

Iron deficiency anemia among children: Addressing a global public health problem within a Canadian context

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Despite current Canadian pre- and perinatal nutrition programs, the prevalence of both iron deficiency and iron deficiency anemia (IDA) is very high among young Aboriginal children from Canada's remote north. The major risk factors for IDA include prolonged consumption of evaporated cow's milk, chronic infection and prolonged exclusive breastfeeding. In the present article, the authors discuss IDA as a significant public health problem in Canadian Aboriginal communities. Whereas the prevalence of IDA in Canadian children is between 3.5% and 10.5% in the general population, in two Northern Ontario First Nations communities and one Inuit community, the anemia rate was 36%, with 56% having depleted iron stores. Traditional methods of preventing IDA, including targeted fortification, dietary diversification and supplementation, have not solved the problem. The authors' research group at The Hospital for Sick Children in Toronto, Ontario, conceived of the strategy of 'home fortification' with 'Sprinkles' – single-dose sachets containing micronutrients in a powder form, which are easily sprinkled onto any foods prepared in the household. In Sprinkles, the iron (ferrous fumarate) is encapsulated within a thin lipid layer to prevent the iron from interacting with food. Sprinkles have been shown to be efficacious in the treatment of anemia in many developing countries. Their use in Aboriginal communities to treat and prevent anemia is described in the present paper. The authors believe that children in Aboriginal communities across Canada would potentially benefit if Sprinkles were incorporated into Health Canada's current distribution system, in combination with a social marketing strategy to encourage their use.

Key Words: *Aboriginal children; Anemia; Iron deficiency; Iron supplement; Sprinkles*

Iron deficiency (ID) remains the most common preventable nutritional deficiency in the world, despite continued global efforts to control it (1). The latest World Health Organization and United Nations Children's Fund estimates suggest that the number of children with ID and anemia is approximately 750 million. Young children between six and 24 months of age are at greatest risk for iron deficiency anemia (IDA) due to their high dietary iron requirements during this period of rapid growth and limited access to iron-containing foods. In children, IDA has a significant impact on motor, cognitive and socioemotional development that may not be reversible (2-4). Although the cause of IDA among young children can be multifactorial, the consumption of foods with low bioavailable iron is likely the primary contributing factor. In industrialized countries, the

L'anémie ferriprive chez les enfants : Un problème mondial de santé publique dans un contexte canadien

Malgré les programmes canadiens de nutrition prénatale et périnatale, la prévalence de carence en fer et d'anémie ferriprive (AF) est très élevée chez les enfants autochtones du Grand Nord canadien. Les principaux facteurs de risque d'AF incluent une consommation prolongée de lait de vache évaporé, une infection chronique et un allaitement exclusif prolongé. Dans le présent article, les auteurs abordent l'AF sous l'aspect d'un grave problème de santé publique dans les communautés autochtones du Canada. Tandis que la prévalence d'AF dans la population générale d'enfants canadiens se situe entre 3,5 % et 10,5 %, dans deux communautés des Premières nations et une communauté inuite du nord de l'Ontario, le taux d'anémie atteignait 36 %, et chez 56 %, leurs réserves de fer étaient épuisées. Les moyens classiques pour prévenir l'AF, y compris l'enrichissement ciblé, la diversification alimentaire et les suppléments, ne résolvent pas le problème. Le groupe de recherche des auteurs à *The Hospital for Sick Children* de Toronto, en Ontario, ont conçu la stratégie d'« enrichissement à domicile » avec le produit Sprinkles, des sachets unidoses contenant des oligoéléments sous forme de poudre, facile à saupoudrer sur les aliments préparés à la maison. Dans Sprinkles, le fer (du fumarate ferreux) est encapsulé dans une fine couche de lipide pour l'empêcher d'interagir avec l'aliment. L'efficacité de Sprinkles dans le traitement de l'anémie a été démontrée au sein de nombreux pays en voie de développement. Son utilisation dans les communautés autochtones pour traiter et prévenir l'anémie est décrite dans le présent article. Les auteurs sont d'avis que les enfants des communautés autochtones du Canada pourraient tirer profit de Sprinkles si ce produit était incorporé au système de distribution de Santé Canada, en association avec une stratégie de commercialisation sociale visant à en favoriser l'usage.

