Recommendations

- Infants who are not exclusively breastfed should be offered a commercial infant formula until 9 – 12 months of age.
- When complementary foods are introduced around 6 months of age, iron-rich foods should be emphasized:
  - An infant's first complementary foods should be iron-rich (e.g. infant cereals with iron, meat, poultry, fish and meat alternatives such as legumes, eggs and tofu).
  - An iron-rich food should be offered at each meal.
  - A variety of iron-rich foods should be offered.
  - Commercial infant cereal with iron should be offered. Homemade infant cereal is not recommended.
- Iron-rich foods should continue to be offered throughout the second year of life and beyond.
- Introduction of 3.25% milk before 9 – 12 months of age is not recommended.
- It is recommended that children 1 year of age and older drink 2 cups (500 mL) of milk each day. Drinking more than this may displace iron-rich foods in their diet.
- Routine iron supplementation is not recommended as a preventative measure against iron deficiency for healthy term infants.

Health Benefits:

Iron is an important mineral involved in oxygen transportation in the body.[1] In infancy, iron is an essential nutrient for normal neurodevelopment.[2]

Iron is the most common single nutrient deficiency in the world.[2,3] Although iron deficiency is higher in developing countries, it is still a concern in developed countries such as Canada.[4]

Universal screening for iron deficiency is not currently done in Canada; therefore, national prevalence rates are not available. One Canadian study that looked at 428 healthy infants 8 – 15 months of age found that more than one third (33.9%) had iron depletion and 4.9% had iron deficiency anemia (IDA).[5] In another Canadian study, researchers analyzed blood from 1647 children 1 – 6 years of age for iron deficiency and IDA.[6] Total prevalence of iron deficiency and IDA was 9.1% and 1.6% respectively.[6] Iron deficiency in Canadian Aboriginal infants 4 – 18 months of age has been reported at 53.3%.[7] Studies in other developed countries have also found variable rates (6.6% – 27%) of iron deficiency in otherwise healthy infants and children.[2,8,9]

Considering the current research indicating that iron deficiency is present in Canada, it is important to provide recommendations to prevent iron deficiency in infants and young children.

Note: This guideline refers to healthy term infants. For information on iron and preterm infants refer to the *Nutrition Guideline: 4.2 Introduction of Complementary Foods for Preterm Infants*.

Key Questions

What are the risk factors for iron deficiency in infants and children?

Factors associated with increased risk of iron deficiency in infants and young children include:[1,2,3,4,10]

- maternal low iron status
- gestational diabetes
- premature birth
- low birth weight
- late introduction of complementary foods
- low intake of iron-rich complementary foods
- early cow's milk introduction
- high cow's milk intake
- prolonged bottle use
- immigrant status
- low socioeconomic status

What are the symptoms of iron deficiency in infants and children?

Iron deficiency occurs on a continuum with symptoms including pallor, poor appetite and irritability; growth faltering and delayed development are often not apparent until a deficiency is severe.[11] IDA in infancy is associated with poor cognitive and behavioural performance in childhood.[3] Even after iron status is corrected, certain cognitive deficits may persist into adulthood,[1,2] although study findings have been inconsistent.[1] One study found that adolescents who had iron deficiency in infancy "scored lower on measures of overall mental and motor functioning" compared to those who were iron sufficient in infancy.[12] Additionally, adolescents who had iron deficiency in infancy "showed more anxiety/depression, social problems and attention problems."[12]

How much iron do infants and children need?

