

Dietary gluten avoidance in Canada: a cross-sectional study using survey data

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Abstract

Background: A gluten-free diet (GFD) is required for the management of some conditions, whereas some Canadians may follow a GFD for discretionary reasons. We sought to estimate the prevalence of Canadians who adhere to a GFD, identify factors associated with adherence to a GFD, and describe and compare the location of food preparation and consumption for those who follow a GFD, those who report no dietary avoidances and those reporting other dietary avoidances.

Methods: We used cross-sectional data from the 2015 Canadian Community Health Survey — Nutrition ($n = 20\,487$). Demographic variables included sex, age group, ethnicity, highest level of household education and income adequacy. The relations between respondent characteristics and report of a GFD were estimated using logistic regression. Respondents were further categorized as avoiding dietary gluten, other dietary avoidances and no dietary avoidances.

Results: An estimated 1.9% of Canadians follow a GFD. Women had 2 times higher odds (odds ratio [OR] 2.08, 95% confidence interval [CI] 1.32 to 3.27) of reporting a GFD than men. After adjustment for income adequacy, household education, sex, age group and ethnicity, residents of Ontario and Quebec had about half the odds (OR 0.52, 95% CI 0.31 to 0.87, and OR 0.55, 95% CI 0.32 to 0.94, respectively) of reporting a GFD compared with residents of Atlantic Canada. Canadians who followed a GFD consumed significantly fewer calories from foods prepared at restaurants than both Canadians who reported no dietary avoidances and those who reported dietary avoidances other than gluten. Canadians following a GFD reported that 2.0% (95% CI 1.1% to 2.9%) of their daily kilocalories were from foods prepared at restaurants, compared with 6.7% (95% CI 5.4% to 7.9%) for Canadians reporting 1 or more dietary avoidances other than gluten, and 6.4% (95% CI 6.0% to 6.9%) for those reporting no avoidances.

Interpretation: The estimated 1.9% prevalence of dietary gluten avoidance likely includes individuals with celiac disease, wheat allergies and nonceliac gluten sensitivity, as well as individuals excluding gluten in the management of irritable bowel syndrome or for reasons related to dietary trends. Canadians eating GFDs consume fewer daily calories from restaurant-prepared foods than other Canadians, which may have social implications.

Celiac disease affects about 1% of the general Western population,¹ and the prevalence appears to be increasing.² Individuals with celiac disease, nonceliac gluten sensitivity and wheat allergy must eliminate gluten, a protein found in cereals such as wheat, rye and barley.^{3,4} Increasingly, individuals with irritable bowel syndrome (IBS) avoid gluten, though this may be partially because of co-occurrence of nonceliac gluten sensitivity.⁵ However, not everyone who avoids dietary gluten has nonceliac gluten sensitivity.

Importantly, gluten-related disorders have diverse symptoms and etiologies, and their diagnosis remains challenging and often time consuming.^{6,7} It has been previously estimated that the global prevalence of the gluten-free diet (GFD) is increasing,^{1,8} including those for whom it is medically necessary, but also for a growing number of people who perceive it as a healthier diet option.³ This perception may be attributed to media and nonscientific reports of health and weight-loss

claims, both of which are unfounded.^{9,10} The extent to which this dietary fad may have penetrated Canadian culture is unclear.

Most research on GFDs remains focused on celiac disease, reflecting the seriousness of associated morbidities, as well as improvements to the diagnostic process.^{11,12} Given the multitude of reasons for adhering to a GFD, it is likely that this population will have differing demographic and socioeconomic characteristics compared with populations with any 1 gluten-related disorder.^{12–14} Therefore, it is critical to characterize the

Competing interests: None declared.

This article has been peer reviewed.

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CMAJ Open 2021. DOI:10.9778/cmajo.20200082

population that follows a GFD to further understand adherence to this dietary restriction in Canada.

