Iron deficiency is a public health problem in Canadian infants and children

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Iron deficiency is the most common nutritional deficiency worldwide. In Canada, there has not been a national study of iron deficiency in infants and children for more than 30 years, when the prevalence of iron deficiency anemia was reported to be approximately 19% (1). Since then, there have been several small studies (2-11) targeting different Canadian population groups (Table 1). The prevalence of iron deficiency in these studies ranges from approximately 12% to 64%, and iron deficiency anemia from 1.5% to 79%. According to the WHO, the prevalence of anemia should be less than 5% and is defined as a mild public health problem if the prevalence is 5% to 19.9%, a moderate problem if the prevalence is 20% to 39.9% and a severe problem when the prevalence is 40.0% or greater (12). Therefore, by definition, there are populations in Canada in which iron deficiency anemia is indeed a public health problem.

Iron is a vital micronutrient that is used by every cell and organ system in the body. It has been found to act as a cofactor in many enzymatic reactions at the cellular level, and affects neurotransmitter production and function, hormone function and DNA replication (13,14). Deficiency of iron, therefore, results in the disruption of normal cell and organ function. The most clinically obvious consequence of iron deficiency is anemia; however, virtually every organ system is affected. Some important consequences of iron deficiency in young children include changes in cognitive and behavioural performance, impairment of physical growth and immune function, and even death (14). There are also more recently described neurological consequences of iron deficiency in children (15). Canadian work has demonstrated an association between iron deficiency and paediatric stroke (ischemic and thrombotic) (16-18). The most recent case-control study (18) found that children who have had a stroke were 10 times more likely to be iron deficient. Breath-holding spells (19) and febrile seizures (20-23) have also been associated with iron deficiency.

Of great concern is the fact that several studies have demonstrated psychomotor delay and behavioural abnormalities in infants and children with iron deficiency. In a review (24) of published literature examining the relationship between iron deficiency and neurodevelopment, the authors concluded that causation was difficult to ascertain in children younger than two years of age, given the lack of developmental improvement in infants who were treated with iron. Some argue that the lack of improvement indicates that socioeconomic factors are causing both the iron deficiency and developmental problems; hence, the reason why the changes are irreversible with iron therapy. Others, however, argue that it is indeed iron deficiency that is responsible for the developmental changes. This notion is supported by work in the basic sciences that has demonstrated the irreversible effects of iron deficiency on the developing brain in animal models (13). Thus, iron supplementation does not result in clinical improvement in infants because the effects of iron deficiency on the developing brain are irreversible.

This review (24) also describes a larger body of evidence in children older than two years of age that demonstrates that iron-deficient children usually have worse cognitive function than their peers, which improves with iron therapy. This is helpful in demonstrating causation, and also suggests that the long-term outcome for children who become iron deficient at an older age is better, given the reversible nature of their cognitive difficulties with treatment. In summary, the authors concluded that iron deficiency and anemia in infants and young children are markers for developmental delay.

Given the negative impact of iron deficiency on child health, what is the current recommendation for screening in Canadian children? In 1979, the Canadian Task Force on the Periodic Health Examination concluded that screening for iron deficiency was not required for infants as part of routine care (25). This was based on the assumption that only infants with severe anemia would benefit from iron therapy. The Canadian Task Force on Preventive Health Care revised these recommendations in 1994 (last updated in 1998) (26). Based on the developing body of literature regarding iron deficiency and neurodevelopmental problems in infants and children, the Task Force suggested that "there is fair evidence to complete a screening hemoglobin as part of routine care of high-risk infants (includes infants of families of low socioeconomic status, Chinese or aboriginal ethnic origin, low birth weight, or fed only whole cow's

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TABLE 1
Summary of studies on iron deficiency in infants and young children in Canada

Author, year (reference)	Population	Age, months	Iron deficiency, %	Iron deficiency anemia, %	Risk factors identified
Chan-Yip and Gray-Donald, 1987 (2)	Chinese children from Montreal, Quebec	6–36	12.1		
Lehmann et al, 1992 (3)	Disadvantaged infants from Montreal	10–14		25	Early cow's milk, delayed cereal
Zlotkin et al, 1996 (4)	Middle-class infants from urban Toronto, Ontario	8.6–15.2	17.2	1.5	
	Middle-class infants from urban Halifax, Nova Scotia	8.6–15.2	50.9	4.7	
	Middle-class infants from urban Montreal	8.6–15.2	60.2	8.4	
	Middle-class infants from urban Edmonton, Alberta	8.6–15.2	63.5	6.1	
	Overall cohort	8.6–15.2	33.9	4.3	
Innis et al, 1997 (5)	Middle-class multiethnic infants from Vancouver, British Columbia	9	24	7	Early cow's milk or low-iron formula; breastfeeding
Sawchuk et al, 1998 (6)	Infants from First Nations reserve, central British Columbia	9–14		52	Iron-deficient diet
Friel et al, 1999 (7)	Infants from Newfoundland (Newfoundland and Labrador) breastfed or fed evaporated milk	18		Breastfed: 4 Evaporated milk: 17	Iron-deficient diet; low maternal level of education and income with evaporated milk diet
Willows et al, 2000 (8)	Inuit infants from northern Quebec	2, 6 and 12	3.8, 16.5, 60.0	1.3, 24.4, 26.3	Use of cow's milk or low-iron formula
Christofides et al, 2005 (9)	One Inuit (Nunavut) and two Cree First Nations (northern Ontario) communities	6–17	53.3	27.6	Cow's milk or evaporated milk consumption; iron-fortified formula decreased risk
Godel et al, 1992 (10)	Western Canadian Arctic	Mother: Pregnant, delivery, 4 months postpartum	34, 25, 51.7		Mother: Poor dietary iron
		Infant: 4	31		Infant: Improved iron status with prenatal iron supplementation
Hodgins et al, 1998 (11)	Nunavik Inuit population	Mother: Pregnant	40		
		Infant: 9–14	58	79	

milk during the first year of life)". There was, however, insufficient evidence to recommend including or excluding hemoglobin screening as part of routine care for normal-risk infants. This recommendation was given because of the "low prevalence of IDA [iron deficiency anemia] in the general population, the inaccuracy of hemoglobin measurement, and the conflicting evidence for iron therapy".

