British Journal of Nutrition (2022), 127, 421–430 doi:10.1017/S0007114521000994

Nutritional considerations of a paediatric gluten-free food guide for coeliac disease

Diana R. Mager[1,2]*, Samantha Cyrkot[1], Christine Lirette[1], Herbert Brill[3], Jenna Dowhaniuk[3], Heather Mileski[3], Carlota Basualdo-Hammond[4], Roseann Nasser[5], Esther Assor[6], Margaret Marcon[7] and Justine M. Turner[2,8]

[1]*Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, Alberta, Canada*
[2]*Department of Pediatrics, University of Alberta, Edmonton, Alberta, Canada*
[3]*Division of Gastroenterology and Nutrition, McMaster Children's Hospital, Hamilton, Ontario, Canada*
[4]*Department of Nutrition Services, Alberta Health Services, Edmonton, Alberta, Canada*
[5]*Department of Nutrition and Food Services, Pasqua Hospital, Saskatchewan Health Authority, Regina, Saskatchewan, Canada*
[6]*Department of Pediatrics, Division of Endocrinology, Hospital for Sick Children, Toronto, Ontario, Canada*
[7]*Division of Gastroenterology, Hepatology and Nutrition, Hospital for Sick Children, Toronto, Ontario, Canada*
[8]*Division of Pediatric Gastroenterology and Nutrition, Stollery Children's Hospital, Edmonton, Alberta, Canada*

(Submitted 20 December 2020 – Final revision received 22 February 2021 – Accepted 8 March 2021 – First published online 22 March 2021)

Abstract

The gluten-free (GF) diet is the only treatment for coeliac disease (CD). While the GF diet can be nutritious, increased reliance on processed and packaged GF foods can result in higher fat/sugar and lower micronutrient intake in children with CD. Currently, there are no evidence-based nutrition guidelines that address the GF diet. The objective of this cross-sectional study was to describe the methodological considerations in forming a GF food guide for Canadian children and youth (4–18 years) with CD. Food guide development occurred in three phases: (1) evaluation of nutrient intake and dietary patterns of children on the GF diet, (2) pre-guide stakeholder consultations with 151 health care professionals and 383 community end users and (3) development of 1260 GF diet simulations that addressed cultural preferences and food traditions, diet patterns and diet quality. Stakeholder feedback identified nutrient intake and food literacy as important topics for guide content. Except for vitamin D, the diet simulations met 100 % macronutrient and micronutrient requirements for age–sex. The paediatric GF plate model recommends intake of >50 % fruits and vegetables (FV), <25 % grains and 25 % protein foods with a stronger emphasis on plant-based sources. Vitamin D-fortified fluid milk/unsweetened plant-based alternatives and other rich sources are important to optimise vitamin D intake. The GF food guide can help children consume a nutritiously adequate GF diet and inform policy makers regarding the need for nutrition guidelines in paediatric CD.

Key words: **Coeliac disease: Gluten-free food guide: Dietary patterns: Nutrition guidelines: Paediatrics**

Coeliac disease (CD) is an autoimmune disorder where the consumption of gluten, a glycoprotein found in wheat, rye and barley, triggers intestinal villous atrophy and leads to intestinal damage. This destruction subsequently leads to the malabsorption of essential nutrients that may cause the clinical symptoms and complications of CD. The only treatment at this time for CD is lifelong adherence to the gluten-free (GF) diet[1,2].

The GF diet has become highly popularised for its perceived health benefits and incidence of food intolerance. However, many children following the GF diet may be relying on processed and packaged GF foods which can increase the risk of unhealthy dietary patterns[3–7]. Most GF processed foods are higher in fat, added sugar and glycaemic index which results in significantly higher intakes of fat and sugar in the diets of children with CD on the GF diet[3,4,6,8,9]. Common micronutrients of concern related to the Western GF diet are low folate and vitamin D intake[5,7,10]. Low folate intake in children consuming the GF diet is likely due to the lack of a folate fortification policy related to GF grains and hence the low folate content of GF processed foods[6,7,10–12]. This can make it challenging for children with CD to eat a nutritiously dense diet. This is of significant public health concern as children consuming the GF diet

Abbreviations: CD, coeliac disease; CFG, Canada's Food Guide; EAR, estimated average requirement; FV, fruits and vegetables; GF, gluten-free; RDA, recommended dietaryallowance.

* **Corresponding author:** Diana Mager, email mager@ualberta.ca

are at increased risk of developing micronutrient deficiencies which may contribute to deficits in growth and development. This is particularly relevant to females of childbearing potential where suboptimal micronutrient deficiencies (e.g. folate) can lead to increased risk for adverse maternal and infant outcomes[13].

Currently, there are no evidence-based nutrition guidelines for the GF diet, and the available general nutrition guidelines in Canada do not address eating GF or the nutritional inadequacies of the GF diet. A GF food guide is essential to ensure that children who follow the GF diet and their families can make informed food choices to consume a nutritious diet. The study objective was to describe the methodological considerations in forming a GF food guide for Canadian children and youth (4–18 years) with CD.

Methods

Three different phases informed the content of the GF food guide for Canadian children (4–18 years) with CD on the GF diet: (1) a comprehensive evaluation of food intake and diet patterns to identify nutrients of concerns[7], (2) pre-guide stakeholder (e.g. health care professionals, adults with CD, parents of children with CD) consultations to inform food guide content and (3) development of GF diet simulations taking into consideration cultural preferences and food traditions, diet patterns and diet quality[7]. This cross-sectional study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research participants were approved by the University of Alberta Human Research Ethics Board–Health Panel (Pro00065489, Pro00033867). Written informed consent/assent was obtained from participants and/or their responsible caregivers.

Evaluation of food intake

A detailed examination of dietary intake from a multi-ethnic cohort of children with CD and commercially available GF foods in the marketplace was completed and previously reported[7,12]. This included an in-depth analysis of diet patterning using cluster analysis which illustrated that >80 % of children with CD consume a Western diet (high fat, moderate-high carbohydrate). Low folate intake was likely secondary to the lack of folate-dense foods in the diet (e.g. legumes) and the lower folate content of GF foods (e.g. grains) purchased by families of children with CD[7,12].

Pre-guide consultations with external stakeholders

Pre-guide stakeholder consultations were conducted via Internet surveys with health care professionals (e.g. Registered Dietitians) and community end users (e.g. adults with CD, parents of children with CD) across Canada. Surveys were launched using RedCap® software through various health professional organisations (e.g. Canadian Association of Gastroenterology, College of Dietitians of Alberta) and through local chapters of the Canadian Celiac Association (e.g. Edmonton, Calgary) (online Supplementary Table S1)[14,15]. Survey content addressed demographic information (e.g. province, urban/rural, type of health care professional, length of CD diagnosis) and perceptions regarding GF food guide content (e.g. relevant nutrition and food literacy topics, and guide layout). Thematic analysis and descriptive statistics were used to analyse open- and close-ended questions.