Adherence to a GFD, particularly when a gluten-related disorder is not implicated, can carry social and economic risks. Hypervigilance in regard to GFD adherence presents challenges for food consumption outside the home, and in institutional and social settings,^{15,16} potentially leading to decreased quality of life.^{16–19} Although there has been considerable growth in the market for gluten-free foods,²⁰ it remains unclear how current food preparation and eating location patterns may differ between Canadians following a GFD and other Canadians. Furthermore, GFDs are costlier than regular diets.²¹

A current description of the eating patterns among those who avoid gluten can inform our understanding of the adequacy of the Canadian food system in responding to the dietary needs of those who must avoid gluten. The objectives of this study were to estimate the prevalence of Canadians who adhere to a GFD, identify factors associated with adherence to a GFD, and describe and compare the location of food preparation and consumption for those who follow a GFD, those who report no dietary avoidances and those reporting other (nongluten) dietary avoidances.

Methods

Design and data source

We used data from the 2015 Canadian Community Health Survey (CCHS) — Nutrition in our cross-sectional study of dietary gluten avoidance in Canada.²² The survey included a representative sample ($n = 20\,487$) covering about 98% of the Canadian population older than 1 year and residing in the 10 provinces. A detailed description of the 2015 CCHS sampling frame and collection methods is available elsewhere.²³ Briefly, the survey used a stratified 3-stage sample, including geographical clusters, households and individuals.²² The response rate for the survey was 61.6%.²² People living on First Nations reserves and other Aboriginal settlements, members of the Canadian Armed Forces and populations living in institutions were excluded from the survey sampling.

The CCHS-Nutrition included a questionnaire component, as well as a 24-hour dietary recall. The recall is a dietary questionnaire designed to assist in collecting detailed information about the foods and beverages consumed by respondents during the previous 24-hour period, from midnight to midnight, to maximize recollection.^{22,23} Eating location and detailed preparation data were collected. For children up to 11 years old, interviews were conducted by, or with the assistance of, a parent or guardian. All other participants completed the survey and interviews themselves.

Variables

Prevalence of and factors associated with dietary gluten avoidance

Adherence to a GFD was defined using self-reported responses to the question, “Do you completely exclude any

of the following foods from your diet? By completely exclude, we mean you never eat it on its own or as part of a prepared dish.” Responses included meat, poultry, fish and shellfish, eggs, dairy products and gluten. Adherence to a GFD was defined as an affirmative response to avoiding gluten sources.²²

Dietary gluten avoidance was described according to sex, age group, province or region, household education, income adequacy and ethnicity. Sex was dichotomized as male and female. Age groups were categorized as ages 2–17 years, 18–49 years, and 50 years or older. Region was grouped as British Columbia, Prairies, Ontario, Quebec and Atlantic provinces.²⁴ Highest level of household education was categorized as less than secondary school graduation, some postsecondary education, and postsecondary graduation, or diploma or equivalent. Household income adequacy, as defined by Statistics Canada using total household income and number of individuals in the household, was classified into 3 categories: lowest to lower-middle income group, middle to upper-middle income group, and highest income group (www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs/canadian-community-health-survey-cycle-2-2-nutrition-2004-income-related-household-food-security-canada-health-canada-2007.html#appd). Ethnicity was categorized as White, and racialized or Indigenous, based on categorizations in the survey.²² Although missing data for income adequacy was imputed by Statistics Canada, other missing data were minimal and therefore ignored.

Location of food consumption and preparation

For analysis related to location of food preparation and consumption, respondents were divided into 3 mutually exclusive groups based on dietary avoidances: respondents who avoid gluten, respondents who have 1 or more dietary avoidances other than gluten, and respondents who report no dietary avoidances. Food consumption location was collected as part of the 24-hour dietary recall. Importantly, we wanted to distinguish between location of food consumption and the location of food preparation, as they are not necessarily the same. For example, any food that was ordered in or taken out would be classified as prepared outside of the home, but would be consumed inside the home. As part of the dietary recall, respondents were asked directly where the meal or snack was consumed. As such, all calories reported in the 24-hour dietary recall were attributed to 1 of 3 consumption locations: home, other and not stated. Home included an individual’s home or someone else’s home. Other locations included fast food or pizza restaurants; take-out; restaurants with servers; bar, tavern or lounge; vending machine; restaurants with no additional information; cafeteria (at school or not at school); child care centre; family or adult care centre; other; grocery, corner or other types of stores; or at work. Any meal or snack where a location was not reported was categorized as not stated.

