premature red blood cell aging (Yamashita, Yabu, & Yamashita, 2010).

Recent studies have reported a relation between vitamin D deficiency and anemia in various populations (Monlezun, Camargo, Mullen, & Quraishi, 2015; Nikooyeh & Neyestani, 2018; Uwaezuoke, 2017). Although the exact mechanism is unknown, some have suggested that vitamin D has anti-inflammatory properties; therefore vitamin D deficiency could lead to ACI (Sim et al., 2010; Smith & Tangpricha, 2015). There is also evidence that vitamin D may have a more direct role in erythropoiesis, stimulating erythroid precursors proliferation (Alon et al., 2002; Sim et al., 2010; Smith & Tangpricha, 2015).

Finally, reduced renal function, even without a renal failure diagnosis, is associated with an inadequate production of red blood cells, and therefore higher rates of anemia (Makipour, Kanapuru, & Ershler, 2008).

Inuit culture, livelihood and being on the land are important determinants of Nunavimmiut health (Inuit Tapiriit Kanatami, 2014). Strong associations between socioeconomic factors and different health outcomes have already been well documented in both non-Inuit (Braveman & Gottlieb, 2014) and Inuit populations (Garner, Carrière, Sanmartin, & Team, 2010). In 2004, a lower socioeconomic status was associated with a higher prevalence of ID and anemia among Nunavimmiut women (Plante, Blanchet, & Turgeon O'Brien, 2007). Food insecurity has also been recognized as a risk factor for ID and anemia among Inuit populations (Egeland, Johnson-Down, Cao, Sheikh, & Weiler, 2011; Pirkle et al., 2014; Plante et al., 2007). Indeed, Jamieson et al. (2012) reported that the lack of a hunter in the home, a potential precursor to food insecurity, was a risk factor for ID among men.

In Nunavik, there are many public health initiatives aiming to prevent anemia and ID among children (Gagne et al., 2013) and pregnant women (such as *Ilagiilluta*). However, despite its clinical importance, anemia among the general adult population, and particularly among the elderly, does not receive its requisite attention in public health worldwide, potentially due to its complex pathophysiology (Kassebaum et al., 2014). It is essential to determine context-specific prevalence of anemia in Nunavik as well as protective and risk factors, in order to develop and implement appropriate local public health interventions to tackle this preventable and treatable health problem.

Surveillance of ID and anemia is challenging, as it requires the use of several clinical biochemistry and hematological tests to diagnose these conditions. In the framework of the *Qanuilirpitaa?* 2017 Health Survey, these diagnostic tests were performed, and data was collected to determine the prevalence of ID and anemia as well as their protective/risk factors.

OBJECTIVES

This report aims to determine the prevalence of ID and anemia and their associated protective and risk factors among Nunavimmiut aged 16 and over.

The specific objectives of this report are to:

- Determine the prevalence of ID and anemia (total, according to severity and type) within this population.
- Compare these results to those of *Qanuippitaa?* 2004 (among women 18 years and over), other Inuit populations in Canada, as well as the general Canadian population.
- Identify protective and risk factors associated with ID and different types of anemia.

3 METHODOLOGICAL ASPECTS

STUDY POPULATION

A total of 1 326 individuals participated in the data collection process onboard the CCGS *Amundsen*, and among them, 93.9% provided a blood sample. The study sample consisted of 1 245 participants aged 16 and over, including 30 pregnant women. Pregnant women were excluded from all bivariate analysis; only their prevalence of anemia and ID is reported in this report.

DATA COLLECTION AND LABORATORY ANALYSES

Blood sample collection and laboratory analyses

Blood samples were collected by venipuncture performed by nurses. Complete blood count (CBC), including Hb and mean corpuscular volume (MCV), was performed onboard the CCGS *Amundsen* using a portable DxH500 hematology analyzer from Beckman-Coulter (Pasadena, CA, USA).

Serum ferritin (SF), iron (SI), transferrin saturation (TSAT), total iron binding capacity (TIBC), vitamin D, vitamin B12 and creatinine [to estimate glomerular filtration rate (eGFR)], and erythrocyte folate were determined using a MODULAR *ANALYTICS* e170 from Roche Diagnostics GmbH (Mannheim, Germany).

H. pylori antibodies (IgG) analysis was carried out using a Captia™ ELISA kit from Trinity Biotech (Bray, Ireland), while whole blood lead and selenium concentrations were determined using inductively coupled plasma mass spectrometry (ICP-MS) with the NexION® instrument from PerkinElmer (Cleveland, Ohio, USA). Finally, serum high-sensitivity C-reactive protein (hs-CRP) was determined using an Integra 800 from Roche Diagnostics and served as the indicator for measuring inflammation. A hs-CRP level equal to or greater than 10 mg/L indicates a clinically significant inflammatory process. Additionally, a hs-CRP level equal to or greater than 3 mg/L but below 10 mg/L indicates minor inflammation, which has recently been associated with several health conditions (Kushner & Antonelli, 2015; Kushner, Rzewnicki D Fau – Samols, & Samols, 2006).

Analyses were performed for the most part at the Institut universitaire de cardiologie et de pneumologie du Québec in Quebec City, except for lead and selenium analyses which were conducted at the Centre de toxicologie du Québec (Quebec, QC) and serum *H. pylori* antibody (IgG) analyses, which were conducted at the Hôpital de Chicoutimi (Chicoutimi, QC).

Participants were asked to collect a stool sample at home and to bring it with them onboard the CCGS *Amundsen* during their appointment. A stool antigen test (SAT) was performed at the Hôpital de Granby (Granby, QC) to determine current *H. pylori* infection (HpSA; Meridian Diagnostics, Cincinnati, OH, USA).

Anthropometric assessment

Anthropometric measurements were collected in order to assess the weight status of participants. Height was measured in centimetres by a nurse using a measuring tape while participants were barefoot and standing on a solid surface against a wall. Weight was measured using a body composition analyzer from InBody (Beverly Hills, California, USA). Subsequently, body mass index (BMI; kg/m^2) was calculated for each participant. Normal weight, overweight and obesity categories were defined using the WHO classification for adults and the BMI-for-age charts for participants aged 16 and 17 years (Cole, Bellizzi, Flegal, & Dietz, 2000). Very few Nunavimmiut were underweight (1.7%) and those that were, were added to the normal weight category.

Dietary assessment and questionnaires

Dietary intake was assessed using a food frequency questionnaire (FFQ). The FFQ measured the frequency of intake for each item in the past three months, but serving sizes were not considered. The FFQ collected information on food intake, dividing the data into two major food

groups: country food (food obtained from hunting, fishing and harvesting) and market food (any store-bought food, which is mostly imported). In addition to the FFQ, questionnaires to document food security, lifestyle habits, and sociodemographic and health characteristics were administered by trained interviewers. An adapted version of the Household Food Security Survey Module (HFSSM) was used to measure food insecurity. Additionally, household overcrowding was quantified using the people per room (PPR) index; crowding occurs if there is more than one person per room. A list of variables used for bivariate analysis as well as the questionnaire from which they were obtained are presented in Table 1[2].

Table 1 List of variables used for bivariate analysis

Source	Variables	Additional information
PHFSI (block 2)	Perceived health and food security.	
PSI (block 3)	Recent pregnancy (in the past 12 months).	
FFQ (block 4)	Consumption of different country food and market food.	
SDI (block 5)	Sex, age, ecological region, community size, employment status, income, education level, marital status, overcrowding, going on the land and practicing traditional activities.	Traditional activities = harvesting, hunting, going on the land and sewing

PSI = psychosocial interview; PHFSI = physical health and food security interview; FFQ = food frequency questionnaire; SDI = sociodemographic interview.

Medical chart review

A few weeks after data collection on board the CCGS *Amundsen*, medical chart reviews were performed by trained research nurses, in order to collect information related to lifetime past medical history. For this thematic report, information was obtained on the diagnosis of a chronic disease (including cardiac and metabolic diseases, cancers, respiratory problems, and chronic infections) and on prescribed medication.

ASSESSMENT OF IRON DEFICIENCY AND ANEMIA

Different biochemical parameters were used to assess iron status among participants; however, none of these parameters were capable of measuring all three overlapping stages of ID. Therefore, a combination of available indicators was used to assess ID. Indeed, the use of multiple indices helps identify cases of ID that would have been missed with a single indicator (Patterson, Brown, Roberts, & Seldon, 2001; Plante et al., 2011; Turgeon O'Brien, Blanchet, Gagné, Lauzière, & Vézina, 2016). Serum ferritin (SF) is the sole best indicator of iron depletion (SF < 15 µg/L); however, since it is an acute phase protein, it increases with inflammation, even when iron stores are depleted (WHO & CDC, 2004). Therefore, it was necessary to increase the iron depletion threshold to SF < 50 ug/L in the presence of inflammation (hs-CRP ≥ 10 mg/L). Thus, the use of two cut-offs for SF allowed the identification of more participants with depleted iron stores than when only SF was used, irrespective of inflammation (Turgeon O'Brien et al., 2016). Moreover, in the absence of inflammation (hs-CRP < 10 mg/L), a third category was also used to assess ID when iron stores were low but not depleted (SF = 15-20 µg/L), in combination with at least two abnormal values among three iron status indicators (SI < 10 µmol/L, TSAT < 15% and/or TIBC ≥ 68 µmol/L) (Greig, Patterson, Collins, & Chalmers, 2013; Plante et al., 2011; Vieira et al., 2007). Since iron deficiency without the presence of anemia (IDWA) has also been associated with different health consequences, it was also measured among Nunavimmiut.

In this study, anemia was defined as a Hb concentration below 130 g/L for men and below 120 g/L for non-pregnant women (WHO, 2011). Hb values were adjusted for smoking status, as suggested by the Centers for Disease Control & Prevention (1989) and WHO (2017). IDA was

2. Please refer to the Methodological Report for survey questionnaires.

defined as the presence of anemia and ID simultaneously. The presence of anemia without ID and with SI < 10 µmol/L was indicative of ACI (Cash & Sears, 1989). Finally, when anemia was present without ID and SI ≥ 10 µmol/L, it was classified as UA. The algorithm of classification for ID and anemia among men and non-pregnant women is presented in Appendix A.

In the case of pregnant women, anemia was defined as a Hb concentration below 110 g/L during the first and third trimester and below 105 g/L during the second trimester. These specific cut-offs consider the physiological blood volume expansion occurring during pregnancy (Centers for Disease Control & Prevention, 1998). Additionally, since hs-CRP is systematically elevated during pregnancy (Pavord et al., 2019; Picklesimer et al., 2008), there are no known cut-offs for SF based on inflammation (O'Brien & Ru, 2017). Therefore, ID during pregnancy was assessed using the most recommended and clinically used cut-off of SF < 30 µg/L (Pavord et al., 2019).

ASSESSMENT OF PROTECTIVE AND RISK FACTORS

Potential correlates of ID and anemia were selected from biochemical parameters, and different socioeconomic, health and lifestyle determinants according to the scientific literature (Cooper et al., 2012; Jamieson & Kuhnlein, 2008; Plante et al., 2011). To ensure a more holistic approach to the complexity of the etiology of anemia in Nunavik, key social determinants of Inuit health highlighted by Inuit Tapiriit Kanatami (2014) were also selected. The conceptual framework used to synthesize potential determinants as well as the relations between them was adapted from UNICEF's conceptual framework of the determinants of child undernutrition (UNICEF, 2013). It is presented in Appendix B.

STATISTICAL ANALYSIS

As in many probability-based surveys, a design weight was applied to each participant to account for the probability of being selected in each unit of stratification. The weight used for estimations was based on the design weight but also adjusted to consider the global non-response and the test-specific non-response.

Sample variance was estimated using the bootstrap method. Coefficients of variation (CVs) were used to assess the precision of estimates. The Institut de la statistique du Québec has suggested CV thresholds to assure dissemination of high-quality estimates. Marginal estimates (CV between 15% and 25%) are identified with an asterisk and should be interpreted with caution due to high sampling variability. Unacceptable estimates (CV > 25%) are identified by double asterisks and are provided for illustrative purposes only. Finally, when estimates are based on fewer than 5 participants, the results are not presented.

The descriptive statistics used for this study were prevalence, arithmetic and geometric means and medians. When a variable was not normally distributed, the median was presented instead of the arithmetic mean. The main outcome variables were ID, IDWA, IDA, ACI, UA and total anemia. The prevalence of the different outcome variables was presented according to age, sex, and red blood cell size. The prevalence of ID and anemia was presented for women who were pregnant at the time of the survey. However, the number of pregnant women was insufficient to permit further analyses.

