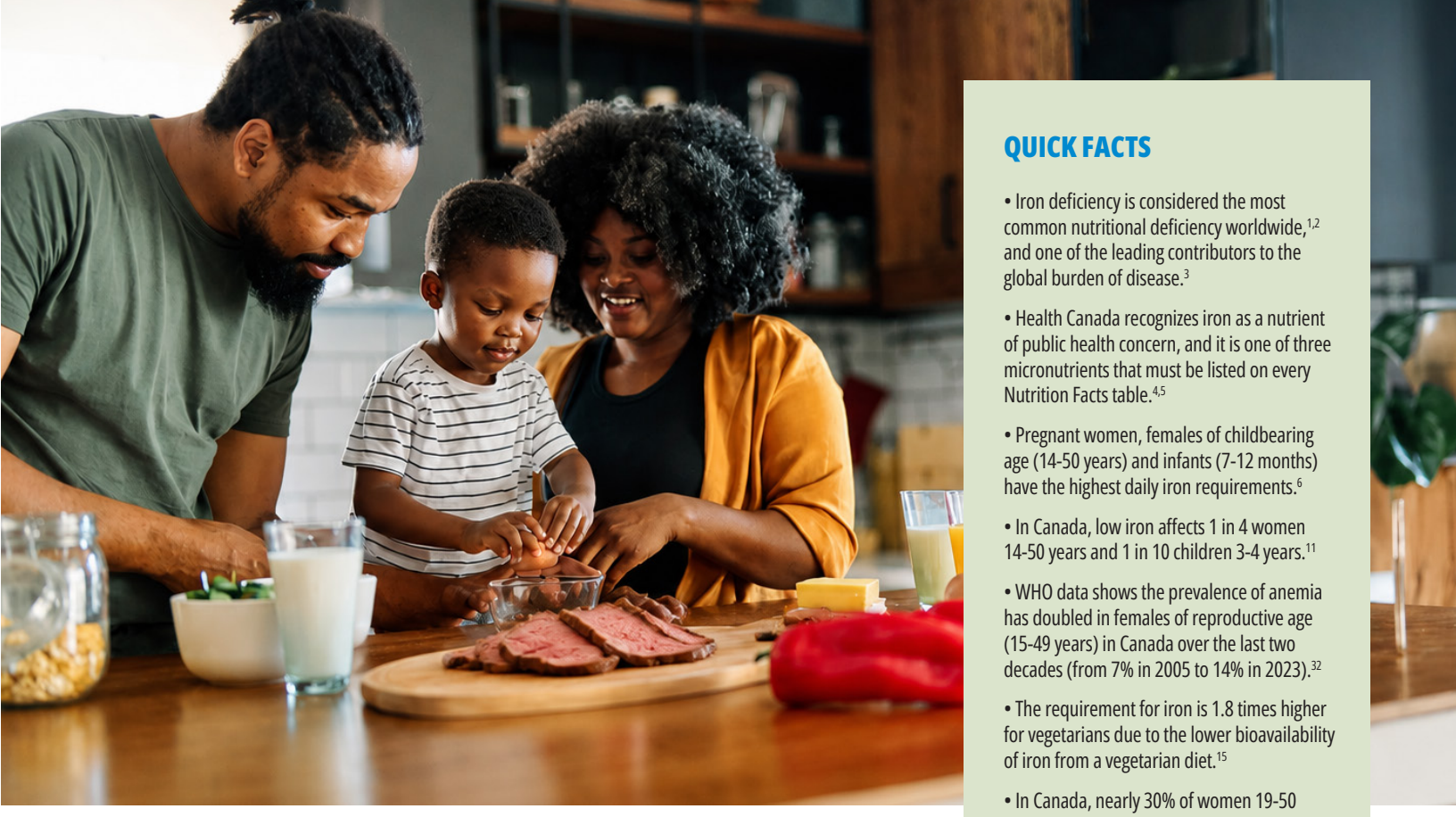

IRON ESSENTIALS
Key Facts and Evidence

Table of Contents

QUICK FACTS

- Iron deficiency is considered the most common nutritional deficiency worldwide,[1,2] and one of the leading contributors to the global burden of disease.[3]
- Health Canada recognizes iron as a nutrient of public health concern, and it is one of three micronutrients that must be listed on every Nutrition Facts table.[4,5]
- Pregnant women, females of childbearing age (14-50 years) and infants (7-12 months) have the highest daily iron requirements.[6]
- In Canada, low iron affects 1 in 4 women 14-50 years and 1 in 10 children 3-4 years.[11]
- WHO data shows the prevalence of anemia has doubled in females of reproductive age (15-49 years) in Canada over the last two decades (from 7% in 2005 to 14% in 2023).[32]
- The requirement for iron is 1.8 times higher for vegetarians due to the lower bioavailability of iron from a vegetarian diet.[15]
- In Canada, nearly 30% of women 19-50 years[35] and 25% of girls 12-18 years[36] do not consume enough iron from foods.
- The Canadian prevalence of inadequate dietary iron intake among women 19-50 years rose from 16-19% in 2004[37] to nearly 30% in 2015.[35]
- Unprocessed red meat contributes 8% to iron intake in Canadians, 1 year and over.[39]
- Research shows that eating meat (85 to 300 g/day) is associated with better iron status in adults.[46]
- Canadian research shows more frequent red meat intake is one of the strongest dietary predictors of better iron status in women.[40]
- Canadian research shows higher grain intake is associated with increased iron deficiency in premenopausal women.[40]
- Beef has been shown to increase non-heme iron absorption by 180% to 200% in adults, and this enhancing effect is more than that of chicken (100% to 140%).[53]
- Iron is essential for healthy brain development.[11] Iron deficiency is associated with ADHD,[58,59] depression and anxiety.[59]

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1. INTRODUCTION

Iron deficiency is considered the most common nutritional deficiency worldwide,[1,2] and one of the leading contributors to the global burden of disease.[3] This burden is not limited to low- and middle-income countries, and recent evidence highlights the growing burden of iron deficiency and iron deficiency anemia in developed countries.[2] Health Canada recognizes iron as a nutrient of public health concern, and it is one of three micronutrients that must be listed on every Nutrition Facts table.[4,5] Iron is especially critical for women during their childbearing years, and for infants, children and teens as it is needed for normal growth and development. Females of reproductive age and children are particularly affected by iron deficiency, due to higher iron requirements.[2] Consequences of iron deficiency range from impaired cognitive and motor development in children, to increased risks during pregnancy for mothers and their babies, to reduced physical performance and quality of life in adults.[2]

2. THE FUNCTION OF IRON