Respondents were asked directly where the meal or snack originated. Preparation is especially important for dietary gluten avoidance, as cross-contamination is a concern. Location of

food preparation was categorized into 5 groups: home recipe or homemade, restaurant (including fast food), other (e.g., from a dry mix, frozen or commercially prepared), no preparation required, and information not available. Again, we calculated mean total calories consumed that were attributed to each location of preparation.

Statistical analysis

Prevalence of and factors associated with dietary gluten avoidance

Prevalence of dietary gluten avoidance was estimated overall and within groups formed by the previously listed sociodemographic variables and compared between groups using χ^2 tests. A multiple logistic regression was fitted with all sociodemographic variables to estimate adjusted odds ratios for their relation to gluten avoidance.

Location of food consumption and preparation

Pregnant or breastfeeding respondents were excluded from this analysis given known effects on energy needs. We used analysis of variance (ANOVA) with post-hoc least-square means to test for differences in percent calories consumed for both food consumption location and food preparation location, according to the 3 dietary avoidance groups. We also determined the prevalence of consuming only food prepared at home according to each of the 3 dietary avoidance groups and tested for differences using ANOVA with least-square means as a post-hoc test.

Given known differences in the sample who follow a GFD as compared with those who do not, we employed coarsened exact matching (CEM) to correct for potential bias.²⁵ Canadians who reported a GFD were matched by age and sex groups based on Dietary Reference Intakes,²⁶ income adequacy and household education with Canadians reporting 1 or more dietary avoidances other than gluten. Observations in strata with only participants who report a GFD or other dietary avoidances were removed. These samples were then reweighted using CEM weights,²⁷ which were multiplied by the survey weights. We tested for differences in average percent calories consumed for each food consumption location and each preparation location between the 2 matched groups using *t* tests. No other variables were adjusted for in the matched analysis.

All analyses were performed using PASW SPSS Statistics, IBM, version 18 and Stata Statistical Analysis Software, RTI International, version 14. Given the complex survey design of the CCHS, we used the survey weights with bootstrapping method to estimate standard errors and 95% confidence intervals (CIs) for all analyses.²² Hypothesis tests used a 2-sided α of 0.05.

Ethics approval

Our analysis was approved by the Social Sciences and Humanities Research Council of Canada. The use of these secondary data does not require institutional research ethics board approval.

Results

Prevalence of and factors associated with dietary gluten avoidance

A total of 488 respondents self-reported dietary gluten avoidance, indicating an overall estimated prevalence of 1.9% among Canadians, with a higher prevalence among women than men (2.5% v. 1.3%, respectively) (Table 1). Ontario and Quebec had similar prevalence, which was the lowest in Canada; residents in Ontario and Quebec were about half as likely to follow a GFD as Atlantic Canadians. Education, income

Table 1: Demographic characteristics of respondents who avoid dietary gluten based on results from the Canadian Community Health Survey — Nutrition, 2015

Characteristic	Dietary gluten avoidance, % ± SE	Adjusted OR (95% CI)
Sex		
Male, <i>n</i> = 9744	1.3 ± 0.2	Reference
Female, <i>n</i> = 10 733	2.5 ± 0.3	2.08 (1.32 to 3.27)
Age, yr		
2–17, <i>n</i> = 5839	0.9 ± 0.2	0.38 (0.23 to 0.63)
18–49, <i>n</i> = 6543	2.3 ± 0.4	Reference
≥ 50, <i>n</i> = 7724	1.9 ± 0.2	0.80 (0.54 to 1.17)
Province or region		
Atlantic provinces, <i>n</i> = 5308	2.9 ± 0.4	Reference
Quebec, <i>n</i> = 3204	1.5 ± 0.3	0.52 (0.31 to 0.87)
Ontario, <i>n</i> = 4228	1.5 ± 0.3	0.55 (0.32 to 0.94)
Prairies, <i>n</i> = 5146	2.4 ± 0.3	0.84 (0.54 to 1.29)
British Columbia, <i>n</i> = 2591	2.7 ± 0.7	0.99 (0.51 to 1.95)
Household education		
Less than secondary school, <i>n</i> = 1780	1.6 ± 0.5	Reference
Postsecondary school, <i>n</i> = 3754	1.5 ± 0.3	0.83 (0.35 to 1.93)
Postsecondary degree or diploma, <i>n</i> = 14 903	2.0 ± 0.2	1.14 (0.50 to 2.62)
Ethnicity		
White, <i>n</i> = 16 127	2.1 ± 0.2	Reference
Racialized or Indigenous, <i>n</i> = 3369	1.4 ± 0.5	0.68 (0.33 to 1.43)
Household income adequacy		
Lowest to lower middle, <i>n</i> = 1318	1.6 ± 0.5	Reference
Middle to upper middle, <i>n</i> = 8496	1.5 ± 0.2	0.83 (0.35 to 1.96)
Highest, <i>n</i> = 10 663	2.2 ± 0.3	1.21 (0.52 to 2.86)

