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Children, Adolescents, and Micronutrient Inadequacies

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After many years of not having data on dietary intakes of representative samples of Canadian children and adolescents, we now have information from the Canadian Community Health Survey (CCHS), Cycle 2.2, Nutrition[1]. This survey, conducted in 2004, used 24-hr recalls to obtain food intake data from almost 14,000 children and adolescents aged 1 to 18 years.

An important limitation of the CCHS nutrient intake data in terms of assessing nutrient inadequacy is that it reflects intakes from food alone, rather than from the combination of food and supplements. Since the contribution of intake from supplements is not considered, and because in 2004 an average of 35% of Canadian children aged 1 – 18 used a vitamin and/or mineral supplement at least once in the past month[2], the true prevalence of inadequacy may be lower than the estimated prevalence. Nevertheless, the data provide important insights about nutrients that may be of potential concern among Canadian children and adolescents.

This report presents selected findings from the CCHS, and when possible supports these with reports of biochemical evidence of micronutrient status. Nationally representative biochemical data have not been collected since the Nutrition Canada survey in the early 1970s; however, the Canadian Health Measures Survey[3] is currently underway and should provide data on the iron, folate, vitamin D and vitamin B12 status of Canadians aged 6-79.

Nutrients with an Estimated Average Requirement (EAR): Vitamin A, vitamin C, B vitamins, iron, magnesium, phosphorus and zinc.

When the distribution of requirements for a nutrient can be determined, the nutrient will have both an Estimated Average Requirement (EAR) and a Recommended Dietary Allowance (RDA). For these nutrients, the proportion of the group with intakes below the EAR estimates the prevalence of nutrient inadequacy (i.e., the proportion of a group with nutrient intakes below requirements).

Table 1 shows the RDA, the mean intake, and the estimated prevalence of nutrient inadequacy for vitamin A, vitamin C, the B vitamins, iron, magnesium, phosphorus and zinc[4,5]. It also shows the criterion that was used to set the nutrient requirement. This is relevant because the prevalence of inadequacy is specific to that criterion. For example, about 7% of teen boys have inadequate vitamin C intakes, which means their intakes wouldn't be high enough to nearly saturate neutrophils with vitamin C. It does not mean that 7% of teen boys would have scurvy. The data also illustrate that a mean intake above the RDA doesn't necessarily reflect a low prevalence of inadequacy: for several nutrients in several age/sex groups, mean intakes were above the RDA but the prevalence of inadequacy was still measureable.

Examination of the prevalence of inadequacy reveals that few children between the ages of 1 and 8 have inadequate intakes of these nutrients from food. Above that age:

- the prevalence of inadequate intakes of vitamin A increases markedly in both boys and girls
- thiamin, riboflavin, niacin and vitamin C intakes are adequate in all but a small proportion
- vitamin B6, folate, vitamin B12, and iron intakes are adequate among teen boys and preteens of both sexes, but the prevalence of inadequacy increases to 10-20% in teen girls
- magnesium intakes are inadequate in over 40% of teen boys and in two-thirds of teen girls
- about one-third of preteen and teen girls have inadequate phosphorus intakes
- about 15-20% of preteen and teen girls have inadequate zinc intakes

The functional significance of the relatively high prevalence of inadequate vitamin A intakes among preteens and teens is not clear, as the vitamin A requirement is based on the amount needed to maintain adequate liver stores[6]. However, requirements were also estimated for the prevention of impaired dark adaptation, an early sign of frank vitamin A deficiency. The requirement for this criterion of adequacy is about half of that needed to maintain liver stores[6]. Based on prevention of impaired dark adaptation, the only group with a measurable prevalence of inadequacy based on intake from food would be girls aged 14-18 (about 10% have intakes below requirements).

The significance of the apparently high prevalence of inadequate intakes of phosphorus in teen girls and of magnesium in both teen boys and girls is also unclear. Both of these nutrients play a role in bone accretion. However, there has been more concern about adverse effects on bone of high phosphorus intakes relative to calcium than from low phosphorus intakes[7,8]. Moreover, it has been suggested that phosphorus intakes may be substantially underestimated because phosphorus-containing food additives are often not reflected in nutrient databases[9]. With regard to magnesium, very little is known about the effect of varied magnesium intakes on bone accretion in children, as no controlled studies have been conducted[10].

