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## Determinants of gluten-free diet adoption among individuals without Celiac disease or non-Celiac gluten sensitivity

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1 **Determinants of gluten-free diet adoption among individuals without Celiac disease or non-**  
2 **Celiac gluten sensitivity**

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20

21 **Abstract**

22 **Objectives:** Gluten free (GF) foods are typically less nutritious and more expensive than  
23 their gluten-containing variants, yet people without a diagnosed gluten sensitivity continue  
24 to adopt this diet. There is a lack of research about what factors drive people without Celiac  
25 disease or non-Celiac gluten sensitivity to follow the GF diet. **Methods:** A nationally  
26 representative sample of 2982 US residents without a diagnosed gluten sensitivity were  
27 surveyed about their attitudes, perceptions, and experiences with the GF diet. Logistic  
28 regression was used to compare respondents who were currently avoiding or had avoided  
29 gluten previously (GF consumer) to respondents who had never tried a GF diet (non-GF  
30 consumer). **Results:** Over one-fifth of respondents were GF consumers. Beliefs that a  
31 gluten-reduced diet is healthier (OR 1.69; 95% CI [1.30,2.18]), that GF products are more  
32 nutritious (OR 1.46, 95% CI [1.11,1.90]), and that a GF diet can help clear acne (OR 1.46;  
33 95% CI [1.13,1.88]) were all positively associated with trying a GF diet. Personal research  
34 was the most influential source of information associated with trying a GF diet (OR 2.92;  
35 95% CI [1.91,4.52]). This was followed by “healthcare center or health professional” (OR  
36 2.57; 95% CI [1.71,3.90]). Respondents who were never encouraged to try the GF diet were  
37 less likely to try the diet (OR 0.33, 95% CI [0.23,0.46]). **Conclusions:** Positive, but  
38 scientifically unsubstantiated, beliefs about the benefits of the GF diet were strongly  
39 associated with trying a GF diet, and the source of recommendation to try a GF diet was  
40 important.

41 **Keywords:** gluten-free; food behavior; food trend; belief; perception; attitude

## 42 **1 Introduction**

43 Celiac disease (CD) and non-Celiac gluten sensitivity (NCGS) are medical conditions that  
44 require a gluten-free (GF) diet. However, in the past decade, the GF diet has been adopted by  
45 many people who have not been diagnosed with either of these conditions (Foschia et al., 2016;  
46 Statista, 2018). Estimates suggest that only 1% of the population has CD and 3-6% have NCGS  
47 (Foschia et al., 2016), yet 25% of Americans consumed GF products in 2015 (Prada et al., 2019).  
48 The popularity of the GF diet raises questions about why approximately 20% of the population  
49 chooses to eat GF foods without having a medically diagnosed reason to do so.

50 Interest in the GF diet by non-gluten-sensitive individuals is suspected to stem, at least in  
51 part, from inaccurate beliefs about the health benefits afforded by a GF diet (Christoph et al.,  
52 2018; Newberry et al., 2017). These beliefs include weight loss, digestive health, clearer skin  
53 complexion, and other conditions. However, the ability of the GF diet to deliver these health  
54 benefits has not been substantiated by scientific studies for people who are not gluten sensitive.  
55 The scientific consensus remains that, for non-gluten-sensitive individuals, removing gluten from  
56 the diet does not improve health (Harvard School of Public Health, 2018).

57 Positive beliefs about the health benefits of the GF diet appear to be widely held. For  
58 instance, in a 2016 survey of over 2000 U.S. residents, 64% considered GF products to be either  
59 “very healthy” or “somewhat healthy” (Statista, 2018). Despite the health perception, GF  
60 products are, in many cases, nutritionally inferior to conventional, gluten-containing products.  
61 Compared to conventional products, GF versions typically contain more calories, fat, and  
62 sodium, while also containing lower amounts of vitamin B-12, folate, niacin, vitamin D, iron,  
63 zinc, magnesium, calcium, dietary fiber, and protein (Ahuja et al., 2017; Christoph et al., 2018;  
64 Diez-Sampedro et al., 2019; Foschia et al., 2016; Thompson, 2000; Vici et al., 2016). Indeed,

65 multiple studies have found, through plasma vitamin levels and food record logs, that CD  
66 patients following a GF diet are deficient in these very nutrients (Diez-Sampedro et al., 2019;  
67 Hallert et al., 2009; Vici et al., 2016). Rather than providing nutritional benefits, consuming GF  
68 versions of conventional products may place individuals at risk of nutrient deficiencies.

69         Although GF products are typically nutritionally inferior to their conventional versions,  
70 Christoph et al. (2018) found that among the general public, people who list GF as an important  
71 food attribute typically have a healthier diet and lifestyle habits. Compared to people who did not  
72 prefer GF products, people preferring GF products consumed more fiber and servings of fruits  
73 and vegetables, along with consuming less sodium, trans fats, and calories from saturated fat and  
74 added sugar in their diet. Therefore, many people who tend to have healthier eating habits may  
75 also choose to consume GF products, creating a non-causal relationship between consuming the  
76 GF diet and positive health outcomes in the general population.

77         The popularity of the GF diet highlights the disconnect between consumer perceptions  
78 and scientifically supported facts about nutrition. There is, in general, a lack of academic  
79 research on the factors that promote consumers to adopt “popular”—which are sometimes  
80 referred to as fad—diets. Information on consumer behavior in the context of the GF diet has  
81 largely been limited to descriptive results and is not based on nationally representative samples  
82 (Dunn et al., 2014; Golmohamadi et al., 2017; Prada et al., 2019; Schlitt et al., 2013). Descriptive  
83 results are unable to link the choice to follow a GF diet with beliefs, knowledge, and whether  
84 individuals were advised to follow the diet. Thus, it is unclear what influenced a person to try the  
85 diet. For instance, it has been suggested that popular media has influenced many non-gluten  
86 sensitive individuals to try a GF diet since unsubstantiated information about purported benefits  
87 of the GF diet has been disseminated through these sources (Christoph et al., 2018; Howard,

88 2017; Jones, 2017; Newberry et al., 2017). However, without research, it is not clear whether  
89 exposure to popular media sources promoting the GF diet increases the likelihood that an  
90 individual will follow a GF diet.