prevalence of ID among children has been greatly reduced with the advent of fortified foods, such as iron-fortified infant cereals, specifically targeted toward children. However, IDA continues to be a significant public health problem among pockets of vulnerable groups within Canada. These include remote Canadian Aboriginal communities, where access to fortified foods is often limited and programs to control IDA have been unsuccessful. Adherence to treatment strategies using ferrous sulphate drops has also been unsuccessful in these communities due to the poor acceptability of the drops.

In response to the global need for alternative strategies to control anemia and other micronutrient deficiencies among infants and young children, 'Sprinkles' were developed in the Research Institute at The Hospital for Sick

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Children (Toronto, Ontario) as a cost-effective, home fortification strategy (5). Sprinkles are single-serve sachets containing iron and other micronutrients that can be 'sprinkled' onto any complementary foods prepared in the home. They were specifically developed to improve compliance, acceptability and ease of use over conventional iron supplements. The efficacy and acceptability of Sprinkles to treat IDA has been well established in a number of clinical trials in developing and low-income countries (5). Within a Canadian context, Sprinkles may be an appropriate option for the control of IDA among Canadian Aboriginal children. In the present article, we discuss IDA as a significant public health problem in Canadian Aboriginal communities, current strategies for its reduction, and the use of Sprinkles as an option for its prevention and treatment. The availability of Sprinkles within Canada and models of distribution being developed internationally are described.

IRON DEFICIENCY IN CANADA

In Canada and the United States, approximately 5% of children from one to five years of age suffer from ID and anemia compared with 40% to 50% of children in nonindustrialized countries (6). Although the prevalence of IDA in Canadian children among the general population is low (3.5% to 10.5%), there are certain remote populations where the prevalence is higher (7).

Previous studies have shown the prevalence of IDA to be very high in Canadian Aboriginal populations, varying from 14% to 50% (8-11). In a recent study completed in two northern Ontario First Nations communities and one Inuit community, the prevalence of anemia (hemoglobin less than 110 g/L) was found to be 36.0%; ID (soluble transferrin receptor greater than 8.5 mg/L) was present in 27.6% of the study population; and approximately 53.3% had depleted iron stores (serum ferritin less than 12 µg/L) (12). As in the developing world, prevention and treatment strategies in these vulnerable populations are vital to prevent the significant adverse effects of IDA in Canadian children.

FACTORS CONTRIBUTING TO IRON DEFICIENCY AND ANEMIA IN GEOGRAPHICALLY REMOTE AREAS, INCLUDING CANADIAN ABORIGINAL POPULATIONS

Native reserves in northwestern Ontario (eg, the Sioux Lookout Zone) are as geographically remote as many villages in rural Africa. Whereas in some parts of rural Africa, the only access to a small town may be an unpaved path, many Canadian settlements are only accessible by airplane in the summer and ice road in the winter. Similar to the situation in developing countries, reducing poverty, preventing infectious diseases and improving access to commercially fortified foods remain challenges in reducing micronutrient deficiencies in at-risk groups such as Aboriginal communities (1,10). In a recently completed study (12) conducted among First Nations and Inuit communities in Canada, the factors associated with IDA were examined. The results showed that the major risk factor at baseline was a high consumption of evaporated milk

and cow's milk after six months of age (12). Both evaporated milk and cow's milk are low in bioavailable iron (13). In addition, consumption of cow's milk by young infants may lead to occult blood loss and resulting anemia. The low cost and ready availability of evaporated milk and cow's milk is a likely explanation for their routine use in these communities. In addition, we showed prolonged exclusive breastfeeding may also be a contributing factor associated with anemia (12). If breast milk is exclusively fed to infants after six months, iron stores are likely to become depleted if a bioavailable source of iron from complementary foods is not provided (14).