Data from the Nunavik Inuit Health Survey *Qanuippitaa?* 2004 were also reanalyzed using the same methodology, in order to accurately compare women aged 18 years and over from 2004 and 2017. The *Qanuippitaa?* 2004 survey methodology is described elsewhere (Rochette & Blanchet, 2007).

The dependent variables used for bivariate analyses, were ID, IDWA, IDA, ACI, UA and total anemia. The independent variables were socioeconomic, health and lifestyle determinants, biochemical parameters, as well as daily intake of different food items. To compare a dependent variable with an independent variable with two or more categories, the global chi-square test for independence was used to determine if there was any association between the two variables. When this global test was significant ($p < 0.05$), two-by-two comparisons were carried out using the Wald statistic on the difference of the logit transformations of the estimated proportions. In order to make sense of the relative effect of a determinant (risk or protective factor) on a dependent variable, prevalence ratios (PR) instead of prevalence are presented in the text (for statistically significant associations). All statistical analyses were conducted using the SAS software package (SAS® Institute Inc; Cary, NC) by statisticians from the Institut national de santé publique du Québec.

4 RESULTS

PREVALENCE OF IRON DEFICIENCY AND ANEMIA

Iron deficiency and anemia

The overall prevalence of ID and IDWA in Nunavimmiut aged 16 and over was 18% and 12%, respectively (Table 2). ID and IDWA were significantly more prevalent in women (26% and 18%) than in men (10%* and 6%*). About a third of women aged between 16 and 49 exhibited ID, compared to 7% of women aged 50 and over. No age-related trend in ID prevalence was noted among men. Three out of four pregnant women (73%) were classified as iron deficient using the recommended cut-off of SF < 30 µg/L (data not shown). Anemia from all causes was present in 15% of men and 23% of women, and the prevalence was higher in Nunavimmiut aged 50 and over than in younger individuals (both sexes). One-third of pregnant women (37%) were anemic (data not shown).

Table 2 Prevalence of iron deficiency, iron deficiency without anemia† and anemia among Nunavimmiut according to age group and sex, population aged 16 years and over, Nunavik, 2017

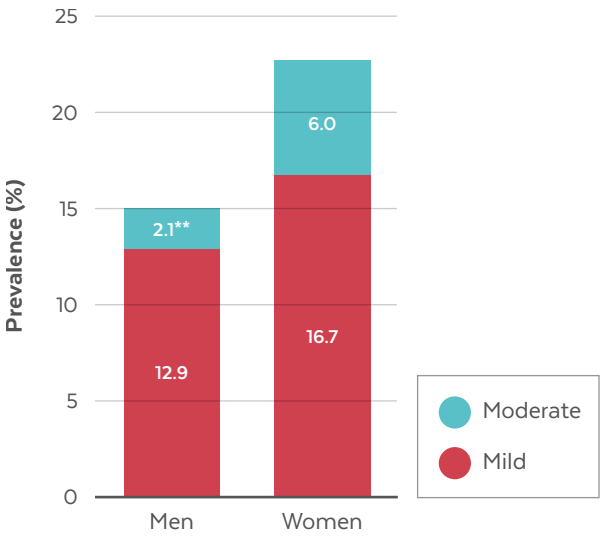
	Total			Men			Women		
	Prevalence (%)	95% CI		Prevalence (%)	95% CI		Prevalence (%)	95% CI	
		from	to		from	to		from	to
Iron deficiency									
16 – 29 years	**21.2**[b]	17.9	25.0	9.5*	5.8	15.3	**34.3**[b]	29.5	39.4
30 – 49 years	**20.8**[b]	16.9	25.3	11.4**	6.7	18.7	**30.4**[b]	24.6	37.0
50 years and over	**7.9***[a]	5.1	11.9	8.8**	4.6	16.2	**7.0****[a]	3.9	12.2
Total	17.8	15.7	20.2	***10.0****	7.2	13.7	***26.0***	23.0	29.3
Iron deficiency without anemia									
16 – 29 years	**13.4**[b]	10.5	16.8	4.3**	1.8	9.9	25.2	20.5	30.6
30 – 49 years	**13.8**[b]	10.3	18.4	8.0**	3.9	15.8	20.2*	14.7	27.1
50 years and over	**4.4****[a]	2.0	9.5	NP	NP	NP	NP	NP	NP
Total	11.6	9.7	13.9	***5.8****	3.5	9.3	***18.4***	15.3	21.9
Anemia									
16 – 29 years	**15.0**[b]	12.1	18.6	**8.6****[b]	5.1	14.3	**22.2***[b]	17.9	27.1
30 – 49 years	**16.2**[b]	12.2	21.1	**14.1***[b]	8.5	22.4	**18.3**[b]	13.6	24.2
50 years and over	**28.8**[a]	23.9	34.4	**28.0**[a]	20.7	36.8	**29.6**[a]	23.4	36.8
Total	18.8	16.5	21.3	***15.0***	11.8	18.9	***22.7***	19.7	26.0

a, b Estimates in **bold** and with different supercripts are statistically different between age groups ($p < 0.05$).
Estimates in ***bold and italics*** are statistically different between men and women of all age groups combined ($p < 0.05$).
* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** The coefficient of variation is greater than 25%. The proportion is shown for information only.
NP Data not presented ($n < 5$).
† Prevalence among non-anemic Nunavimmiut only.

Severity of anemia

The prevalence of anemia according to severity among men and women is presented in Figure 1. Anemia was classified as mild, moderate, or severe using WHO recommendations (WHO, 2011). Overall, all anemias were mild or moderate, and none were severe.

Figure 1 Prevalence of anemia according to sex and severity among Nunavimmiut, population aged 16 years and over, Nunavik, 2017

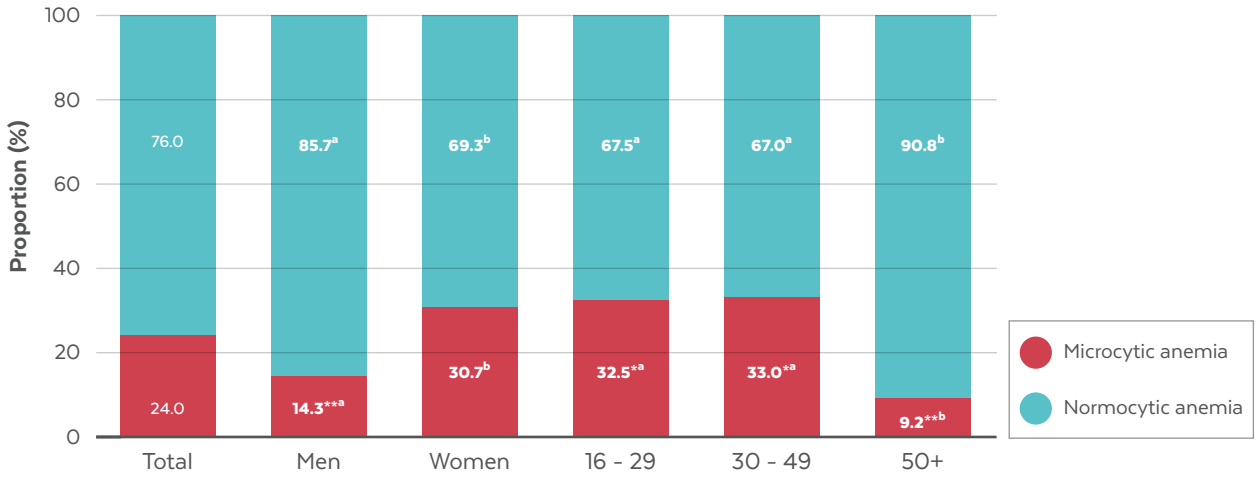


** The coefficient of variation is greater than 25%. The proportion is shown for information only.

Red blood cell size

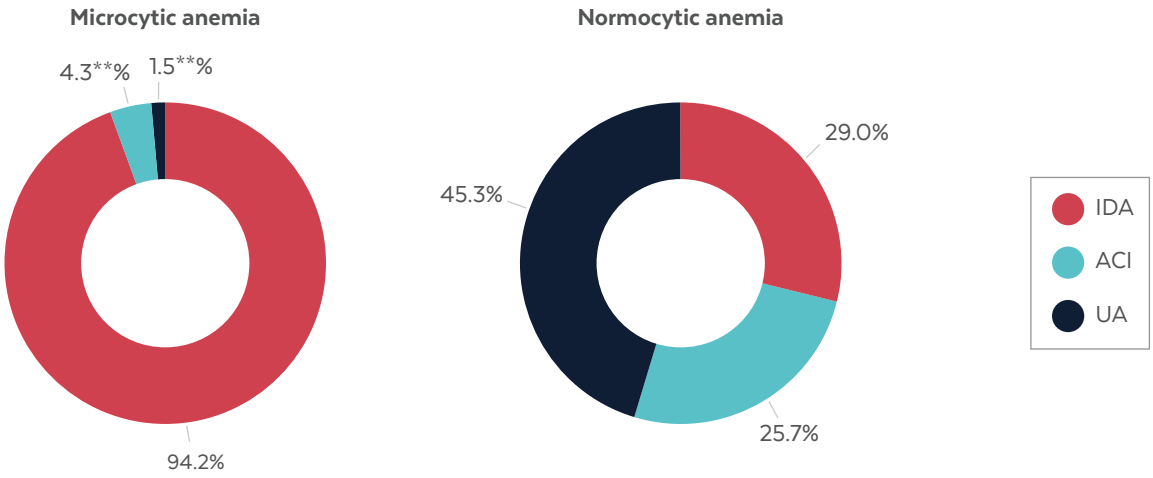
Anemia can be caused not only by ID, but by many other factors as well. Mean corpuscular volume (MCV), an indicator of red blood cell size, helps to distinguish between the different causes of anemia. In the case of IDA, low values of MCV are expected. Among those who had anemia, 24% had a low MCV (microcytic anemia), 76% had a normal MCV (normocytic anemia) and none had an elevated MCV (macrocytic anemia). The proportion of microcytic and normocytic anemia according to age and sex is shown in Figure 2. The prevalence of microcytic anemia was highest among women and 16 to 49-year-olds. The proportion of different types of anemia according to MCV among men and women is presented in Figure 3. As expected, the vast majority (94%) of microcytic anemia cases were associated with IDA. UA, IDA and ACI represented 45%, 29% and 26%* of normocytic anemia cases, respectively.

Figure 2 Proportion of microcytic and normocytic anemia according to sex and age group among anemic Nunavimmiut, population aged 16 years and over, Nunavik, 2017



a, b Estimates in bold and with different superscripts are statistically different from the other sex or other age groups ($p < 0.05$).
* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** The coefficient of variation is greater than 25%. The proportion is shown for information only.

Figure 3 Proportions of iron deficiency anemia (IDA), anemia of chronic inflammation (ACI) and unexplained anemia (UA) according to anemia classified based on mean corpuscular volume among anemic Nunavimmiut, population aged 16 years and over, Nunavik, 2017



* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** The coefficient of variation is greater than 25%. The proportion is shown for information only.

Hematological and biochemical parameters

Descriptive statistics of hematological and biochemical parameters among men and women are reported in Table 3. Most biochemical parameters were not normally distributed; therefore, medians and their 95% confidence intervals are presented instead of arithmetic means. Median Hb was higher among men (144 g/L) than women (130 g/L). Similarly, median SF was also higher among men (59 µg/L) than women (35 µg/L). An increased TIBC and a decreased TSAT, both indicative of ID, were observed in approximately a third of Nunavimmiut. A level of selenium below or equal to 3.0 µmol/L, suggesting low selenoneine, was observed in 41% of Nunavimmiut, 24% had an elevated hs-CRP (≥ 3.0 mg/L), and a third (32%) had vitamin D deficiency. The proportion of Nunavimmiut exhibiting abnormal values for vitamin B12, folate, lead and eGFR was too low to allow further statistical analyses.