91 No previous studies have linked determinants of consumer behavior to a person's  
92 decision to follow a GF diet. To address this gap, we surveyed a nationally representative sample  
93 of 3051 residents of the United States—2982 of whom had not been diagnosed with a gluten  
94 sensitivity (and did not answer “prefer not to respond” to questions included in the analysis).  
95 Respondents were surveyed about their attitudes, perceptions, and experiences with the GF diet.  
96 The experience with the GF diet of respondents without a diagnosed gluten sensitivity was  
97 related to their beliefs about the diet's health benefits; who recommended the respondent follow  
98 a GF diet; objective and subjective nutritional knowledge; perceived health; and demographic  
99 variables.

100

## 101 **2 Methods**

### 102 **2.1 Data collection**

103 A 55-question survey about people's experience with, perceptions of, and attitudes about the GF  
104 diet was distributed online to a sample of residents designed to be representative of the  
105 population of the United States by sex, age, and household income. The survey was distributed  
106 from 3-15 May 2019 by a market research firm, IRi (<https://www.iriworldwide.com/en-us>),  
107 which targeted a sample that was nationally representative of the demographic variables sex, age,  
108 and income. The University of Nebraska-Lincoln Institutional Review Board approved this  
109 research (IRB# 20190118770EX). Participants provided written informed consent before  
110 completing the research. The survey was distributed online by IRi to approximately 32,000

111 people. The survey link was live until our target sample size of at least 3000 people was reached,  
112 after which the link was terminated and no additional participants could complete the survey. A  
113 sample size of 3000 was selected to ensure that we would have sufficient representation in the  
114 GF consumer group (based on the most recent information about the percentage of the  
115 population—25%—consuming GF products (Prada et al., 2019)). During the time the survey link  
116 was active, 5513 people began the survey; however, participants who did not complete the  
117 survey, finished the survey unreasonably quickly (under five minutes), answered an “attention  
118 check” question incorrectly, or selected answers in the same position throughout the survey (e.g.,  
119 always selected the first option listed) were removed from the dataset by IRi and were not  
120 included in the 3051 responses we received. The design of the survey covered many topics  
121 related to the GF diet and only those survey questions that were relevant to the objectives of this  
122 paper were included in the analysis (Supplementary File 1). These included questions related to  
123 GF health benefit beliefs, sources that recommended a GF diet, subjective and objective nutrition  
124 knowledge, perceived health status, and demographics.

125         In the analysis, the decision to follow a GF diet among respondents who did not have a  
126 medical diagnosis of CD or NCGS was examined as the dependent variable. Participants who  
127 had been formally diagnosed with either CD or NCGS were removed from the analysis (n=50;  
128 1.6% of the original dataset). Respondents who currently or in the past had followed a strict GF  
129 diet or had consciously limited their gluten consumption constituted observations of the diet and  
130 were coded with a value of 1 (abbreviated henceforth as GF consumers), while respondents who  
131 also had not been diagnosed with CD nor NCGS, but had never reduced or eliminated gluten  
132 from their diet were coded as 0 (non-GF consumers). An additional 19 (0.6% of the original  
133 dataset) participants were removed from the dataset because of missing data for a question used

134 in the model. Therefore, out of the total 3051 respondents who completed the survey, 2982  
135 subjects were included in the analysis.

136

## 137 **2.2 Data analysis**

138 The survey data were analyzed using R (R Core Team, 2019). Summary statistics, chi square  
139 tests, and t-tests were used to report and compare variables of the whole sample and between  
140 sub-samples of respondents who had and had not tried a GF diet. To control for multiple  
141 statistical comparisons, p-values were adjusted using Bonferroni's method. Multivariate logistic  
142 regression was used to examine the relationship of multiple independent variables to having  
143 followed a GF diet. Independent variables in the model included beliefs about health benefits of  
144 the GF diet; the source of the suggestion that the respondent try a GF diet; objective and  
145 subjective knowledge about grain-based products, gluten, and nutrition; subjective health status;  
146 and demographic variables (Table 1).

147 [Table 1]

148 Beliefs about the health benefits of the GF diet were measured using five questions that  
149 asked participants to indicate the extent to which they agreed that the GF diet exhibited certain  
150 health benefits. The health benefits were expressed through statements asking how much  
151 respondents believed a GF diet can help with "acne" and "weight loss"; as well as eliciting  
152 agreement with statements such as "Gluten can cause disease in non-gluten sensitive people";  
153 "GF products are generally more nutritious than their gluten containing variant"; and "A gluten-  
154 reduced diet is healthier for people than a full-gluten containing diet." Respondents' answers  
155 were provided on a 5-point scale, with points ranging from "strongly agree" to "strongly  
156 disagree." Since the purpose of the belief questions was to examine which perceived benefits



157 influence people to follow a GF diet, the scale was converted to a binomial variable. The variable  
158 took a value of one if the respondent agreed that the GF diet exhibited the benefit in question and  
159 zero if the respondent was neutral or disagreed.

160 To examine which information sources influenced a person's decision to try a GF diet,  
161 participants were asked to mark all applicable groups of people or sources of information that  
162 had suggested he or she try a GF diet from a list of sources provided in the survey. Information  
163 sources included: "Family member or friend"; "Healthcare center or health professional (doctor,  
164 dietitian, etc.)"; "Online checklist suggested I try it"; "Self (including through personal  
165 research)"; "TV personality, blogger, video blogger, and or celebrity"; "Wellness coach,  
166 personal trainer, and or sports coach/Nutrition/Fitness shop or gym employee"; and "No one has  
167 ever suggested that I try a gluten-free diet." The sources were included as separate binomial  
168 variables in the model, where a value of "1" was given if the source had recommended the GF  
169 diet to the person and "0" if the source had not suggested the diet to the person. A binary variable  
170 was also included for the "No one has ever suggested that I try a gluten-free diet" statement.