Diet simulations of nutritionally adequate gluten-free diets for children 4–18 years

Diet simulations were designed so that when evaluated, the nutrient content met relative dietary reference intake values for macronutrient and micronutrient intake for age–sex[16]. Simulations were made to represent a 24-h dietary intake pattern for children (females and males) between 4 and 18 years to ensure that age-appropriate estimated average requirements (EAR) or adequate intakes were met. This methodology was modelled after Health Canada's methodological approach for the preparation of the 2007 and the 2019 Canada's Food Guide (CFG)[17,18]. Simulations were created from an in-depth analysis of diet patterns of children with CD in Canada[5,7,10]. This included a comprehensive evaluation of GF foods available in Canadian grocery stores[4,6,8,12]. Simulations were altered to meet the macronutrient and micronutrient recommendations for diet patterns across age–sex using Food Processor Nutrition Analysis Software (SQL 11.0.124, ESHA Research) and the Canadian Nutrient File[19] (Fig. 1). The average nutrient content of GF bread and GF breakfast cereal was calculated using food labels based on the top twelve brands for GF breads and the top twenty brands for GF cereals available to consumer in Canada as identified in phase one[7,12] (online Supplementary Table S2A). While the simulations evaluated the content of all macronutrients and micronutrients, an enhanced focus was placed on the intake of fat, added sugar, fibre, vitamin B_{12}, vitamin D, folate, Ca, Fe, Na and Zn. The gluten content of all diet simulations was assessed using the Osborne method with a cut-off value of <10 mg/d to indicate a safe gluten threshold[7,10,20]. Cuisines representing various cultures were chosen based on the ethnic diversity of the Canadian population and to reflect the global prevalence of CD[21]. Diet simulations (>40 %) reflected a plant-predominant diet with fruits, vegetables, grains and plant-based proteins (e.g. legumes, tofu, nuts and seeds)[22]. To encompass different food selections among the selected cuisines and diet patterns, numerous food substitution lists were developed prior to the diet simulations to ensure that representation of different ethnicities and diet patterns was incorporated into the guide (online Supplementary Table S2A–J)[7,10]. Substitutions and alterations to food items and food guide servings were made until diets were nutritionally adequate and fell within macronutrient and micronutrient, and energy ranges for age–sex (online Supplementary Table S3A–B)[16].

The nutritional adequacy of the diet simulations was assessed by diet quality index scores (Mediterranean Diet Quality Index in children and adolescence and the Canadian Healthy Eating Index)[23,24]. Mediterranean Diet Quality Index in children and adolescence ranged from 0 to 12 with >8 indicating an 'optimal Mediterranean diet', 4–7 'needs improvement' and ≤3 indicating 'low diet quality'[23]. The Canadian Healthy Eating Index was subcategorised based on adequacy (maximum score

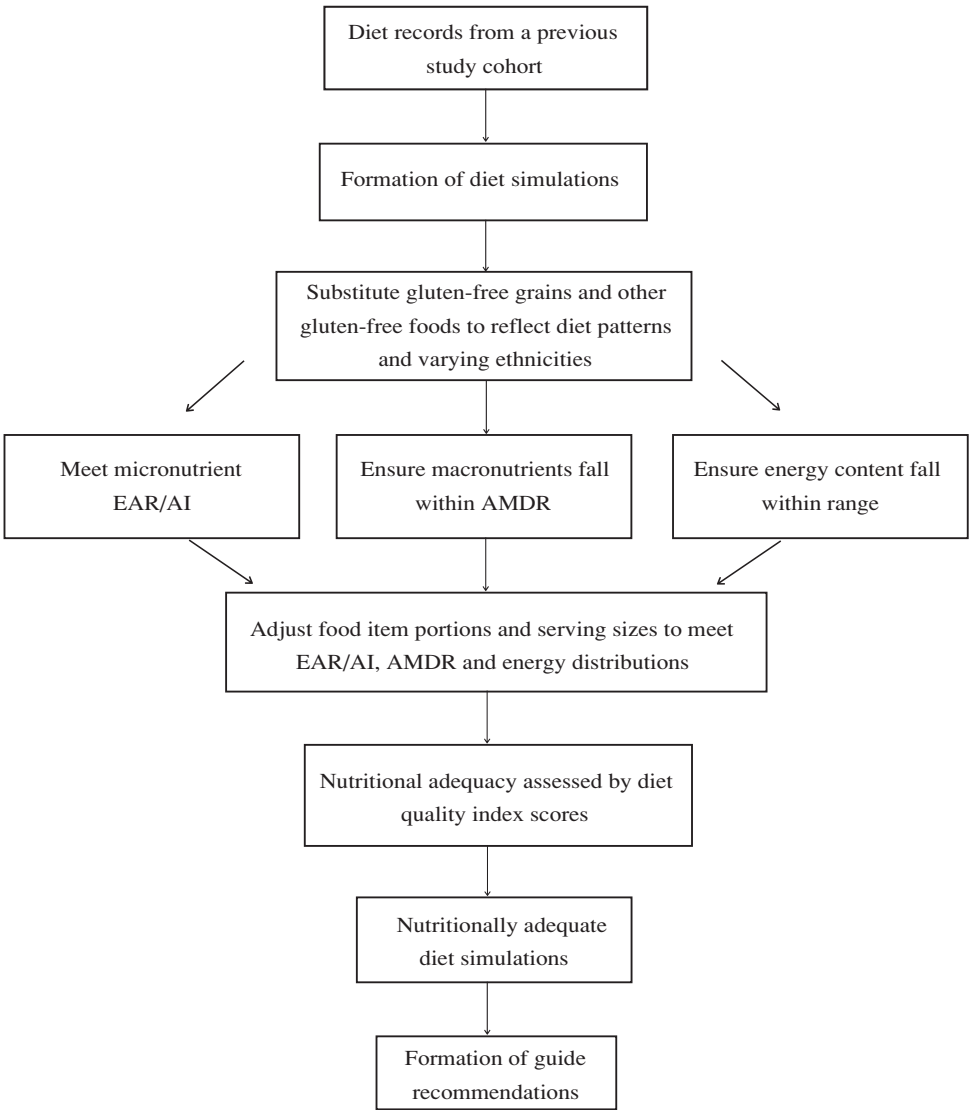

Fig. 1. The diet simulation process used to inform the content of the gluten-free food guide. EAR, estimated average requirement; AI, adequate intake; AMDR, acceptable macronutrient distribution range. Dietary data on children with coeliac disease was used to develop the diet simulations[7]. Diets were adjusted using Food Processor Nutrition Analysis Software (SQL 11·0·124, ESHA Research), the Canadian Nutrient File and manufacturer information to reflect diet patterns, cultural preferences and food traditions of the Canadian population and were based on the global prevalence of coeliac disease among the Canadian population[19,21]. To meet Health Canada[16] and the Alberta Nutrition Guidelines for Children and Youth[25] recommendations, nutrient-dense foods were added or the serving sizes of nutrient-dense foods were adjusted to meet the EAR/AI. Proportions of food items and food group servings were adjusted until macronutrients and energy content fell within ranges. Diet quality of these nutritionally adequate diets was assessed by the Mediterranean Diet Quality Index in children and adolescence[23] and the Canadian Healthy Eating Index[24].