Dietary iron deficiency was uncommon except for girls aged 14-18, among whom about 12% had inadequate intakes. This is consistent with the relative rarity of iron-deficiency anemia among most Canadian children and adolescents. For example, in a study of 232 teen girls and 164 teen boys, 6% and 3% of the girls had biochemical evidence of iron deficiency and iron deficiency anemia, respectively, whereas none of the boys had either iron deficiency or anemia[11]. However, because of the potential for long-term consequences of iron deficiency in infancy and early childhood[12], and because non-anemic iron deficiency affects cognitive function in teen and young adult women[13,14], attention to this nutrient remains a priority. Finally, it is important to note that Aboriginals living on reserves were not sampled in the CCHS: Among this group, infants and children have a high prevalence of iron deficiency anemia[1]

Nutrients with an Adequate Intake (AI): Calcium and vitamin D

For some nutrients, it was not possible to set an EAR (and corresponding RDA) because the distribution of requirements was not known. When this occurred, Adequate Intakes (AIs) were set instead. An AI is an intake level thought to meet or exceed the requirements of almost all healthy individuals, had it been possible to ascertain those requirements. Unlike nutrients with an EAR and RDA, it's not possible to determine the prevalence of nutrient inadequacy for nutrients with an AI. Instead, one can only surmise that the prevalence of inadequacy is likely low when a group's median intake meets or exceeds the AI. If the group's median intake is below the AI, no conclusions about adequacy can be made. However, one would likely recommend that intakes be increased to meet the AI.

Table 2 shows data on Canadian children's calcium and vitamin D intakes from food[4]. Although inferences about adequacy for nutrients with AIs must be made with caution, it appears that calcium intakes of most young children are adequate, as median intakes exceed the AI and most individuals have intakes above the AI. There is potential concern among those aged 9 and above, especially females, as median intakes are considerably below the AI and few individuals have intakes that meet the AI.

Given that median vitamin D intakes exceed the AI, and (except for teen girls) the majority of individuals in most age/sex groups have intakes that exceed the AI, it is probable that most Canadian children maintain plasma 25 (OH) vitamin D levels above 27.5 nmol/L, the level used to set the AI. This is supported by a study of 68 children aged 2-16 who presented at a pediatric emergency department in Edmonton at the end of winter, and consented to have a blood sample taken[16]. The mean serum 25 (OH) vitamin D concentration was 47.2 nmol/L, and only 4 children (6%) had levels below 25 nmol/L.

However, since the vitamin D AI was established in the mid 1990s, a large body of research now suggests that higher plasma concentrations may be associated with benefits in terms of bone and other health outcomes[17-20]. Many experts consider that circulating 25 (OH) vitamin D concentrations below 50 nmol/L reflect deficiency, and that 80 nmol/L may be an 'optimal' concentration. When assessed against these standards, it is likely that considerably higher proportions of Canadian children have vitamin D intakes that are not adequate to maintain vitamin D status. For example, in the study of Edmonton children described above, 34% had 25 (OH) vitamin D below 40 nmol/L[16], and presumably many more were below 80 nmol/L. In that study, meeting the AI for vitamin D did not protect against levels that are now considered low, as 27% of children with intakes at or above the AI had 25 (OH) D levels below 40 nmol/L. Children who used a multivitamin regularly were less likely to have low serum levels than those who did not.

Table 1. Recommended intakes, mean intakes, and estimated prevalence of inadequate vitamin A, vitamin C, B vitamin, iron, magnesium, phosphorus and zinc intakes from food among Canadian children