Table 3 Median and 95% confidence intervals for hematological and biochemical parameters and prevalence of abnormal values among men and women, population aged 16 years and over, Nunavik, 2017

Biochemical parameters	Men			Women			Cut-off point (abnormal)	Prevalence of values below or above the cut-off point (%)
	Median	95% CI		Median	95% CI			
		from	to		from	to		
Hb (g/L)	**144.2**	142.8	145.6	**129.9**	128.9	130.9	< 130/120[a]	18.8
MCV (fL)	**88.2**	87.8	88.6	**87.2**	86.8	87.7	< 80[b]	24
SF (µg/L)	**59.4**	53.1	65.7	**34.6**	32.6	36.6	< 15	13.2
SI (µmol/L)	**14.9**	13.9	15.9	**11.9**	11.4	12.4	< 10	28.1
TSAT (%)	**21.6**	20.5	22.8	**16.6**	15.9	17.3	< 15	34.1
Transferrin (g/L)	2.90	2.85	2.97	2.95	2.91	2.99	< 2	2.1*
TIBC (µmol/L)	73.0	71.5	74.5	74.1	73.0	75.1	> 80	29.6
Vitamin B12 (pmol/L)	**358.7**	346.3	371.1	**403.3**	390.6	416.0	< 148	0.4**
Folate (nmol/L)	**786.5**	770.7	802.3	**730.7**	717.5	743.9	< 320	0.4**
Vitamin D (nmol/L)	61.5	58.1	64.8	65.4	62.4	68.3	< 50	31.6
Lead (µmol/L)	**0.132**	0.120	0.144	**0.109**	0.101	0.118	≥ 0.5	3.4*
Selenium (µmol/L)	**3.03**	2.80	3.26	**3.78**	3.59	3.96	≤ 3.0	41.4
hs-CRP (mg/L)	1.00	0.80	1.20	1.35	1.18	1.52	≥ 3	23.9[c]
eGFR (ml/min/1.73m^2)	**103.9**	101.8	106.0	**108.6**	107.4	109.8	< 60	1.5*

Hb = hemoglobin; MCV = mean corpuscular volume; SF = serum ferritin; SI = serum iron; TSAT = transferrin saturation; TIBC = total iron binding capacity; hs-CRP = high sensitivity C-reactive protein; eGFR = estimated glomerular filtration rate.

Estimates in **bold** are statistically different between men and women based on CI comparison.

a 130 g/L is the cut-off for men, and 120 g/L is the cut-off for women.

b Cut-off values vary with sex and age (from 78 to 103 fL).

c When the cut-off for hs-CRP was ≥ 10 mg/L, the prevalence above the cut-off value was 4.6%.

* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.

** Coefficient of variation greater than 25%. The proportion is shown for information only.

Different types of anemia

The prevalence of IDA, ACI and UA according to age and sex is presented in Table 4. Approximately half the cases of anemia were due to IDA, with most of the cases of iron deficiency anemia observed among women 16 to 49 years old. The prevalence of UA was significantly higher among men and women 50 years or older than among younger adults. Additionally, women over 50 years of age had significantly more ACI than younger women. Overall, among men and women, 8% had IDA, 4% had ACI, and 7% had UA, but the prevalence of IDA was significantly higher among women than among men. There were no significant differences in the prevalence of ACI and UA between men and women.

Table 4 Prevalence of iron deficiency anemia, anemia of chronic inflammation and unexplained anemia among Nunavimmiut according to age group and sex, population aged 16 years and over, Nunavik, 2017

	Total			Men			Women		
	Prevalence (%)	95% CI		Prevalence (%)	95% CI		Prevalence (%)	95% CI	
		from	to		from	to		from	to
Iron deficiency anemia									
16 – 29 years	**9.9**[b]	7.5	12.8	5.6**	2.9	20.3	**14.6**[b]	11.2	18.9
30 – 49 years	**9.1***[b]	6.4	12.8	4.6**	2.0	9.9	**13.9***[b]	9.8	19.5
50 years and over	**4.8****[a]	2.9	7.8	5.0**	2.2	11.0	**4.5****[a]	2.5	8.1
Total	8.4	6.9	10.2	***5.1****	3.3	7.7	***11.8***	9.6	14.5
Anemia of chronic inflammation									
16 – 29 years	**0.7****[c]	0.3	1.6	NP	NP	NP	**1.4****[b]	0.6	3.3
30 – 49 years	**3.4****[b]	1.5	7.7	6.2**	2.5	14.5	NP	NP	NP
50 years and over	**9.9***[a]	6.9	14.1	8.7**	4.7	15.6	**11.1***[a]	7.2	16.7
Total	3.9*	2.7	5.5	4.1**	2.4	14.5	*3.6	2.5	5.1
Unexplained anemia									
16 – 29 years	**4.5***[c]	2.9	7.0	**3.0****[b]	1.2	7.8	**6.1***[b]	3.9	9.5
30 – 49 years	**3.6****[b]	2.1	6.2	**3.4****[b]	1.4	8.2	**3.8****[b]	2.0	7.2
50 years and over	**14.2**[a]	10.6	18.7	**14.3***[a]	9.0	21.9	**14.0***[a]	9.8	19.8
Total	6.5	5.2	8.2	5.8*	3.8	8.6	7.3	5.7	9.4

a, b, c Estimates in **bold** and with different superscripts are statistically different from other age groups ($p < 0.05$).

Estimates in ***bold and italics*** are statistically different between men and women of all age groups combined ($p < 0.05$).

* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.

** The coefficient of variation is greater than 25%. The proportion is shown for information only.

NP Data not presented ($n < 5$).

COMPARISON WITH *QANUIPPITAA?* 2004 AND OTHER POPULATIONS

Qanuippitaa? 2004

A detailed comparison of the prevalence of ID and anemia among women aged 18 or older, which was documented in *Qanuilirpitaa?* 2017 and *Qanuippitaa?* 2004, is presented in Table 5 using the same age groups. There has been a two-fold decrease in the prevalence of total anemia, IDA, ACI, and UA among women aged 18 and older since 2004. The prevalence of ID and IDWA was also lower in 2017 compared to 2004 (1.5-fold).

Table 5 Comparison of the prevalence of anemia, iron deficiency anemia, anemia of chronic inflammation, unexplained anemia, iron deficiency, and iron deficiency without anemia†

	Qanuippitaa? 2004[1]			*Qanuilirpitaa?* 2017		
	Prevalence (%)	95% CI		Prevalence (%)	95% CI	
		from	to		from	to
Anemia (total)						
18 – 29 years	41.7	34.8	49.0	19.8	15.3	25.2
30 – 49 years	39.5	33.7	45.7	18.3	13.6	24.2
50 – 74 years	60.8	51.9	69.1	28.6	22.3	35.9
Total	44.8	41.0	48.6	21.6	18.5	25.0
Iron deficiency anemia						
18 – 29 years	27.1	21.4	33.7	12.6*	9.1	17.2
30 – 49 years	20.9	16.2	26.5	13.9*	9.8	19.5
50 – 74 years	8.0**	4.4	14.3	4.6**	2.5	8.3
Total	20.4	17.3	24.0	11.0	8.7	13.7
Anemia of chronic inflammation						
18 – 29 years	5.7**	3.0	31.9	NP	NP	NP
30 – 49 years	5.4*	3.2	8.8	NP	NP	NP
50 – 74 years	25.3*	18.1	34.1	11.1*	7.2	16.8
Total	9.6	7.4	12.4	3.6*	2.5	5.3
Unexplained anemia						
18 – 29 years	8.0*	5.0	12.6	6.0**	3.6	9.7
30 – 49 years	13.3*	9.5	18.2	3.8**	2.0	7.2
50 – 74 years	26.1*	19.1	34.6	12.9*	8.6	18.7
Total	14.0	11.5	17.1	7.0	5.3	9.2
Iron deficiency						
18 – 29 years	47.1	40.7	53.6	30.6	25.5	36.2
30 – 49 years	36.0	30.3	42.2	30.4	24.6	37.0
50 – 74 years	9.8**	5.7	16.4	7.2**	4.0	12.5
Total	34.4	31.0	38.0	24.2	21.1	27.7
Iron deficiency without anemia						
18 – 29 years	33.8	25.9	42.7	22.3	17.5	28.1
30 – 49 years	25.8	19.5	33.3	20.2*	14.7	27.1
50 – 74 years	NP	NP	NP	NP	NP	NP
Total	25.5	21.2	30.2	16.9	13.8	20.5

1. Data source: *Qanuippitaa?* 2004 (Unpublished results).
* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** The coefficient of variation is greater than 25%. The proportion is shown for information only.
NP Data not presented (n < 5)
† Prevalence among non-anemic Nunavimmiut only

Other Inuit populations in Canada

The prevalence of total anemia, ID, IDA and other types of anemia (ACI and UA, combined) were similar to those observed in the IHS of 2007-2008 in the Inuit Nunangat (excluding Nunavik) (Table 6) (Jamieson et al., 2012, 2013, 2016). In fact, when comparing 95% confidence intervals from both surveys, there were no significant differences between the results from the IHS and those from *Qanuilirpitaa?* 2017 for both sexes and all age groups.

Table 6 Prevalence of total anemia, iron deficiency, iron deficiency anemia and other types of anemia in adults living in the Inuit Nunangat (excluding Nunavik) (IHS 2007-2008) and adults living in Nunavik (*Qanuilirpitaa?* 2017)

			IHS 2007-2008[1]			*Qanuilirpitaa?* 2017		
	Age group		Prevalence (%)	95% CI		Prevalence (%)	95% CI	
				from	to		from	to
TOTAL ANEMIA	Men	18 – 30 years	6.4	3.0	13.0	5.1**	2.2	11.7
		31 – 50 years	10.6	6.7	16.2	14.1*	8.5	22.4
		51 years and over	30.3	22.1	40.0	30.1	22.2	39.3
		Total	16.1	12.5	20.6	14.5	11.2	18.6
	Women	18 – 30 years	17.9	12.7	24.6	20.2	15.8	25.5
		31 – 50 years	21.3	16.7	26.8	17.8	13.2	23.5
		51 years and over	24.9	18.1	33.3	30.5	23.9	38.1
		Total	21.7	18.3	25.5	21.9	18.9	25.3
IRON DEFICIENCY ANEMIA	Men	18 – 30 years	2.7	0.9	8.0	NP	NP	NP
		31 – 50 years	3.2	1.4	7.5	4.5**	2.0	9.9
		51 years and over	1.1	0.2	4.6	5.4**	2.4	11.7
		Total	2.4	1.3	4.5	4.1**	2.5	6.7
	Women	18 – 30 years	11.7	7.4	18.2	12.2*	8.8	16.7
		31 – 50 years	15.4	11.5	20.3	13.6*	9.5	19.2
		51 years and over	3.9	1.5	9.6	4.9**	2.7	8.7
		Total	11.1	8.7	14.0	10.9	8.7	13.6
IRON DEFICIENCY	Men	18 – 30 years	9.9	5.6	16.8	5.2**	2.5	10.6
		31 – 50 years	6.3	4.1	9.6	11.4**	6.7	18.6
		51 years and over	4.2	2.0	8.4	9.5**	5.0	17.3
		Total	6.5	4.8	8.7	8.6*	6.0	12.2
	Women	18 – 30 years over	40.3	34.3	46.6	29.8	24.9	35.3
		31 – 50 years	37.0	32.7	41.6	30.5	24.6	37.2
		51 years and over	9.2	6.3	13.2	6.0**	3.6	10.1
		Total	29.4	26.7	32.3	24.1	21.0	27.5
OTHER TYPES OF ANEMIA (ACI & UA)	Men	18 – 30 years	2.7	—		NP	NP	NP
		31 – 50 years	5.9			9.5**	5.0	17.4
		51 years and over	27.5			24.7*	17.7	33.3
		Total	—			10.4*	7.6	14.0
	Women	18 – 30 years	6.3	—		5.1*	3.2	7.9
		31 – 50 years	6.0			6.9*	4.2	11.1
		51 years and over	19.7			25.2	20.4	30.7
		Total	—			11.0	9.0	13.5

1. Data source: Inuit Health Survey 2007–2008 (Jamieson et al., 2012, 2013, 2016).

* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.

** The coefficient of variation is greater than 25%. The proportion is shown for information only.

NP Data not presented (n < 5).

— Information not available.

Non-Inuit Canadian population

Comparisons with data from the Canadian Health Measures Survey (CHMS) of 2009–2011 revealed that ID and anemia were five and six times more prevalent among Nunavimmiut aged 16 and over than in the general Canadian population (3 to 79 years old) (ID: 18% vs 4%; anemia: 19% vs 3%) (Cooper et al., 2012). Furthermore, data from CHMS 2014-2015 were compared to data from *Qanuilirpitaa?* 2017 using the same age groups and revealed that mean Hb and mean SF were generally lower among Nunavimmiut than among the general Canadian population (Table 7). When comparing 95% confidence intervals, mean Hb and SF among men were significantly different for all age groups. Among women, mean Hb was significantly different for all women except those aged 30 to 49 years. Although mean SF was significantly different among all Nunavimmiut women, the differences were not significant between age groups.