of 50), moderation (maximum score of 40) and variety (maximum score of 10). An overall score of ≥80 signified 'optimal/excellent diet quality', 51–80 indicated 'needs improvement' and ≤50 signified 'poor diet quality'[24]. Food guide servings were calculated from the diet simulations according to the 2007 CFG and Alberta Nutrition Guidelines for Children and Youth[25,26].

Results

Stakeholder consultations: pre-guide formation

Health care professionals (*n* 151) and community end users (*n* 383) from all provinces and territories across Canada completed the Internet surveys. Health care respondents included Registered Dietitians (80 %, *n* 121), Pediatric Gastroenterologist and Pediatricians (11 %, *n* 16), Family Physicians (3 %, *n* 4), Registered Nurses (3 %, *n* 4), Social Workers (3 %, *n* 5) and others (<1 %, *n* 1). Health care professionals (17 %, *n* 22 of 127) reported seeing over five cases of CD per month, and 37 % (*n* 56) reported working with the paediatric CD population for more than 10 years. Most community participants were between 31–40 years (>35 %) and 41–50 years (>25 %). Over 65 % of community end users (*n* 256) reported having CD, and 42 % (*n* 160) reported having at least one child or grandchild diagnosed with CD.

Feedback from the health care professionals and members of the community for guide content was related to

https://doi.org/10.1017/S0007114521000994 Published online by Cambridge University Press

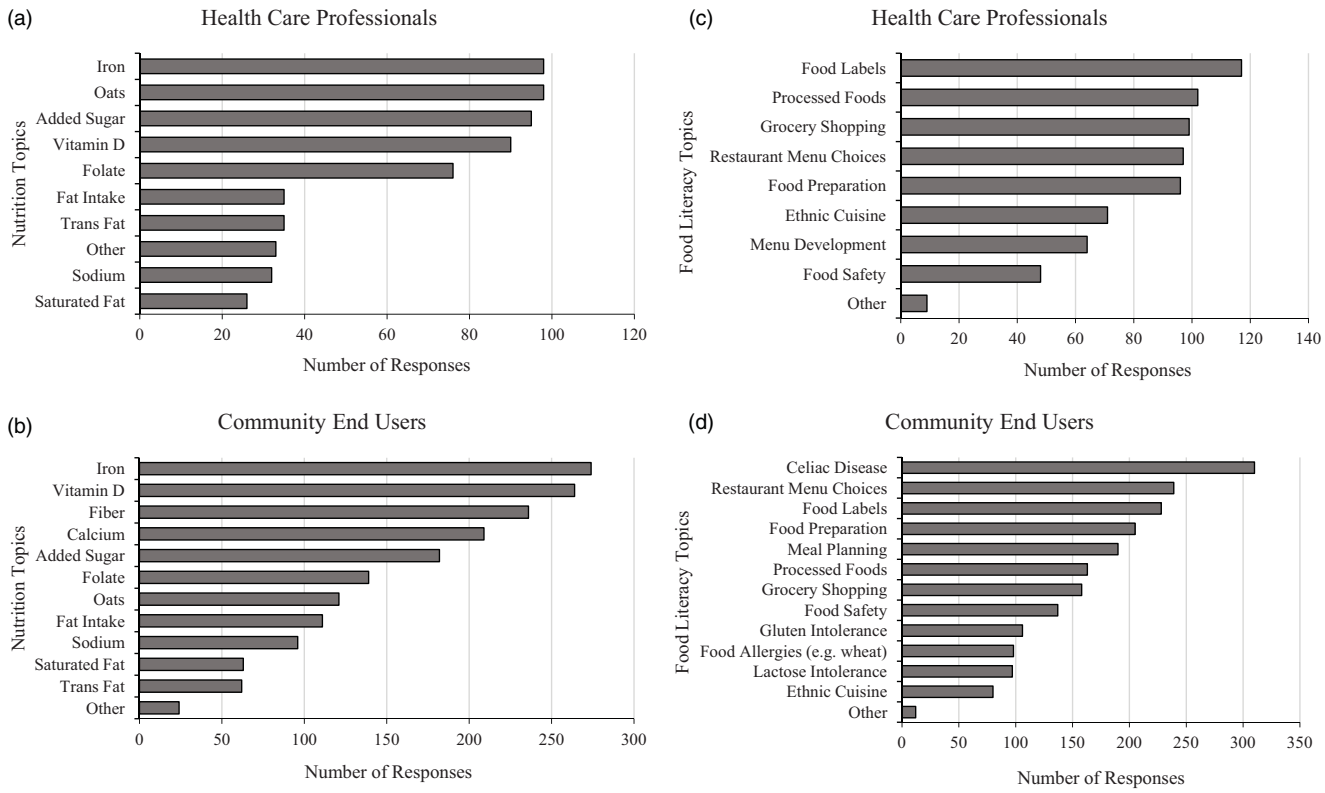

Fig. 2. (a)–(d) Important gluten-free food guide topics identified during pre-guide stakeholder consultations related to (a) and (b) nutrition topics and (c) and (d) food literacy topics. Online surveys were completed by stakeholders which included health care professionals (Registered Dietitians *n* 121, Gastroenterologists/Pediatricians *n* 16, Family Physicians *n* 4, Registered Nurses *n* 4, Social Workers *n* 5, and others *n* 1) and community end users (*n* 383, e.g. adults with coeliac disease, parents of children with coeliac disease). Participants had the option to select ≥1 sub-topic from each of the two major topics if they felt that multiple sub-topics were important.