2.1 The Role of Iron

Iron is an essential mineral that is required for normal growth and development, and health throughout the entire life cycle.[6] Numerous human physiological processes depend on it. Iron is key to the formation of hemoglobin, the protein in red blood cells that transports oxygen from the lungs to tissues throughout the body.[7,8] Iron is also required for the function of myoglobin, a protein that aids in the storage and release of oxygen in muscles.[7-9] Iron plays a critical role in cellular metabolism, as a central component of mitochondrial enzymes involved in energy production.[10] Iron is also needed for DNA synthesis, synthesis of some hormones, neurodevelopment, central nervous system function, and immune function.[7-10]

2.2 Health Canada's Infographic on Iron

Health Canada's infographic on Iron – Iron a Powerhouse Nutrient for Your Health highlights that getting enough iron helps:[11]

- make red blood cells
- transport oxygen throughout the body
- support healthy brain development

3. IRON CLAIMS

3.1 Daily Values for Iron

Daily Values (DV) are used for the purposes of nutrition labelling and advertising in Canada.

The Canadian Food Inspection Agency notes the Daily Value is:

- a reference point upon which the % daily value is based.
- used to set criteria for nutrient content claims for vitamins and mineral nutrients.

The Daily Value (DV) for iron is 18 mg - unless the food is intended solely for infants or children less than 4 years of age.

Health Canada's Nutrition labelling – Table of daily values outlines the following DVs for iron:

Daily Values for Iron

Food intended solely for infants six months of age or older but less than one year of age	Food intended for infants six months of age or older but less than one year of age or children one year of age or older but less than four years of age	Any other case
11 mg iron	7 mg iron	18 mg iron

3.2 Iron Content Claims

- Beef is a good source of iron. A 100-gram serving of cooked beef contains 3.5 mg of iron, equal to 19% of the Daily Value (DV) for iron.[12]

- Beef is a good source of iron. A 100-gram serving of cooked beef contains 3.5 mg of iron, equal to 19% of the Daily Value (DV) for iron - 3 times the amount in an equal serving of chicken breast.[13]

3.3 Nutrient Function Claims

Specific Claims for Iron:[14]

- a factor in red blood cell formation
- helps build red blood cells

General Claims for Energy and Nutrients:[14]

Two general nutrient function claims are also permissible for all nutrients, including iron:

- Energy (or Name of the nutrient) is a factor in the maintenance of good health.
- Energy (or Name of the nutrient) is a factor in normal growth and development.

Examples of how to use nutrient function claims for iron:

- Beef is a good source of iron, which helps build red blood cells.
- Beef is high in iron, a factor in normal growth and development.

For more information about specific requirements for nutrient function claims see: Canadian Food Inspection Agency. 2025. Health claims on food labels – nutrient function claims.