Table 7 Mean hemoglobin and ferritin concentrations in adults of the general Canadian population from CHMS 2014-2015 and adults living in Nunavik from *Qanuilirpitaa?* 2017

			CHMS 2014-2015[1]			*Qanuilirpitaa?* 2017		
	Age group		GM	95% CI		GM	95% CI	
				from	to		from	to
HEMOGLOBIN (g/L)	Men	16 – 29 years	**151.09**	149.11	153.09	**145.13**	142.77	147.36
		30 – 49 years	**150.81**	149.40	152.24	**143.59**	141.33	145.86
		50 years and over	**147.60**	146.41	148.81	**137.12**	134.51	139.76
		Total	**149.56**	148.71	150.41	**142.71**	141.34	144.10
	Women	16 – 29 years	**131.34**	129.48	133.22	**127.44**	126.16	128.75
		30 – 49 years	130.39	128.60	132.21	128.79	127.16	130.32
		50 years and over	**133.21**	132.03	134.41	**127.24**	125.83	128.76
		Total	**131.77**	130.85	132.70	**127.85**	126.99	128.67
FERRITIN (µg/L)	Men	16 – 29 years	**99.60**	88.07	112.65	**47.69**	41.33	54.80
		30 – 49 years	**140.91**	124.77	159.12	**61.68**	54.07	71.19
		50 years and over	**134.00**	122.77	146.25	**68.24**	58.33	79.88
		Total	**127.56**	119.79	135.83	**56.62**	51.93	61.87
	Women	16 – 29 years	27.63	22.45	34.02	25.34	23.22	27.86
		30 – 49 years	32.27	28.38	36.69	28.92	25.50	32.81
		50 years and over	64.33	59.10	70.02	58.91	52.42	66.08
		Total	**41.31**	38.09	44.81	**32.63**	30.58	34.87

1. Data source: Canadian Health Measures Survey Cycle 4 (2014-2015).

Estimates in **bold** are statistically different between two populations based on comparison of 95% CI.
GM: Geometric mean.

DETERMINANTS OF IRON DEFICIENCY AND ANEMIA

The prevalence of ID and anemia according to sociodemographic, socioeconomic and health determinants, as well as biochemical parameters and dietary habits are reported in tables 8, 9, 10, and 11. The prevalence of ACI was very low and many estimates were non-reliable. Therefore, ACI was excluded from these tables.

Sociodemographic and socioeconomic determinants

The prevalence of ID and anemia did not vary between Nunavik ecological regions or community size (Table 8). In contrast, anemia and iron status were associated with many socioeconomic determinants. Having completed secondary school education was significantly associated with a lower prevalence of total anemia (PR = 0.53), ID (PR = 0.70), IDWA (PR = 0.69) and UA (PR = 0.42) compared to having incomplete secondary school

education. A higher personal income ($20 000/year and over) was significantly associated with a lower prevalence of total anemia (PR = 0.49), ID (PR = 0.52), IDWA (PR = 0.64) and IDA (PR = 0.32). Similar results were observed for various socioeconomic determinants, such as marital status and employment status, as shown in Table 8. Furthermore, those who were food secure also had significantly less total anemia (PR = 0.60), ID (PR = 0.53) and IDA (PR = 0.41) compared to those in the severe food insecure category. Finally, those who lived in an overcrowded home had significantly more ID (PR = 1.39) but not anemia.

Table 8 Prevalence of iron deficiency, iron deficiency without anemia, iron deficiency anemia, unexplained anemia and total anemia according to sociodemographic and socioeconomic determinants of Nunavimmiut, population aged 16 years and over, Nunavik, 2017

Variables	Iron deficiency	Iron deficiency without anemia	Iron deficiency anemia	Unexplained anemia	Total anemia
	Prevalence (%)				
Community size[1]					
Large	17.6	11.8	8.0	6.2*	18.8
Small	18.2	11.4	8.9*	7.0	18.7
Ecological region[2]					
Hudson Bay	20.0	14.2	8.7*	6.3*	20.1
Ungava Bay	16.9	10.2	8.5*	7.5*	18.0
Hudson Strait	15.5	9.4*	7.8*	6.0*	17.5
Income					
Less than $20 000	**22.7**[b]	**13.8**[b]	**12.4**[b]	7.0*	**25.2**[b]
$20 000 and over	**11.7**[a]	**8.8***[a]	**4.0***[a]	5.9*	**12.3**[a]
Employment status[3]					
Employed	**16.0**[b]	10.3	7.2	5.6	**15.2**[b]
Not employed	**21.6**[a]	14.8	10.7*	8.3*	**26.1**[a]
Marital status					
Single, separated, divorced or widowed	**21.7**[b]	12.9	**11.7**[b]	5.5*	**22.3**[b]
Married or common law	**14.4**[a]	10.6	**5.4***[a]	7.5*	**15.7**[a]
Education level					
Elementary school or less	**9.0****[b]	NP	6.1**	**18.7***[c]	***29.0**[b]
Secondary school not completed	**21.2**[a]	**14.0**[a]	10.0	**6.0***[b]	**20.3**[b]
Seconday school or higher	**14.9**[b]	**9.7***[b]	*6.3	**2.5****[a]	***10.7**[a]
Food insecurity					
Food secure	**13.6**[b]	8.9*	**6.0***[b]	5.8*	**14.5**[b]
Moderately insecure	**17.1**[b]	11.5	**7.7***[b]	6.4*	17.6
Severely insecure	**25.9**[a]	14.8*	**14.5***[a]	6.2**	**24.1**[a]
Household overcrowding (PPR)					
Yes	**22.4**[b]	14.7*	10.6*	5.2*	19.1
No	**16.1**[a]	10.6	7.5	6.8	17.9

1. Large communities: Kuujjuaq, Salluit, Puvirnituq, Inukjuak; Small communities: Kuujjuarapik, Umiujaq, Akulivik, Ivujivik, Kangiqsujuaq, Quaqtaq, Kangirsuk, Aupaluk, Tasiujaq, Kangiqsualujjuaq.
2. Hudson Bay: Kuujjuarapik, Umiujaq, Inukjuak, Puvirnituq, Akulivik; Ungava Bay: Kangirsuk, Aupaluk, Tasiujaq, Kangiqsualujjuaq, Kuujjuaq; Hudson Strait: Ivujivik, Salluit, Kangiqsujuaq, Quaqtaq.
3. Employed: full-time, part-time or occasional employment; Not employed: Hunter support program, housework, retired or on pension, employment insurance, parental leave, income support, student, other.

a, b, c Estimates in **bold** and with different superscripts are statistically different from one another ($p < 0.05$).

* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.

** The coefficient of variation is greater than 25%. The proportion is shown for information only.

NP Data not presented ($n < 5$).

Lifestyle and health determinants

Nunavimmiut who reported going often on the land during the year prior to the survey had significantly less total anemia (PR = 0.68) and ID (PR = 0.60) compared to those who never spent any time on the land (Table 9). Interestingly, obese individuals had significantly less total anemia (PR = 0.39), ID (PR = 0.49), IDWA (0.46), IDA (PR = 0.42) and ACI (0.26; data not shown) than those who had a normal weight. Conversely, those who had at least one diagnosed chronic health problem in their medical chart had a significantly higher prevalence of total anemia (PR = 1.66) and IDA (PR = 1.63) compared to those without any chronic disease diagnosis. Nunavimmiut who perceived their health as excellent, very good or good had a lower prevalence of total anemia (PR = 0.68) and UA (PR = 0.52) compared to those who perceived their health as fair or poor. Women who had been pregnant in the 12 months prior to the survey were significantly more affected by total anemia (PR = 1.56), ID (PR = 1.72), IDWA (PR = 1.86) and IDA (PR = 1.90). Individuals who had a prescription for iron supplementation in their medical chart had a higher prevalence of total anemia (PR = 3.08). Similarly, Nunavimmiut with a prescription for antacid medication in their medical chart had a higher prevalence of total anemia (PR = 1.88) and UA (PR = 2.39).

Table 9 Prevalence of iron deficiency, iron deficiency without anemia, iron deficiency anemia, unexplained anemia and total anemia according to lifestyle and health determinants among Nunavimmiut, population aged 16 years and over, Nunavik, 2017

Variables	Iron deficiency	Iron deficiency without anemia	Iron deficiency anemia	Unexplained anemia	Total anemia
	Prevalence (%)				
Going on the land					
Never	**24.4**^{*b}	12.3*	15.3*	7.1**	**25.9**^{*a}
Occasionally	19.2	13.5	8.0*	6.3*	**17.3**^{b}
Often	**14.6**^{a}	9.7*	6.7	6.2*	**17.7**^{b}
Traditional activities[1]					
Yes	17.7	12.0	7.8	6.1	**17.6**^{b}
No	18.3*	8.0**	12.6*	9.7**	**28.0**^{*a}
Weight status					
Normal	**20.9**^{b}	**13.2**^{b}	**11.0**^{a}	7.6*	**24.7**^{c}
Overweight	**16.8**^{b}	13.1*	**5.8**^{**b}	7.1*	**16.0**^{b}
Obese	**10.3**^{*a}	**6.1**^{*a}	**4.7**^{*b}	3.4**	**9.7**^{*a}
Chronic health problem					
Yes	19.4	10.8*	**11.4**^{b}	7.8*	**25.9**^{b}
No	17.1	12.0	**7.0**^{a}	6.0*	**15.6**^{a}
Perceived health status					
Excellent, very good, good	17.6	12.0	7.5	**5.2**^{*b}	**16.5**^{b}
Fair, poor	18.8	11.2*	10.3*	**10.0**^{*a}	**24.1**^{a}
Recent pregnancy (12 months)					
Yes	**41.5**^{b}	**31.4**^{*b}	**20.1**^{*b}	8.5**	**32.1**^{b}
No	**24.1**^{a}	**16.9**^{a}	**10.6**^{a}	7.3	**20.6**^{a}
Iron supplement					
Yes	34.7**	NP	NP	NP	**56.7**^{*b}
No	17.7	11.6	8.1	6.5	**18.4**^{a}
Antacid medication					
Yes	16.6**	NP	8.4**	**14.8**^{**b}	**34.2**^{*b}
No	17.9	11.6	8.4	**6.2**^{a}	**18.2**^{a}

1. Traditional activities: harvesting, hunting, fishing, going on the land, sewing.

a, b, c Estimates in **bold** and with different superscripts are statistically different from one another ($p < 0.05$).

* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.

** The coefficient of variation is greater than 25%. The proportion is shown for information only.

NP Data not presented ($n < 5$).

Biochemical determinants

Men and women with sufficient vitamin D levels had a significantly lower prevalence of ID (PR = 0.68) and IDA (PR = 0.50) but a higher prevalence of UA (PR = 2.11), compared to those who were vitamin D deficient (Table 10). Additionally, those who had selenium levels of 2.0 µmol/L or above had significantly less total anemia (PR = 0.50-0.60) and ID (PR = 0.48-0.62) than those who had levels below 2.0 µmol/L. Similarly, IDA (PR = 0.33-0.61) was also significantly less prevalent among those with higher levels of selenium, but only at the 3.0 µmol/L cut-off. Men and women with hs-CRP equal to or greater than 3 mg/L but below 10 mg/L had a lower prevalence of ID compared to those who had hs-CRP of 10 mg/L or above (PR = 0.36) and hs-CRP below 3 mg/L (PR = 0.65). Finally, those who had a positive serology for *H. pylori* had significantly more IDA (PR = 1.76) than those with a negative serology. However, this association was not statistically significant for people having an active infection documented by SAT, for which the sample size was much smaller.

Table 10 Prevalence of iron deficiency, iron deficiency without anemia, iron deficiency anemia, unexplained anemia and total anemia according to biochemical parameters of Nunavimmiut, population aged 16 years and over, Nunavik, 2017

Variables	Iron deficiency	Iron deficiency without anemia	Iron deficiency anemia	Unexplained anemia	Total anemia
	Prevalence (%)				
Vitamin D					
< 50 nmol/L	**22.8**[b]	12.1	**12.8**[b]	**3.7****[b]	17.2
≥ 50 nmol/L	**15.5**[a]	11.4	**6.4**[a]	**7.8**[a]	19.5
Selenium					
< 2.0 µmol/L	**31.6***[a]	18.9**	**19.0****[b]	NP	**33.3***[a]
≥ 2.0 and ≤ 3.0 µmol/L	**19.7**[b]	12.1*	**10.1***[b]	6.6*	**20.0**[b]
> 3.0 µmol/L	**15.2**[b]	10.7	**6.2**[a]	7.1	**16.5**[b]
hs-CRP					
< 3 mg/L	**18.4**[c]	**12.4**[c]	8.2	6.5	18.0
≥ 3 and < 10 mg/L	**11.9***[b]	**4.9****[b]	8.0*	7.0**	21.0
≥ 10 mg/L	**33.2****[a]	**27.1****[a]	12.2**	NP	22.3**
H. pylori (serology)					
Positive	18.7	11.4	**9.5**[b]	6.5	19.4
Negative	15.5	12.3*	**5.4***[a]	6.7*	17.2
H. pylori (active, SAT)					
Positive	15.2	9.8*	7.0*	6.0*	6.0*
Negative	13.8*	10.0**	5.8*	7.6*	7.6*

a, b, c Estimates in **bold** and with different superscripts are statistically different from one another (p < 0.05).
* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** The coefficient of variation is greater than 25%. The proportion is shown for information only.
NP Data not presented (n < 5).