Infants are born with iron stores accumulated from the third trimester of pregnancy.[1] Most healthy term infants are born with sufficient stores of iron to meet their iron needs until they are approximately 6 months old.[1,13,14] Around 6 months of age, iron stores have been utilized and external sources of iron (from food) are required.[1,3,13,14,15] Because of the rapid growth that occurs between 6 and 24 months of age, iron requirements per kilogram of body weight are higher than during any other period of life.[1,3]

The Dietary Reference Intakes (DRI) are "a common set of reference values (on macro and micro nutrients) based on scientifically grounded relationships between nutrient intakes and indicators of adequacy, as well as the prevention of chronic diseases, in apparently healthy populations."[16] The DRI recommendations include a Recommended Dietary Allowance (RDA) for iron. This refers to the average daily iron intake level sufficient to meet the needs of almost all healthy individuals in a particular life stage.[16] Table 1 provides the RDA for iron for healthy term infants and young children.[1]

Table 1. Recommended Dietary Allowance (RDA) for Iron[1]

Age	RDA
0 – 6 months	0.27 mg/day*
7 – 12 months	11 mg/day
1 – 3 years	7 mg/day**
4 – 8 years	10 mg/day**

* Adequate Intake (AI) rather than RDA; used when an RDA cannot be determined
** The requirement for iron is 1.8 times higher for vegetarians due to the lower bioavailability of iron from a vegetarian diet.[1]

For the first 6 months of life, iron requirements are based on iron amounts in the average amount of breastmilk consumed (0.78 L/day).[1] The RDA for 7 – 12 month olds was calculated assuming relatively low meat consumption (10% bioavailability), whereas the RDA for 1 – 3 and 4 – 8 year olds were calculated assuming a mixed diet (18% bioavailability).[1]

How much iron is absorbed from breastmilk?

Bioavailability refers to the accessibility of a nutrient to participate in metabolic and/or physiological processes.[1] Only some of the iron in food is considered bioavailable and is able to be absorbed and used by the body. Breastmilk contains about 0.35 mg/L of iron and 45 – 100% of this iron is bioavailable.[1] Bioavailability of iron from breastmilk decreases to approximately 15% once complementary foods have been introduced.[1]

Why is it important for infants who are not exclusively breastfed to be fed commercial infant formula?

All commercial infant formulas must undergo a full safety and nutritional quality assessment by Health Canada before they can be sold.[17] Homemade infant formula is nutritionally incomplete (low in iron, essential fatty acids and other essential nutrients) and may deliver a high renal solute load, which could affect renal function with prolonged use.[18,19,20]

Commercial infant formulas contain adequate iron (≥4 mg/L) for most healthy term infants. In 1994, Moffatt et al, randomized high risk Canadian infants with non-fortified (1.1 mg iron/L) and fortified (12.8 mg iron /L) formula.[21] Iron status was tested at 6, 9, 12 and 15 months. Iron depletion rates, defined as two or more low ferritin values (<10 µg/L), were 52.8% and 9.7% for infants consuming non-fortified and fortified formula, respectively. A homemade infant formula made with cow's milk, goat's milk or a plant-based beverage, without the addition of iron supplementation would have <1mg iron/L. Therefore, it could be speculated that the risk of iron depletion would be even higher if infants were solely fed homemade infant formula.

How much iron is in commercial infant formula?

Commercial infant formulas are regulated under the Canadian Food and Drug Regulations.[17] Infant formulas for sale in Canada contain 4 – 13 mg iron/L,[17] which is considered adequate for most healthy term infants.[17] It is prudent to recommend that infants at risk of iron deficiency consume infant formula with iron levels at the higher end of the range.[17] Although commercial infant formulas contain more iron than breastmilk, only 10% of the iron is bioavailable.[1]

Does the iron in infant formulas cause any gastrointestinal side effects?

Taking supplemental iron may have gastrointestinal side effects;[22] however, research indicates that infants fed iron-fortified formulas are no more likely to suffer gastrointestinal side effects than infants fed non-fortified formulas. No differences have been observed in the number of stools, consistency of stools, incidence of gas, colic, or spitting up between infants fed iron-fortified (12 mg/L) and those fed non-fortified (1 – 1.5 mg/L) formulas.[23,24,25] The stool colour is the only notable difference. Stools were light brown when infants consumed non-fortified formula (1.5 mg/L) compared to dark brown, black, or greenish when infants consumed iron-fortified formula (12 mg/L).[26] Practically speaking, stool patterns vary from child to child. A change in formula or introducing new foods can affect stool patterns.