4. DIETARY REFERENCE INTAKES FOR IRON

4.1 Recommended Daily Iron Intakes

Daily iron requirements depend on age, sex, and life stage.[6] Pregnant women, females of childbearing age (14-50 years), and infants (7-12 months) have the highest daily iron requirements.[6]

The following table shows the Recommended Dietary Allowances (RDAs) to meet daily iron needs for healthy Canadians.[6] These reference values, from the Dietary Reference Intakes report on iron, are intended for normal, apparently healthy individuals eating a mixed North American diet[15] (i.e., not a vegetarian diet). Individuals may have physiological, health, or lifestyle characteristics that require tailoring of specific nutrient values like iron. For example:

- Diet and lifestyle factors such as, following vegetarian diets that avoid meat or engaging in regular intense physical activity, can increase iron requirements.[6]
- The growth spurt experienced during puberty increases dietary iron requirements by approximately 2.9 mg/day for boys, and 1.1 mg/day for girls.[6]
- Another key factor that influences iron requirements in females is the age of onset and cessation of menstruation, which can differ from those assumed in the RDAs.[15] The assumptions made for females are included in the footnotes below the table.

Recommended Dietary Allowances (RDAs) for Iron [6,15]

Life Stage and Age	Male	Female	Pregnancy	Lactation
Infants				
0-6 months	0.27 mg*	0.27 mg*		
7-12 months	11 mg	11 mg		
Children				
1-3 years	7 mg	7 mg		
4-8 years	10 mg	10 mg		
9-13 years	8 mg	8 mg**		
Teens				
14-18 years	11 mg	15 mg**	27 mg	10 mg**
Adults				
19-50 years	8 mg	18 mg**	27 mg	9 mg**
51 + years	8 mg	8 mg**		

* The value for Infants 0-6 is an Adequate Intake (AI). There is no RDA for this age group.

** The RDA values for females assume that:
- girls younger than 14 years do not menstruate and girls 14 years and older do menstruate.
- females 51 years and older are post-menopausal.
- requirements during lactation are until menstruation resumes, assumed to be after 6 months of exclusive breast feeding.

"The requirement for iron is 1.8 times higher for vegetarians due to the lower bioavailability of iron from a vegetarian diet."[15] **– Health Canada Dietary Reference Intake Tables, 2025**

4.2 Tolerable Upper Intake Levels

The Tolerable Upper Intake Levels (ULs) are "the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects for almost all individuals."[6] The ULs are not meant to apply to individuals who receive iron under medical supervision.[6] Higher doses may be prescribed to correct iron deficiency.

The ULs for iron from food and supplements are:[6,15]

- 40 mg/day for infants 0-12 months and children 1-13 years.
- 45 mg/day for adolescents 14-18 years and adults 19-70 years and over.

5. IRON DEFICIENCY AND ANEMIA

5.1 Definitions of Iron Deficiency and Iron Deficiency Anemia

Iron deficiency can progress along a continuum to iron deficiency anemia:

- Iron deficiency is defined as low iron stores (commonly measured as low serum ferritin).[7] Guidelines vary by country and laboratory. WHO guidelines recommended low serum ferritin cut offs for apparently healthy individuals of <12 µg/L for children younger than 5 years of age and <15 µg/L for children older than 5, adolescents and adults, and higher cut offs for individuals with infection or inflammation.[16]
- Iron deficiency anemia is generally defined by low hemoglobin, < 120 g/L in females and < 130 g/L in males,[7] along with low ferritin. Iron deficiency anemia occurs when iron deficiency results in reduced red blood cell production.[7]
- While anemia may be caused by several factors, iron deficiency is the leading cause of anemia globally.[17]

In practice, it is far better to prevent low iron than to try to correct iron deficiency anemia, which can take months.[2,18]

5.2 Evolving Iron Deficiency Guidelines

Experts around the world have been advocating for increased serum ferritin cutoffs in clinical practice. In 2024, the Ontario Association of Medical Laboratories published new guidelines that raised the threshold for detecting iron deficiency.[19] These evidence-based guidelines were developed and introduced as part of the Raise the Bar[20] initiative. The guidelines were officially adopted by Ontario Health as well as two major Canadian laboratory companies in September 2024. The key change is an increase in the cut off values for serum ferritin, which is recognized as the most sensitive and specific marker for iron deficiency.[19] This means more Canadians will now be identified as iron deficient. The new guidelines aim to help healthcare providers detect and treat iron deficiency earlier to improve health outcomes.[21]

Ontario Guidelines for Detecting Iron Deficiency[19]

Life Stage	Low Ferritin is Defined As
Adults	< 30 µg/L
Children	< 20 µg/L

The previous low ferritin thresholds varied by lab in Ontario, from < 10 µg/L to < 15 µg/L.[21]