micronutrient concerns (Fe (65 % professionals *v.* 72 % community, $P > 0{\cdot}05$), vitamin D (60 % professionals *v.* 69 % community, $P = 0{\cdot}048$), folate (50 % professionals *v.* 36 % community, $P = 0{\cdot}003$), added sugars (63 % professionals *v.* 48 % community, $P = 0{\cdot}002$) and fat (23 % professionals *v.* 30 % community, $P > 0{\cdot}05$)) in GF foods. Community end users also focused on Ca (55 %) and fibre (62 %) as important topics (Fig. 2(a) and (b)). Food literacy topics related to reading food labels (77 % professionals *v.* 60 % community, $P < 0{\cdot}001$), GF processed foods (68 % professionals *v.* 43 % community, $P < 0{\cdot}001$), eating out at restaurants (64 % professionals *v.* 62 % community, $P > 0{\cdot}05$) and grocery shopping (66 % professionals *v.* 41 % community, $P < 0{\cdot}001$) were identified by both groups as important guide content. Health care professionals and community members felt that addressing cultural preferences and food traditions were also needed (47 % professionals *v.* 21 % community, $P < 0{\cdot}001$). Guide content related to CD (81 %) and lactose intolerance (25 %) was reported as important by community end users but addressing a wheat allergy was important to both groups (33 % professionals *v.* 26 % community, $P > 0{\cdot}05$) (Fig. 2(c) and (d)). Over 80 % of health care professionals requested that the GF food guide be available in both electronic and hardcopy formats, while 80 % of community end users preferred electronic formats only.

Diet simulations

There was a total of 1260 diet simulations created for the GF food guide to ensure that the guide met the nutritional needs of children (age 4–18 years) diagnosed with CD. Each age–sex category had a total of 210 diets created across all diet patterns. Diet simulations were created for Western (*n* 150), First Nations, Inuit and Métis (*n* 102), East Indian (*n* 150), Somalian (*n* 150), Chinese (*n* 150), Brazilian (*n* 150) and Iranian (*n* 102) cuisines, as well as lactose-free (*n* 102), lacto-ovo (*n* 102) and vegan (*n* 102) diets.

Gluten, macronutrient and micronutrient content of the diet simulations

The median (interquartile range) gluten content of all diet simulations was 4·3 mg/d (2·6–5·5). Macronutrient distributions across all diet simulations and all ages (20·9 (SD 2·2) % protein, 28·1 (SD 2) % fat, 52 (SD 3) % carbohydrate) were not significantly different between simulated diet patterns ($P > 0{\cdot}05$). Except for the micronutrient vitamin D, diet simulations met 100 % EAR and 80–100 % of recommended dietary allowance (RDA) for all micronutrients based on age–sex (Table 1). Only 23 % of the diet simulations met the EAR (10µg) for vitamin D, and only 5 % met the RDA (15µg). To achieve the EAR for vitamin D, the diet

British Journal of Nutrition

Table 1. Macronutrient and micronutrient summary from the diet simulations based on age–sex*

Age–sex distributions	Female (4–8 years, *n* 210)	Male (4–8 years, *n* 210)	Female (9–13 years, *n* 210)	Male (9–13 years, *n* 210)	Female (14–18 years, *n* 210)	Male (14–18 years, *n* 210)
Macronutrient intake†						
Energy content (kcals)‡	1421	1480	1631	1682	2071	2074
Protein (g)§	73·3	77·4	86·3	89·4	110·3	110·5
Protein %	20·7	20·9	21·2	21·2	21·3	21·3
Carbohydrate (g)	191·7	200·2	220·2	226·0	275·2	275·3
Carbohydrate %§	53·9	54·1	54·0	53·8	53·2	53·1
Fat (g)	44·8	46·8	51·7	52·4	66·1	65·5
Fat %§	28·4	28·5	28·5	28·1	28·7	28·4
Sat Fatǁ (g)	10·7	11·1	12·3	12·7	14·7	15·4
Sat Fat %	6·8	6·7	6·8	6·8	6·4	6·7
MUFA¶ (g)	16·0	17·3	19·3	18·5	25·4	24·1
MUFA %	10·1	10·5	10·6	9·9	11·0	10·4
PUFA** (g)	11·7	12·0	13·5	13·9	17·7	17·1
PUFA %	7·4	7·3	7·5	7·5	7·7	7·4
Fibre (g)	26·3	29·7	30·5	30·9	36·8	38·2
Fibre %AI	105·2	118·8	117·3	99·7	141·5	100·5
Micronutrient intake†						
Vitamin B_{12} (mg)	4·9	4·8	5·5	5·8	6·7	7·1
Vitamin B_{12} %EAR	490·0	480·0	366·7	386·7	335·0	355·0
Vitamin B_{12} %RDA	408·3	400·0	305·6	322·2	279·2	295·8
Vitamin D (µg)	7·5	6·8	8·2	8·5	10·6	9·9
Vitamin D %EAR	75·2	68·3	82·4	84·8	105·9	98·9
Vitamin D %RDA	50·2	45·5	55·0	56·6	70·6	66·0
Folate (DFE µg)	398·1	436·9	449·3	485·3	566·2	607·4
Folate %EAR	248·8	273·1	179·7	194·1	171·6	184·1
Folate %RDA	199·1	218·5	149·8	161·8	141·6	151·9
Ca (mg)	1212·0	1188·6	1458·5	1402·8	1579·6	1605·0
Ca %EAR	151·5	148·6	132·6	127·5	143·6	145·9
Ca %RDA	121·2	118·9	112·2	107·9	121·5	123·5
Fe (mg)	12·0	13·1	14·0	14·1	17·5	18·0
Fe %EAR	292·7	319·5	245·6	239·0	221·5	257·1
Fe %RDA	120·0	131·0	175·0	176·3	116·7	163·6
Na (mg)	1406·1	1389·2	1618·0	1647·4	1692·1	1691·2
Na %AI	117·2	115·8	107·9	109·8	112·8	112·7
Na %UL	74·0	73·1	73·5	74·9	73·6	73·5
Zn (mg)	9·2	10·7	11·8	12·5	14·6	14·4
Zn %EAR	230	267·5	168·6	178·6	200·0	169·4
Zn %RDA	184·0	214·0	147·5	156·3	162·2	130·9

AI, adequate intake; EAR, estimated average requirement; RDA, recommended dietary allowance; DFE, dietary folate equivalent; UL, tolerable upper intake level.
* %EAR/RDA/AI/UL for select nutrients were determined by dividing the absolute nutrient intake by the EAR/RDA/AI/UL based on age–sex and then multiplying by 100.
† Reference ranges for nutrient intake were based on guidelines from Health Canada[16] and the FAO of the UN[47].
‡ Energy (kcals) range for female/male age ≤6 years = 1200–1500, age 7–13 years = 1500–1800, ≥14 years = 2000–2300.
§ Acceptable macronutrient distribution range: carbohydrate, 45–65 %; protein, 10–30 %; fat, 25–35 %[16]. All diet simulations (100 %, *n* 1260) based on age–sex met carbohydrate and protein recommendations. 94 % (*n* 1187) met fat recommendations with the remainder having fat intakes in the range of 23–25 % of total energy intake.
ǁ Sat Fat, saturated fat; recommended <10 %[47].
¶ MUFA, monounsaturated fatty acids; recommended 10-14 %[47].
** PUFA, polyunsaturated fatty acids; recommended >3 %[47].

simulations included an average of 2·5 servings of fortified fluid milk (or 3 servings of a fortified unsweetened plant-based beverage) and 1 serving of fish. When fish was not included in a diet simulation, 3·5 servings of fortified fluid milk (or 4 servings of a fortified unsweetened plant-based beverage) and 2 eggs or 1 serving of fortified yogurt was used instead. When a vitamin D supplement (10µg) was included in a simulation, only 2–2·5 servings of fortified fluid milk or an unsweetened plant-based beverage was needed to meet the RDA. The diet simulations were able to provide enough folate across all ages–sexes without supplementation (100 % EAR were met). Higher folate-containing food items (e.g. legumes, spinach, oranges) were added to the diets to meet the EAR.