171 Subjective and objective knowledge about grain-based products, gluten, and nutrition were  
172 also elicited. Subjective knowledge captured participants' self-assessment of their knowledge by  
173 asking them to rank how much they agreed with the statement, "I have a lot of knowledge about  
174 [grain-based products/gluten/nutrition]." Responses to these questions were presented on a 5-  
175 point scale, which was collapsed into a 3-point scale for analysis. "Strongly disagree" and  
176 "Disagree" were combined into one category and "Strongly agree" and "Agree" were combined  
177 into another category. "Disagree" was used as the reference category. Objective knowledge was  
178 assessed using a five-question quiz on each of the three topics. However, one gluten-related  
179 question consisted of five sub-questions, which were each scored separately, and, due to

180 ambiguity identified after the survey was administered, one grain question was removed.  
181 Therefore, objective knowledge scoring included nine questions about gluten, five questions  
182 about nutrition, and four questions about grains. Objective knowledge scores were calculated  
183 separately for grain-based products, gluten, and nutrition by taking the sum of correct answers in  
184 the category and dividing it by the total number of questions in the category. Objective  
185 knowledge scores, therefore, could take values from 0 to 1. People’s health perception was  
186 analyzed using three questions. First, participants marked all symptoms he or she experienced  
187 when consuming gluten-containing foods. The list of symptoms was randomized in the survey.  
188 Symptoms that were sex-specific or that were not scientifically supported symptoms of gluten  
189 sensitivity were omitted from this symptom count. Symptoms included in the model were  
190 “Abdominal pain,” “Acid Reflux,” “Bloating or inflammation,” “Body aching (including muscle  
191 or joint discomfort),” “Brain fog,” “Diarrhea or constipation,” “Fatigue or lack of energy,”  
192 “Headache or migraine,” and “Nausea.” For each symptom, we created a binomial variable  
193 taking the value of 1 if the respondent reported experiencing the symptom after consuming food  
194 that contained gluten and 0 if they did not experience the symptom. The other two health  
195 questions, “How satisfied are you with your current health status?” and “Select how much you  
196 agree or disagree with this statement. *My eating habits are very healthy,*” were asked on a 5-  
197 point scale which was converted into a 3-point scale for analysis. People who marked “Prefer not  
198 to answer” (n=19) for the health satisfaction question were omitted from the analysis.  
199 “Unsatisfied” and “Disagree” were used as the reference categories for these questions,  
200 respectively, in the analysis.

201           Demographics included in the model were sex, age, body mass index (BMI), household  
202 income, and education. Sex was collapsed into “female” (1) and “not female” (0) categories (the

203 “not female” category was predominantly male but included six respondents who declined to  
204 respond to the question). Respondents indicated their age in 5-year intervals ranging from “19-24  
205 years old” to “65 and older.” These categories were merged into “19-44” and “45 and older”.  
206 The “45 and older” category was used as the reference for age. Self-reported height and weight  
207 were used to calculate BMI. Three BMI categories were established:  $\leq 24.9$ , 25-29.9, and  $\geq 30$ ,  
208 which correspond to categories that are commonly used to describe weight status: “under or  
209 normal weight,” “overweight,” and “obese,” respectively. A fourth category, “Prefer not to  
210 answer,” was assigned to participants who did not disclose enough information to calculate BMI.  
211 The category “BMI $\leq 24.9$ ” was used as the reference. Household income was recorded in  
212 categories spanning \$20,000 intervals, beginning with “Less than \$20,000” and stopping at  
213 “\$100,000 or more.” Due to the small number of people with the income “Less than \$20,000”,  
214 the category was combined with “\$20,000-\$39,999” and renamed as “Less than \$40,000” for  
215 analysis. Finally, respondents indicated their highest level of education completed. Choices  
216 included: “Less than high school”; “High school/G.E.D.”; “Some college/associate degree”;  
217 “Bachelor’s degree”; “Advanced degree (M.B.A., M.D., J.D., M.S., M.A., Ph.D.)”; and “Prefer  
218 not to answer.” Education categories were merged into “No Postsecondary” which included  
219 “Prefer not to answer” responses, and “Postsecondary.” Throughout the analysis, collapsing  
220 response categories was done to ensure adequate sample sizes within each category included in  
221 the analysis and for simplicity when reporting results.

222

## 223 **3 Results**

### 224 **3.1 Descriptive Results**

225 Table 2 presents summary statistics for participants' demographic characteristics. The  
226 survey was designed to be representative of the US population in terms of sex, age, and income.  
227 Females comprised 52.0% of the sample, which is close to the percentage of females in the US  
228 population: 50.8% (U.S. Census Bureau, 2019). Participants' age was split into two categories  
229 for this research: 19-44 years of age, and over 45 years of age. The 19-44 age group constituted  
230 44.3% of the sample. This is slightly higher than the percentage of the US population in 2018  
231 between 21 and 44 years of age (43.4%)—which is the most similar range of ages reported by  
232 the US Census data relative to our data (U.S. Census Bureau, 2018). According to US Census  
233 Quickfacts, median US household income from 2014-2018 was \$60,293 (in 2018 dollars), and  
234 the median category selected for household income in our sample was \$60,000-\$79,999 (U.S.  
235 Census Bureau, 2019). Nearly 47% of our respondents reported household income below  
236 \$60,000 so the precise median value is likely quite similar to the US population's median  
237 household income. Chi square tests using the Bonferroni correction for multiple comparisons of  
238 differences between GF consumers and non-GF consumers among these variables showed the  
239 only significant difference was that a greater proportion of GF than non-GF consumers were  
240 between 19-44 years old (Table 2).

241 [Table 2]

242 A larger percentage of GF consumers believed in the health benefit statements (Fig. 1),  
243 all of which were statistically significant. The belief held by the most people regardless of GF  
244 consumer category was that the GF diet could help with weight loss (48.9% of full sample),  
245 although a much higher percentage of GF consumers (66.6%) believed in this benefit than non-  
246 GF consumers (43.8%). The second most endorsed benefit was that “in general, a gluten-reduced

247 diet is healthier for people than a full-gluten containing diet” (39.1% of full sample). Nearly two-  
248 thirds of GF consumers (62.2% of GF consumers) agreed with this statement.