Many Canadians experiencing symptoms and feeling unwell, who were previously told their iron status was 'normal' based on the old ferritin cut-offs, may now be diagnosed as iron deficient.[21]

5.3 Common Causes of Iron Deficiency

Iron deficiency can be caused by increased iron requirements during periods of rapid growth, increased blood loss, lower dietary iron intakes, decreased iron absorption due to many gastrointestinal conditions (GI) or bariatric surgery, or a combination of these factors.[19]

Common causes of iron deficiency vary in different population groups. For example:

- Iron deficiency can occur in the context of inadequate intakes to meet high demands for rapid growth and development in infants, children, and adolescents.
- Menstrual blood loss and inadequate dietary intakes are common key drivers of iron deficiency in females of childbearing age.
- Insufficient iron intake to meet very high iron requirements to cover demands for fetal development is common in pregnant females.
- Conditions leading to blood loss or decreased absorption are common causes of iron deficiency in adult men and postmenopausal women.
- Inadequate dietary iron intake and infections (such as parasites) are common causes of iron deficiency in people from developing countries (e.g., immigrants or refugees).

Some Key Causes of Iron Deficiency[19]

Increased Iron Requirements • Growth in infants and children • Menstruation in females • Pregnancy and lactation • Recent major surgery	**Decreased Iron Intakes** • Vegetarian or vegan diets • Low intake of iron rich foods • Excess intake of iron inhibitors • Low socioeconomic status
Increased Blood Loss • Heavy or long menstrual bleeding • Gastrointestinal (GI) bleeding • Regular blood donation • Parasitic infection	**Decreased Iron Absorption** • GI disease (e.g., celiac or IBD) • Atrophic gastritis • H. pylori infection • Chronic use of antacids

Adapted from: Table 1 in Ontario Association of Medical Laboratories. 2024. Guidelines for the use of laboratory tests for iron deficiency. Revised July 2024

5.4 Symptoms of Iron Deficiency and Iron Deficiency Anemia

Both iron deficiency and iron deficiency anemia can cause symptoms and have adverse health consequences.[7,20]

Iron deficiency: Common symptoms of iron deficiency, even without anemia, include a lack of energy, fatigue, headaches, irritability, depression, difficulty concentrating, impaired memory, reduced cognitive and work performance, decreased exercise performance, dry skin, hair and nails, restless leg syndrome, and pica (cravings for non-food items).[7,20]

Iron deficiency anemia: Symptoms of iron deficiency anemia include those for iron deficiency noted above, plus insomnia, dizziness or light-headedness, fainting, shortness of breath, muscle weakness, paleness, cold hands and feet, rapid heart rate, heart palpitations, and chest pain or tightness.[7,20]

"Iron deficiency without anemia often goes unrecognized and is associated with symptoms that can negatively affect health related quality of life."[19]

– Ontario Association of Medical Laboratories, 2024

5.5 Consequences of Iron Deficiency and Anemia

Iron deficiency in infancy and childhood can have serious and irreversible effects on brain development and function. According to the Canadian Paediatric Society, "Iron deficiency can cause delayed cognitive and physical development, poor acquisition of language and learning skills, and increases risk of infection in children and adolescents."[22]

A study of mothers and their first-born child in Ireland found maternal iron deficiency during pregnancy (i.e. low ferritin < 30 µg/L at 15 and 20 weeks gestation) was associated with lower iron status in their babies at birth and poorer language and motor development in their children at 2 years of age.[23]

Research shows anemia during pregnancy can have lasting adverse health consequences for pregnant women and their offspring.[7] It is associated with an increased risk of preterm labour, postpartum hemorrhage, peripartum death, post-partum depression, and intellectual disability, autism, and attention deficit hyperactivity disorder in exposed offspring.[7]

6. PREVALENCE OF IRON DEFICIENCY AND ANEMIA

6.1 Health Canada Estimates of Iron Deficiency

Health Canada analysis shows iron deficiency is more prevalent than previously reported, especially among females of childbearing age.[1] They estimated the prevalence of iron deficiency by age and sex group in Canada based on the CHMS 2012-2019 data using different approaches to correct for inflammation.[†] They concluded their uncorrected and regression-corrected estimates provide a reasonable range for the prevalence of iron deficiency in the Canadian population. The table that follows presents this range:

Range of Estimated Prevalence of Iron Deficiency by Age Group in Canada[1]

Age Groups (years)	Uncorrected	Regression-Corrected*
Women 19-50 (non-pregnant)	18%	29%
Teenage Girls 14-18	21%	27%
Girls 5-13	9%	12.5%
Boys 5-13	7%	10%
Girls and Boys 3-4	10%	17%

*Estimates of the prevalence of iron deficiency regression-corrected for inflammation.