Assessment of diet quality and food group intake of the diet simulations

Mediterranean Diet Quality Index in children and adolescence and the Canadian Healthy Eating Index scores were indicative of optimal/excellent diet quality in 100 % and 93·5 % of the diet simulations, respectively. Fig. 3(a)–(c) outlines the daily number of servings based on each food group that children with CD need to eat to meet their macronutrient and micronutrient needs. This led to the formation of a plate model where >50 % represents fruits and vegetables (FV), <25 % GF grains and 25 % protein foods with a stronger emphasis on plant-based protein sources and those higher in vitamin D (e.g. fish) (online Supplementary Table S4). Fluid milk and/or unsweetened plant-based

British Journal of Nutrition

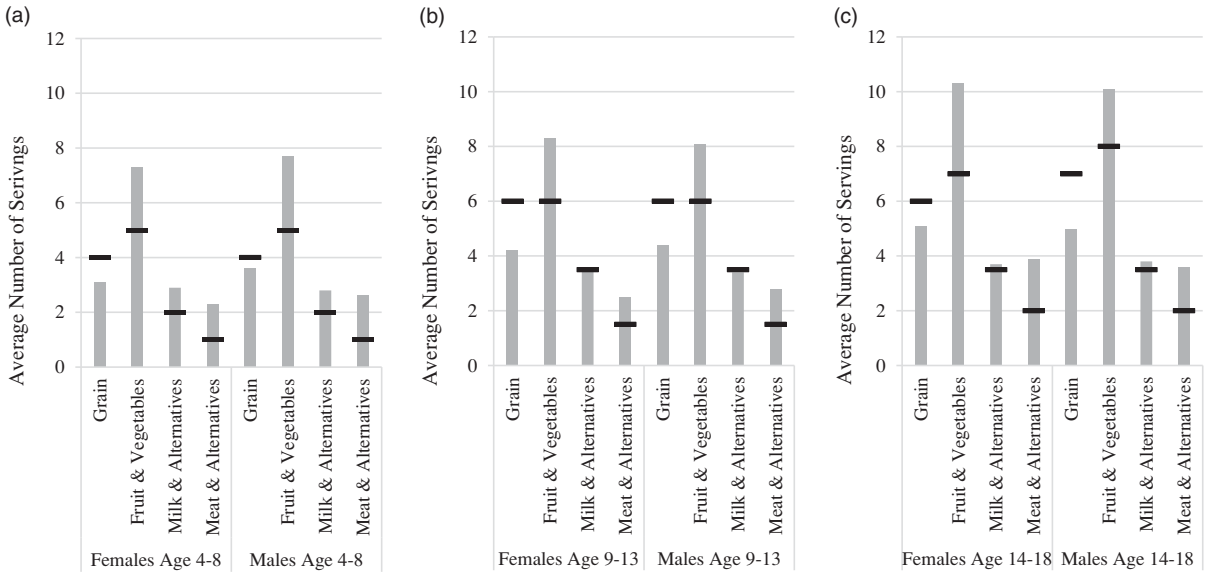

Fig. 3. (a)–(c) Recommended number of food group servings for children with coeliac disease (a) ages 4–8 years, (b) ages 9–13 years and (c) ages 14–18 years. Servings are based on nutritionally adequate gluten-free diet simulations. The black horizontal bar indicates recommended servings based on the four food groups according to the 2007 Canada's Food Guide and the Alberta Nutrition Guidelines for Children and Youth[25,26].

alternatives that are fortified with Ca and vitamin D are included as the primary beverages of choice with a particular focus to increase vitamin D intake.

Discussion

The development of a GF food guide was in response to end-stakeholder users (e.g. health care professionals, parents of children with CD) identifying a need for universally available nutrition guidelines on the GF diet[7,10]. Most families and their children with CD understand the need to follow a GF diet, but many do not have in-depth knowledge related to the nutritional limitations[27]. Almost 80 % of Canadian adults report seeing a dietitian at least once at time of CD diagnosis, but longitudinal follow-up has been reported at 15 % with some clinics only conducting dietitian-led follow-up if requested[27,28]. This is potentially due to limited resources (e.g. dietitian), extended clinic wait times or those with CD reverting to the Internet for quicker access despite the possibility for inaccurate information. For this reason, accessible and evidence-based GF nutrition guidelines are warranted for children with CD. A GF food guide will help educate families and their children on the complexities of nutrient intake, label reading and manoeuvring complex food environments (e.g. school, social gatherings, travel). The methods used to inform the development of the GF food guide were based on standard methodological approaches used to develop the 2007 and 2019 CFG, and the Alberta Nutrition Guidelines for Children and Youth[17,18,22,25]. The study objective was to describe the methodological considerations in forming a GF food guide for Canadian children and youth (4–18 years) with CD.

The GF pre-guide consultations yielded similar themes compared with the 2019 CFG regarding fat and added sugar, but micronutrient intake (e.g. folate) was a unique theme for the GF food guide due to the nature of the GF diet[29]. The GF diet can be nutritious, but many individuals inadvertently consume more fat and added sugar from GF processed products[5,7,10]. This is likely due to GF processed grains where fat and sugar have been added to replace the loss of taste and texture when gluten is removed[3,6]. This is concerning as a higher intake has been associated with obesity and chronic disease[22]. As a result, the development of the diet simulations was critical to ensure that diet patterns for age–sex were nutritionally adequate for children by primarily focusing on the consumption of whole foods and reducing the intake of ultra-processed GF foods. This will ensure that the GF food guide can meet the nutritional needs of children with CD while providing evidence-based information to follow a healthy eating patterns while on the GF diet.