As is the case in developing countries, there is a significant burden of *Helicobacter pylori* infection among Aboriginal Canadians that exceeds the prevalence in Canada as a whole (10). The pathogenic mechanism by which *H pylori* may contribute to anemia is unknown; however, occult blood loss, decreased iron absorption, and sequestration and utilization of iron by the bacteria have been hypothesized. In the authors' recently completed study (12) in Canadian Aboriginal communities, the prevalence of *H pylori* infection was found to be high at 31% (33 of 108) of the study population and was statistically associated with anemia. The reason for the high prevalence in these communities is unknown, although overcrowding and inadequate sanitation increase the risk of infection (10).

STRATEGIES TO REDUCE IRON DEFICIENCY

Health Canada recommends exclusive breastfeeding for the first six months of life for healthy term infants because breast milk is the best food for optimal growth. Infants should be introduced to solid foods that are rich in nutrients, particularly iron, at six months, with continued breastfeeding for up to two years and beyond (15). In general, three major approaches are used to reduce the prevalence of ID within a population: fortification, dietary diversification and supplementation.

Targeted fortification

The first fortified baby food, Pablum, was invented at The Hospital for Sick Children, and became commercially available in 1931. By the early 1960s, all North American commercial infant cereal products were fortified with iron. Currently, the major source of iron in the diet of a Canadian child is commercial infant cereal or fortified formula.

Dietary diversification

In areas where access to commercially fortified foods is limited, dietary diversification may be an appropriate strategy. Dietary diversification involves the promotion of a diet with a wider variety of iron-containing foods, especially those containing heme iron, such as meat and fish. However, young children do not consume a large variety of foods; when eaten, the quantity is often quite small. Perhaps more importantly, in most countries, heme iron-containing foods are expensive and, thus, unavailable to those who need them the most. Therefore, this strategy alone may be inadequate to prevent ID in vulnerable groups.

TABLE 1
Iron status of 10 anemic children after three months of treatment with Sprinkles or iron drops

Outcome	Sprinkles (n=7)	Iron drops (n=3)
Hemoglobin (g/L)*		
Baseline	95.6±3.3	85.3±7.4
End of supplementation	110.3±14.2	107.7±18.1
Difference	14.7±12.3	22.3±20.4
Participants with anemia, n (%)		
Baseline	7 (100)	3 (100)
End of supplementation	2 (29)	1 (33)

*Mean ± SD

Supplementation

When food-based strategies (fortification and diversification) are not feasible to protect children from IDA, supplementation may be an option. For example, the World Health Organization and the United Nations Children's Fund recommend routine iron supplementation to all children six to 24 months of age who are living in communities where the prevalence of anemia is 40% or greater (16). For the past 150 years or more, oral ferrous sulphate syrups (iron drops) have been the primary strategy used to control IDA in infants and young children (17). However, adherence to iron drops is often limited owing to a combination of their unpleasant metallic aftertaste, the dark stain they may leave on the child's teeth and abdominal discomfort (18,19).

DEVELOPMENT OF SPRINKLES

Sprinkles – microencapsulated iron and other micronutrients packaged in a single-serve sachet – are a hybrid between targeted fortification and supplementation (5). The Sprinkles concept is based on 'home fortification', allowing for unfortified complementary foods, including homemade foods, to be fortified instantly with an appropriate level of micronutrients for infants and young children. It is a food-based approach rather than a medicinal intervention. When targeted fortification and dietary diversification are not adequate to control IDA, Sprinkles offer a valuable additional strategy.

STRATEGIES FOR THE REDUCTION OF IRON DEFICIENCY IN CANADIAN ABORIGINAL COMMUNITIES

The Canadian Task Force on the Periodic Health Examination recommends that all high-risk infants should be screened at nine months of age (20). However, screening is not routinely performed in Aboriginal communities; thus, a significant number of infants with IDA remain unrecognized and untreated.