†Ferritin (an acute phase protein) rises in inflammatory states (e.g., infection, malignancy, chronic kidney disease), even when iron stores are depleted, which can mask iron deficiency.[1,7]

Based on this evidence Health Canada concluded that low iron affects:[11]

- 1 in 4 women 14-50 years
- 1 in 10 children 3-4 years

Health Canada considers iron deficiency a public health problem of "moderate magnitude" among females of childbearing age (14-50 years) in Canada.[1]

6.2 Vulnerable Groups at Higher Risk

According to Health Canada newcomers are twice as likely to have low iron.[11] A study of immigrant and refugee children in Toronto found iron deficiency in 53%.[24] Another study in Toronto found low family income is associated with increased risk of iron deficiency and iron deficiency anemia in young children (12-29 months).[25] The Canadian Paediatric Society also notes the prevalence of iron deficiency anemia in Indigenous communities may be up to ten times higher than in the rest of Canada.[26] They highlight estimates ranging from 36% to 58% in indigenous infants 4-18 months and 9-14 months respectively, due to poverty, food insecurity, and other factors such as diminishing access to traditional iron-rich foods.[26]

Obesity is often associated with an increased risk of iron deficiency and iron deficiency anemia.[27] Chronic, low-grade inflammation that occurs with obesity increases serum hepcidin, a hormone that inhibits iron absorption. Thus, obese individuals may have reduced iron absorption despite adequate iron intakes. However, dysmetabolic iron overload syndrome (DIOS) is also associated with obesity and other components of metabolic syndrome.[28]

6.3 Risk in Females of Reproductive Age

In females of reproductive age, iron stores are depleted by inadequate dietary intake as well as:[7]

- blood-loss due to menstruation in non-pregnant females
- high iron demands for fetal development during pregnancy
- direct and indirect iron losses during the postpartum period

Menstrual bleeding increases the risk of iron deficiency in females.[7] Normal menstrual cycles cause the loss of 10-20 mg of iron, and heavy blood loss (i.e., greater than 80 mL per cycle) is associated with an increased risk of iron deficiency.[7] While 18%-50% of females meet criteria for heavy menstrual bleeding, this remains underdiagnosed and undertreated.[7]

The risk of iron deficiency increases during pregnancy due to high iron demands for fetal growth and development.[7] Postpartum blood loss and lactation can further compound iron losses.[7]

Given that females of reproductive age are at high risk of iron deficiency and iron deficiency anemia, Canadian researchers are advocating for regular screening.[7] Recent studies have examined the prevalence of iron deficiency among females who have been screened.[29-31]

Screening in Non-Pregnant Females:

2024 – a study of non-pregnant females of reproductive age (15-54 years), found iron deficiency in about 50% of those screened in Ontario.[29] In this relatively privileged cohort:

- 38% had non-anemic iron deficiency
- 13% had iron deficiency anemia

Screening in Pregnant Females:

2021 – a study reported iron deficiency affected more than 50% of pregnancies in pregnant women screened in Ontario.[30] Ferritin tests revealed that, at least once during pregnancy:

- 53% were iron deficient
- 24% were severely iron deficient (ferritin <15 µg/L)

This study also found 40% of patients never had their ferritin checked during pregnancy.

2022 – secondary analysis of data from a clinical trial in Vancouver found high rates of iron deficiency in pregnant women, despite receiving 27 mg/day of elemental iron:[31]

- 28% had iron deficiency at 8 to 21 weeks gestation
- 81% had iron deficiency at 24 to 38 weeks gestation

6.4 Prevalence of Anemia in Canada

The prevalence of anemia in women of childbearing age[32] and young children[33] is being tracked globally. The World Health Organization (WHO) Global Health Observatory data for Canada shows the prevalence of anemia has increased over the last two decades in:

- women of reproductive age (15-49 years) - from about 7% in 2005 to 14% in 2023[32]
- children under 5 years (6-59 months) - from about 10% in 2004 to over 13% in 2019[33]

6.5 UN Global Target to Reduce Anemia

The United Nations set a Sustainable Development Goal in 2012, aiming to reduce the global prevalence of anemia among females of reproductive age by 50% by the year 2030.[34] While some countries have made progress towards this goal, Canada has not.[32]