Dietary intake

The prevalence of ID and anemia among men and women according to daily food intake is presented in Table 11. According to the food frequency questionnaire (FFQ), participants who consumed more country food than the median intake had significantly less ID (PR = 0.73) but more UA (PR = 1.67) compared to those who consumed less. The opposite was observed between market food consumption and total anemia, where higher market food consumers had a higher prevalence of total anemia (PR = 1.38) than lower market food consumers.

Higher country meat consumers had a significantly lower prevalence of ID (PR = 0.70) and IDA (PR = 0.58). Higher marine mammal consumers had a significantly lower prevalence of ID (PR = 0.67) and IDWA (PR = 0.65). The same association was observed for IDA among women

(PR = 0.51; data not shown) but not men. Conversely, women, but not men, who were higher marine mammal consumers had significantly more UA (PR = 2.20; data not shown). Among both men and women, higher game animal and bird consumers had significantly less total anemia (PR = 0.68), ID (PR = 0.72) and IDA (PR = 0.57) compared to lower consumers. However, those who consumed more fish and seafood had a lower prevalence of ID (PR = 0.73) but a higher prevalence of UA (PR = 1.82). There was no difference between higher and lower market meat consumers, regardless of the type of meat (data not shown).

The consumption of sweet beverages (including real fruit juices) was associated with a higher prevalence of ID (PR = 1.47) and IDWA (PR = 1.63) but not anemia. Furthermore, the consumption of hot beverages (tea, herbal tea and coffee) was significantly associated with a higher prevalence of total anemia (PR = 1.68), and UA (PR = 1.90).

Table 11 Prevalence of iron deficiency, iron deficiency without anemia, iron deficiency anemia, unexplained anemia and total anemia among Nunavimmiut according to daily food intake, population aged 16 years and over, Nunavik, 2017

Nutrition variables	Median (times a day)	Intake ≥ or < median	Iron deficiency	Iron deficiency without anemia	Iron deficiency anemia	Unexplained anemia	Total anemia
			Prevalence (%)				
Total country food	2.71	Above	**14.9**[b]	10.2	6.7*	**8.8***[b]	19.7
		Below	**20.3**[a]	12.9	9.6	**5.3***[a]	17.5
Country meat	1.49	Above	**14.5**[b]	10.2	**6.0***[b]	8.1*	17.6
		Below	**20.7**[a]	12.9	**10.3**[a]	6.0*	19.6
Marine mammals	0.33	Above	**14.1**[b]	**9.1***[b]	6.6*	8.4*	18.1
		Below	**21.0**[a]	**14.0**[a]	9.7	5.7*	19.1
Game animals and birds	0.43	Above	**14.7**[b]	10.3	**5.9***[b]	6.8*	**15.0**[b]
		Below	**20.4**[a]	12.8	**10.3**[a]	7.3	**22.1**[a]
Fish & seafood	0.35	Above	**14.8**[b]	9.8*	6.9*	**9.1***[b]	19.7
		Below	**20.3**[a]	13.2	9.4	**5.0***[a]	17.5
Total market food	21.23	Above	18.8	12.9	9.0	7.9*	**21.5**[b]
		Below	16.3	10.7	7.3*	6.2*	**15.6**[a]
Market meat	2.19	Above	18	12.8	7.5*	7.3*	18.3
		Below	17.1	10.2*	8.9*	6.8*	18.9
Sweets and baked goods	0.71	Above	18.7	12.5	8.7*	8.5*	19.8
		Below	16.4	10.6	7.7*	5.6*	17.5
Sweet beverages	1.07	Above	**20.8**[b]	**14.5**[b]	9.4	7.3*	20.7
		Below	**14.2**[a]	**8.9***[a]	6.9*	6.8*	16.4
Hot beverages (tea and coffee)	2.64	Above	16.5	10.3*	8.6*	**9.3***[b]	**23.4**[b]
		Below	18.6	12.6	7.7	**4.9***[a]	**13.9**[a]
Country and market fruits and vegetables	1.91	Above	18	12.1	8	6.3*	17.9
		Below	17.1	10.9	8.3*	7.8*	19.3

a, b Estimates in bold and with different superscripts are statistically different from one another ($p < 0.05$).
* The coefficient of variation is greater than 15% and lower than or equal to 25%. The proportion should be interpreted carefully.
** Coefficient of variation greater than 25%. The proportion is shown for information only.

5 DISCUSSION

PORTRAIT OF IRON DEFICIENCY AND ANEMIA

In the framework of the *Qanuilirpitaa?* 2017 Health Survey, the prevalence of ID and anemia was measured in a representative sample of adults aged 16 and over living in Nunavik. Nearly one out of five Nunavimmiut exhibited ID and a similar proportion were anemic. WHO considers anemia to be a public health concern when its prevalence is equal to or greater than 5%. The prevalence of anemia in Nunavik (19%) is almost four times this limit and is near the upper limit of what constitutes a *mild* public health problem (WHO, 2011). In Nunavimmiut women, the prevalence of anemia in 2017 (23%) represented a public health problem of *moderate* significance, which is an improvement from *Qanuippitaa?* 2004, when the prevalence of anemia (43%) was deemed a *severe* public health problem (Plante et al., 2011). Further analyses are necessary to identify factors responsible for this significant reduction in both ID and anemia among Nunavimmiut women 18 years and older.

Severity of anemia

Qanuilirpitaa? 2017 revealed that most cases of anemia were mild (men: 86%, women: 74%), some were moderate (men: 14%, women: 26%) and none were severe. Mild cases were fewer than in other studies among Inuit (Jamieson et al., 2016; Plante et al., 2011) since the WHO cut-off used in this survey was more restrictive (WHO, 2011). However, these results are comparable to those of *Qanuippitaa*? 2004, which indicated that 89% of anemia cases were mild among women (Plante et al., 2011). The prevalence of mild anemia was also comparable to that of other Inuit Nunangat populations (96% of men and 88% of women) (Jamieson et al., 2016). That being said, even mild anemia can have major health consequences (Willows & Gray-Donald, 2004). In fact, ID is already advanced when anemia is detected and has consequences even when anemia is undetectable (WHO, 2011); for example, an alteration of immune defence mechanisms and a decrease in energy and work performance (Beard, 2001). Since approximately half the cases of anemia in this study were IDA, mild anemia should not be taken lightly.

Sex and age differences

Higher prevalence of ID and anemia were observed among women compared to men, and most iron indicators (SF, SI, Hb and TSAT) were affected disproportionally among women compared to men. This is likely due to distinctive physiological phenomena occurring in men and women, such as menstrual blood loss, periods of increased iron requirement or hormonal differences (Murphy, 2014). Androgens, a group of sex hormones present in higher concentrations among men, stimulate erythropoietin production which, in turn, stimulates the production of red blood cells. In contrast, estrogens, which are present in higher concentrations among women, have an inhibitory effect on red blood cell production (Murphy, 2014). The results of this survey are comparable to those observed during the IHS of 2007-2008 among other Inuit in Canada (Jamieson et al., 2012, 2013). Globally, among non-Inuit from various countries, anemia was also more prevalent among adult women than among men between 1990 and 2010, for all ages and geographic regions (Kassebaum et al., 2014).

The prevalence and causes of anemia also vary greatly with age. In *Qanuilirpitaa*? 2017, younger men (16-49 years) had a lower prevalence of anemia, whereas women of childbearing age (16-49 years) were disproportionally affected by ID. IDA was the most common cause of anemia for this latter group. In fact, there was a five-fold decrease in ID between women of childbearing age and women 50 years or older. This was also true in 2004, when 61% of anemia cases among women of childbearing age were due to IDA, compared to 14% among women aged 50 years and over (Plante et al., 2011). The prevalence of ID in 2004 was also much higher among younger women 18 to 29 years old (48%) than that observed in women aged 50 years and older (10%) (Plante et al., 2007). This pattern was also reported in other Inuit in Canada (Jamieson et al., 2013), the general Canadian population (Cooper et al., 2012), and globally (McLean, Cogswell, Egli, Wojdyla, & de Benoist, 2009).

Total anemia was most prevalent among older men and women aged 50 and over than among younger men and women, as reported in different studies of various

Inuit populations (Jamieson et al., 2016; Milman, Byg, Mulvad, Pedersen, & Bjerregaard, 2001a; Plante et al., 2011). The same pattern has been observed in the general Canadian population and globally. Indeed, Cooper et al. (2012) measured sufficient Hb among the general Canadian population using data from CHMS 2009-2011 and found sufficient Hb to be less prevalent in adults 65 to 79 years of age than among younger adults (Cooper et al., 2012). Similarly, in a study using data from the WHO Vitamin and Mineral Nutrition Information System (VMNIS) from 1993 to 2005, McLean et al. (2009) reported that the global prevalence of anemia was higher among adults 60 years or older than among younger men and women, in both developing and developed countries. However, these results are different from those of Petersen et al. (1996) who studied ID and anemia in Alaska Inuit and US residents between 1981 and 1988 and found a decrease in anemia prevalence among adults 45 years or older compared to younger adults in both populations.

The present survey also showed that the main types of anemia among older adults were ACI and UA, as reported in other studies (Cooper et al., 2012; Jamieson et al., 2016; Plante et al., 2011). In fact it was observed that only 15% and 18% of all anemia cases among women and men 50 years or older, respectively, were IDA cases. This is much lower than in other studies such as the Third National Health and Nutrition Examination Survey (NHANES III), which reported that a third (33%) of anemia cases among adults 65 years or older in the US between 1988 and 1994 were related to ID (Guralnik, Eisenstaedt, Ferrucci, Klein, & Woodman, 2004). The exact pathophysiology of ACI remains unclear, but generally, with chronic disease, there is an inability to mobilize and use iron effectively. Therefore, with ACI, there are adequate levels of stored iron, but it can't be used to form red blood cells (Balducci, 2003). Anemia in older adults is known to be associated with increased disability, mortality and hospitalization (Stauder & Thein, 2014). Therefore, it is important that anemia receives adequate attention and is not just seen as simply a normal part of aging (Guralnik et al., 2004).

North-south disparities

This portrait also demonstrates that the proportion of Nunavimmiut affected by ID and anemia remains much higher than in the general Canadian population. In fact, great disparities in ID and anemia between Inuit communities and southern communities of the same country have been documented in recent decades by various studies (Milman et al., 2001a; Petersen et al., 1996). Milman et al. (2001a) compared Inuit from Greenland who participated in the National Health Interview Survey of 1993-1994 to Caucasian Danes from the 1983-1984 Iron Status Survey and found that mean Hb values were much lower in Inuit, regardless of sex and age group. They also speculated that lower Hb levels among Inuit could be due to genetic differences (Milman et al., 2001a). However, this hypothesis has not yet been empirically demonstrated among Inuit in Canada.

PROTECTIVE AND RISK FACTORS OF IRON DEFICIENCY AND ANEMIA

Socioeconomic status and food insecurity

With regard to correlates of ID and anemia, the findings of this survey suggest that a higher socioeconomic status is an important protective factor. In this study, a higher personal income, a completed secondary school education and a married or common-law relationship status were all negatively associated with ID and anemia. These results are consistent with those of the *Qanuippitaa*? 2004 survey (Plante et al., 2007) and studies of other Inuit populations in Canada (Jamieson et al., 2012, 2013, 2016) and non-Inuit Canadians (Cooper et al., 2012). Moreover, food insecurity was associated with a higher prevalence of ID and anemia. Nunavimmiut are currently experiencing a high prevalence of food insecurity (See thematic report on Food Security), resulting in inadequate access to sufficient nutritious (iron-rich) and culturally preferred food (Arriagada, 2017). Therefore, the association between food insecurity and ID as well as anemia, as previously reported in several studies (Egeland et al., 2011; Pirkle et al., 2014; Plante et al., 2007), was expected.

Dietary intake

Country food and country meat intake were negatively associated with the prevalence of ID. Inversely, market food intake was positively associated with the prevalence of total anemia. These findings are comparable to those of Plante et al. (2007) in Nunavik and Jamieson et al. (2013) in other Inuit populations in Canada. Indeed, Jamieson et al. (2013) found that frequency of country food consumption was positively associated with SF and Hb among Canadian Inuit. Milman, Byg, Mulvad et al. (2001b) also noted that individuals from Greenlandic communities consuming more country foods exhibited higher serum SF concentrations than those of individuals who eat less country food.