Interestingly, published work provides contrary information regarding the prevalence of iron deficiency anemia in 'normal-risk' infants and children. Zlotkin et al (4) found that groups of urban infants who were considered to be 'normal risk' had a prevalence of iron deficiency anemia ranging between 1.5% and 8.4%, with two of the four groups having rates exceeding 5%. This indicates a mild public health problem. Another study (5) of middle-class infants from Vancouver, British Columbia, found the prevalence of iron deficiency anemia to be 7%. Furthermore, a study (27) recently completed in the Edmonton (Alberta) area using a large database of more than 32,000 patients 12 to 59 months of age, between 2002 and 2008, determined that the peak age for iron deficiency anemia was 19 months, with a prevalence of 7.69%. Futhermore, the prevalence exceeded 5% at one to two years of age and two to three years of age (27). These studies suggest that iron deficiency anemia is more common in 'normal-risk' children than what is assumed, and above the acceptable prevalence of 5%.

The current recommendations for iron deficiency screening in Canada are more than 10 years old, and are based on data generated from small dated population studies. Therefore, before one is able to effectively develop a plan to address the problem of iron deficiency, it is essential to ascertain the current prevalence and severity of iron deficiency in a diverse group of Canadian children. The information attained will provide a basis to develop a strategy to redefine risk groups, and revisit screening recommendations.

In terms of a specific nutritional intervention, the first step to decreasing iron deficiency in infants is the prevention of iron deficiency in mothers during pregnancy and lactation. It has been demonstrated that infants born to women with adequate iron stores are less likely to be iron deficient (10,28). Interventions such as ensuring adequate

nutrition, screening, and supplementation with iron, as required for pregnant and lactating women, would be sensible first steps. Follow-up data measuring the effectiveness of these interventions in the Canadian context would contribute to the evidence that can inform future decision making.

Nutritional intervention in infancy begins with the promotion of breastfeeding or healthy alternatives for infants whose mothers choose not to breastfeed. Promotion of breastfeeding, as recommended by the WHO, to improve the nutritional status of infants should be ongoing (12,29). A recent Canadian study (30) found that 85% of women attempted to breastfeed their newborn; however, by six months, fewer than one-half continued to breastfeed partially or exclusively. Furthermore, only 17% of women exclusively breastfed their newborn until six months of age, and these were women of higher education and socioeconomic status. Given the low rates of breastfeeding, it is critical to ensure that infant formula is safe and nutritionally complete to protect the infants of mothers who choose not to breastfeed. An example of how advocacy has been effective is reflected in the near removal of low-iron formulas (which are known to contribute to iron deficiency) from the Canadian market. Finally, identified risk factors for iron deficiency in Canadian children that may be easily targeted for intervention include delayed introduction of iron-rich solids beyond six months (3), the early introduction of cow's milk or evaporated milk (3,5,7-9), the use of low-iron infant formulas (5,8), and lower socioeconomic status and maternal education level (7) (Table 1).

The WHO recommends that in communities with prevalence rates of iron deficiency anemia exceeding 40%, all infants and toddlers receive iron supplementation (12). In Canada, geographical areas with severe iron deficiency anemia include largely remote, socially disadvantaged areas that have limited access to affordable iron-fortified formulas and complementary infant foods. These communities typically have a health care centre that is responsible for meeting the communities' primary health care needs, and is suited to take on this responsibility. Breastfeeding support and iron-fortified infant formula should be provided for infants younger than one year of age whose mothers choose not to breastfeed in spite of education and positive encouragement. This approach has been demonstrated to be successful. Provision of an iron-fortified infant formula to infants who lived in a First Nations Canadian community and who were not being breastfed resulted in an observed decrease (from 52% to 4.2%) in the prevalence of iron deficiency anemia (6). For infants and children who eat solid food, an alternative method of delivery of iron supplementation in communities with a high prevalence of iron deficiency anemia is the use of micronutrient 'sprinkles'. These sprinkles, which are poured from a premeasured sachet and mixed into food, have been found to be effective, safe and culturally acceptable when introduced to First Nations and Inuit communities in Canada (31). Unfortunately, this product is not currently available in North America, but has been approved for clinical trials in the past.

SUMMARY

Iron deficiency is an inadequately addressed and significant public health problem among Canadian infants and children that has short- and long-term health consequences. Guidelines for screening for iron deficiency in our population are dated. This has contributed to a lack of current prevalence data and, thus, the true extent of the problem is not well elucidated, although the published literature suggests that it is likely greater than anticipated. Several risk factors for severe iron deficiency have been identified in Canada, and some initial work has informed us of potential evidence-based interventions. In spite of recommendations by the WHO (29), Canada does not have a national strategy to address infant and childhood nutrition and iron deficiency. The Canadian Paediatric Society is in an excellent position to provide leadership in the development of such a strategy, including collecting prevalence data, redefining risk groups and screening recommendations, and developing targeted and evidence-based interventions with appropriate follow-up that will further our knowledge. Iron deficiency is a preventable public health problem with serious consequences for Canadian children, and requires urgent attention.

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