Prevention of iron deficiency

The Canadian Prenatal Nutrition Program (CPNP) is a Health Canada initiative to prevent anemia (21). It advocates exclusive breastfeeding until six months of age, followed by the use of iron-fortified cereals and formulas. The CPNP provides funding for programs developed by community groups for vulnerable pregnant women. The goals of CPNP

TABLE 2
Reported side effects in 10 anemic children after three months of using Sprinkles or iron drops

Side effect	Sprinkles (%) (n=7)	Drops (%) (n=3)
Did they have diarrhea?	19	52
Did they experience vomiting?	18	52
Did the product stain the teeth?	N/A	61

N/A Not applicable

are to reduce the incidence of low birth weights, improve the health of both infants and mothers, and encourage breastfeeding. Examples of services provided by the programs include food supplementation, nutrition counselling, support and education; and referral for and counselling on health and lifestyle issues. Despite the success of the CPNP, anemia remains a major problem in Canadian Aboriginal communities.

Treatment of iron deficiency

When children in Aboriginal communities are found to be iron deficient, they are treated with iron drops, free of charge, as part of the Non-Insured Health Benefits Program (22). Despite this, iron drops are not well accepted and adherence is low (M Phelps, personal communication). The side effects of using drops, such as gastrointestinal discomfort, staining of the teeth and unpleasant taste, are likely barriers to the effectiveness of such programs (18).

SPRINKLES IN FIRST NATIONS AND INUIT COMMUNITIES

Prevention

Recognizing that alternative strategies are needed, Health Canada sponsored a multicentre trial (23) in 2000 to investigate the acceptability and safety of Sprinkles to control IDA among Aboriginal children. The trial involved 102 nonanemic children (six to 24 months of age) from two First Nations communities and one Inuit community who were randomly assigned to receive Sprinkles or a placebo for a period of six months. Sprinkles were found to be safe and acceptable in these communities, and, therefore, may be an option for use in IDA prevention programs (23).

Treatment

From those children initially screened in the study described above (23), a total of 13 children had moderate anemia (hemoglobin less than 100 g/L). Six of those children were treated with iron drops (40 mg iron) and seven received two sachets of Sprinkles each day (60 mg iron in total). After three months of treatment, hemoglobin data were collected from the seven children who had received Sprinkles and three of the children who had received drops (Table 1). The overall mean hemoglobin increased significantly from 93.2 g/L to 109.5 g/L. The cure rate for anemia in both groups was approximately 70%. Side effects, including diarrhea and vomiting, were reported more frequently in children who received drops than in those who received Sprinkles (Table 2). Focus group discussions suggested that Sprinkles were well accepted, with no adverse effects.

TABLE 3
Sprinkles distribution models

Distribution model	Description
Nongovernmental organization (NGO)	<ul style="list-style-type: none"> • Uses existing program infrastructure and relationships of local and international NGOs • Focuses on community outreach and involvement, and capacity building • Programs are designed to target most vulnerable populations
Government	<ul style="list-style-type: none"> • Uses existing public health infrastructure and programs, such as ante-/postnatal care, promotion of breastfeeding, child growth monitoring, improved infant and young child feeding practices, family planning, reproductive health and control of infectious diseases
Commercial	<ul style="list-style-type: none"> • In-country manufacturing and local economy used for distribution (capacity building, ownership and accountability) • Market niche and value are created for the product, which creates demand from the population • Focuses on behaviour change communication through social marketing • Becomes self-financing, which increases sustainability
Subsidized commercial	<ul style="list-style-type: none"> • Same as commercial approach
Public-private partnership	<ul style="list-style-type: none"> • Public sector (government and Ministries of Health) or NGOs contract production of Sprinkles from private sector to ensure distribution to the most vulnerable populations
Social franchising	
Relief	<ul style="list-style-type: none"> • Sprinkles are distributed by humanitarian and relief organizations as part of the food aid package to prevent micronutrient deficiencies in emergency situations and areas of high food insecurity