249 [Fig. 1]

250 A larger percentage of GF consumers than non-GF consumers reported that they had  
251 been encouraged to try a GF diet (Fig. 2). The differences in the proportion of GF consumer  
252 groups that were recommended to try a GF diet by various sources were all significant at  
253  $p < 0.001$ . In both groups, family and friends was the most common recommendation source. The  
254 second most common recommendation source was “Healthcare center or health professional”,  
255 which was higher among GF consumers. Other sources that respondents indicated had  
256 recommended the GF diet included “TV personality, blogger, video blogger, and or celebrity”;  
257 and “Self (including through personal research)”. A larger proportion of people who marked that  
258 they self-recommended the diet were GF consumers.

259 [Fig. 2]

260 GF consumers reported having more grain, gluten, and nutrition knowledge than non-GF  
261 consumers (Table 3). Less than a fourth of the sample population felt that they “have a lot of  
262 knowledge about grains” (17.7% of full sample) or “gluten” (9.2% of full sample). A larger  
263 percentage of GF Consumers agreed with the statement “I have a lot of knowledge about grains”  
264 than non-GF Consumers. Compared to non-GF consumers, GF consumers felt more confident in  
265 their gluten knowledge: a greater proportion of GF consumers agreed with the statement “I have  
266 a lot of knowledge about gluten” compared to non-GF consumers. GF consumers also felt more  
267 knowledgeable about nutrition than non-GF consumers. GF consumers scored significantly  
268 higher on the gluten objective knowledge questions (Table 4) but did not receive significantly  
269 different scores from non-GF consumers for either grains or nutrition objective knowledge.

270 [Table 3] [Table 4]

271 Respondents were asked three questions about their health (Table 5). The first question  
272 asked participants if they experienced each of nine different gluten-intolerance related symptoms  
273 after consuming gluten. For all nine symptoms, a larger percentage of GF Consumers marked  
274 that they experienced the symptom after consuming food with gluten. Although the two GF  
275 groups were similarly satisfied with their overall health status, a larger percentage of GF  
276 consumers thought their eating habits were very healthy compared to non-GF consumers.  
277 Additionally, a smaller percentage of GF consumers disagreed with the statement “My eating  
278 habits are very healthy.”

279 [Table 5]

280

### 281 **3.2 Model Results**

282 Data were analyzed using a multivariate logistic regression model to determine how these  
283 independent variables influence a person’s decision to eat GF, despite not having been diagnosed  
284 with CD or NCGS (Table 6, Supplementary File 2 for raw estimates). In the regression,  
285 household income and age were the only significant demographic variables. Younger  
286 respondents (19-44 years old) were more likely to have tried the GF diet, while respondents who  
287 had an annual household income between \$60,000-\$79,000 or \$100,000 or more were less likely  
288 to have gone on the diet.

289 [Table 6]

290 People were more likely to try a GF diet if they believed the diet improved their health.  
291 Individuals who believed that a GF or gluten-reduced diet was healthier than a conventional full-  
292 gluten containing diet were significantly more likely to have tried the GF diet. This was followed

293 by the belief that the GF diet helps with acne and that GF products are more nutritious than their  
294 conventional gluten-containing version.

295 Multiple sources of recommendation significantly influenced whether a person tried the  
296 GF diet. Self-suggesting, including through personal research, increased the odds of trying the  
297 diet the most, followed by “healthcare center or health professional (doctor, dietitian, etc.)” A  
298 recommendation from a “wellness coach, personal trainer, and or sports coach/nutrition/fitness  
299 shop or gym employee” was also positively correlated with trying a GF diet. Receiving no  
300 recommendation to follow a GF diet decreased the likelihood of trying the GF diet.

301 The relationship of subjective and objective knowledge about grain-based products,  
302 gluten, and nutrition to eating a GF diet was included in the model. Agreeing or feeling neutral  
303 about the statement “I have a lot of knowledge about gluten” increased the likelihood that an  
304 individual had tried the GFD.

305 People were more likely to eat GF if they experiencing abdominal pain, bloating or  
306 inflammation, or fatigue or lack of energy after consuming gluten. Agreeing or feeling neutral  
307 about the statement “My eating habits are very healthy” also increased the likelihood that a  
308 respondent was a GF consumer.

309

#### 310 **4. Discussion and Conclusion**

311 Eating a GF diet without a CD or NCGS diagnosis has gained popularity despite a lack of  
312 scientific evidence demonstrating its efficacy to help people achieve health goals commonly  
313 attributed to the diet. To understand why the GF diet has gained popularity, this research  
314 analyzes the influence that factors—such as beliefs, the source of recommendation to try a GF  
315 diet, and knowledge—have on encouraging consumption of gluten-free foods.

316 An unexpected finding of this research is that believing the GF diet helps with weight-  
317 loss does not increase the likelihood that an individual has tried the diet after controlling for  
318 other variables. While this research corroborates previous reports that have documented that  
319 many people believe that eating a GF diet promotes weight-loss (Christoph et al., 2018;  
320 Newberry et al., 2017; Watson, 2013)—this was the most commonly held belief about health  
321 benefits of the GF diet among our sample—the belief did not lead people to try the GF diet.

322 On the other hand, we find that people are more likely to try a GF diet if they believe the  
323 diet can help with acne. A possible explanation is that GF consumers are also more likely to be  
324 in the age group that suffers from acne in adulthood. Adult acne does not significantly decrease  
325 until around age 45 (Goulden et al., 1999), and the model found that people ages 19-44 were  
326 more likely to be a GF consumer than people 45 and older.

