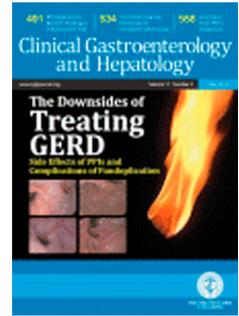


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**The Gluten-Free Diet Epidemic: Socioeconomic Factors Predict Google Search Trends  
More Than Health Related Factors**

Short Title: Google Search Trends for Gluten-Free Diet

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Abbreviations: Celiac disease (CD); Confidence Interval (CI); Designated market areas (DMAs); Hazard Ratios (HR); National Health and Nutrition Examination Surveys (NHANES); United States (US); US Census American Community Survey (ACS)

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- Monika Laszkowska: Study concept and design; acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.
- Henna Shiwani: Analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.
- Julia Belluz: Acquisition of data; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.
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- Peter HR Green: Study concept and design; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content; study supervision.
- Daniel Sheehan: Study concept and design; analysis and interpretation of data; drafting of the manuscript; critical revision of the manuscript for important intellectual content.
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Keywords: Celiac disease; diet choices; epidemiology

## INTRODUCTION

A gluten-free diet is the treatment for celiac disease (CD).<sup>1</sup> This diet has gained popularity in the United States (US) out of proportion to shifts in diagnosis and incidence of CD.<sup>2</sup> Socio-demographic factors can affect food purchases and nutritional habits, and popular diets may be unrelated to recommendations from medical professionals.<sup>3</sup> The aim of this study was to test whether socio-demographic and health data predict the popularity of Google searches for “gluten-free diet.”

## METHODS

Google Trends data were obtained for nine diet-related search terms most commonly searched annually from 2005 to 2015 across 210 Nielsen designated market areas (DMAs) in the US.<sup>4</sup> Dietary terms included: Atkins diet, gluten-free diet, low-calorie diet, low-carbohydrate diet, low-fat diet, organic food diet, Paleolithic diet, South Beach diet, and veganism. DMAs were linked to county identifiers. County data from the US Census American Community Survey (ACS), the Center for Disease Control and Prevention Diabetes Interactive Atlas, and County Health Rankings National Data were aggregated to create DMA-level estimates of socio-demographic and health-related factors.

We categorized DMAs into quartiles for median household income (Q1: \$29,951-\$42,008, Q2: \$42,009-\$45,621, Q3: \$45,622-\$51,403, and Q4: \$51,404-\$81,123) and percent of non-Hispanic white residents (Q1: 4-60%, Q2: 61-76%, Q3: 77-86%, and Q4: 86-96%) using ACS 2007 data. We performed Cox proportional hazards modeling to estimate Hazard Ratios (HR) and identify predictors of the gluten-free diet becoming the top-searched diet between 2005 and 2015. We

tested the following variables, all of which we included in the multivariable model: median household income, racial/ethnic composition, prevalence of diabetes or obesity, levels of leisure-time physical inactivity, and limitations in access to healthy food. Years until “gluten-free diet” became the most frequent dietary search was used as the time parameter in Cox modeling.

## RESULTS

“Gluten-free diet” became the most popular dietary search term for the first time in 4 of 210 DMAs (1.9%) in 2006, and in >50% of DMAs (63%) by 2011. This proportion increased annually until its peak in 2014, when it was the most popular search in 175 of 210 DMAs (83%).<sup>4</sup> Once this search became the most popular in a DMA, it remained most popular in consecutive years through 2015 in 115 of 210 DMAs (55%).

On multivariate analysis, shorter time to gluten-free diet being the top search term was associated with both increasing quartiles of median household income and the proportion of the residents who were non-Hispanic white (Figure 1). Diabetes and obesity prevalence, levels of leisure-time physical inactivity, and limitations in access to healthy food were not associated with gluten-free searches. Prevalence of obesity, diabetes, and levels of leisure-time physical inactivity were all highly correlated (Pearson correlation coefficients 0.70-0.79). When the analysis was repeated excluding the two latter variables, the associations of gluten-free diet searches with median household and the proportion of non-Hispanic white residents were essentially unchanged.

## DISCUSSION

The prevalence of CD in the US remained stable in recent years, approximately 0.7%.<sup>2,5</sup> In contrast, adherence to a gluten-free diet among individuals without CD increased from 0.52% in 2009-2010 to 1.69% in 2013-2014.<sup>2</sup> Our results reflect growing interest in the gluten-free diet, which became the most popular of nine dietary search terms across 83% of the US between 2005 and 2015.<sup>4</sup>

Popularity of gluten-free diet searches was significantly correlated with higher proportion of non-Hispanic white residents and higher household incomes. While the prevalence of CD in the US is higher among the Caucasian population (approximately 1%), this modestly increased prevalence does not adequately explain these high search rates.<sup>5</sup> Cost has been cited as a burden to adherence to a gluten-free diet in CD patients,<sup>6</sup> which may explain why this diet among non-CD patients achieved popularity earlier in regions with higher incomes.

A third of Americans who purchase gluten-free items cite no specific reason for this dietary habit.<sup>7</sup> Contrary to evidence, another third believe it is healthier or promotes weight loss.<sup>7,8</sup> Nonetheless, we found that gluten-free diet searches were not correlated with health-related factors such as obesity.

Our study has several limitations. Exposures were assessed on a population level, and caution must be taken in applying them at an individual level. While we adjusted for potential confounding, there may be unmeasured variables driving the association between income, race/ethnicity and interest in the gluten-free diet.

In summary, the gluten-free diet has become a dominant dietary internet search term and is more strongly associated with socio-demographic characteristics than health-related factors. Given the popularity of the gluten-free diet, future research should investigate the motivations of those maintaining this diet, and its consequences.

ACCEPTED MANUSCRIPT

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