For more information on constipation, refer to the *Nutrition Guideline: Healthy Infants and Young Children:* *7.1 Management of Constipation*

What are some examples of iron-rich complementary foods?

Iron requirements increase substantially from 0.27 mg/day for infants birth to 6 months of age, to 11 mg/day for infants 7 – 12 months of age.[1] It is important that an infant's first complementary foods be iron-rich to help meet their increased requirements.[3]

Iron-rich complementary foods include infant cereals with iron, meat, poultry, fish and meat alternatives such as legumes (dried beans and peas, lentils, chickpeas), eggs and tofu.

What impacts iron absorption from complementary foods?

Iron bioavailability (ability to be absorbed and used by the body) is impacted by both iron status of the individual and by diet.[27]

Iron is present in food as either heme iron, found in meat, poultry and fish, or as non-heme iron, which is found in both plant (e.g. legumes, vegetables, fruit, grains, nuts and iron-fortified grain products) and animal (eggs, meat, poultry, fish) sources.[1] The bioavailability of heme iron (approximately 20%) is only slightly influenced by dietary factors and is substantially higher than it is in non-heme iron sources (approximately 5%).[1]

The absorption of non-heme iron is strongly influenced by its interaction with other meal components.[1] Inhibitors include phytates (found in grain products and legumes), polyphenols (found in vegetables, fruit, some cereals and legumes) and calcium.[27] Enhancers include ascorbic acid (vitamin C) and heme iron sources (meat, poultry, fish).[27]

Because iron absorption is so complex and variable, it is not practical for health professionals to educate parents on all of the potential contributing factors. However, there are a few simple strategies that parents can focus on to help enhance iron absorption for their child:

- When meat and non-heme iron sources are eaten together, the meat has been shown to enhance the absorption of non-heme iron by 150%.[28,29]
  - For example, combining beef and kidney beans in a food like chili can enhance the absorption of the iron from the kidney beans.
- Vitamin C also strongly enhances the absorption of non-heme iron. Studies have concluded that iron absorption from meals is increased approximately two-fold when 25 mg of vitamin C is added and as much as three to six-fold when 50 mg is added.[1,30] Therefore, pairing food sources of non-heme iron with foods rich in vitamin C (e.g. broccoli, kiwi, oranges, red pepper, strawberries and sweet potato) can help a child's body absorb the iron. This is especially important for children being fed a vegetarian diet.
  - Practical examples of this include pairing infant cereal with iron and kiwi, black beans and mango, chickpeas and sweet potato, or making a tofu smoothie with strawberries.

What quantity of iron-rich complementary foods does an infant need to consume in order to meet their iron requirement?

It is challenging to meet an infant's iron requirement without offering a *variety* of iron-rich foods such as infant cereals with iron, meat and meat alternatives. Table 2 outlines the amount of bioavailable iron from select iron-rich foods, along with the quantities that would need to be consumed to meet an infant's iron requirement through a single iron-rich food source (e.g. only offering meat and excluding infant cereal and meat alternatives).

Table 2. Unrealistic Amounts of a Single Iron-Rich Food Needed to Meet an Infant's RDA[1,31,32,33]

Food	Total Iron Per Tbsp[A]	Bioavailable Iron Per Tbsp[B]	Amount Needed To Meet RDA for a 7 – 12 Month Old Infant Drinking 3 Cups (750 mL) Breastmilk Daily[C]
Infant cereal	1.4 mg	0.084 mg	13 Tbsp. (195 mL)
Beef	0.23 mg	0.046 mg	23 Tbsp. (245 mL)
Lentils	0.42 mg	0.021 mg	50 Tbsp. (750 mL)