327 The model also shows that people who believe that reducing gluten in one's diet  
328 improves the health of the diet are more likely to follow a GF diet. Thus, GF consumers are more  
329 likely than non-GF consumers to incorrectly treat gluten as a nutrient to limit, such as salt or  
330 sugar, rather than an allergen that must be avoided. Gluten must be completely removed for the  
331 GF diet to be effective at healing gastrointestinal symptoms of people with CD (Newberry et al.,  
332 2017). Yet, most respondents reported simply reducing their gluten-intake rather than  
333 exclusively following a GF diet. Additionally, GF consumers were more likely to perceive GF  
334 products as more nutritious than their gluten-containing counterparts, when GF versions are  
335 usually the nutritionally inferior product, based on nutrition data (Christoph et al., 2018).

336 Results related to the source of recommendation to try a GF diet show that respondents  
337 who did their own research on the diet had the highest likelihood of following the diet. Self-  
338 diagnosis of a condition requiring a GF diet is not uncommon (Biesiekierski et al., 2014) and is



339 an issue that should be addressed. In addition to being more likely to believe in unproven  
340 benefits of the diet, our model also identified that people who felt they had a lot of knowledge  
341 about gluten were more likely to have followed a GF diet. A person's lack of knowledge about  
342 the GF diet and when it is beneficial may lead to the unnecessary eating of the GF diet.  
343 Biesiekierski et. al. (2014) reported that a fourth of their sample that self-diagnosed themselves  
344 with a condition requiring a GF diet did so incorrectly and that the GF diet did not ameliorate  
345 their perceived health issues.

346 To better understand how to address self-diagnosing a GF diet, "self" as a source of  
347 recommendation needs further investigation to understand what people consider "personal  
348 research." It is unclear how people distinguish personal research from, for example, the  
349 information they read on the internet. While articles have blamed celebrities and media for  
350 promoting false GF beliefs and encouraging people to try a GF diet (Christoph et al., 2018;  
351 Howard, 2017; Jones, 2017; Newberry et al., 2017), our research found that popular media was  
352 not significantly associated with a person eating GF. However, a possibility is that respondents  
353 may have first heard about the GF diet through popular media, but then conducted further  
354 research on their own, leading them to identify "self" as the ultimate recommendation source.  
355 Therefore, while a person may have reported that they self-suggested the GF diet, the inclination  
356 and desire to do research may have stemmed from other sources.

357 Beyond self-suggesting the diet, many GF consumers were influenced to try a GF diet  
358 when recommended by a wellness advisor or healthcare provider. This finding supports a study  
359 by Ianiro et al. (2016) that reported the occurrence of CD misdiagnosis by healthcare  
360 professionals in Italy. The study occurred at a clinic where patients came to confirm their CD  
361 diagnosis. The clinic identified that 43 of 107 (40.2%) patients were misdiagnosed with CD by a

362 healthcare professional. Upon further inquiry, the clinic also found that over half of the 107  
363 patients (55) had been improperly tested for CD (Ianiro et al., 2016). Therefore, it is possible that  
364 healthcare professionals may not thoroughly or correctly test patients before providing a  
365 diagnosis—or that patients misunderstand a professional’s discussion of a possible condition as a  
366 statement of fact. Additionally, healthcare professionals could also be prematurely suggesting a  
367 GF diet before fully considering other possible causes of a patient’s gastrointestinal symptoms,  
368 which may not be as prominent. Falling for an availability bias is a common issue among  
369 healthcare professionals (Wellbery, 2011); the increased recognition of CD and NCGS and the  
370 rising popularity of the GF diet may have created an availability heuristic.

371       Experiencing abdominal pain, bloating or inflammation, or a lack of energy increased the  
372 likelihood that a person would adopt a GF diet. Many symptoms for CD and NCGS overlap with  
373 other diseases such as irritable bowel syndrome and Crohn’s disease (Roszkowska et al., 2019).  
374 While for CD biomarkers can confirm diagnosis, there are no identifying biomarkers for NCGS  
375 (Volta et al., 2014). The lack of biomarkers and the overlap of symptoms with other diseases  
376 may also lead health professionals to incorrectly suggest a person eat a GF diet.

377       An important limitation of this study is that because our data about following a GF diet  
378 are retrospective—we were unable to recruit and study people just as they made a decision to  
379 follow the GF diet—individuals who followed a GF diet have different experiences than those  
380 who have not tried a GF diet. This difference in experiences may have influenced some of the  
381 measures we collected to be independent variables, such as the subjective and objective gluten  
382 knowledge variables—both of which were significantly higher among GF consumers than non-  
383 GF consumers, suggesting some potential for reverse causality. In practice, the only feasible way  
384 to conduct a large-scale survey of individuals at the point in time in which they choose whether

385 to follow the diet would necessitate hypothetical choice, since actual choices are difficult to  
386 anticipate, which has its own weaknesses.

387         In conclusion, this research quantifies the influence of common GF perceptions and  
388 motivations to eat a GF diet for reasons other than CD or NCGS. Individuals are more likely to  
389 follow the diet if they believe GF is generally healthier than gluten-containing foods or if they  
390 convinced themselves to try the diet based on their own research, were recommended by  
391 healthcare professionals or by a wellness advisor. The identification of these influences is useful  
392 for understanding drivers of a behavior—following a GF diet—widely believed to be health-  
393 improving for the general population, but which may in reality provide inferior nutrition (Diez-  
394 Sampedro et al., 2019; Hallert et al., 2009; Vici et al., 2016).

395

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**Beliefs in GF Health Benefits**

Do you believe the GF diet can help with (\_\_\_\_)?

Acne: Yes/(No)

Ability to lose weight: Yes/(No)

Please indicate whether you agree, disagree, or do not have an opinion about the statement.

Gluten can cause diseases in non-gluten sensitive people: Agree/(Disagree)

Gluten-free products are generally more nutritious than their gluten-containing variant: Agree/(Disagree)

In general, a gluten-free or gluten-reduced diet is healthier for people than a full-gluten containing diet: Agree/(Disagree)

**Information Source that Recommended the GF Diet**

Who, if anyone, has suggested that you try a gluten-free diet?