The GF diet simulations address the concerns of fat and sugar intake and improve diet quality after modelling the GF diet using the Dietary Approach to Stop Hypertension and the Mediterranean-style diet[22]. These diet patterns have been associated with lower cardiovascular risk factors and disease risk, respectively[22]. The simulations also focused on a plant-predominant diet (e.g. fruits, vegetables, legumes, nuts and seeds) which was highlighted in the 2019 CFG. It placed a larger focus on the regular intake of plant-based foods with less emphasis on animal-based[22]. Limited amounts of animal-based foods (meat, poultry, fish) in conjunction with a plant-predominant diet can contribute to a healthy diet and lower chronic disease risk factors such as blood pressure[30].

The incorporation of more plant-based foods (i.e. legumes, FV) into the diet simulations helped achieve the EAR for folate. Unlike the 2019 CFG where folate is not a nutrient of concern due to wheat fortification, suboptimal intake in children on the GF diet has been observed without a mandated fortification of GF grains[7,10–12]. Fortunately, the diet simulations identified that by following a plant-predominant diet pattern, folate requirements can be met across all ages–sexes without

British Journal of Nutrition

supplementation (100 % EAR met). This was achieved by incorporating higher folate-containing foods (e.g. pulses, spinach, oranges) into the simulations. This finding is extremely encouraging and means that the GF food guide can help educate families who are following the GF diet to better meet their nutrient requirements. Nevertheless, advocacy for nutrient fortification (e.g. folate) of GF foods, particularly GF grains, continues to remain a priority so that the burden of meeting nutritional requirements does not fall solely on the child with CD and their family. This is especially needed when dietary intake is highly impacted by food/taste preferences, food traditions, multiple food allergies and intolerances, and/or from a food insecurity perspective where recommendations may impact the practicality of guide recommendations.

The diet simulations met the EAR for all micronutrients (e.g. Ca) except for vitamin D whereby diet alone was challenging to meet due to the limited food supply of vitamin D-rich sources. In order to meet the EAR for vitamin D, numerous servings per day of fortified fluid milk or unsweetened plant-based alternatives in addition to fish, eggs or fortified yogurt would need to be consumed by children. This intake is likely not practical on a routine basis due to food/taste preferences and the higher cost of vitamin D-rich sources (e.g. fish) which could be impacted by food insecurity. Despite recently proposed updates to vitamin D fortification in Canada, it is still currently challenging to meet vitamin D needs[31]. This is worrisome as the risk of vitamin D deficiency is of concern especially in Canada with the northern latitude[32,33]. No known information is available on Health Canada's website identifying whether daily vitamin D intake can be achieved by following the 2019 CFG recommendations[34]. Though, a recent study analysing the 2019 CFG suspects that most Canadians will not meet their vitamin D needs due to the plate's de-emphasis of milk products and/or fortified plant-based alternatives[34,35]. Moreover, the 2019 CFG emphasises water as the beverage of choice with little focus on Ca and vitamin D-fortified fluid milk or plant-based alternatives[34]. Without a doubt, water is important for adequate hydration but choosing fortified fluid milk or unsweetened plant-based alternatives in its place provides the added benefit of vitamin D for bone health[32]. Previous reports on the 2007 CFG also indicate that meeting vitamin D (≥10μg) by diet alone is not routinely achievable without drastically increasing dietary intake or a routine vitamin D supplement[17]. Therefore, parents of children with CD should seek dietary advice from a physician or dietitian on vitamin D supplementation until fortification policies are re-evaluated. Until then, the GF food guide will encourage purchasing and consuming fortified Ca and vitamin D fluid milk or unsweetened plant-based alternatives in addition to other rich vitamin D sources (e.g. fish, fortified yogurt, eggs) whenever possible to increase nutrient intake. It is worth noting that those who primarily follow a vegetarian or vegan diet may also benefit from choosing vitamin B_{12}-fortified foods to optimise intake given that most naturally rich sources are found in animal-based foods[36].

The methodology behind the GF food guide was used to justify the rationale for the proportion of fruits, vegetables, grains and protein foods on the GF plate. Compared with the 2019 CFG plate model[34], the GF plate will put more emphasis on the consumption of FV (>50 % of the plate) with reduced servings of GF grains (<25 % of plate). Protein foods will represent 25 % of the plate with a focus on plant-based (e.g. legumes, tofu, nuts and seeds) and vitamin D-rich sources (e.g. fish). Fortified fluid milk and/or unsweetened plant-based alternatives will be included as the primary beverage of choice. The total number of servings per d of GF grains is recommended to be lower than the Alberta Nutrition Guidelines for Children and Youth and the 2007 CFG[25,26]. This was implemented due to the higher fat and sugar content of many GF processed grain products[3,4,6,8,9]. By reducing the proportion of grains, it also allowed for more emphasis on FV intake to enhance micronutrient (e.g. folate) and fibre intake.

The layout of the GF food guide is in the form of a plate to mirror the 2019 CFG plate model[34]. In 2018, it was noted that twelve countries officially use the plate model as their primary food guide format, while the majority of other countries continue to use the pyramid[37]. The plate model has been preferred by both adults and children in parts of the world like Australia[38]. The key features that have been noted include visual ease, organised design, ability to clearly show food group proportions, the ease of interpretation and being conducive to children's learning[38]. The 2019 CFG uses photos of real food items which have also been identified as a preferred aesthetic feature compared with cartoon depictions[34,38]. Real photos will be incorporated into the GF food guide while considering the unique nutritional attributes of GF foods and the selection of age-appropriate foods.

Post-guide stakeholder consultations to evaluate food guide content and strategies for food guide dissemination and uptake are in progress. End-stakeholder consultations will include health care professionals, community end users and professional organisations such as the Canadian Celiac Association, Health Canada, Canadian Association of Gastroenterology and/or the Canadian Nutrition Society. This will ensure that guideline content has been scientifically peer-reviewed. This will also ensure that guideline uptake can occur and will be devoid of potential sources of bias. Nutrition champions and an informed process to critically evaluate nutrition guideline content are important in all phases of guidelines development[39–43]. This method was used in the development of the recently released CFG[18,41].

The intake of FV has notoriously been low in children, and it is important to acknowledge that this could impact guide uptake[44,45]. To address this barrier, visually appeasing supplementary educational materials (e.g. handouts, videos with recipes) will be developed to help educate parents and their children on how to incorporate more FV into their meals and snacks. This may include additional tips on increasing FV accessibility within the home, parental role modelling, allowing children to taste foods multiple times, or focusing on developing food skills to promote greater FV intake[44]. Eating FV on a budget will also be addressed as guide uptake may be affected by the feasibility of purchasing FV on a regular basis.

The GF food guide will include various cuisines that reflect cultural preferences and food traditions. This will ensure that the guide is tailored and applicable to meet the needs of culturally diverse populations. This is important as evidence indicates that adherence to nutritional guidelines may be a concern for

youth of multi-ethnic backgrounds[46]. This will also complement the 2019 CFG which focuses heavily on cultural preferences and food traditions[22].