Advantages of Sprinkles

Sprinkles may be a reasonable addition to current programs, such as the CPNP, because they offer a number of advantages over iron-fortified infant formulas and iron drops. Although 'Women, Infants and Children' programs in the United States have contributed to a reduction of anemia by subsidizing the cost of formulas (mostly iron-fortified formulas), this strategy may compete with the promotion of breastfeeding and may not be cost-effective for Aboriginal communities (24). Sprinkles can be added to a wide variety of complementary foods, including traditional foods; they do not compete with breastfeeding; they are low in cost; they have minimal side effects; and they have been shown to be acceptable within these communities. Sprinkles also provide a source of other micronutrients in addition to iron. These additional minerals and vitamins may be beneficial in Aboriginal communities where low intakes of vitamin D, calcium and folate have been reported (25). Whether drops or Sprinkles are used to address ID, there is a need for a combination of health promotion and education directed at understanding the impact of anemia on the health and development of children in the community.

SPRINKLES DISTRIBUTION PROGRAMS WORLDWIDE

Sprinkles programs are being implemented by various organizations (government and nongovernment) as part of national IDA control programs worldwide (Table 3). Countries implementing or planning Sprinkles programs include Mongolia, Indonesia, Pakistan, Bangladesh, Bolivia and Haiti. The Sprinkles Global Health Initiative at The Hospital for Sick Children has partnered with local nongovernmental organizations, United Nations agencies and Ministries of Health to identify sustainable distribution models that can reach the most vulnerable populations. Improving access to Sprinkles to a wide range of populations may be possible through social marketing strategies. Social marketing, as defined by Andreason (1995) (26), is "the application of commercial marketing technologies to

the analysis, planning, execution, and evaluation of programs designed to influence the voluntary behavior of target audiences in order to improve their personal welfare and that of their society." In the case of Sprinkles, public-private alliances can promote the marketing, distribution and sale of Sprinkles at a subsidized price for the target population.

RECOMMENDATIONS FOR USE OF SPRINKLES IN CANADA

The authors believe that children in Aboriginal communities across Canada would potentially benefit if Health Canada were to incorporate Sprinkles in their current distribution system, in combination with a social marketing strategy to encourage their use. In addition, when children need more iron than is available in a typical Canadian diet (eg, infants born prematurely or small for gestational age, children with celiac disease and children with inflammatory bowel diseases) or where iron drops are an unacceptable vehicle for iron delivery, Sprinkles may be an effective alternative.

CONCLUSIONS

IDA is a major public health problem in developing countries and in certain vulnerable populations in North America. The prevalence of IDA in some Canadian Aboriginal communities is as high as that found in low-income countries such as China (26%) and Brazil (36% to 40%). Given the high prevalence of anemia among Canadian Aboriginal populations, it is apparent that current Canadian prevention strategies, such as the CPNP, are not adequate to control ID in these communities. Thus, additional strategies are needed. Sprinkles may be a valuable addition to current prevention programs as an alternative to iron drops or syrup. Sprinkles have been shown to be efficacious in the developing world and are being scaled up to reach children at risk of anemia worldwide. We believe that Sprinkles also has a role to play among high-risk children in Canada. Improving the iron status of Aboriginal children may have a positive impact on their health and development.

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COMPETING INTERESTS: Dr Stanley Zlotkin owns the intellectual property rights to Sprinkles. The HJ Heinz Company Ltd is supporting the technical development of Sprinkles on a cost-recovery basis. Any profit from the technology transfer of Sprinkles is currently donated to The Hospital for Sick Children Foundation (Toronto, Ontario).

Sprinkles availability: Sprinkles will be commercially available for retail sale in winter 2005 at the Specialty Food Shop, which is owned and operated by The Hospital for Sick Children in Toronto, Ontario. On-line ordering is available and can be accessed at <<http://www.specialtyfoodshop.com>>.

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