Total country food intake as well as fish and seafood intake were associated with higher prevalence of UA among Nunavimmiut of both sexes. Similarly, marine mammal intake was associated with higher prevalence of UA among women. These prevalences were not adjusted for age, and it is well known that older Inuit tend to consume more traditional iron-rich foods than younger Inuit (Blanchet, 2008; Blanchet et al., 2000). Therefore, the association between country food consumption and UA could be confounded by age. Multivariate analyses are needed to confirm these findings.

Tea and coffee, which are known iron inhibitors due to their tannins and polyphenols content, were associated with higher prevalence of UA and total anemia in this survey. Other studies have also reported a positive association between tea drinking and anemia (Zijp, Korver, & Tijburg, 2000). Additionally, the consumption of sweet beverages, including fruit juices, was associated with higher prevalence of ID and IDWA in *Qanuilirpitaa?* 2017. This was also the case in 2004 among Nunavimmiut women 18 years and older (Plante et al., 2007).

The survey also revealed that selenium was negatively associated with ID, total anemia and IDA. Selenoneine, the selenium compound predominantly present in Nunavimmiut, possesses antioxidant properties, which could prevent premature red blood cell destruction (Yamashita & Yamashita, 2010). However, this association between selenium and anemia could have been influenced by the consumption of country food. In fact, nearly all sources of iron-rich country food in Nunavik, especially marine mammals such as beluga, seal and walrus, are also good sources of selenium, (Lemire et al., 2015; Nunavut, 2005).

Traditional lifestyle

Participating in traditional activities, such as hunting, fishing, harvesting country food, handicrafts and artwork, and going on the land were associated with a lower prevalence of anemia in *Qanuilirpitaa*? 2017. Similarly, Jamieson et al. (2012) reported that the lack of a hunter in the home was a risk factor for ID among men. Hunting and fishing can contribute to food security and the consumption of nutrient-rich country food, and in turn prevent ID and anemia.

Additionally, vitamin D deficiency was associated with a higher prevalence of ID and IDA. The latter association could have been influenced by the consumption of vitamin D and iron-rich country food. People who go more frequently out on the land, hunting and fishing, likely consume more country food. Furthermore, they are more likely to be exposed to sun light, an additional source of vitamin D.

Other correlates

Among all participants, 99.5% had adequate vitamin B12 and folate levels, which is consistent with the absence of macrocytic anemia. The same results were observed during *Qanuippitaa?* 2004 (Plante et al., 2007) among women.

The present survey reports that an obese weight status is associated with lower total anemia, ID, IDA and ACI. Results from IHS 2007-2008 were comparable to those found with *Qanuilirpitaa*? 2017, where it was noted that obese Inuit from other regions of the Inuit Nunangat consumed more calories from country food rich in iron and other nutrients (Jamieson et al., 2013; Kuhnlein et al., 2004) compared to normal weight individuals. The same protective effect of obesity for anemia was observed among women of childbearing age in Colombia (Kordas, Centeno, Pachón, & Soto, 2012) and in Egypt (Hassan, El-Hussinie, & El-Nahal, 1999), where it was also hypothesized that obese women had a higher intake of iron-rich food. It is also possible that normal weight individuals may be more affected by food insecurity compared to overweight and obese individuals (Huet, Rosol, & Egeland, 2012).

The presence of chronic diseases was associated with a higher prevalence of total anemia and IDA. Based on the *Qanuippitaa?* 2004 data, Plante et al. (2007) previously reported that anemia was more prevalent among Nunavimmiut who had one or more chronic health problems in 2004. Another study by Guralnik et al. (2004) found that UA increased with the presence of a chronic

condition among adults aged 65 years or older in the United States and also found that the prevalence of UA increased with each additional chronic condition. Obesity and the presence of comorbidities can alter iron homoeostasis through inflammation-induced hepcidin expression (Tussing-Humphreys, Pusatcioglu, Nemeth, & Braunschweig, 2012), leading to ID and subsequently anemia despite adequate iron stores (Nemeth & Ganz, 2006).

H. pylori seropositivity, which indicates current or past infection, was positively associated with IDA, but was not significantly associated with ID or other types of anemia. However, no significant association was found between *H. pylori* SAT, which indicates an active infection, and ID or anemia, potentially due to the much smaller sample size. Many researchers have studied the association between *H. pylori* and ID and anemia among different Inuit populations, but results remain controversial. Among other Inuit in Canada, Jamieson et al. (2012) found that *H. pylori* seropositivity was associated with lower SF, but not ID. Additionally, Christofides et al. (2005) observed a positive association between *H. pylori* and both ID and IDA among children from Northern Ontario and Nunavut. The same association was observed in Alaska among children (Baggett et al., 2006; Centers for Disease Control & Prevention, 1988) and adults (Miernyk et al., 2013; Parkinson et al., 2000), but not among children in Nunavut (Pacey, Weiler, & Egeland, 2010). Lastly, a recent meta-analysis of worldwide studies reported an association between *H. pylori* and ID, but no changes in Hb attributable to eradication of *H. pylori* during various randomized control trials, suggesting that *H. pylori* is not associated with anemia (Hudak, Jaraisy, Haj, & Muhsen, 2017).

LIMITATIONS

This survey has a number of limitations. Firstly, it is based on a cross-sectional design, limiting inferences about the direction of associations and causality. Secondly, bivariate analyses do not consider any confounding factors; therefore, some associations could be under or overestimated. For example, older adults (50 years and over) eat more country food (Blanchet, 2008) and have a lower prevalence of ID than younger adults. Without taking age into consideration, the protective effect of country food consumption on ID could be overestimated. More in depth multivariate analyses are needed and will be conducted to confirm these associations. Thirdly, distinguishing between IDA and ACI can be quite difficult since most iron biomarkers are affected by inflammation. Measurements of soluble transferrin receptor (sTfR), a biomarker of iron status, could have been helpful to differentiate IDA from ACI since it is not affected by inflammation. However, since sTfR was unavailable, conventional indicators of iron status (SF, SI, TIBC, and TSAT) were used and inflammation was taken into account using hs-CRP. Turgeon O'Brien et al. (2016) found that this method yielded a prevalence of iron deficiency erythropoiesis similar to that obtained using sTfR among children in Nunavik. Additionally, although the SF cut-off was increased for pregnant women to consider subclinical inflammation (Pavord et al., 2019), no adjustments were made to consider inflammation in the classification of ID. Therefore, ID may have been underestimated in this group.

6 CONCLUSION

Although the prevalence of ID and anemia among women in Nunavik has markedly decreased since 2004, both conditions remain a significant public health concern affecting almost one out of five Nunavimmiut. Most anemia cases among women of childbearing age are related to ID, while anemia among older men and women are mostly due to ACI or UA. ID and anemia prevalence is comparable to that observed among other Inuit in Canada, but much higher than that found in the general Canadian population. Public health and local interventions targeting modifiable risk factors, such as supporting traditional lifestyles and improving socioeconomic status, are still needed to enhance these outcomes.

REFERENCES

Achouba, A., Dumas, P., Ouellet, N., Little, M., Lemire, M., & Ayotte, P. (2019). Selenoneine is a major selenium species in beluga skin and red blood cells of Inuit from Nunavik. *Chemosphere, 229*, 549-558. doi:10.1016/j.chemosphere.2019.04.191

Alon, D. B., Chaimovitz, C., Dvilansky, A., Lugassy, G., Douvdevani, A., Shany, S., & Nathan, I. (2002). Novel role of 1,25(OH)2D3 in induction of erythroid progenitor cell proliferation. *Experimental Hematology, 30*(5), 403-409. doi:10.1016/S0301-472X(02)00789-0

Arriagada, P. (2017). *L'insécurité alimentaire chez les Inuits vivant dans l'Inuit Nunangat.* Ottawa, Canada: Statistique Canada.

Baggett, H. C., Parkinson, A. J., Muth, P. T., Gold, B. D., & Gessner, B. D. (2006). Endemic iron deficiency associated with Helicobacter pylori infection among school-aged children in Alaska. *Journal of Pediatrics, 117*(3), e396-e404. doi:10.1542/peds.2005-1129

Balducci, L. (2003). Epidemiology of anemia in the elderly: information on diagnostic evaluation. *J Am Geriatr Soc, 51*(3), S2-9. doi:10.1046/j.1532-5415.51.3s.4.x

Barabino, A. (2002). Helicobacter pylori-related iron deficiency anemia: a review. *Helicobacter, 7*(2), 71-75. doi:10.1046/j.1083-4389.2002.00073.x

Beard, J. L. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning. *Journal of Nutrition, 131*(2), 568S-579S. doi:10.1093/jn/131.2.568S

Blanchet, C. (2008). *Nutrition and food consumption among the Inuit of Nunavik. Nunavik Inuit Health Survey 2004.* INSPQ.

Blanchet, C., Dewailly, E., Ayotte, P., Bruneau, S., Receveur, O., & Holub, B. J. (2000). Contribution of selected traditional and market foods to the diet of Nunavik Inuit women. *Canadian Journal of Dietetic Practice and Research, 61*(2), 50-59.

Braveman, P., & Gottlieb, L. (2014). The social determinants of health: it's time to consider the causes of the causes. *Public Health Reports, 129*(2), 19-31. doi:10.1177/00333549141291s206

Cash, J. M., & Sears, D. A. (1989). The anemia of chronic disease: spectrum of associated diseases in a series of unselected hospitalized patients. *Am J Med, 87*(6), 638-644. doi:10.1016/S0002-9343(89)80396-1

Centers for Disease Control & Prevention. (1988). High prevalence of iron deficiency anemia among Alaskan Native children. *Morbidity and Mortality Weekly Report, 37*(13), 200-202.

Centers for Disease Control & Prevention. (1989). CDC criteria for anemia in children and childbearing-aged women. *Morbidity and Mortality Weekly Report, 38*(22), 400-404.

Centers for Disease Control & Prevention. (1998). Recommendations to prevent and control iron deficiency in the United States. Centers for Disease Control and Prevention. *MMWR Recommendations and Reports, 47*(Rr-3), 1-29.

Christofides, A., Schauer, C., & Zlotkin, S. H. (2005). Iron deficiency and anemia prevalence and associated etiologic risk factors in First Nations and Inuit communities in northern Ontario and Nunavut. *Canadian Journal of Public Health, 96*(4), 304-307.

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal, 320*(7244), 1240. doi:10.1136/bmj.320.7244.1240

Cooper, M., Greene-Finestone, L., Lowell, H., Levesque, J., & Robinson, S. (2012). Iron sufficiency of Canadians. *Statistics Canada: Health Report, 23*, 1-10.

Couture, A., Levesque, B., Dewailly, É., Muckle, G., Déry, S., & Proulx, J.-F. (2012). Lead exposure in Nunavik: from research to action. *International Journal of Circumpolar Health, 71*, 18591-18591. doi:10.3402/ijch.v71i0.18591

Egeland, G. M., Johnson-Down, L., Cao, Z. R., Sheikh, N., & Weiler, H. (2011). Food insecurity and nutrition transition combine to affect nutrient intakes in Canadian Arctic communities. *The Journal of Nutrition, 141*(9), 1746-1753. doi:10.3945/jn.111.139006

First Nations Center. (2007). OCAP®: Ownership, Control, Access and Possession. *Sanctioned by the First Nations Information Governance Committee, Assembly of First Nations, Ottawa: National Aboriginal Health Organization.*

Fishman, S. M., Christian, P., & West, K. P. (2000). The role of vitamins in the prevention and control of anaemia. *Public Health Nutrition, 3*(2), 125-150. doi:10.1017/S1368980000000173

Flanagan, P. R., Haist, J., & Valberg, L. S. (1980). Comparative effects of iron deficiency induced by bleeding and a low-iron diet on the intestinal absorptive interactions of iron, cobalt, manganese, zinc, lead and cadmium. *The Journal of Nutrition, 110*(9), 1754-1763. doi:10.1093/jn/110.9.1754

Gagne, D., Blanchet, R., Vaissiere, E., Lauziere, J., Vezina, C., Vinet-Lanouette, C., & O'Brien, H. T. (2013). Impact of a childcare centre nutrition program on nutrient intakes in Nunavik Inuit children. *Can J Diet Pract Res, 74*(1), e311-317. doi:10.3148/74.1.2013.e311

Garner, R., Carrière, G., Sanmartin, C. A., & Team, L. R. (2010). *The health of First Nations living off-reserve, Inuit, and Métis Adults in Canada: the impact of socio-economic status on inequalities in health.* Ottawa, Canada: Statistics Canada.