To develop comprehensive GF nutrition guidelines, the supplementary educational materials (e.g. handouts and videos) will further address healthy eating habits and food environments (home/community). Encouraging the development of food literacy (e.g. grocery shopping, label reading, food preparation) will promote informed food choices and the consumption of nutritious meals[22]. This is needed for children with CD as they enter adulthood due to the complexities of buying and eating safe and healthy GF foods.

The content of the GF food guide was derived by using important methodological approaches which include pre-guide consultations and the evaluation of diet patterns and nutrient intake through diet simulations[48–56]. A GF food guide is needed to adequately educate families and their children with CD due to the complexities of the GF diet. Evidence-based and easily accessible resources will provide educational opportunities to help children and their families make informed foods choices to consume a nutritious GF diet. Important nutrients of concern for children with CD on the GF diet are fat, added sugar, folate and vitamin D. This methodological and nutritional analysis highlights the need for policy makers to support the development of dietary guidelines for specialised therapeutic diets and to advocate for nutrient fortification of GF foods particularly when diets represent the main treatment strategy to treat a highly prevalent chronic disease.

Acknowledgements

The authors would like to acknowledge Shelley Case RD, Amanda Liu MSc and Kristin Harms BSc for their assistance with feedback and diet simulation development. The authors would also like to gratefully acknowledge the contribution of the Canadian Celiac Association: Edmonton and Calgary Chapters, and the health care professionals and community end users who provided feedback in the stakeholder consultations.

This work was supported by the Canadian Celiac Association: Edmonton and Calgary Chapters; Alberta Health Services - Maternal Newborn Child and Youth Strategic Clinical Network; Alberta Health Services - the Diabetes, Obesity and Nutrition Strategic Clinical Network; the Canadian Celiac Association: JA Campbell Award 2019 to D. R. M.; and the Vitamin Fund provided by the University of Alberta. Funders had no role in the design, analysis or writing of this article.

D. R. M.: lead role and responsible for all study aspects including design/inception, supervision of data collection, methodology, data analysis, intellectual and scientific interpretation, co-wrote manuscript and approved final manuscript prior to submission. S. C.: contributed to guide conceptualisation, data curation, formal analysis, methodology, resources, software, validation, co-wrote manuscript and approved final manuscript prior to submission. C. L.: contributed to guide conceptualisation, data curation, formal analysis, methodology, project administration, resources, software, validation, co-wrote manuscript and approved final manuscript prior to submission. H. B.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. J. D.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. H. M.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. C. B-H.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. R. N.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. E. A.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. M. M.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission. J. M. T.: contributed to guide conceptualisation, data curation, investigation, validation, writing-review/editing and approved final manuscript prior to submission.

The authors declare that there are no conflicts of interest.

Supplementary material

For supplementary material referred to in this article, please visit https://doi.org/10.1017/S0007114521000994

References

1. Snyder J, Butzner JD, DeFelice AR, *et al.* (2016) Evidence-informed expert recommendations for the management of celiac disease in children. *Pediatrics* 138.
2. Green PH & Cellier C (2007) Celiac disease. *N Engl J Med* **357**, 1731–1743.
3. Miranda J, Lasa A, Bustamante MA, *et al.* (2014) Nutritional differences between a gluten-free diet and a diet containing equivalent products with gluten. *Plant Foods Hum Nutr* **69**, 182–187.
4. Elliott C (2018) The nutritional quality of gluten-free products for children. *Pediatrics* **142**, 1–8.
5. Alzaben AS, Turner J, Shirton L, *et al.* (2015) Assessing nutritional quality and adherence to the gluten-free diet in children and adolescents with celiac disease. *Can J Diet Pract Res* **76**, 56–63.
6. Kulai T & Rashid M (2014) Assessment of nutritional adequacy of packaged gluten-free food products. *Can J Diet Pract Res* **75**, 186–190.
7. Mager DR, Liu A, Marcon M, *et al.* (2019) Diet patterns in an ethnically diverse pediatric population with celiac disease and chronic gastrointestinal complaints. *Clin Nutr ESPEN* **30**, 73–80.
8. Jamieson JA, Weir M & Gougeon L (2018) Canadian packaged gluten-free foods are less nutritious than their regular gluten-containing counterparts. *PeerJ* **6**, e5875.
9. Wild D, Robins GG, Burley VJ, *et al.* (2010) Evidence of high sugar intake, and low fibre and mineral intake, in the gluten-free diet. *Aliment Pharmacol Ther* **32**, 573–581.