[A] These values represent typical iron content of the identified foods. Iron content may vary depending on the food or product.
[B] Calculations were based on 6% bioavailability for infant cereal, 20% bioavailability for beef, and 5% bioavailability for lentils.[1]
[C] The RDA for iron for infants 7 – 12 months of age is 11 mg/day.[1] This was calculated assuming 10% bioavailability;[1] therefore 1.1 mg/day of bioavailable iron is needed. Three cups (750 mL) breastmilk would provide around 0.039 mg of bioavailable iron.[1]

Table 2 showcases that it would be difficult for an infant to meet their iron requirement without infant cereal. Heme iron sources have greater iron bioavailability than non-heme sources like infant cereal, vegetables and meat alternatives.[1] However, infant cereal has extra iron added to compensate for the decreased bioavailability. Therefore, per tablespoon, infant cereal has almost twice the amount of bioavailable iron than beef and almost four times as much as lentils (See Table 2).

Table 2 also highlights that an infant would need to eat unrealistic quantities of food to meet their iron requirements through a single food source. Conversely, Table 3 provides a sample menu that outlines how a 9 month old infant's iron requirement can be met practically by offering a variety of iron-rich foods throughout the day. It should be noted that infants should be fed according to their cues of hunger and fullness; they may eat more or less than the amounts displayed.

Table 3. Sample Menu that Meets Iron Needs of a 9 Month Old Breastfed Infant[1,31,32,33]

Meal	Food (iron-rich foods in **bold**)	Amount Offered	Total Iron (mg)[A]
Breastfed on demand (estimated at 3 cups [750 mL])			0.26
Breakfast	**Infant cereal**	2 Tbsp	2.80
	Berries	2 Tbsp	0.08
Lunch	**Lentils**	2 Tbsp	0.84
	Sweet potato	3 Tbsp	0.28
	Cheese	2 Tbsp	0.12
Snack	**Infant cereal**	2 Tbsp	2.80
Supper	**Beef**	2 Tbsp	0.46
	Pasta	3 Tbsp	0.35
	Tomato sauce	2 Tbsp	0.24
Snack	**Infant cereal**	2 Tbsp	2.80
	Banana	2 Tbsp	0.05
		Total	11.08 mg[B]

[A] These values represent typical iron content of the identified foods. Iron content may vary depending on the food or product.
[B] The RDA for iron for infants 7 – 12 months of age is 11 mg/day.[1] This was calculated assuming 10% bioavailability from a typical infant diet.[1]

Parents do not need to follow a specific meal plan for their child. Rather, a practical recommendation is that an iron-rich food be offered **at each meal**, once an infant is eating complementary foods. To help meet an infant's iron needs, a combination of infant cereals with iron and a variety of meat and meat alternatives should be offered.

Can parents make their own infant cereal?

In most cases, homemade food is a simple and healthy way to feed an infant and offers many benefits including taste, nutrition and adaptable texture. However, infant cereal with iron is one product that is difficult to replicate because of the iron fortification. It is recommended that *commercial* infant cereal with iron be offered to help meet an infant's iron needs. Homemade infant cereals made from grains (e.g. rice, quinoa, oats) or regular commercial cereals (not designed for infants) will not give infants the iron they need to grow and develop. For example, a 30 g serving (dry) of large flake or quick oats has approximately 1 mg iron.[31] The iron in commercial infant cereals ranges from approximately 6 – 8 mg per 30 g serving (dry), with most being 7 mg or above.[32,33,34] There is also variability in iron absorption depending on the type of iron added to fortified foods.[27] The iron in some fortified cereal products may not be as highly bioavailable as the iron added to infant cereals. It is also not practical or safe for a parent to attempt to add iron to homemade cereal; iron deficiency and toxicity are both serious concerns.