Note: CI = confidence interval, OR = odds ratio, SE = standard error.

and ethnicity were not significant independent predictors of following a GFD.

Location of food consumption

Respondents consumed most of their calories at home (74%–81% of total calories), regardless of dietary exclusions (Table 2). However, respondents who avoided dietary gluten consumed significantly more calories at home and significantly fewer calories from other locations when compared with respondents reporting any other dietary avoidance, as well as when compared with those with no dietary exclusions. Almost half of respondents who followed a GFD consumed foods only at home (45.7%), whereas 36.8% and 37.8% of respondents who reported 1 or more dietary avoidances other than gluten and no dietary avoidances, respectively, consumed foods only at home (Table 3).

The matching of the samples who reported a GFD and those who reported 1 or more dietary avoidances resulted in few observations that were pruned (Table 2) and similar results. However, differences in energy intake at home between the same groups were no longer significant after matching ($p = 0.06$).

Location of food preparation

Percent daily energy intake from homemade or home-prepared recipes ranged from 11.7% to 12.6% of total calories for the 3 groups. Percent calories consumed from home-prepared foods did not differ significantly among the 3 groups, and the percent daily energy intake from foods prepared at restaurants was significantly lower (2.0%) among

Canadians who avoid dietary gluten compared with those with other avoidances (6.7%) and those with none (6.4%) (Table 4). Again, results from the matched analysis revealed similar significant differences in energy intake from restaurants between those adhering to a GFD and those with other avoidances ($p < 0.001$). However, energy attributed to foods not requiring preparation was no longer significant in the matched analysis.

Interpretation

We report an estimated 1.9% prevalence of Canadians who avoid dietary gluten. This prevalence likely includes individuals with celiac disease, wheat allergies and nonceliac gluten sensitivity, as well as individuals excluding gluten in the management of IBS or for reasons related to dietary trends. Unfortunately, the survey did not allow for determination of the reason for gluten avoidance. Our finding is reasonable given the 1.0% estimated prevalence of celiac disease,¹ the approximately 0.3%–0.4% of Canadians with wheat allergies²⁸ and the prevalence of nonceliac gluten sensitivity, which ranges from 0.6% to 6%.^{29,30}

Data from the United States indicate a similar prevalence of gluten avoidance, which in 2014 was estimated at 2.1%.³¹ Interestingly, the prevalence in Australia is considerably higher, with 3.8% total gluten avoidance and upwards of 24.2% partial avoidance;³² this may be partially attributed to the increasing popularity of FODMAP (fermentable oligo-, di-, mono-saccharides and polyols) diets, originally theorized in Australia.³³

Table 2: Total calories by type of food consumption location according to type of dietary avoidance(s)

Variable	Total kilocalories consumed, % (95% CI)		
	At home*	Other locations†	Not stated
Respondents who avoid dietary gluten, $n = 488$	81.0 (74.0 to 75.9)	15.4 (11.6 to 19.3)	3.6 (–0.2 to 7.4)
Respondents reporting ≥ 1 dietary avoidances,‡ $n = 2653$	75.3 (75.7 to 86.2)¶	23.0 (20.5 to 25.4)¶	1.7 (1.0 to 2.4)
Respondents who report no dietary avoidances, $n = 17\ 336$	74.9 (74.0 to 75.9)**	23.0 (22.0 to 23.9)¶	2.1 (1.7 to 2.5)
Matched analysis§			
Respondents who avoid dietary gluten, $n = 466$	80.6 (75.2 to 85.9)	16.4 (12.3 to 20.6)	3.0 (–0.9 to 6.9)
Respondents reporting ≥ 1 dietary avoidances, $n = 2304$	74.9 (72.2 to 77.5)	23.4 (20.8 to 26.0)¶	1.7 (1.0 to 2.4)

Note: CI = confidence interval.