Family member or friend: Yes/(No)

Healthcare center or health professional (doctor, dietitian, etc.): Yes/(No)

Online checklist suggested I try it: Yes/(No)

Self (including through personal research): Yes/(No)

TV personality, blogger, video blogger, and or celebrity: Yes/(No)

Wellness coach, personal trainer, and or sports coach/Nutrition/Fitness shop or gym employee: Yes/(No)

No one has ever suggested that I try a gluten-free diet: Yes/(No) \*Conditional\*

**Knowledge**

Please mark how much you agree with the following statements.

I have a lot of knowledge about grain-based products: Agree/Neutral/(Disagree)

I have a lot of knowledge about gluten: Agree/Neutral/(Disagree)

I have a lot of knowledge about nutrition: Agree/Neutral/(Disagree)

Grain Objective Knowledge: Score 0-1

Gluten Objective Knowledge: Score 0-1

Nutrition Objective Knowledge: Score 0-1

**Perceived Health Status**

When you consume foods that contain gluten, what symptoms do you experience?

Abdominal pain: Yes/(No)

Acid Reflux: Yes/(No)

Bloating or inflammation: Yes/(No)

Body aching (including muscle or joint discomfort): Yes/(No)

Brain fog: Yes/(No)

Diarrhea or constipation: Yes/(No)

Fatigue or lack of energy: Yes/(No)

Headache or migraine: Yes/(No)

Nausea: Yes/(No)

How satisfied are you with your current health status: Satisfied/Neutral/(Dissatisfied)

My eating habits are very healthy: Agree/Neutral/(Disagree)

**Demographic Characteristics**

Sex: Female/(Not Female)

Age: 19-44/(≥45)

BMI: (Under or normal weight)/Overweight/Obese/Prefer not to answer

Household Income: (≤\$40,000)/\$40,000-\$59,999/\$60,000-\$79,999/\$80,000-\$99,999/\$100,000 or more/Prefer not the answer

Education: Postsecondary/(No Postsecondary)

406 **Table 2: Participant Demographic Characteristics**

	GF Consumer		Non-GF Consumer		p-value
	Count	%	Count	%	
n	667	22.4	2315	77.6	
Sex					1.000
Female	353	52.9	1199	51.8	
Not female	314	47.1	1116	48.2	
Age					<0.001
19-44	379	56.8	934	40.3	
45 and older	288	43.2	1381	59.7	
BMI					0.130
Underweight or normal	215	32.2	644	27.8	
Overweight	213	31.9	703	30.4	
Obese	178	26.7	748	32.3	
Prefer not to answer	61	9.1	220	9.5	
Household Income					1.000
Less than \$40,000	189	28.3	643	27.8	
\$40,000 – \$59,999	123	18.4	409	17.7	
\$60,000 – \$79,999	89	13.3	354	15.3	
\$80,000 – \$99,999	76	11.4	249	10.8	
\$100,000 or more	182	27.3	614	26.5	
Prefer not to answer	8	1.2	46	2.0	
Education					1.000
No postsecondary	524	78.9	1846	79.9	
Postsecondary	143	21.1	469	20.1	

407 Note: p-value compares significant differences between groups (chi-squared test with Bonferroni  
408 correction).

409 **Table 3: Distribution of Participants' Subjective Knowledge of Grain, Gluten, and**  
 410 **Nutrition**

	GF Consumer		Non-GF Consumer		p-value
	Count	%	Count	%	
Grain					<0.001
Agree	219	32.8	309	13.3	
Neutral	238	35.7	710	30.7	
Disagree	210	31.5	1296	56.0	
Gluten					<0.001
Agree	158	23.7	116	5.0	
Neutral	263	39.4	468	20.2	
Disagree	246	36.9	1731	74.8	
Nutrition					<0.001
Agree	356	53.4	783	33.8	
Neutral	198	29.7	812	35.1	
Disagree	113	16.9	720	31.1	

411 Note: Abbreviations: Grain = I have a lot of knowledge about grain-based products; Gluten = I  
 412 have a lot of knowledge about gluten; Nutrition = I have a lot of knowledge about nutrition. p-  
 413 values compare the significant differences between groups (chi-squared test with Bonferroni  
 414 correction).

415 **Table 4: Mean and Standard Deviation of Participants' Objective Knowledge Scores**

	GF Consumer		Non-GF Consumer		p-value
	Mean	SD	Mean	SD	
Objective Knowledge Score					
Grain	0.31	0.22	0.32	0.20	1.000
Gluten	0.41	0.19	0.37	0.20	0.027
Nutrition	0.43	0.24	0.43	0.23	1.000

416 Note: [grain/gluten/nutrition] objective refers to their objective knowledge scores on a scale of 0-  
 417 1 and calculated as a continuous variable. p-values compare the significant differences between  
 418 groups (t-test) using the Bonferroni correction for multiple comparisons.  
 419



420 **Table 5: Distribution of Participants' Perceived Health Status**

	GF Consumer		Non-GF Consumer		p-value
	Count	%	Count	%	
<b>Symptoms Experienced After Consuming Gluten</b>					
Abdominal pain	122	18.3	50	2.2	<0.001
Acid Reflux	112	16.8	69	3.0	<0.001
Bloating or inflammation	231	34.6	150	6.5	<0.001
Body aching	80	12.0	43	1.9	<0.001
Brain fog	74	11.1	43	1.9	<0.001
Diarrhea or constipation	135	20.2	74	3.2	<0.001
Fatigue or lack of energy	176	26.4	113	4.9	<0.001
Headache or migraine	88	13.2	43	1.9	<0.001
Nausea	57	8.5	21	0.9	<0.001
<b>Health Satisfaction</b>					0.159
Satisfied	340	51.0	1083	46.8	
Neutral	75	11.2	277	12.0	
Unsatisfied	252	37.8	955	41.3	
<b>Healthy Eating Habits</b>					<0.001
Agree	341	51.1	797	34.4	
Neutral	208	31.2	816	35.2	
Disagree	118	17.7	702	30.3	

421  
 422 Note: Abbreviations: Symptoms Experienced After Consuming Gluten = When you consume  
 423 foods that contain gluten, what symptoms do you experience; Body aching (including muscle or  
 424 joint discomfort); Health Satisfaction = How satisfied are you with your current health status;  
 425 Healthy Eating Habits = My eating habits are very healthy. p-values compare the significant  
 426 differences between groups (chi-squared test with Bonferroni correction).