For parents who are concerned about commercial infant cereal being a "processed" food with additives, health professionals can help parents read and interpret ingredient lists. Health professionals can educate clients about the purpose of ingredients (See Table 4) so that ingredients are not unnecessarily perceived as unhealthy. If parents are still concerned, there are also a variety of infant cereals with iron on the market that do not contain any additives.

Table 4. Food Additives Found in Commercial Infant Cereals[35]

Food additive	Purposes	Description
Ascorbic acid (Vitamin C)	Antioxidant	Used to preserve food by hindering deterioration, rancidity, or discoloration due to oxidation
Dicalcium phosphate Tricalcium phosphate	Anticaking	Keep powders free-running
	Emulsifier	Permit the mixture of two liquids that would not normally mix; improve the volume, uniformity and fineness of grains
	pH adjusting	Reduce, increase or maintain the acidity of food which can affect microbiological quality, cooking results, flavour and texture
Lecithin	Antioxidant	See above
	Emulsifier	See above

What if an infant or toddler will not eat infant cereal with iron?

Few studies have examined the potential for infants to meet their iron requirements through meat without the addition of iron fortified foods.[9] Infant cereals with iron are an easy way to help meet an infant's iron needs.

As infants progress from pureed and smooth foods to foods with more texture, and show more interest in self-feeding, they may not be as accepting of smooth infant cereal. Because iron is an important nutrient for both infants and young children, it is important that iron-rich foods such as infant cereal with iron continue to be offered throughout the second year of life. Infant cereal can be added to other foods the child is eating such as yogurt, fruit sauce, and cooked cereals such as oatmeal. It can also be used in baking by replacing half of the flour in recipes for pancakes, muffins, and loaves with infant cereal with iron. For example, if the recipe calls for 1 cup (250 mL) of whole wheat flour, parents can use ½ cup (125 mL) of whole wheat flour and ½ cup (125 mL) of infant cereal with iron.

Does the introduction of 3.25% milk impact iron status?

At 9 – 12 months of age, infants can be offered 3.25% milk.[29] At this time, infants should be eating iron-rich foods at most meals. 3.25% milk is not an appropriate replacement for breastmilk or commercial infant formula prior to 9 months of age. Early introduction of 3.25% milk is not recommended as it increases the risk of iron deficiency because it is low in iron and can inhibit iron absorption.[29]

Excessive consumption of cow's milk has been identified as the most common risk factor for severe anemia in young children.[29,36,37] Consumption of more than 2 cups (500 mL) a day has been identified as a risk factor associated with IDA.[3,4,38] It is recommended that children 1 year of age and older drink 2 cups (500 mL) of milk each day to help meet their vitamin D requirement.[29] Children drinking more than 2 cups (500 mL) of milk daily may fill up on milk, displacing iron rich foods in their diet. Offering milk in an open cup may help to avoid excess consumption.[29,39]

Do infants need an iron supplement?

Although iron is an essential nutrient, routine supplementation is not recommended for healthy term infants as it may have negative side effects (e.g. increased risk of infections and impaired growth) on infants and young children who are iron replete.[3]

Can a child have too much iron?

The tolerable upper intake level or upper limit for iron is 40 mg/day for infants and children 8 years old and under.[1] The upper limit is based on gastrointestinal adverse effects including: constipation (most common), vomiting, nausea and diarrhea.[1] These side effects typically occur with large dose supplements of iron on an empty stomach.[1]

Children can be seriously injured by excessive doses of supplemental iron.[1] Side effects from accidental iron overdose from an iron supplement include vomiting and diarrhea, and can proceed to damaged organs. However, these side effects are associated with 20 – 60 mg iron/kg (well above the upper limit for most children).[1]

Are there any handouts on iron for healthy infants and children that I can use with my clients?

For infant nutrition resources visit Nutrition Education Materials at http://www.albertahealthservices.ca/nutrition/Page11115.aspx and click on **Infants**.

For more information related to healthy infants and children see Healthy Parents Healthy Children.

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