*Home refers to foods prepared at the participant's home or at someone else's home.

†All other locations refer to the following locations: fast food or pizza restaurants; take-out; restaurants with server; bar, tavern or lounge; vending machine; restaurants with no additional information; cafeteria not at school; cafeteria at school; child care centre; family or adult care centre; other; grocery; corner or other types of stores; or at work.

‡With the exception of gluten.

§Respondents avoiding gluten were matched to respondents with ≥ 1 dietary avoidances according to age groups, sex, income adequacy and household education as described in the Methods.

¶ $p < 0.01$ in comparison with respondents who avoid dietary gluten.

** $p < 0.05$ in comparison with respondents who avoid dietary gluten.

Table 3: Prevalence of exclusive at-home food consumption* according to type of dietary avoidance(s)

Variable	Percent ± SE
Respondents who avoid dietary gluten	45.7 ± 0.5
Respondents who report ≥ 1 dietary avoidances other than gluten	36.8 ± 0.2†
Respondents who report no dietary avoidances	37.8 ± 0.1†

Note: SE = standard error.
 *Home refers to foods prepared at the participant's home or at someone else's home.
 †p < 0.01 in comparison with respondents who avoid dietary gluten.

In our study, Canadian women were twice as likely as men to follow a GFD, similar to reports of celiac disease, showing a female-to-male ratio of 2:1 or 3:1,^{12,13} and nonceliac gluten sensitivity, which also appears to be female predominated.³⁴ White participants had a higher proportion of gluten avoidance than racialized or Indigenous participants, also similar to previous reports;^{35,36} however, ethnicity was no longer significant after adjusting for other variables. Celiac disease was originally thought to be more prominent among Europeans, but more recent studies have disproven this theory.³⁷

In both Ontario and Quebec, the likelihood of individuals adhering to a GFD was about half that in the Atlantic provinces, which had the highest prevalence at 2.9%. The lower prevalence of adherence to a GFD in Quebec and higher prevalence in the Atlantic provinces may be partially reflective of provincial rates of IBS,³⁸ which show a similar regional pattern.

This may suggest that those avoiding gluten includes a substantial proportion of people with IBS.³⁹ A potential explanation for the lower prevalence of GFD in Ontario is the limited access to serologic testing for celiac disease through lack of provincial funding. However, further research would be required to examine regional differences in prevalence of celiac disease.

Our results suggest that it is likely that most Canadians following a GFD are vigilant in their avoidance. Indeed, the differences in the caloric profile by location of preparation or consumption among Canadians who are following a GFD indicates the degree of caution required, particularly from lack of control over and trust of the preparation process.⁴⁰ There is documented variation in the attentiveness to which food service establishments respond to dietary needs.⁴¹ The practical importance of these statistical differences in patterns of food preparation and eating location is likely considerable. Although an approximate absolute difference in energy intake of 4% from restaurants may seem negligible, this translates to just over 500 kcal/wk in an 1800 kcal/d diet, or the equivalent of about 1 restaurant meal per week, on average. This has important implications for individuals' social lives and does not capture the often limited availability of gluten-free meals when they are available in restaurants.

Limitations

One of the strengths of this study is the use of CCHS data, which includes a large and representative sample size, making it the best available data of the Canadian population currently available. Nevertheless, the CCHS included data from only the 10 provinces, excluding people from the territories, First

Table 4: Total calories for type of food preparation according to type of dietary avoidance(s)

Variable	Total kilocalories consumed, % (95% CI)				
	Home recipe or homemade	Restaurants*	Other†	No preparation required	Information not available
Respondents who avoid dietary gluten	12.2 (9.6 to 14.7)	2.0 (1.1 to 2.9)	10.5 (7.7 to 13.3)	54.9 (50.5 to 59.3)	20.4 (15.9 to 25.0)
Respondents reporting ≥ 1 dietary avoidances other than gluten	11.7 (10.6 to 12.9)	6.7 (5.4 to 7.9)§	11.4 (10.5 to 12.3)	49.3 (47.8 to 50.9)¶	20.9 (19.6 to 22.1)
Respondents who report no dietary avoidances	12.6 (12.1 to 13.2)	6.4 (6.0 to 6.9)§	12.1 (11.6 to 12.6)	47.5 (46.8 to 48.2)**	21.3 (20.7 to 21.9)
Matched analysis‡					
Respondents who avoid dietary gluten	12.2 (9.6 to 14.7)	2.6 (1.2 to 3.9)	9.7 (6.6 to 12.8)	53.5 (48.3 to 58.6)	22.9 (19.5 to 22.2)
Respondents reporting ≥ 1 dietary avoidances other than gluten	11.8 (10.7 to 13.0)	6.4 (5.1 to 7.7)§	11.7 (10.7 to 12.6)	49.2 (47.6 to 50.7)	20.9 (19.5 to 22.2)