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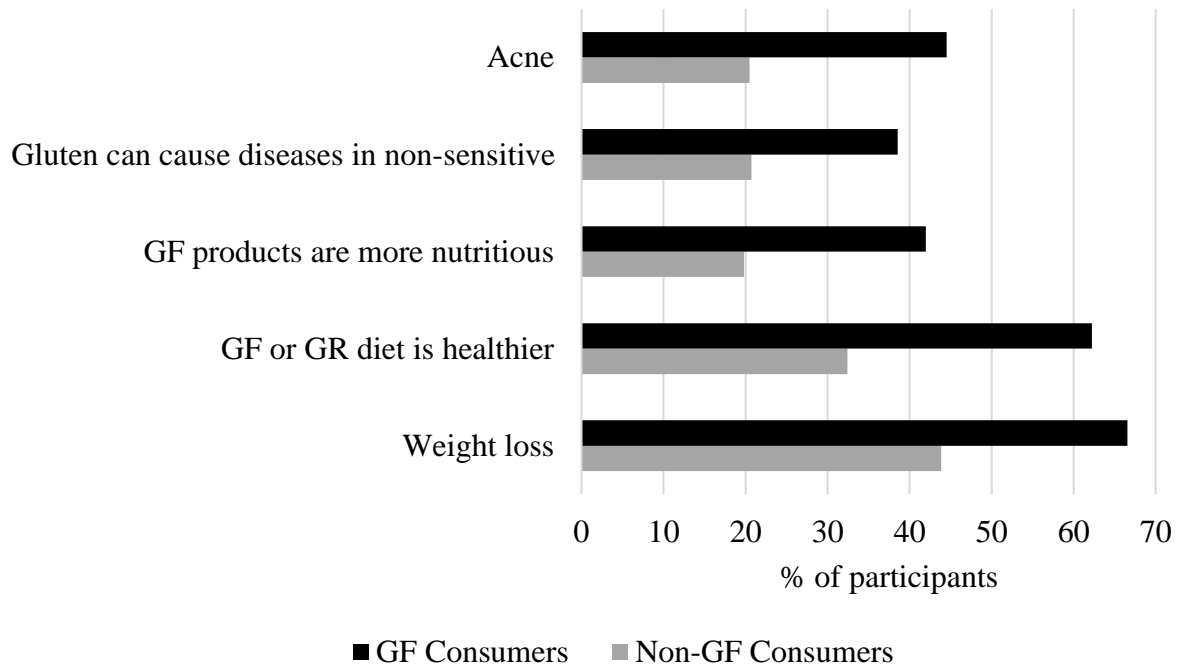
430 **Table 6: OR Representing All Variables in Model**

	OR	Low CI	High CI	p-value
<b>Demographic Characteristics</b>				
Female (Not female)	1.23	0.96	1.56	
Age: 19-44 ( $\geq 45$ )	1.29	1.02	1.64	*
Overweight (Underweight or normal)	1.07	0.80	1.44	
Obese (Underweight or normal)	0.88	0.65	1.20	
BMI Prefer not to answer (Underweight or normal)	1.15	0.74	1.76	
House income: \$40,000 – \$59,999 ( $\leq \$40,000$ )	0.95	0.67	1.34	
House income: \$60,000 – \$79,999 ( $\leq \$40,000$ )	0.69	0.47	1.01	
House income: \$80,000 – \$99,999 ( $\leq \$40,000$ )	0.99	0.66	1.47	
House income: \$100,000 or more ( $\leq \$40,000$ )	0.70	0.51	0.98	*
House income: Prefer not to answer ( $\leq \$40,000$ )	0.62	0.24	1.43	
Education: Postsecondary (No postsecondary)	0.89	0.67	1.20	
<b>Beliefs in GF Health Benefits</b>				
Acne: Yes (No)	1.46	1.13	1.88	**
Gluten can cause diseases in non-sensitive: Yes (No)	0.99	0.76	1.28	
GF products are more nutritious: Yes (No)	1.46	1.11	1.90	**
GF or GR diet are healthier: Yes (No)	1.69	1.30	2.18	***
Weight Loss: Yes (No)	1.20	0.93	1.54	
<b>Information Source that Recommended the GF Diet</b>				
Family & friends: Yes (No)	1.31	0.96	1.79	
Health professional: Yes (No)	2.57	1.71	3.90	***
Online checklist: Yes (No)	0.72	0.40	1.30	
Self: Yes (No)	2.92	1.91	4.52	***
TV personality, blogger, video blogger, and or celebrity: Yes (No)	1.17	0.77	1.76	
Wellness advisor: Yes (No)	1.90	1.06	3.48	*
No one: Yes (No)	0.33	0.23	0.46	***
<b>Knowledge</b>				
Grain subjective: Agree (Disagree)	1.20	0.81	1.76	
Grain subjective: Neutral (Disagree)	0.96	0.69	1.32	
Grain objective: Score 0-1	0.73	0.41	1.29	
Gluten subjective: Agree (Disagree)	2.36	1.54	3.59	***
Gluten subjective: Neutral (Disagree)	2.41	1.79	3.26	***
Gluten objective: Score 0-1	1.47	0.76	2.84	
Nutrition subjective: Agree (Disagree)	0.96	0.66	1.40	
Nutrition subjective: Neutral (Disagree)	0.83	0.59	1.17	
Nutrition objective: Score 0-1	0.68	0.40	1.15	
<b>Perceived Health Status</b>				
Abdominal pain: Yes (No)	1.85	1.17	2.96	**
Acid Reflux: Yes (No)	1.48	0.96	2.28	
Bloating or inflammation: Yes (No)	1.85	1.32	2.60	***
Body aching: Yes (No)	1.35	0.79	2.34	
Brain fog: Yes (No)	1.02	0.60	1.74	
Diarrhea or constipation: Yes (No)	1.47	0.98	2.20	
Fatigue or lack of energy: Yes (No)	1.71	1.18	2.49	**
Headache or migraine: Yes (No)	1.49	0.89	2.49	
Nausea	1.70	0.89	3.31	
Health satisfaction: Satisfied (Unsatisfied)	1.13	0.86	1.50	
Health satisfaction: Neutral (Unsatisfied)	0.99	0.66	1.46	
Healthy eating habits: Agree (Disagree)	2.02	1.43	2.87	***
Healthy eating habits: Neutral (Disagree)	1.59	1.15	2.21	**