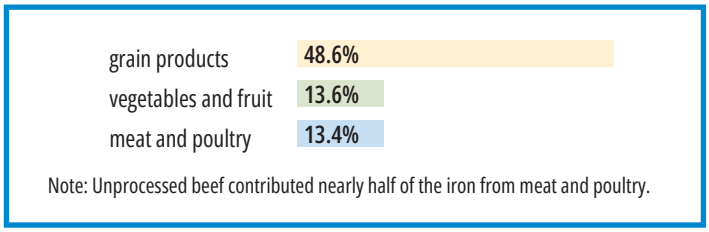
7. DIETARY IRON INTAKES

7.1 Dietary Iron Intakes in Canada

Analysis based on the most recent 2015 Canadian Community Health Survey (CCHS) - Nutrition data showed that nearly 30% of women 19-50 years[35] and 25% of girls 12-18 years[36] did not consume enough iron from foods. The prevalence of inadequate iron intake from foods increased over the previous decade, from 16-19% of women 19-50 years based on CCHS 2004 data.[37] In 2023, the Food and Nutrition Security for Manitoba Youth Study reported 31% of girls and 15% of boys in grade 9 did not meet recommended iron intakes.[38]

7.2 Sources of Iron in the Canadian Diet

Top Food Sources of Iron in The Canadian Diet[39]



Source: Health Canada. 2025. Food source contribution tool – iron.

7.3 Dietary Patterns and Iron Status

A recent Canadian study found more frequent red meat consumption is one of the strongest dietary predictors of better iron status in women.[40] This study also found higher grain intake was associated with increased iron deficiency in premenopausal women.[40] The authors note that while their results confirmed that heme iron-rich foods contribute to body iron stores, they found no such associations for plant-based foods, which contain only non-heme iron.

A Swedish study found teenage girls who limit their meat consumption were at increased risk of iron deficiency.[41] Teenage girls who ate more red meat were less likely to be iron deficient than those who ate less. The authors emphasize the need to encourage the consumption of balanced diets to ensure adequate iron intakes, especially in the context of plant-based dietary guidance.

Iron Deficiency in Teen Girls Following Different Diets[41]

Dietary Pattern	Mean Serum Ferritin µg/L	% With Iron Deficiency*
Omnivores	20	31
Pescatarians	15	49
Vegans/Vegetarians	11	69

*After adjusting for BMI, menstruation, and iron supplements

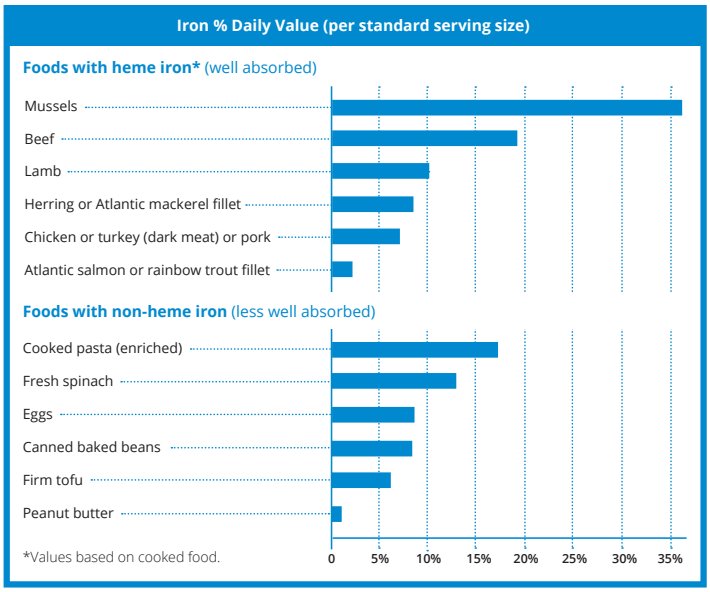
Intervention studies investigating serum ferritin levels in teenagers[42] and iron-deficient women[43] suggest beef outperforms poultry and fish.[44]

Recognising the shift to a more grain-based diet and reduced meat intake, Health Canada researchers noted the need to educate Canadians to ensure they consume enough bioavailable iron from meat, poultry, and fish, as well as vitamin C to boost non-heme iron absorption in a 2006 paper on the iron status of Canadians.[45] In 2025, Health Canada published an infographic encouraging Canadians to focus on getting enough iron.[11]

> "Robust evidence shows that meat intake (85 to 300 g/day) is positively associated with iron status in adults."[46]
>
> **– Food and Agriculture Organization of the United Nations (FAO), 2023**

8. IRON CONTENT AND BIOAVAILABILITY

8.1 Iron Content of Foods



Health Canada. Canadian Nutrient File, 2026. Serving sizes based on Health Canada's 2024 Table of Reference Amounts for Food.
% DVs calculated based on Health Canada's 2022 Nutrition Labelling – Table of Daily Values.