Note: CI = confidence interval.
 *Includes fast food establishments.
 †Includes dry mix, frozen or commercially packaged foods.
 ‡Respondents avoiding gluten were matched to respondents avoiding ≥ 1 dietary avoidances according to age groups, sex, income adequacy and household education as described in the Methods.
 §p < 0.001 in comparison with respondents who avoid dietary gluten.
 ¶p < 0.01 in comparison with respondents who avoid dietary gluten.
 **p < 0.05 in comparison with respondents who avoid dietary gluten.

Nations people living on reserves and settlements, full-time members of the Canadian Armed Forces and individuals living in institutions. These exclusions further limit our ability to examine the health and well-being of Indigenous people, of which we know very little regarding digestive health issues. Given the importance of sex and gender to dietary gluten avoidance, the omission of survey questions pertaining to the diversity of sex and gender precludes a deeper analysis. Another limitation is that GFDs were self-reported, and we cannot determine the proportion of the sample who avoid dietary gluten owing to celiac disease, nonceliac gluten sensitivity, wheat allergy or other reasons. Finally, dietary data are also limited by recall bias.

Conclusion

This study provides an estimated prevalence of dietary gluten avoidance in Canada of 1.9%. Factors associated with dietary gluten avoidance are similar to those for celiac disease and nonceliac gluten sensitivity, reflecting approximately a 2:1 ratio of women to men. Further research is required to ascertain the reasons Canadians avoid dietary gluten and to examine how both sex and gender may inform our understanding of the varying etiologies of gluten-related disorders. Lastly, we have documented statistically different eating patterns among Canadians who follow a GFD. Patients excluding gluten may benefit from a referral to a registered dietitian to navigate these challenges.

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drafting the manuscript. All of the authors revised the manuscript, gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Funding: This study was supported by the Canadian Celiac Association's J.A. Campbell Research Award (2018) to Natalie Riediger and the J.A. Campbell Young Investigator Award (2019) to Adriana Mudryj. The study was also supplemented by start-up funds to Natalie Riediger from the University of Manitoba. Natalie Riediger is supported by a Canadian Institutes of Health Research (CIHR) Early Career Investigator Award (155435). Anne Waugh is a recipient of a CIHR Masters Canada Graduate Scholarship (2020/21). This research was also supported by funds to the Canadian Research Data Centre Network from the Social Science and Humanities Research Council, the CIHR, the Canadian Foundation for Innovation and Statistics Canada.

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Data sharing: The 2015 CCHS-Nutrition data are available through any of the Research Data Centres that facilitate research using Statistics Canada data. Researchers may apply to access the data.

Disclaimer: Although the research and analysis are based on data from Statistics Canada, the opinions expressed do not represent the views of Statistics Canada.

Acknowledgements: The authors gratefully acknowledge the Manitoba Research Data Centre data analyst Dr. Ian Clara for his support in data vetting. The authors also acknowledge Melissa Secord and the Canadian Celiac Association (CCA) for their support of this research and in knowledge translation, particularly the Manitoba Chapter of the CCA for hosting some of the authors (A.M., N.R. and A.W.) at its annual meeting. As well, the authors thank both the French and English Quebec Chapters of the CCA for their insights regarding dietary gluten avoidance in Quebec. Another patient partner, Linda Diffey, also informed the study, and the authors are grateful for her insightful comments. Lastly, the authors thank Dr. Luc Clair for his assistance with the matching process.

Supplemental information: For reviewer comments and the original submission of this manuscript, please see www.cmajopen.ca/content/9/2/E317/suppl/DC1.