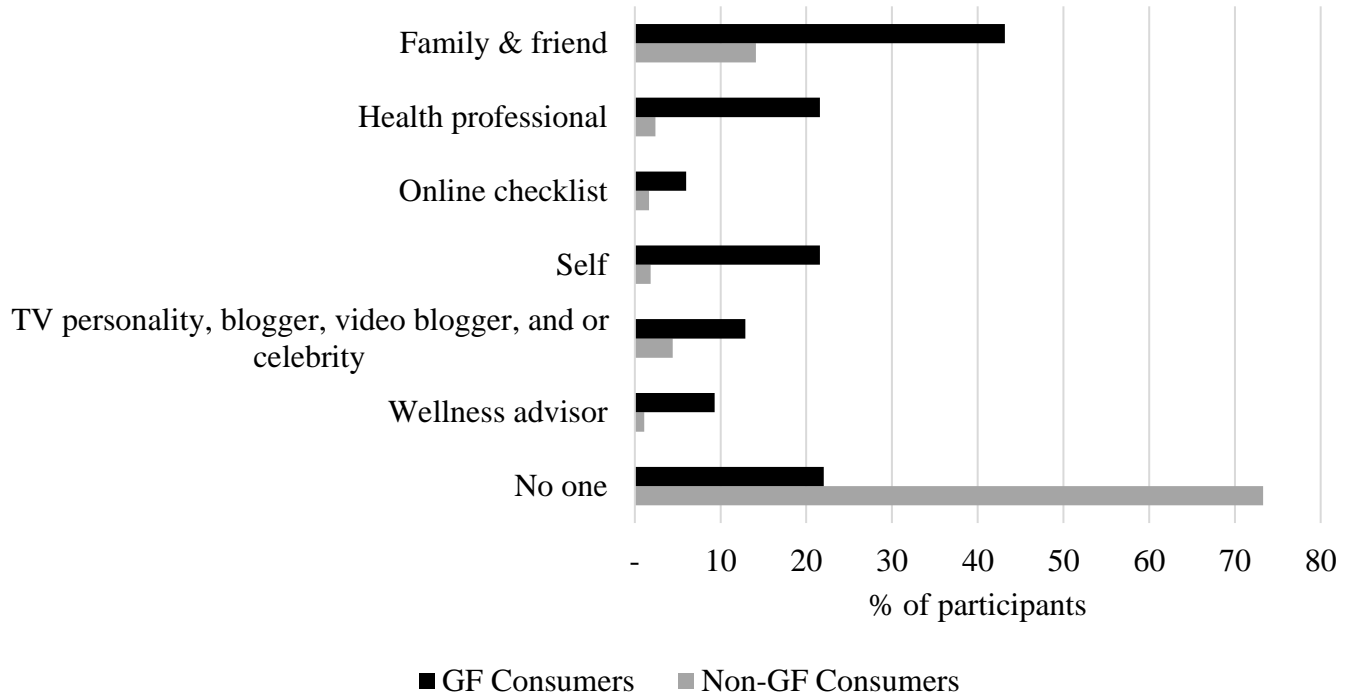
431 Note: Text in parentheses represent the reference category for each variable. Abbreviations: A  
 432 GF diet can help with acne; Gluten can cause disease in non-gluten sensitive people; GF  
 433 products are generally more nutritious than their gluten containing variant; In general, a GF or

434 GR diet is healthier for people than a full gluten containing diet; A GF diet can help with weight  
435 loss; Family & friends = Family member or friend; Healthcare center or health professional  
436 (doctor, dietitian, etc.); Self (including through personal research); Wellness advisor = Wellness  
437 coach, personal trainer, and or sports coach/nutrition/fitness shop or gym employee; No one (has  
438 ever suggested I try the diet); Grain subjective = I have a lot of knowledge about grain-based  
439 products; Gluten subjective = I have a lot of knowledge about gluten; Nutrition subjective = I  
440 have a lot of knowledge about nutrition. [grain/gluten/nutrition] objective refers to their objective  
441 knowledge scores on a scale of 0-1 and calculated as a continuous variable. Health satisfaction =  
442 How satisfied are you with your current health status; Healthy eating habits = My eating habits  
443 are very healthy.  
444 \*p<0.05, \*\*p<0.01, \*\*\*p<0.001

445 **Figures**  
446



447 **Fig. 1 Distribution of Participants' Beliefs in GF Health Benefits.** Abbreviations: A GF diet  
448 can help with acne; Gluten can cause disease in non-gluten sensitive people; GF products are  
449 generally more nutritious than their gluten containing variant; In general, a GF or GR diet is  
450 healthier for people than a full gluten containing diet; A GF diet can help with weight loss. All  
451 differences between GF Consumers and Non-GF Consumers are significant at  $p < 0.001$ .  
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**Fig. 2 Distribution of Participants who were Recommended to Try a GF Diet by an Information Source.** Abbreviations: Family & friends = Family member or friend; Healthcare center or health professional (doctor, dietitian, etc.); Self (including through personal research); Wellness advisor = Wellness coach, personal trainer, and or sports coach/nutrition/fitness shop or gym employee; No one (has ever suggested I try the diet). All differences between GF Consumers and Non-GF Consumers are significant at  $p < 0.001$ .

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