See also: Foods that Provide Iron

8.2 Heme and Non-Heme Iron

Two types of iron are found in foods, heme iron and non-heme iron. The heme iron found in meat, poultry, and fish is more bioavailable and better absorbed (15%-35%) than the non-heme iron in plant foods (tofu, lentils, cereal) and eggs (2-20%).[6,47] Since heme iron is better absorbed than non-heme iron, it can account for more than 40% of total iron absorption.[48]

Iron and Heme Iron Content of Cooked Meat, Poultry, Fish, and Eggs[49]

Foods	Total Iron mg/100g	Heme Iron mg/100g	Heme Iron % of Total
Beef	2.5-3.3	1.61-2.16	65
Pork	1.0-1.7	0.38-0.68	39
Chicken	0.4-1.5	0.11-0.39	26
Fish	0.2	0.04-0.06	26
Egg yolk	3.1	0	0

Adapted from: Domellöf M, Sjöberg A. Iron - a background article for the Nordic Nutrition Recommendations 2023. Food Nutr Res 2024;68.

Beal and Ortenzi classified foods into one of three levels of iron absorption:[50]

- 20% for ruminant meat
- 15% for all other animal-source foods
- 10% for all plant-source foods

8.3 Iron Enhancers and Inhibitors

Some factors enhance non-heme iron absorption while others inhibit it.[48,51]

Enhancers and Inhibitors of Non-Heme Iron Absorption[48]

Enhancers	vitamin C, muscle tissue, and some other proteins
Inhibitors	polyphenols, phytates, calcium, and egg yolk

Note: calcium decreases the absorption of both non-heme and heme iron.[48]

Research on the "Meat Factor":

- Studies have shown that including meat, poultry, or fish in a meal can increase non-heme iron absorption by 2 to 3 times.[48,52-53] This effect, commonly known as the "Meat Factor", is thought to be related to the muscle tissue in meat, poultry, and fish.[52]
- Beef has been shown to increase non-heme iron absorption by 180% to 200% in adults, and this enhancing effect is more than that of chicken (100% to 140%).[53]
- In 2011, the European Food Safety Authority concluded there is good evidence to support the claim "Meat or fish contributes to the improvement of non-haem iron absorption."[54] They suggest that "In order to obtain the claimed effect, foods providing at least 50 g of meat or fish should be consumed in one serving, together with food(s) containing non-haem iron. Such amounts can be easily consumed as part of a balanced diet."

Research on Grain Products:

- While many grain products such as cereals are fortified with elemental iron, researchers have noted this iron is poorly absorbed and makes "little practical contribution to improving iron status".[55] Iron compounds that are relatively soluble, such as ferrous sulfate, are not widely used for food fortification because they can cause undesirable organoleptic changes over time. The use of elemental iron which has low solubility and is relatively inert results in fortified foods with longer shelf life, but this iron has little impact on iron status.
- While nearly half of the iron in the Canadian diet comes from grain products,[39] higher grain intake is associated with increased iron deficiency in premenopausal women.[40]
- Despite their relatively high contributions to dietary iron intakes,[39] grains also contain phytates which inhibit iron absorption.[40,51] This may explain the association between higher grain consumption and iron deficiency in premenopausal women.[40]
- It is worth noting that whole grains generally contain more phytate than refined grain products.[56]
- Legumes including beans, peas, lentils and soy foods also contain phytates that inhibit the absorption of non-heme iron.[40,51]

9. IRON AND BRAIN HEALTH

9.1 Iron and Brain Development

Health Canada highlights that:[11]

- Getting enough iron helps support healthy brain development.
- Low iron levels can affect baby's development during pregnancy and lead to developmental delays in young children.

Canada's infant nutrition guidelines emphasize that:[57]

- Iron is a critical nutrient for brain development.
- Adequate iron is essential for infant growth and neurological, cognitive, motor, and behavioural development.
- Iron deficiency during infancy and childhood may have serious and irreversible effects on brain development.

The Canadian Paediatric Society's position statement on Iron requirements in the first 2 years of life states that:[26]

- Appropriate iron intake in the first 2 years of life is critical.
- Infants and toddlers are particularly vulnerable to iron deficiency as their needs increase during this period of rapid growth, especially if they have low iron stores at birth.
- Iron deficiency in early childhood is associated with
- impaired neurodevelopment.
- Studies suggest that suboptimal neurodevelopment associated with iron deficiency may not be completely reversible with iron supplementation, highlighting the importance of preventing iron deficiency, starting before birth.

The Canadian Paediatric Society also notes:[22]

- Iron deficiency can cause delayed cognitive development and poor acquisition of language and learning skills in children.