Nutrient	Both		Males		Females		Criterion used to set the nutrient requirement
	1-3 y	4-8 y	9-13 y	14-18 y	9-13 y	14-18 y	
Vitamin A (µg)							
RDA	300	400	600	900	600	700	Adequate liver vitamin A stores; extrapolated from data in adults
Mean intake	530	591	709	736	608	567	
% inadequate*	<3#	2.5	11.6	38.3	23.1	42.2	
Vitamin C (mg)							
RDA	15	25	45	75	45	65	Near-maximal neutrophil ascorbate concentrations (reflecting antioxidant function); extrapolated from adults
Mean intake	135	145	157	163	146	147	
% inadequate*	<3	<3	<3	7.1	<3	6.0	
Thiamin (mg)							
RDA	0.5	0.6	0.9	1.2	0.9	1.0	Urinary thiamin excretion and normal erythrocyte transketolase activity; extrapolated from adults
Mean intake	1.21	1.61	2.06	2.39	1.65	1.64	
% inadequate*	<3	<3	<3	<3	<3	4.1	
Riboflavin (mg)							
RDA	0.5	0.6	0.9	1.3	0.9	1.0	Urinary excretion, blood riboflavin levels, and erythrocyte glutathione reductase activity coefficient; extrapolated from adults
Mean intake	1.82	2.03	2.41	2.65	1.97	1.90	
% inadequate	<3	0	<3	<3	<3	2.4	
Niacin (mg NE)-							
RDA	6	8	12	16	12	14	Urinary excretion of niacin metabolites; extrapolated from adults
Mean intake	23.5	29.8	39.8	48.8	32.0	33.2	
% inadequate	0	0	0	0	0	<3	
Vitamin B6 (mg)							
RDA	0.5	0.6	1.0	1.3	1.0	1.2	Normal plasma pyridoxal phosphate levels and other biochemical indicators; extrapolated from adults
Mean intake	1.26	1.49	1.83	2.22	1.54	1.51	
% inadequate	<3	<3	<3	<3	<5	11.1	
Folate (DFE)¥							
RDA	150	200	300	400	300	400	Red cell folate, plasma homocysteine and plasma folate data; extrapolated from adults
Mean intake	283	396	490	571	425	445	
% inadequate*	2.9	<3	<3	5.2	<5	20.1	
Vitamin B12 (µg)							
RDA	0.9	1.2	1.8	2.4	1.8	2.4	Hematological status (normal mean cell volume & reticulocyte response, stable hemoglobin), serum B12 values; extrapolated from adults
Mean intake	3.4	3.6	4.6	5.5	3.5	3.3	
% inadequate	<3	<3	<3	1.7	<5	15.8	
Iron (mg)							
RDA	7.0	10.0	8.0	11.0	8.0	15.0	Factorial modeling of amounts needed for growth, replacing basal losses, and menstrual losses in girls aged 14-18
Mean intake	9.7	12.8	16.5	19.1	13.5	13.1	
% inadequate*	1.4	0.6	<3	<3	<3	11.9	
Magnesium (mg)							
RDA	80	130	240	410	240	360	Balance studies (for 1-8 year olds, extrapolated from studies in older children)
Mean intake	220	257	316	364	265	269	
% inadequate*	<3	<3	4.7	41.5	18.3	66.3	
Phosphorus (mg)							
RDA	460	500	1250	1250	1250	1250	Factorial modeling
Mean intake	1123	1250	1557	1790	1255	1219	
% inadequate	<3	<3	8.9	4.9	30.2	35.1	
Zinc (mg)							
RDA	3.0	5.0	8.0	11.0	8.0	9.0	Factorial modeling of amounts needed for growth and to replace basal losses
Mean intake	7.4	9.3	12.2	14.8	9.8	9.5	
% inadequate*	<3	<3	<3	5.6	14.6	19.6	

Data from Health Canada and Statistics Canada[4,5]
*Estimated as the percent with intakes below the Estimated Average Requirement (for iron, the probability approach was used to estimate the prevalence of inadequacy).
<3% is used when the coefficient of variation was >33%, but the 95% confidence interval was entirely between 0% and 3%.
- NE = Niacin Equivalent, where 1 NE = 1 mg niacin from food, or 60 mg tryptophan
¥ DFE = Dietary Folate Equivalents, where 1 DFE = 1 µg folate from food, or 0.6 µg synthetic folic acid (e.g. consumed through fortified grain products)

CONCLUSION

Data from the Canadian Community Health Survey suggest that Canadian children have adequate dietary intakes of many micronutrients. This is particularly true for children up to the age of 8. Among older children and adolescents, inadequate intakes of vitamin A are common, although the physiological significance of this is unclear. Older children and teens may also have suboptimal intakes of calcium and vitamin D. Teen girls aged 14-18 appear to be at the highest risk for inadequate intakes of micronutrients. An important limitation of the CCHS data is that they do not consider the contribution of intakes from vitamin-mineral supplements. The upcoming Canadian Health Measures Survey will provide important information on biochemical status for several nutrients.

Table 2. Calcium and vitamin D intakes of Canadian children

Nutrient	Males & Females		Males		Females		Criterion used to set the AI
	1-3 y	4-8 y	9-13 y	14-18 y	9-13 y	14-18 y	
Calcium							
median intake (mg)	1041	1003	1164	1288	950	888	Change in bone mineral content and desirable calcium retention.
AI (mg)	500	800	1300	1300	1300	1300	
% >AI	96.8	76.7	38.0	49.0	17.0	16.8	
Vitamin D							
median intake (µg)	6.3	5.6	6.6	7.2	5.2	4.4	Maintenance of plasma 25 (OH) vitamin D above 27.5 nmol/L, in the absence of sunlight.
AI (µg)	5.0	5.0	5.0	5.0	5.0	5.0	
% >AI	67.0	60.7	73.9	75.1	53.0	40.9	

Data from Health Canada and Statistics Canada[4]

The Whitehall-Robins Report is a Wyeth Consumer Healthcare Inc. publication that focuses on current issues on the role of vitamins and minerals in health promotion and disease prevention. Complimentary copies are distributed to Canadian health care professionals active or with a special interest in nutrition. Each issue is written and/or reviewed by independent health care professionals with expertise in the chosen topic.

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