Goodman, K. J., Jacobson, K., & van Zanten, S. V. (2008). Helicobacter pylori infection in Canadian and related Arctic aboriginal populations *Canadian Journal of Gastroenterology, 22*(3). doi:10.1155/2008/258610

Greenberg, A. S., & Obin, M. S. (2006). Obesity and the role of adipose tissue in inflammation and metabolism. *The American Journal of Clinical Nutrition, 83*(2), 461S-465S. doi:10.1093/ajcn/83.2.461S

Greig, A. J., Patterson, A. J., Collins, C. E., & Chalmers, K. A. (2013). Iron deficiency, cognition, mental health and fatigue in women of childbearing age: a systematic review. *J Nutr Sci, 2*(e14), 1-14. doi:10.1017/jns.2013.7

Guralnik, J. M., Eisenstaedt, R. S., Ferrucci, L., Klein, H. G., & Woodman, R. C. (2004). Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. *Blood, 104*(8), 2263-2268. doi:10.1182/blood-2004-05-1812

Hamel, D., Hamel, G., Gagnon, S. (2020). *Methodological Report.* Nunavik Inuit Health Survey 2017 *Qanuilirpitaa?* – How are we now? Quebec: Nunavik Regional Board of Health and Social Services (NRBHSS) & Institut national de santé publique du Québec (INSPQ).

Hassan, E. O., El-Hussinie, M., & El-Nahal, N. (1999). The prevalence of anemia among clients of family planning clinics in Egypt. *Contraception, 60*(2), 93-99. doi:10.1016/S0010-7824(99)00066-9

Hegazy, A. A., Zaher, M. M., Abd el-hafez, M. A., Morsy, A. A., & Saleh, R. A. (2010). Relation between anemia and blood levels of lead, copper, zinc and iron among children. *British Medical Journal, 3*(1), 133. doi:10.1186/1756-0500-3-133

Hudak, L., Jaraisy, A., Haj, S., & Muhsen, K. (2017). An updated systematic review and meta-analysis on the association between Helicobacter pylori infection and iron deficiency anemia. *Helicobacter, 22*, e12330. doi:10.1111/hel.12330

Huet, C., Rosol, R., & Egeland, G. M. (2012). The Prevalence of Food Insecurity is High and the Diet Quality Poor in Inuit Communities. *The Journal of Nutrition, 142*(3), 541-547. doi:10.3945/jn.111.149278

Hurrell, R., & Egli, I. (2010). Iron bioavailability and dietary reference values. *The American Journal of Clinical Nutrition, 91*(5), 1461S-1467S. doi:10.3945/ajcn.2010.28674F

Inuit Tapiriit Kanatami. (2014). *Social determinants ofInuit health in Canada.* Retrieved from https://www.itk.ca/wp-content/uploads/2016/07/ITK_Social_Determinants_Report.pdf

Jain, N. B., Laden, F., Guller, U., Shankar, A., Kazani, S., & Garshick, E. (2005). Relation between blood lead levels and childhood anemia in India. *Am J Epidemiol, 161*(10), 968-973. doi:10.1093/aje/kwi126

Jamieson, J. A., & Kuhnlein, H. V. (2008). The paradox of anemia with high meat intake: a review of the multifactorial etiology of anemia in the Inuit of North America. *Nutr Rev, 66*(5), 256-271. doi:10.1111/j.1753-4887.2008.00030.x

Jamieson, J. A., Weiler, H. A., Kuhnlein, H. V., & Egeland, G. M. (2012). Traditional food intake is correlated with iron stores in Canadian Inuit men. *The Journal of Nutrition, 142*, 764-770. doi:10.3945/jn.111.140475

Jamieson, J. A., Weiler, H. A., Kuhnlein, H. V., & Egeland, G. M. (2013). Higher n3-fatty acid status is associated with lower risk of iron depletion among food insecure Canadian Inuit women. *BMC Public Health, 13*, 289. doi:10.1186/1471-2458-13-289

Jamieson, J. A., Weiler, H. A., Kuhnlein, H. V., & Egeland, G. M. (2016). Prevalence of unexplained anaemia in Inuit men and Inuit post-menopausal women in Northern Labrador: International Polar Year Inuit Health Survey. *Canadian Journal of Public Health, 107*(1), e81-87. doi:10.17269/cjph.107.5173

Kassebaum, N. J., Jasrasaria, R., Naghavi, M., Wulf, S. K., Johns, N., Lozano, R., Murray, C. J. (2014). A systematic analysis of global anemia burden from 1990 to 2010. *Blood Journal, 123*(5), 615-624. doi:10.1182/blood-2013-06-508325

Kordas, K., Centeno, Z. Y. F., Pachón, H., & Soto, A. Z. J. (2012). Being overweight or obese is associated with lower prevalence of anemia among Colombian women of reproductive age. *The Journal of Nutrition, 143*(2), 175-181. doi:10.3945/jn.112.167767

Krümmel, E. M. (2009). The circumpolar Inuit health summit: a summary. *International Journal of Circumpolar Health, 68*, 509-518. doi:10.3402/ijch.v68i5.17381

Kuhnlein, H. V., Receveur, O., Soueida, R., & Egeland, G. M. (2004). Arctic indigenous peoples experience the nutrition transition with changing dietary patterns and obesity. *Journal of Nutrition, 134*(6), 1447-1453. doi:10.1093/jn/134.6.1447

Kushner, I., & Antonelli, M. (2015). What should we regard as an "elevated" C-reactive protein level? *Annals of Internal Medicine, 163*(4), 326-326. doi:10.7326/L15-5126

Kushner, I., Rzewnicki D Fau – Samols, D., & Samols, D. (2006). What does minor elevation of C-reactive protein signify? *Am J Med, 119*(2), e17-28.

Lemire, M., Kwan, M., Laouan-Sidi, A. E., Muckle, G., Pirkle, C., Ayotte, P., & Dewailly, E. (2015). Local country food sources of methylmercury, selenium and omega-3 fatty acids in Nunavik, Northern Quebec. *Science of the Total Environment, 509-510,* 248-259. doi:10.1016/j.scitotenv.2014.07.102

Lynch, S. (2007). Iron metabolism. In K. Kraemer & M. B. Zimmermann (Eds.), *Nutritional anemia* (pp. 59 – 76). Zurich, Switzerland: Zimmermann Swiss Federal Institute of Technology.

Makipour, S., Kanapuru, B., & Ershler, W. B. (2008). Unexplained anemia in the elderly. *Seminars in hematology, 45*(4), 250-254. doi:10.1053/j.seminhematol.2008.06.003

Margrete Meltzer, H., Lise Brantsæter, A., Borch-Iohnsen, B., Ellingsen, D. G., Alexander, J., Thomassen, Y., Ydersbond, T. A. (2010). Low iron stores are related to higher blood concentrations of manganese, cobalt and cadmium in non-smoking, Norwegian women in the HUNT 2 study. *Environ Res, 110*(5), 497-504. doi:10.1016/j.envres.2010.03.006

McLean, E., Cogswell, M., Egli, I., Wojdyla, D., & de Benoist, B. (2009). Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. *Public Health Nutrition, 12*(4), 444-454. doi:10.1017/S1368980008002401

Menzie, C. M., Yanoff, L. B., Denkinger, B. I., McHugh, T., Sebring, N. G., Calis, K. A., & Yanovski, J. A. (2008). Obesity-related hypoferremia is not explained by differences in reported intake of heme and nonheme iron or intake of dietary factors that can affect iron absorption. *J Am Diet Assoc, 108*(1), 145-148. doi:10.1016/j.jada.2007.10.034

Miernyk, K., Bruden, D., Zanis, C., McMahon, B., Sacco, F., Hennessy, T. Bruce, M. (2013). The effect of helicobacter pylori infection on iron stores and iron deficiency in urban Alaska Native adults. *Helicobacter, 18*, 222-228. doi:10.1111/hel.12036

Milman, N., Byg, K.-E., Mulvad, G., Pedersen, H. S., & Bjerregaard, P. (2001a). Haemoglobin concentrations appear to be lower in indigenous Greenlanders than in Danes: assessment of haemoglobin in 234 Greenlanders and in 2804 Danes. *67*(1), 23-29. doi:10.1034/j.1600-0609.2001.067001023.x

Milman, N., Byg, K.-E., Mulvad, G., Pedersen, H. S., & Bjerregaard, P. (2001b). Iron status markers in 224 indigenous Greenlanders: influence of age, residence and traditional foods. *66*(2), 115-125. doi:10.1034/j.1600-0609.2001.00312.x

Monlezun, D., Camargo, C., Mullen, J., & Quraishi, S. (2015). Vitamin D status and the risk of anemia in community-dwelling adults: results from the National Health and Nutrition Examination Survey 2001–2006. *Medicine, 95*, e1799. doi:10.1097/MD.0000000000001799

Murphy, W. G. (2014). The sex difference in haemoglobin levels in adults: mechanisms, causes, and consequences. *Blood Reviews, 28*(2), 41-47. doi:10.1016/j.blre.2013.12.003

Nead, K. G., Halterman, J. S., Kaczorowski, J. M., Auinger, P., & Weitzman, M. (2004). Overweight children and adolescents: a risk group for iron deficiency. *Journal of Pediatrics, 114*(1), 104-108. doi:10.1542/peds.114.1.104

Nemeth, E., & Ganz, T. (2006). Regulation of iron metabolism by hepcidin. *Annu Rev Nutr, 26*, 323-342. doi:10.1146/annurev.nutr.26.061505.111303

Nikooyeh, B., & Neyestani, T. R. (2018). Poor vitamin D status increases the risk of anemia in school children: National Food and Nutrition Surveillance. *Nutrition, 47*, 69-74. doi:10.1016/j.nut.2017.09.008

Nunavut, G. o. (2005). *Nutrition fact sheet series – Inuit traditional foods*. Nunavut .Retrieved from https://livehealthy.gov.nu.ca/sites/default/files/NutritionFactsheetsEnglish11-13-13-low%20res_0.pdf

O'Brien, K. O., & Ru, Y. (2017). Iron status of North American pregnant women: an update on longitudinal data and gaps in knowledge from the United States and Canada. *The American Journal of Clinical Nutrition, 106*(6), 1647s-1654s. doi:10.3945/ajcn.117.155986

Pacey, A., Weiler, H., & Egeland, G. M. (2010). Low prevalence of iron-deficiency anaemia among Inuit preschool children: Nunavut Inuit Child Health Survey, 2007–2008. *Public Health Nutrition, 14*(8), 1415-1423. doi:10.1017/S1368980010002429

Parkinson, A. J., Gold, B. D., Bulkow, L., Wainwright, R. B., Swaminathan, B., Khanna, B.,Fitzgerald, M. A. (2000). High prevalence of Helicobacter pylori in the Alaska native population and association with low serum ferritin levels in young adults. *Clinical Diagnostic Laboratory of Immunology, 7*, 885-888. doi:1071-412X/00/$04.00≤0

Patterson, A. J., Brown, W. J., Roberts, D. C., & Seldon, M. R. (2001). Dietary treatment of iron deficiency in women of childbearing age. *The American Journal of Clinical Nutrition, 74*(5), 650-656. doi:10.1093/ajcn/74.5.650

Pavord, S., Myers, B., Robinson, S., Allard, S., Strong, J., Oppenheimer, C., & on behalf of the British Committee for Standards in, H. (2019). UK guidelines on the management of iron deficiency in pregnancy. *Br J Haematol, 156*(5), 588-600. doi:10.1111/j.1365-2141.2011.09012.x

Penninx, B. W., Guralnik, J. M., Onder, G., Ferrucci, L., Wallace, R. B., & Pahor, M. (2003). Anemia and decline in physical performance among older persons. *Am J Med, 115*(2), 104-110. doi:10.1016/S0002-9343(03)00263-8

Petersen, K. M., Parkinson, A. J., Nobmann, E. D., Bulkow, L., Yip, R., & Mokdad, A. (1996). Iron deficiency anemia among Alaska Natives may be due to fecal loss rather than inadequate intake. *The Journal of Nutrition, 126*(11), 2774-2783. doi:10.1093/jn/126.11.2774

Petry, N., Olofin, I., Hurrell, R. F., Boy, E., Wirth, J. P., Moursi, M., Rohner, F. (2016). The proportion of anemia associated with iron deficiency in low, medium, and high human development index countries: a systematic analysis of National Surveys. *Nutrients, 8*(11), 1-17. doi:10.3390/nu8110693

Picklesimer, A. H., Jared, H. L., Moss, K., Offenbacher, S., Beck, J. D., & Boggess, K. A. (2008). Racial differences in C-reactive protein levels during normal pregnancy. *American Journal of Obstetrics & Gynecology, 199*(5), 523.e521-523.e526. doi:10.1016/j.ajog.2008.04.017