10. Mager DR, Marcon M, Brill H, *et al.* (2018) Adherence to the gluten-free diet and health-related quality of life in an ethnically diverse pediatric population with celiac disease. *J Pediatr Gastroenterol Nutr* **66**, 941–948.
11. Health Canada (2018) *Fortification of Gluten-Free Foods*. Ottawa, ON: Canadian Food Inspection Agency.
12. Cyrkot S, Anders S, Kamprath C, *et al.* (2020) Folate content of gluten-free food purchases and dietary intake are low in children with coeliac disease. *Int J Food Sci Nutr* **71**, 863–874.
13. McGarel C, Pentieva K, Strain JJ, *et al.* (2015) Emerging roles for folate and related B-vitamins in brain health across the lifecycle. *Proc Nutr Soc* **74**, 46–55.
14. Harris PA, Taylor R, Minor BL, *et al.* (2019) The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform* **95**, 103208.
15. Harris PA, Taylor R, Thielke R, *et al.* (2009) Research electronic data capture (REDCap)–a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* **42**, 377–381.
16. Health Canada (2010) *Dietary Reference Intake*. Ottawa, ON: Health Canada.
17. Katamay SW, Esslinger KA, Vigneault M, *et al.* (2007) Eating well with Canada's Food Guide (2007): development of the food intake pattern. *Nutr Rev* **65**, 155–166.
18. Health Canada (2019) *Revision Process for Canada's Food Guide*. Ottawa, ON: Health Canada.
19. Deeks J, Verreault MF & Cheung W (2017) Canadian Nutrient File (CNF): update on Canadian food composition activities. *J Food Compos Anal* **64**, 43–47.
20. Assor E, Davies-Shaw J, Marcon MA, *et al.* (2014) Estimation of dietary gluten content using total protein in relation to gold standard testing in a variety of foods. *J Nutr Food Sci* **4**, 1–4.
21. Singh P, Arora A, Strand TA, *et al.* (2018) Global prevalence of celiac disease: systematic review and meta-analysis. *Clin Gastroenterol Hepatol* **16**, 823–836 e822.
22. Health Canada (2019) *Canada's Dietary Guidelines for Health Professionals and Policy Makers*. Ottawa, ON: Health Canada.
23. Serra-Majem L, Ribas L, Ngo J, *et al.* (2004) Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr* **7**, 931–935.
24. Woodruff SJ & Hanning RM (2010) Development and implications of a revised Canadian Healthy Eating Index (HEIC-2009). *Public Health Nutr* **13**, 820–825.
25. Government of Alberta (2012) Alberta Nutrition Guidelines for Children and Youth. https://open.alberta.ca/dataset/1c291796–4eb0–4073-be8e-bce2d331f9ce/resource/3319786c-1df1–43ca-8693–067f733682dc/download/nutrition-guidelines-ab-children-youth.pdf (accessed September 2012).
26. Health Canada (2007) *Eating Well with Canada's Food Guide*. Ottawa, ON: Health Canada.
27. Isaac DM, Wu J, Mager DR, *et al.* (2016) Managing the pediatric patient with celiac disease: a multidisciplinary approach. *J Multidiscip Healthc* **9**, 529–536.
28. Zarkadas M, Cranney A, Case S, *et al.* (2006) The impact of a gluten-free diet on adults with coeliac disease: results of a national survey. *J Hum Nutr Diet* **19**, 41–49.
29. Health Canada (2017) *Canada's Food Guide Consultation Phase 1: What we Heard Report.*. Ottawa, ON: Health Canada.
30. Gibbs J, Gaskin E, Ji C, *et al.* (2020) The effect of plant-based dietary patterns on blood pressure: a systematic review and meta-analysis of controlled intervention trials. *J Hypertens* **39**, 23–37.
31. Government of Canada (2018) Regulations amending certain regulations made under the food and drugs act (nutrition symbols, other labelling provisions, partially hydrogenated oils and vitamin D). Canada Gazette 2018, Part 1, Vol. 152, No. 6. https://gazette.gc.ca/rp-pr/p1/2018/2018-02-10/html/reg2-eng.html (accessed February 2018).
32. Munasinghe LL, Willows N, Yuan Y, *et al.* (2015) Dietary reference intakes for vitamin D based on the revised 2010 dietary guidelines are not being met by children in Alberta, Canada. *Nutr Res* **35**, 956–964.
33. Munasinghe LL, Willows N, Yuan Y, *et al.* (2015) The prevalence and determinants of use of vitamin D supplements among children in Alberta, Canada: a cross-sectional study. *BMC Public Health* **15**, 1063.
34. Health Canada (2019) *Canada's Food Guide*. Ottawa, ON: Health Canada.
35. Barr SI (2019) Is the 2019 Canada's food guide snapshot nutritionally adequate?. *Appl Physiol Nutr Metab* **44**, 1387–1390.
36. Health Canada (2008) *Nutrient Value of Some Common Foods*. Ottawa, ON: Health Canada.
37. Truman E (2018) Exploring the visual appeal of food guide grpahics: a compositional analysis of dinner plate models. *Br Food J* **120**, 1682–1695.
38. Talati Z, Pettigrew S, Moore S, *et al.* (2017) Adults and children prefer a plate food guide relative to a pyramid. *Asia Pac J Clin Nutr* **26**, 169–174.
39. Downs SM, Farmer A, Quintanilha M, *et al.* (2011) Alberta nutrition guidelines for children and youth: awareness and use in schools. *Can J Diet Pract Res* **72**, 137–140.
40. Petkovic J, Riddle A, Akl EA, *et al.* (2020) Protocol for the development of guidance for stakeholder engagement in health and healthcare guideline development and implementation. *Syst Rev* **9**, 21.
41. Dai Z, Kroeger CM, Lawrence M, *et al.* (2020) Comparison of methodological quality between the 2007 and 2019 Canadian dietary guidelines. *Public Health Nutr* 1–7.
42. Cluzeau F, Wedzicha JA, Kelson M, *et al.* (2012) Stakeholder involvement: how to do it right: article 9 in Integrating, coordinating efforts in COPD guideline development. An official ATS/ERS workshop report. *Proc Am Thorac Soc* **9**, 269–273.
43. Quintanilha M, Downs S, Lieffers J, *et al.* (2013) Factors and barriers associated with early adoption of nutrition guidelines in Alberta, Canada. *J Nutr Educ Behav* **45**, 510–517.
44. Chu YL, Farmer A, Fung C, *et al.* (2013) Fruit and vegetable preferences and intake among children in Alberta. *Can J Diet Pract Res* **74**, 21–27.
45. Garriguet D (2006) *Overview of Canadian's Eating Habits. In Nutrition: Findings from the Canadian Community Health Survey*. Ottawa: Statistics Canada.
46. Kolahdooz F, Nader F, Daemi M, *et al.* (2018) Adherence to Canada's Food Guide recommendations among Alberta's multi-ethnic youths is a major concern: findings from the WHY ACT NOW project. *J Hum Nutr Diet* **31**, 658–669.
47. Food and Agriculture Organization of the United Nations (2010) *Fats and Fatty Acids in Human Nutrition: Report of an Expect Consultation, 10–14 November 2008*. Rome: FAO UN.
48. Health Canada (2007) *Eating Well with Canada's Food Guide: First Nations, Inuit, and Métis*. Ottawa, ON: Health Canada.
49. Chapman GE, Ristovski-Slijepcevic S & Beagan BL (2011) Meanings of food, eating and health in Punjabi families living in Vancouver, Canada. *Health Educ J* **70**, 102–112.
50. Office of the Registrar General & Census Commissioner (2015) *Population by Religious Community*. New Delhi: Ministry of Home Affairs.
51. Toronto Public Health (2004) Guide to understanding Halal foods. http://www.halalrc.org/images/Research%20Material/Literature/Guide%20to%20Halal%20Foods.pdf (accessed May 2020).

52. Wang SS, Lay S, Yu HN, *et al.* (2016) Dietary guidelines for Chinese residents (2016): comments and comparisons. *J Zhejiang Univ Sci B* **17**, 649–656.
53. Ministry of Health of Brazil, Secretariat of Health Care & Primary Health Care Department (2014) *Dietary Guidelines for the Brazilian Population*. Brasília: Ministry of Health of Brazil.
54. Amit M (2010) Vegetarian diets in children and adolescents. *Paediatr Child Health* **15**, 303–314.
55. University of Rochester Medical Center: Golisano Children's Hospital, Pediatric Nutrition (2020) Lactose-free diet. https://www.urmc.rochester.edu/childrens-hospital/nutrition/lactose-free.aspx (accessed May 2020).
56. Wold Health Organization (2015) Guideline: Sugars intake for adults and children. https://www.who.int/publications/i/item/9789241549028 (accessed March 2015).

British Journal of Nutrition