A study of mothers and their first-born child found maternal iron deficiency during pregnancy was associated with:[23]

- lower iron status in their babies at birth, and
- poorer language and motor development in their children at 2 years of age.
- Studies have found anemia in pregnancy to be associated with increased risk of intellectual disability, autism spectrum disorder, and attention-deficit/hyperactivity disorder (ADHD) in exposed offspring in early childhood.[7]

Studies have also found postnatal iron deficiency in children and adolescents to be associated with ADHD.[58,59]

9.2 Iron and Cognitive Function

- Cognitive symptoms of iron deficiency, even without anemia, include brain fog, decreased concentration, impaired memory, lower IQ (i.e., Intelligence Quotient), and reduced cognitive function.[7,20]
- A 2025 systematic review concluded that iron deficiency in early childhood disrupts neurodevelopment, leading to long-term effects on cognition, motor skills, behaviour and neuroendocrine functions compared to those with no history of iron deficiency.[60]

9.3 Iron and Mental Health

- Iron deficiency can have adverse effects on mental health including mood changes (such as irritability and low mood), anxiety, depression, and post-partum depression.[7,20,59]
- Insomnia and fatigue are common symptoms of iron deficiency[7,20] which may also impact both mental health and cognitive function.

10. RECOMMENDATIONS FOR INFANTS AND TODDLERS

10.1 Why Iron Matters for Infants and Toddlers

The Canadian Paediatric Society position statement on iron requirements during the first two years of life highlight that, "Rapid growth during infancy and early childhood increases iron requirements per kilogram more than at any other developmental stage."[26] Canada's nutrition guidelines for healthy term infants emphasize that by about 6 months of age, iron stores are depleted and infants need iron from solid foods.[61] Iron is critical for brain development in infants and children.[57] It is essential for infant's healthy growth and neurological, cognitive, motor, and behavioural development.[57] Iron deficiency during early childhood is associated with impaired neurodevelopment,[26] and can have serious and irreversible consequences.[57]

10.2 Risk of Iron Deficiency in Infants and Toddlers

The risk of iron deficiency increases from 6 to 12 months due to higher demands to support infants' rapid growth.[61] This risk remains present from 12 to 24 months when nutritional quality of the diet and consumption of key micronutrients, including iron, tend to decline.[61]

Iron deficiency occurs on a continuum, and symptoms such as poor appetite, irritability, pallor, slowed growth and development may not be apparent until the deficiency is severe.[61] Iron deficiency during these early years can progress to iron deficiency anemia which is associated with irreversible developmental delays in cognitive function.[61]

The Canadian nutrition recommendations are intended for healthy term infants.[57,61] Factors that can help health professionals identify older infants at risk of iron deficiency include the:[61]

- infant's iron status at birth
- infant's growth rate
- duration of exclusive breastfeeding
- age of introduction of cow milk, and the frequency and amount consumed
- age of introduction of solid foods
- age of introduction of foods that contain heme iron such as meat, fish, and poultry, and the frequency of consumption.

10.3 Infant Feeding Recommendations

Canadian Infant Feeding Recommendations:

Health Canada highlights the risk of iron deficiency can be reduced by the timely introduction and regular consumption of iron-rich foods, such as meat, meat alternatives, and iron-fortified cereal as infant's first complementary foods.[61] They note the bioavailability of heme iron in meat is substantially higher than non-heme iron in cereals, legumes, eggs, and tofu.[61]

Health Canada recommends that baby's first foods should be iron-rich:[61]

- From 6 to 12 months, iron-rich foods should be offered two or more times a day.
- From 12 to 24 months of age, iron-rich foods should be offered at each meal.

When infants are ready to start eating solid foods, parents and caregivers should be encouraged to offer them meat, fish, poultry, or meat alternatives each day.[61]

> **"Even small servings of meat, poultry, or fish contribute to iron intake, because much of the iron in these foods is in the heme form." [61]**
>
> **– Health Canada, 2014**

WHO Infant Feeding Guideline:

The WHO Guideline for complementary feeding of infants and young children 6-23 months of age recommends that they be fed a diverse diet with a variety of foods to ensure their nutritional needs are met and to support healthy growth and development.[62] The guidelines recommend animal source foods, including meat, fish, or eggs, should be consumed daily.[62] Dietary modelling showed that the consumption of animal source foods is essential to close nutrient gaps, and particularly that of iron, which is critical for cognitive development.[62]

- Evidence suggests the consumption of animal source foods improved growth outcomes, increased hemoglobin concentrations and reduced the risk of anaemia.[62]
- Dietary modelling showed that when meat, poultry, fish, and eggs were excluded, the diet could not fulfil needs for iron, zinc, and vitamin B12 for 6 to 8 month-old infants.[62] The gap in meeting iron requirements increased for 9 to 11 month-old infants.[62]
- All best-case diets for infants included beef, lamb, game, liver, or small fish.[62]

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