Pirkle, C. M., Lucas, M., Dallaire, R., Ayotte, P., Jacobson, J. L., Jacobson, S. W., Muckle, G. (2014). Food insecurity and nutritional biomarkers in relation to stature in Inuit children from Nunavik. *Canadian Journal of Public Health, 105*(4), e233-238. doi:10.17269/cjph.105.4520

Plante, C., Blanchet, C., Rochette, L., & O'Brien, H. T. (2011). Prevalence of anemia among Inuit women in Nunavik, Canada. *International Journal of Circumpolar Health, 70*(2), 154-165. doi:10.3402/ijch.v70i2.17811

Plante, C., Blanchet, C., & Turgeon O'Brien, H. (2007). *Iron deficiency and anemia among women in Nunavik*. Retrieved from Québec: https://www.inspq.qc.ca/pdf/publications/690_esi_iron_deficiency_anemia_among_women.pdf

Rochette, L., & Blanchet, C. (2007). *Qanuippitaa? Methological Report*. Retrieved from Québec: https://www.inspq.qc.ca/pdf/publications/692_esi_methodological_report.pdf

Semba, R. D., Ferrucci, L., Cappola, A. R., Ricks, M. O., Ray, A. L., Xue, Q. L., Fried, L. P. (2006). Low serum selenium is associated with anemia among older women living in the community: the Women's Health and Aging Studies I and II. *Biol Trace Elem Res, 112*(2), 97-107. doi:10.1385/bter:112:2:97

Sim, J. J., Lac, P. T., Liu, I. L. A., Meguerditchian, S. O., Kumar, V. A., Kujubu, D. A., & Rasgon, S. A. (2010). Vitamin D deficiency and anemia: a cross-sectional study. *Annals of Hematology, 89*(5), 447-452. doi:10.1007/s00277-009-0850-3

Smith, E. M., & Tangpricha, V. (2015). Vitamin D and anemia: insights into an emerging association. *Current opinion in endocrinology, diabetes, and obesity, 22*(6), 432-438. doi:10.1097/MED.0000000000000199

Soppi, E. T. (2018). Iron deficiency without anemia – a clinical challenge. *Clinical case reports, 6*(6), 1082-1086. doi:10.1002/ccr3.1529

Stauder, R., & Thein, S. (2014). Anemia in the elderly: clinical implications and new therapeutic concepts. *Haematologica, 99*(7), 1127-1130. doi:10.3324/haematol.2014.109967

Turgeon O'Brien, H., Blanchet, R., Gagné, D., Lauzière, J., & Vézina, C. (2016). Using soluble transferrin receptor and taking inflammation into account when defining serum ferritin cutoffs improved the diagnosis of iron deficiency in a group of Canadian preschool Inuit children from Nunavik. *Anemia Journal, 2016*, 10. doi:10.1155/2016/6430214

Tussing-Humphreys, L., Pusatcioglu, C., Nemeth, E., & Braunschweig, C. (2012). Rethinking iron regulation and assessment in iron deficiency, anemia of chronic disease, and obesity: introducing hepcidin. *J Acad Nutr Diet, 112*(3), 391-400. doi:10.1016/j.jada.2011.08.038

UNICEF. (2013). *Improving child nutrition: the achievable imperative for global progress*. New York: UNICEF. Retrieved from https://www.unicef.org/nutrition/index_68661.html

Uwaezuoke, S. N. (2017). Vitamin D deficiency and anemia risk in children: a review of emerging evidence. *Pediatric health, medicine and therapeutics, 8*, 47. doi:10.2147/PHMT.S129362

Van Nhien, N., Yabutani, T., Khan, N. C., Khanh le, N. B., Ninh, N. X., Chung le, T. K.,Nakaya, Y. (2009). Association of low serum selenium with anemia among adolescent girls living in rural Vietnam. *Nutrition, 25*(1), 6-10. doi:10.1016/j.nut.2008.06.032

Vieira, A. C., Diniz, A. S., Cabral, P. C., Oliveira, R. S., Lola, M. M., Silva, S. M., & Kolsteren, P. (2007). Nutritional assessment of iron status and anemia in children under 5 years old at public daycare centers. *J Pediatr (Rio J), 83*(4), 370-376. doi:10.2223/jped.1680

WHO. (2011). *Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity.* Geneva, Switzerland.

WHO. (2015). *The global prevalence of anaemia in 2011.* Geneva, Switzerland.

WHO. (2017). *Nutritional anaemias: tools for effective prevention and control.* Geneva, Switzerland

WHO, & CDC. (2004). *Assessment of iron status of populations.* Geneva, Switzerland.

Willows, N. D., & Gray-Donald, K. (2004). Infection and anemia in Canadian Aboriginal infants. *Canadian Journal of Dietetic Practice and Research, 65*(4), 180-182. doi:10.3148/65.4.2004.180

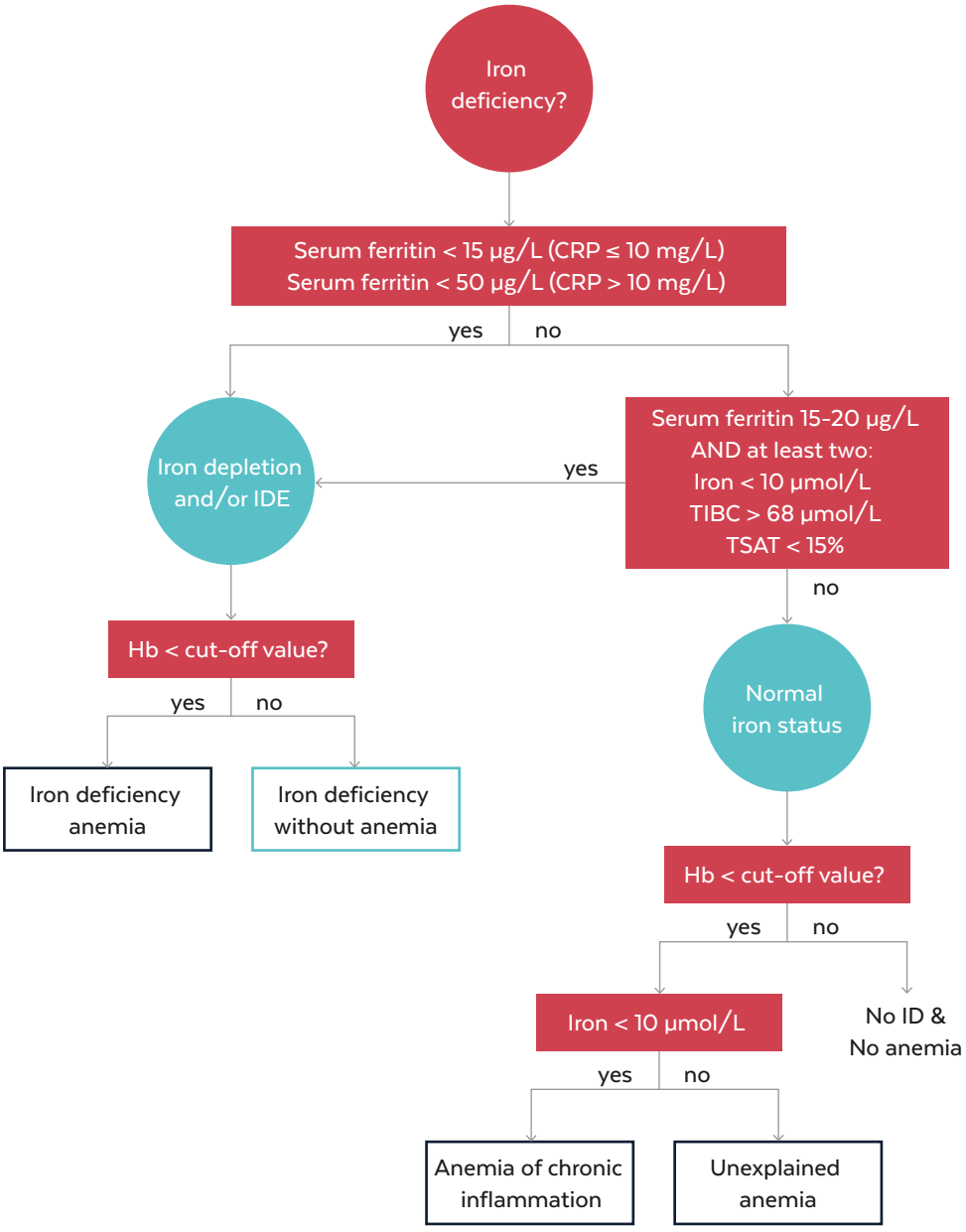
Yamashita, Y., Yabu, T., & Yamashita, M. (2010). Discovery of the strong antioxidant selenoneine in tuna and selenium redox metabolism. *World Journal of Biological Chemistry, 1*(5), 144-150. doi:10.4331/wjbc.v1.i5.144

Yamashita, Y., & Yamashita, M. (2010). Identification of a novel selenium-containing compound, selenoneine, as the predominant chemical form of organic selenium in the blood of bluefin tuna. *J Biol Chem, 285*(24), 18134-18138. doi:10.1074/jbc.C110.106377

Zijp, I. M., Korver, O., & Tijburg, L. B. M. (2000). Effect of tea and other dietary factors on iron absorption. *Critical Reviews in Food Science and Nutrition, 40*(5), 371-398. doi:10.1080/10408690091189194

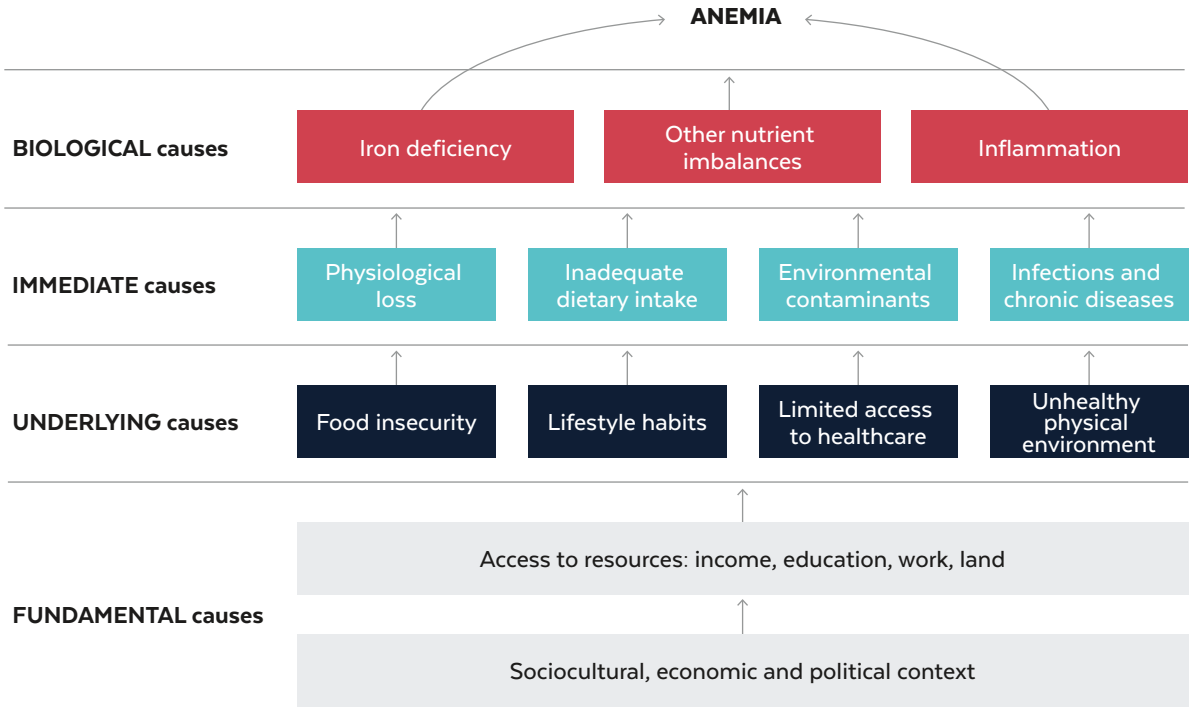
APPENDIX A

ALGORITHM OF CLASSIFICATION OF IRON DEFICIENCY AND ANEMIA AMONG MEN AND NON-PREGNANT WOMEN



APPENDIX B

CONCEPTUAL FRAMEWORK FOR DETERMINANTS OF ANEMIA AMONG NUNAVIMMIUT



ᓄᓇᕕᒻᒥ ᐃᓅᓯᓕᕆᓂᕐᒧᑦ ᑲᑎᒪᔩᑦ
RÉGIE RÉGIONALE DE LA SANTÉ ET DES SERVICES SOCIAUX DU NUNAVIK
NUNAVIK REGIONAL BOARD OF HEALTH AND SOCIAL SERVICES